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ICSAS 2nd INTERNATIONAL CONFERENCE ON MATHEMATIC
MARCH 7 - 9, 2025
İZMIR

Edited By
Prof. Dr. Elif Akpınar Külekçi

ORGANIIZATION
ACADEMY GLOBAL CONFERENCES

EVALUATION PROCESS
All applications have undergone a double-blind peer review process.

PARTICIPATING COUNTRIES

TURKEY – Ghana – Tanzania – Ghana- Kenya – Nigeria- South Africa – Uganda- Egypt- Taiwan- Bangladesh- China - South Korea

PRESENTATION
Oral presentation

PERCENTAGE OF PARTICIPATION
More than 50 % of paper are presented by participants from maintained countries.
12 papers from Turkey and 24 paper from other countries.

Members of the organizing committees of the conference perform their duties with an "official assignment letter"

LANGUAGES
Turkish, English, Russian, Persian, Arabic

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Konu : Doç.Dr.Elif AKPINAR KÜLEKÇİ'nin Görevlendirilmesi

MİMARLIK VE TASARIM FAKÜLTESİ DEKANLIĞINA

İlgi : 29.11.2023 tarihli ve E-53120705-000-2300381989 sayılı belge.

Fakülteniz Peyzaj Mimarlığı Bölümü öğretim üyelerinden Doç.Dr.Elif AKPINAR KÜLEKÇİ'nin, Yükseköğretim Genel Kurulunun 15.06.2023 tarihli, 10 sayılı oturumunda alınan 2023.10.183 sayılı kararı gereğince Doçentlik Başvuru Şartlarında bulunan ve doçent olacak adaylardan istenen "Diğer uluslararası/ ulusal bilimsel toplantının düzenleme komitesinde resmi olarak görevlendirilmiş üniversite akademisyen temsilcisi bulunması zorunludur." maddesi gereğince, Academy Global Conference & Journals tarafından yapılan kongrelerin düzenleme kurullarında yolluksuz ve gündeliksiz olarak görevlendirilmesi Rektörlüğümüzce uygun görülmüştür.

Bilgilerini ve gereğini rica ederim.

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- Oturuma bağlanmadan önce Salon numaranızı adınızın önüne aşağıdaki gibi ekleyiniz. Bu sayede kongre açılışında beklemeden oturumlarınıza gönderilebileceksiniz. Ör. 5 Ahmet Ahmetoglu
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7 Mart / March 7, 2025 / 11:00 – 13:00 Time zone in Turkey (GMT+3)				
Salon	Moderator		Bildiri No ve Başlığı / Paper ID and Title	Authors
HALL / SALON 1	**Dr. Öğr. Üyesi Özge ÖZCAN**	1	COMPARISON OF R PROGRAM AND CHATGPT IN PHYLOGENETIC TREE CONSTRUCTION: PROBLEMS AND SOLUTIONS	Undergraduate, ÜMMÜHAN ŞAŞ Professor Doctor, YUSUF KURT
		2	Türkiye'deki *Anatololacerta anatolica* (Werner, 1900) Türünün Genom-Çaplı Belirteçlere Dayalı Filocoğrafyası	Araş. Gör. Ahmet Gökay KORKMAZ Prof. Dr. Çetin ILGAZ Prof. Dr. Yusuf KUMLUTAŞ Dr. Öğr. Üyesi Mehmet Kürşat ŞAHİN Prof. Dr. Serkan GÜL Doç. Dr. Elif YILDIRIM CAYNAK Doç. Dr. Kamil CANDAN
		3	ARONYA (*Aronia melanocarpa*) MEYVESİNİN METANOL EKSTRESİNİN ANTİOKSİDAN ETKİSİNİN BELİRLENMESİ	Dr. Öğr. Üyesi Özge ÖZCAN Öğr. Gör. Elif GEZER ASLAN
		4	GÜVEM MEYVESİNİN *(PRUNUS SPİNOSA* L.) ANTİOKSİDAN, ANTİMİKROBİYAL VE SİTOTOKSİKETKİSİNİN BELİRLENMESİ	Mehmet Halim KAHRAMAN Prof. Dr. Figen ERTAN Dr. Öğr. Üyesi Özge ÖZCAN
		5	*Escherichia coli'* DE NAKAVT OLMASI İLE FERULİK ASİTE KARŞI DUYARLILIĞI ARTIRAN BAZI GENLER	PhD Student Hatice ÖZTÜRKEL KABAKAŞ PhD Student Kadriye Aslıhan Onat Taşdelen Dr. Öğr. Gör. Merve SEZER KÜRKÇÜ Doç. Dr. Bekir ÇÖL
		6	FERULİK ASİTİN BİYOYARARLANIMINI ANLAMADA MOLEKÜLER VE MİKROBİYOLOJİK ÇALIŞMALAR	PhD Student Hatice ÖZTÜRKEL KABAKAŞ Dr. Öğr. Gör. Merve SEZER KÜRKÇÜ Doç. Dr. Bekir ÇÖL
		7	*Escherichia coli'*DE p-KUMARİK ASİT TOLERANSINI AZALTAN BAZI GENLER: *pgpB, fadL, ydeU*	KADRİYE ASLIHAN ONAT TAŞDELEN HATİCE ÖZTÜRKEL KABAKAŞ Dr. Öğr. Gör. MERVE SEZER KÜRKÇÜ Doç. Dr. BEKİR ÇÖL

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HALL / SALON 2	**Prof. Dr. Hasan Ekim**	1	The Place of Salt and Iodine in Our Health	Doç. Dr. Meral Ekim Prof. Dr. Hasan Ekim
		2	HYPERTENSION IN ELDERLY PEOPLE	Doç. Dr. Meral Ekim Prof. Dr. Hasan Ekim
		3	MOR LAHANA'DAN (*Brassica oleracea var. capitata f. rubra*) İZOLE EDİLEN POLİFENOL OKSİDAZ ENZİMİNİN BİYOKİMYASAL KARAKTERİZASYONU	Y. Lisans Öğrencisi, Çiğdem ULAMAN Dr. Öğr. Üyesi Elif Duygu KAYA
		4	DİYABETİK HASTALARDA LAKTAT/ALBUMİN (L/A) ve SİSTEMİK İMMUN İNFLAMATUVAR İNDEKS (SII) DEĞERLERİNİN DİYABETİK KRONİK BÖBREK HASTALIĞI İLE İLİŞKİSİ	Dr. Öğretim Üyesi Murat ARI Dr. Hakan CENGİZ Dr. Öğretim Üyesi Ayça TUZCU
		5	ANTIMICROBIAL POTENTIAL ACTIVITIES OF VARIOUS SOLVENT EXTRACTS OF *Hyocyamus aureus* (SOLANACEAE)	Elanur DEMİR Alevcan KAPLAN Emine ÇELİKOĞLU Mehmet BOĞA
		6	TIROID UYARICI HORMON TRIIYODOTIRONIN VE TIROKSIN HORMONLARININ EŞ ZAMANLI ÖLÇÜLMESINDE ÇIFT KATLI NANOPARTIKÜL TABANLI IMMÜNOSENSÖR GELIŞTIRILMESI	Dr. Öğretim Üyesi ÜMİT YAŞAR Dr. Öğretim Üyesi UMUT KÖKBAŞ Dr. Öğretim Üyesi ZEHRA GÜL YAŞAR Ar. Gör. Dr. BAŞAK GÜNAŞTI MSc. YASEMİN ÖZKÜÇÜK Prof. Dr. ABDULLAH TULİ

ICSAS 4th INTERNATIONAL CONFERENCE ON EDUCATION March 7 – 9, 2025 IZMIR Meeting ID: 885 7151 8350 Passcode: 202224				
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HALL / SALON 3	**Öğr. Gör. Dr. OKAN DEDE**	1	EĞİTİM FAKÜLTESİ ÖĞRENCİLERİNİN ÇOCUKLARIN DİJİTAL HAKLARINA YÖNELİK GÖRÜŞLERİ	DOÇ. DR. AYŞEGÜL AYYILDIZ ASİL ÖĞRETMEN, ABDURRAHMAN ASİL
		2	EĞİTİM FAKÜLTESİ ÖĞRENCİLERİNİN PAYLAŞAN EBEVEYNLİK (SHARENTING) HAKKINDAKİ FARKINDALIKLARININ İNCELENMESİ	DOÇ. DR. AYŞEGÜL AYYILDIZ ASİL ÖĞRETMEN, ABDURRAHMAN ASİL
		3	INTERDISCIPLINARY LEARNING THROUGH STEM AND MAKER ACTIVITIES: AN APPLICATION AT THE PRIMARY SCHOOL LEVEL	Uzm. NESRİN ÖZBABA ULUĞ AYŞEGÜL İLİKÇİ
		4	EĞİTİM PROGRAMLARINDA OYUNLAŞTIRMA YAKLAŞIMLARI: TEORİK TEMELLER VE UYGULAMA ALANLARI	Öğr. Gör. Dr. OKAN DEDE
		5	YAPAY ZEKA DESTEKLİ ÖĞRENME ORTAMLARININ EĞİTİM PROGRAMLARINA ENTEGRASYONU: FIRSATLAR VE ZORLUKLAR	Öğr. Gör. Dr. OKAN DEDE
		6	MAVİ BİLYE ENSTİTÜSÜ YAZ BİLİM KAMPININ ORTAOKUL ÖĞRENCİLERİNİN ÇEVRESEL DUYGU VE DÜŞÜNCELERİNE ETKİSİ	Uzman Öğretmen GÜLHANIM YAĞMUR Doç.Dr. ÖNDER ŞENSOY Doç.Dr. SEDA ÇAVUŞ GÜNGÖREN Prof.Dr. NAİM UZUN
		7	7. SINIF ÖĞRENCİLERİNİN SİSTEM DÜŞÜNME BECERİLERİNİ ÖLÇMEYE YÖNELİK AÇIK UÇLU ANKET GELİŞTİRME ÇALIŞMASI	Öğretmen AYŞEGÜL ÇİNKİZ Prof. Dr. CANSU FİLİK İŞÇEN

ICSAS 4th INTERNATIONAL CONFERENCE ON EDUCATION March 7 – 9, 2025 IZMIR Meeting ID: 885 7151 8350 Passcode: 202224				
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Salon	Moderator		Bildiri No ve Başlığı / Paper ID and Title	Authors
HALL / SALON 4	**Dr. Öğr. Üyesi, Fadile AYDIN**	1	EXAMINING TEACHERS' PROFESSIONAL BURNOUT, MOTIVATION AND STRESS LEVELS	Dr. Öğr. Üyesi, Fadile AYDIN
		2	INVESTIGATION OF TEACHERS' PROFESSIONAL COMMITMENT, JOB SATISFACTION AND LIFELONG LEARNING LEVELS ACCORDING TO THEIR DESIRES FOR GRADUATE EDUCATION	Dr. Öğr. Üyesi, Fadile AYDIN
		3	Öğretmen Adaylarının Yaratıcı Öğretmen Kavramına İlişkin Metaforları	Fatmanur Eren Doç. Dr. Gülbin Zeren Nalinci
		4	ORTAOKUL ÖĞRENCİLERİNİN SANATSAL YARATICILIK DÜZEYLERİNİN BELİRLENMESİ	Burcu ÖZTAŞ Doç. Dr. Gülbin Zeren NALİNCİ
		5	ALGILANAN ÖRGÜTSEL DESTEK VE ÖĞRETMEN MUTLULUĞU ARASINDAKİ İLİŞKİ	Dr. Öğr. Üyesi Erdal MERİÇ Öğretmen Fatma BAŞDAĞ Okul Müdürü Kadir BAŞDAĞ
		6	EĞİTİMDE SANAL EVREN (METAVERSE): YENİ UFUKLAR	Öğr. Gör. Dr. Mustafa AKSOĞAN
		7	EĞİTİMDE SANAL ve ARTIRILMIŞ GERÇEKLİĞİN KULLANIMI: GELECEĞİN ÖĞRENME ORTAMLARI	Öğr. Gör. Dr. Mustafa AKSOĞAN
		8	TÜRKİYE'DE ORTAOKUL BİNALARI ÖĞRETİM PROGRAMLARINA NE KADAR UYGUN?	İngilizce Öğretmeni, SİBEL SARAN YILDIZ Doç. Dr. ŞABAN BERK

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HALL / SALON 5	**Prof. Dr. Mikail BATU**	1	ETHICAL LITERACY: A CONCEPTUAL DISCUSSION	Prof. Dr. Emet GÜREL Prof. Dr. Mikail BATU
		2	MOBBING AS AN ETHICAL VIOLATION	Prof. Dr. Emet GÜREL Prof. Dr. Mikail BATU
		3	AİLE DANIŞMANLIĞI AÇISINDAN AİLE FONKSİYONLARINA YÖNELİK FELSEFİ BİR YAKLAŞIM: P4C	Aile Danışmanı, ZEYNEP KORKMAZ
		4	GARETH B. MATTHEWS'İN ÇOCUKLUK FELSEFESİ VE P4C YAKLAŞIMI	Bilim Uzmanı, ZEYNEP KORKMAZ
		5	M.S. DAWKINS'DE HAYVANLARA YÖNELİK İNSANBİÇİMCİ DİLİN ELEŞTİRİSİ	Yüksek Lisans Öğrencisi GÜLŞAH ERTÜRK Prof.Dr. HASAN AYDIN
		6	ON NERMI UYGUR'S LANGUAGE-CULTURE RELATIONSHIP AS A POSSIBILITY OF TURKISH PHILOSOPHY	Arş. Gör. Faruk YORGUN

ICSAS 1st INTERNATIONAL CONFERENCE ON FINANCE and BANKING ICSAS 2nd INTERNATIONAL CONFERENCE ON BUSINESS MANAGEMENT March 7 - 9, 2025 İzmir Meeting ID: 885 7151 8350 Passcode: 202224				
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HALL / SALON 6	**Dr. Öğr. Üyesi HİLAL OK ERGÜN**	1	SECTORAL EXAMINATION OF DIGITAL-BASED PAYMENTS: AN EMPIRICAL ANALYSIS	Dr. Öğr. Üyesi HİLAL OK ERGÜN
		2	ANALYSIS OF THE RELATIONSHIP BETWEEN TRANSPORTATION SECTOR INDEXES: ARDL BOUNDS TEST APPROACH	Dr. Öğr. Üyesi, ERCÜMENT DOĞRU
		3	BANKACILIK SEKTÖRÜNDE FİNANSAL ESNEKLİK: KATILIM BANKALARI VE GELENEKSEL BANKALARIN KARŞILAŞTIRMALI DEĞERLENDİRİLMESİ	Öğr. Gör. Dr. Sevim Ezgi İSLAH Dr. Öğr. Üyesi İsmet BOLAT
		4	TÜRKİYE'DEKİ REASÜRANS ŞİRKETLERİNİN FİNANSAL ETKİNLİKLERİNİN KARŞITLAŞTIRILMASI ÜZERİNE BİR ÇALIŞMA	Dr.Öğr.Üyesi İsmet BOLAT Öğr.Gör.Dr. Sevim Ezgi İSLAH
		5	THE ROLE OF INTEGRATED MARKETING COMMUNICATION ACTIVITIES IN INDIVIDUALS' ATTITUDES AND BEHAVIORS TOWARDS HEDONIC CONSUMPTION	Dr. Öğr. Üyesi Musa ÇAKIR
		6	THE MODERATING ROLE OF SELF-EFFICACY ON THE RELATIONSHIP BETWEEN ORGANIZATIONAL COMMUNICATION AND ORGANIZATIONAL COMMITMENT	Dr., ALAADDIN MOHAMMEDHASSAN

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HALL / SALON 7	**Prof. Dr. Aynur AYTEKİN ÖZDEMİR**	1	PEDİATRİK HASTALARDA TIBBİ GİRİŞİMLERDE NONFARMAKOLOJİK AĞRI YÖNETİMİNDE MEKANİK VİBRASYONUN KULLANIMI	Prof. Dr. Aynur AYTEKİN ÖZDEMİR Araş. Gör. Büşra KÜTÜK
		2	GELİŞİM DÖNEMLERİNE GÖRE HASTA ÇOCUKLA İLETİŞİM	Prof. Dr. Aynur AYTEKİN ÖZDEMİR Araş. Gör. Büşra KÜTÜK
		3	OKUL ÇAĞI ÇOCUKLARINA VERİLEN ORAL HİJYEN EĞİTİMİNİN ETKİNLİĞİNİN BELİRLENMESİ	Arş. Gör. Büşra KÜTÜK Prof. Dr. Aynur AYTEKİN ÖZDEMİR Erdinç YILDIZ
		4	DİYABETİK YARALAR VE TEDAVİLER ÜZERİNE BİBLİYOMETRİK ANALİZ	Dr. Öğr. Üyesi Elif AYDIN Doç. Dr. Ayşe KOÇAK SEZGİN
		5	*HELICOBACTER PYLORI* INFECTION: PREVALENCE, TRANSMISSION, AND PHYTOTHERAPY-BASED TREATMENT APPROACHES	Dr. Öğr. Üyesi Elif AYDIN Doç. Dr. Ayşe KOÇAK SEZGİN
		6	MALE NURSES’ EXPERIENCES TOWARDS NURSING PROFESSION FROM THE PERSPECTIVE OF GENDER ROLES: A PHENOMENOLOGICAL STUDY	Student, BİRCAN YILMAZ Res. Assistant Dr., BEDİA TARSUSLU
		7	PLACENTA RETENTION AND CURRENT APPROACHES	Fatma Nur YILMAZ Arş. Gör. Dr., Fatma YILDIRIM Prof. Dr., Nuriye BÜYÜKKAYACI DUMAN

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HALL / SALON 8	**Öğr. Gör. Dr. Emine ERSÖZLÜ**	1	ADVANTAGES, ETHICAL PRINCIPLES, AND CHALLENGES OF ARTIFICIAL INTELLIGENCE IN PERIOPERATIVE NURSING	Öğr. Gör. Dr. Emine ERSÖZLÜ Öğr. Gör. Ümit Topcuoğlu
		2	ROBOTIK CERRAHIDE PERIOPERATIF HEMŞIRELIK ROLÜ VE KARŞILAŞILAN ZORLUKLAR	Öğr. Gör. Dr. Emine ERSÖZLÜ Öğr. Gör. Ümit Topcuoğlu
		3	BELIEFS ABOUT MIDWIFERY IN PREHISTORY AND ANTIQUITY: GOD AND GODDESSES	Dr. Ebe, SEZİN GÜRSU Prof. Dr., BİRSEN KARACA SAYDAM
		4	EBELERİN SERVİKS KANSERİ KONUSUNDAKİ AKADEMİK FAALİYETLERİ	Dr. Ebe, SEZİN K. GÜRSU Uzman Ebe, SİNEM GÜLÜMSER Uzman Ebe, DENİZ SELÇUK Prof. Dr., BİRSEN KARACA SAYDAM
		5	CHALLENGES FACED BY PATIENT RELATIVES CARING FOR PATIENTS WITH STOMA	Assistant Professor, Melike DURMAZ Research Assistant Dr., Tuğba GÖZÜTOK KONUK
		6	GAMIFICATION AND GAME-BASED LEARNING IN NURSING EDUCATION: INNOVATIVE APPROACHES AND THEIR EFFECTS	Research Assistant Dr. TUĞBA GÖZÜTOK KONUK Assistant Professor, MELİKE DURMAZ
		7	HİPOTİROİDİ HASTALARINDA SEMPTOM ŞİDDETİ VE SEMPTOM YÖNETİMİ: ÖLÇEK GELİŞTİRME ÇALIŞMASI	Öğr. Gör.,ŞEYMA TRABZON Doç. Dr.,HAVVA SERT Doç.Dr., TANER DEMİRCİ
		8	AĞIZ VE DİŞ SAĞLIĞI HASTANESİNDE GÖREV YAPAN SAĞLIK PERSONELİNİN HEPATİT B, HEPATİT C VE HIV BULAŞ VE KORUNMA BİLGİ, TUTUM VE DAVRANIŞLARI	Öğr. Gör.,ŞEYMA TRABZON Dr. Öğr. Üyesi, GÜLSÜM KAYA Hemşire, RASİME ÖZNUR HALICI

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HALL / SALON 9	**Doç Dr. Müslüm Arpacı**	1	FOSTERING NATIONAL ADVANCEMENT: THE PIVOTAL INFLUENCE OF PHILOSOPHY AND EDUCATION IN THE POST-PANDEMIC LANDSCAPE	Dr. Emre Yılmaz Taha Bilen
		2	EMPOWERING STUDENTS THROUGH SUSTAINABLE LIVING: MOTIVATION AND ECONOMIC SELF-SUFFICIENCY AMONG UNDERGRADUATES IN KENYA	Dr. Öğr. Gör. Ayşe Demir Doç. Dr. Arslan Yavuzoğlu
		3	A PHILOSOPHICAL INQUIRY INTO ABSURDISM AND EXISTENTIALISM IN CONTEMPORARY THEATRE	Dr. Mehmet Kaya
		4	EXPLORING THE SYMBOLISM AND PHILOSOPHY IN HINDU TEMPLE ARCHITECTURE	Araş. Gör. Dr. Elif Öztürk
		5	YALIN İLKELER KULLANILARAK BAKIM PROGRAMI VERIMLILIĞININ OPTIMIZE EDILMESI: LIBYA PETROL VE GAZ SEKTÖRÜNDE BIR VAKA ÇALIŞMASI	Doç Dr. Müslüm Arpacı
		6	INTEGRATION OF EASTERN PHILOSOPHIES AND ETHICAL PRINCIPLES IN BUSINESS MANAGEMENT	Cheng Liwei
		7	CORE PRINCIPLES OF THE THEORY OF CONSTRAINTS: A NEW PERSPECTIVE	Dr. Can Aydın
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HALL / SALON 10	**Doç .Dr. Hakan Aydın**	1	BLOK ZİNCİRİ TEKNOLOJİSİ İLE MERKEZİYETSİZ FİNANS: ETKİLERİ, ZORLUKLAR VE ÇÖZÜM ÖNERİLERİ	Dr. Öğretim Üyesi . Gökhan Bütün, Yl. Öğrencisi Gülcan Durmaz.
		2	API GÜVENLİĞİ: GÖMÜLÜ VE AÇIK FİNANS UYGULAMALAR	Nimet Şahin , Dr. Esra Yücel
		3	KIRSAL ALANLARDA KÜÇÜK VE ORTA ÖLÇEKLİ İŞLETMELERİN FİNANSA ERİŞİMİ: ENDONEZYA VE TAYLAND ÖRNEĞİ	Buket Oran, Dr. Öğr. Üyesi Fatma Fındık
		4	KOBİ'LERİN FİNANSA ERİŞİMİ: TÜRKİYE ÖRNEĞİ – MODEL YAKLAŞIMI	Nimet Demirci. Doç . Dr. Sevil Doğan
		5	FINANSAL KARAR VERME: TÜRKIYE'DEN FINANS ÖĞRENCILERI ÜZERINE AMPIRIK BIR ÇALIŞMA	Doç .Dr. Hakan Aydın
		6	ETIK FINANS VE İSLAMI FINANS: ÖZELLIKLER, OLASI YAKINSAMALAR VE POTANSIYEL GELIŞIM	Dr. Öğr. Gör. Burak Uzal
		7	FINANS ÖĞRENCILERININ FINANSAL OKURYAZARLIĞI: TÜRKIYE'DEN BIR AMPIRIK ÇALIŞMA	Dr. Feyza Hacılaroğlu.

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HALL / SALON 1	**Assoc. Prof. Dr. Sékou Traoré**	1	DEVELOPMENT OF AN INTERDISCIPLINARY UNDERGRADUATE COURSE COMBINING BIOLOGY AND CHEMISTRY	Emily J. Carter
		2	ENHANCED PRODUCTION OF EICOSAPENTAENOIC ACID AND FUCOXANTHIN IN COLD-ADAPTED DIATOM SPECIES	Minh Hoang Nguyen, Linh Thi Mai,
		3	BIOPROPHYLACTIC POTENTIAL OF PYOCYANIN FROM PSEUDOMONAS AERUGINOSA AGAINST SAPROLEGNIASIS IN INCUBATED AFRICAN CATFISH EGGS	A. O. Adeyemi, B. K. Oladipo, C. M. Eze, D. F. Onifade
		4	MONITORING WILDFIRE IMPACT AND ECOSYSTEM RECOVERY USING REMOTE SENSING TECHNIQUES	Assis. Prof. Dr. R. S. Deshmukh
		5	UTILIZATION OF DRONE TECHNOLOGY IN WILDFIRE MANAGEMENT: IGNITION DETECTION AND 3D FUEL LOAD ASSESSMENT"	Ahmed Al-Mansoori, Fatima Al-Haddad
		6	ASSESSMENT OF MICROBIAL CONTAMINANTS IN DRINKING WATER FROM VARIOUS REGIONS OF JORDAN	Ahmed Al-Mansoori, Fatima Al-Haddad
		7	MAPPING RESEARCH TRENDS IN WILDFIRE MANAGEMENT IN MEDITERRANEAN ECOSYSTEMS	Amara Diallo, Assoc. Prof. Dr. Sékou Traoré
		8	Epigenetic Impact of Alpha-Particle Radiation on Drosophila melanogaster: A Short-Term Experimental Study	Muhammed Al-Shehhi

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HALL / SALON 2	**Dr. Nino Dolidze**	1	DIVERSITY AND CONSERVATION OF USEFUL PLANT FAMILIES IN THE CAUCASUS REGION: A FOCUS ON ENDEMIC AND ETHNOBOTANICAL RESOURCES	Giorgi Ivanidze, Dr. Mariam Svanidze, Dr. Nino Dolidze
		2	ECONOMIC EVALUATION, GROWTH, AND PRODUCTIVITY OF GRAFTED TOMATO VARIETIES USING SOLANUM TORVUM AS ROOTSTOCK	Amina Hassan, Assis. Prof. Dr. Fatima Ahmed, Mohamed El-Sayed
		3	DIFFERENTIAL RESPONSES OF LEAF CARBON, NITROGEN, AND PHOSPHORUS TO CLIMATIC VARIABLES ACROSS BIOMES AND PLANT FUNCTIONAL TYPES	Zhang Wei, Dr. Liu Mei
		4	PHYTOCHEMICAL PROFILING AND FTIR ANALYSIS OF SAPONINS IN THREE NIGERIAN RUELLIA SPECIES: RUELLIA PROSTRATA, RUELLIA LINEARI-BRACTEOLATA, AND RUELLIA BIGNONIIFLORA	Amina O. Adeyemi, Chinedu P. Okeke, Fatima B. Musa, Ibrahim S. Eze, Grace N. Okafor
		5	IMPACT OF PHYSICAL ACTIVITY ON REPRODUCTIVE PERFORMANCE AND SEMEN CHARACTERISTICS OF JERSEY BULLS	James O. Thompson, Michael A. Richardson
		6	EXPERT EVALUATION AND CLASSIFICATION OF HERITAGE TREES: A SOUTHEAST ASIAN APPROACH	R. Sari, D. W. Putra, L. H. Wijaya
		7	FUNGAL PATHOGENS ASSOCIATED WITH THE DECLINE OF ACACIA NILOTICA AND EUCALYPTUS CAMALDULENSIS IN PUNJAB, PAKISTAN	S. Khan, Dr. R. Ali, Assis. Prof. Dr. A. Rehman
		8	EVALUATING THE CURRENT STATE AND FARMERS' PERSPECTIVES ON AGROFORESTRY IN PUNJAB, INDIA :	P. Verma, A. Singh, M. Yadav
		9	ENGAGING LOCAL YOUTH IN THE PRESERVATION OF FORESTS AND PROTECTED AREAS IN NEPAL	Rajesh Thapa, Dr. Sunita Gurung

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HALL / SALON 3	**Prof. Dr. Aibek Nursultanov**	1	ASSESSING WILDFIRE SUSCEPTIBILITY IN THE BIA FOREST REGION OF GHANA: AN INTEGRATED GEOSPATIAL APPROACH	Samuel Osei, Kwame Asante
		2	SEASONAL INFLUENCE OF MINING OPERATIONS ON WATER QUALITY IN THE MFOLOZI RIVER, KWAZULU-NATAL, SOUTH AFRICA	Thabo M. Dlamini, Nomvula S. Khumalo, Sipho N. Mthembu
		3	ASSESSING TREE GROWTH FACTORS IMPACTING CARBON STORAGE IN RESPONSE TO CLIMATE VARIABILITY	A. O. Mensah, K. A. Boateng
		4	ASSESSING SOIL HEALTH AND CONTAMINATION TRENDS IN A MAJOR URBAN CENTER OVER TWO DECADES	Dr. John Mwangi, Assoc. Prof. Dr. Grace Wambui
		5	EVALUATING THE EFFECTIVENESS OF MECHANIZED WEED CONTROL IN THE RESTORATION OF DEGRADED OAK FORESTS	Ahmed Al-Mansoori, Fatima Al-Harthy
		6	SEASONAL IMPACT ON TERMITE INFESTATION OF WOODEN BEEHIVES IN ENUGU, NIGERIA	Eze Nwankwo, P. U. Okeke
		7	A MATHEMATICAL FRAMEWORK FOR ANALYZING FOREST RESOURCE DEPLETION: IMPACT OF SYNTHETIC PRODUCT INDUSTRIES	Priya Sharma, Rajesh Kumar, Anjali Mehta
		7	ENHANCING CREATIVITY IN TECHNICAL DRAWING EDUCATION: AN ASSESSMENT APPROACH	João R. Almeida, Camila S. Ferreira, Lucas M. Costa, Beatriz L. Oliveira
		8	AGRICULTURAL GOVERNANCE AND RURAL DEVELOPMENT IN KAZAKHSTAN	Prof. Dr. Aibek Nursultanov

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HALL / SALON 4	**Prof. Dr. Kenji Yamamoto,**	1	REVOLUTIONIZING TEACHING METHODS WITH ADVANCED DIGITAL SOLUTIONS	Ling Chen, Haruto Sato, Kwame Boateng
		2	IMPROVING ENGINEERING EDUCATION STANDARDS THROUGH QUALITY ASSURANCE AND SELF-ASSESSMENT	Wei Li, Yuki Nakamura,
		3	BOOSTING HISTORY EDUCATION WITH MULTIMEDIA TOOLS: A CROSS-CULTURAL ANALYSIS	Dr. Samuel Owusu, Dr. Grace Wambui, Dr. Amina Diallo
		4	TRANSFORMING SCIENCE EDUCATION: CUTTING-EDGE APPROACHES TO TEACHING NUCLEAR CONCEPTS	Lin Zhang, Ahmed El-Sayed
		5	EVALUATING MENTAL HEALTH SUPPORT FOR ENGINEERING STUDENTS: THE ROLE OF THERAPIST CHARACTERISTICS	Prof. Dr. Kenji Yamamoto,
		6	OVERCOMING CHALLENGES IN CONSTRUCTION MEASUREMENT EDUCATION	Jamal Mwangi
		7	CHANGING BEHAVIORS THROUGH EDUCATIONAL GAMES: A FOCUS ON ENVIRONMENTAL CONSCIOUSNESS	Sakura Yamamoto, Assoc. Prof. Dr. Ochieng Mwangi
		8	TRANSFORMING LEARNING THROUGH HYBRID EDUCATION: THE IMPACT OF DIGITAL TOOLS	Haruto Tanaka

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HALL / SALON 5	**Dr. Aoi Yamamoto**	1	ADVANCING ROBOTIC SYSTEMS EDUCATION THROUGH INNOVATIVE LEARNING METHODS: A CASE STUDY AT SHANGHAI INSTITUTE OF TECHNOLOGY, CHINA	Wang Lei, Sun Jing, Li Min
		2	INVESTIGATING UNDERGRADUATE STUDENTS' UNDERSTANDING OF MATHEMATICAL CONCEPTS IN RATE OF CHANGE	Haruto Suzuki, Dr. Aoi Yamamoto
		3	EXAMINING THE ROLE OF MATHEMATICAL CONFIDENCE, ENGAGEMENT, AND IDENTITY IN STUDENT ACHIEVEMENT	Wei Liu, Assis. Prof. Tunde Ojo
		4	REVOLUTIONIZING MEDICAL EDUCATION THROUGH AUGMENTED REALITY: A NEW FRONTIER IN EMBRYOLOGY TEACHING	Yuki Sato, Chen Li, Fatima Ali, Haruto Nakamura, Kwame Asante, Nurul Hasanah
		5	A STUDY OF CAREER GOALS AMONG FINAL-YEAR STUDENTS IN THE SCHOOL OF MEDICINE, UNIVERSITY OF LAGOS, NIGERIA	E. Okonkwo, F. Balogun, P. Eze, S. Ahmed, B. Okafor, T. Adeyemi, G. Oladipo, H. Suleiman
		6	IMPROVING EMPLOYEE PERFORMANCE ANALYSIS IN CORPORATE TRAINING USING XAPI: INSIGHTS INTO BEHAVIORAL TRENDS AND PREDICTIVE MODELING	Taro Suzuki, Fatima Ibrahim,
		7	EXPLORING ACTIVE LEARNING PRACTICES AMONG ONLINE GRADUATE STUDENTS: A CASE STUDY IN SOUTH ASIA	Yuki K. Sato, Sipho Dlamini
		8	BOOSTING ONLINE GRADUATE STUDENT PARTICIPATION THROUGH EFFECTIVE TEACHING STRATEGIES IN SOUTH ASIA	Assoc. Prof. Dr. Kwame O. Asante
		9	ASSESSING INTERACTIVE ENGAGEMENT IN BLENDED LEARNING SETTINGS: A FOCUS ON DATA SYNCHRONIZATION AND FEEDBACK LOOPS	Fatima Al-Hassan, Kwame Osei

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HALL / SALON 6	**Assis. Prof. Dr. Aiko Nakamura**	1	EMPOWERING PEDAGOGY STUDENTS WITH LEARNING DISABILITIES: CAREER PATHWAYS AND CHALLENGES IN THAILAND	Somchai Ratanakul Ananya Sirisom
HALL / SALON 6	**Assis. Prof. Dr. Aiko Nakamura**	2	BOOSTING COMPUTATIONAL THINKING IN STEM EDUCATION THROUGH PHYSICAL COMPUTING INNOVATIONS	Dr. Maria Gonzalez
HALL / SALON 6	**Assis. Prof. Dr. Aiko Nakamura**	3	FOSTERING CREATIVITY IN EARLY CHILDHOOD EDUCATION: THE IMPACT OF GRAPHIC ACTIVITIES IN ZAMBIA	Lindiwe Nkosi Tafadzwa Moyo
HALL / SALON 6	**Assis. Prof. Dr. Aiko Nakamura**	4	TRANSFORMING TEACHER TRAINING WITH TECHNOLOGY-DRIVEN KNOWLEDGE BUILDING: INSIGHTS FROM SECONDARY EDUCATION	Kenji Yamamoto Amina Sani
HALL / SALON 6	**Assis. Prof. Dr. Aiko Nakamura**	5	ASSESSING COGNITIVE LOAD IN PILOT TRAINING: A STUDY ON MODERN RECREATIONAL AIRCRAFT	Chinedu Okeke Youssef Ahmed
HALL / SALON 6	**Assis. Prof. Dr. Aiko Nakamura**	6	INNOVATING STEM EDUCATION WITH NEUROCOGNITIVE LEARNING STRATEGIES	Assis. Prof. Dr. Aiko Nakamura
HALL / SALON 6	**Assis. Prof. Dr. Aiko Nakamura**	7	ENHANCING METACOGNITIVE SKILLS THROUGH MOBILE LEARNING APPS: A STUDY ON HIGH-ACHIEVING STUDENTS	Assoc. Prof. Dr. Haruto Tanaka Sofia Martinez

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HALL / SALON 7	**Dr. Sofia Martinez**	1	ADOPTING EDUCATION 4.0 PRINCIPLES IN MODERN LANGUAGE TEACHING	Dr. Sofia Martinez
		2	THE IMPACT OF SOCIAL SKILLS AND COMMUNICATION TRAINING IN EARLY CHILDHOOD EDUCATION: PATHWAYS TO FUTURE SUCCESS	Mei Lin, Nadia Ahmed
		3	BUILDING INTERCULTURAL AWARENESS AMONG DIVERSE STUDENT GROUPS IN ISRAELI HIGHER EDUCATION	Rachel Cohen, David Levy
		4	IMPROVING MATHEMATICAL ABILITIES IN CHILDREN WITH AUTISM USING THE PROJECT MIND FRAMEWORK: A PRELIMINARY STUDY*:*	Dr. James Carter, Maria Gonzalez, Emma Wilson, Michael Brown, Olivia Davis
		5	REDESIGNING CLASSROOM SPACES: A COLLABORATIVE WORKSHOP WITH CHINESE DESIGN STUDENTS	P. J. Anderson, S. T. Nguyen,
		6	ASSESSING THE EFFECTIVENESS OF THE VARK LEARNING MODEL IN HIGHER EDUCATION SETTINGS	Assoc. Prof. Dr. Emma Harris, Dr. Daniel White
		7	BOOSTING STUDENT PARTICIPATION AND ACADEMIC PERFORMANCE THROUGH INTERACTIVE DIGITAL TOOLS	Fatoumata Diallo
		8	THE ROLE OF EDUCATIONAL MEDIA IN SHAPING THE CREATIVE DEVELOPMENT OF CHILDREN: A CASE STUDY ANALYSIS	Aiko Sato, Li Chen
		9	ADVANCING WRITING SKILLS THROUGH TARGETED TEACHING METHODS: LESSONS FROM A SOUTHEAST ASIAN PROGRAM*:*	K. Sato, J. Park, A. Ochieng, S. Lee

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HALL / SALON 8	**Assis. Prof. Dr. Olivia Carter**	1	IMPROVING LANGUAGE SKILLS AND CROSS-CULTURAL AWARENESS: A PILOT INITIATIVE FOR UNIVERSITY STUDENTS FROM A TEACHER TRAINING COLLEGE IN ATEQUIZA, MEXICO	Dr. Sofia M. González, Dr. Carlos A. Martínez, Dr. Isabel T. López
		2	INVESTIGATING ACADEMIC STRESS LEVELS AMONG UNIVERSITY STUDENTS WITH DYSLEXIA	Assis. Prof. Dr. Olivia Carter
		3	REVOLUTIONIZING MEDICAL TRAINING IN BRAZIL THROUGH ADVANCED SIMULATION TECHNIQUES: KEY FINDINGS AND RECOMMENDATIONS	Dr. Ana J. Santos
		4	CURRICULUM REFORM IN CHILEAN UNIVERSITIES: A COMPREHENSIVE EXAMINATION OF POLICY CHANGES	Dr. Camila R. Fernández
		5	USING CHILDREN'S ARTWORK TO GAIN INSIGHTS INTO THEIR EXPERIENCES WITH EQUINE-ASSISTED THERAPY	Dr. Sophia Johnson
		6	THE EFFECTS OF COMMERCIALIZATION ON HIGHER EDUCATION: SHIFTING FOCUS IN TEACHING AND LEARNING PRIORITIES	Emma Thompson, Prof.Dr. Michael Richards
		7	THE ROLE OF COLLABORATIVE WORK ENVIRONMENTS IN SHAPING MIDDLE SCHOOL TEACHERS' PRACTICES	Olivia Carter
		8	EVALUATING THE USE OF CHATBOTS IN UNIVERSITY EDUCATION: FINDINGS FROM AN INITIAL PILOT STUDY	John Smith, L. Williams

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HALL / SALON 9	**Dr. Sofia Oliveira Dr. Hiroshi Tanaka**	1	PHILOSOPHICAL HERMENEUTICS AND ITS IMPACT ON JUDICIAL IMPARTIALITY IN BRAZIL	Gabriel M. Costa, Sofia P. Fernandes
		2	A COMPARATIVE STUDY OF SPIRITUAL IMPACTS ON ARCHITECTURAL DESIGN: ISLAMIC AND GOTHIC TRADITIONS	R. Almeida, Y. Chen
		3	EXAMINING THE RELATIONSHIP BETWEEN RELIGION AND DEVELOPMENT: A FOCUS ON ISLAMIC PERSPECTIVES	Leila Marais, Haruto Nakamura
		4	BRIDGING ANCIENT WISDOM AND MODERN SOCIETY: LESSONS FROM SUFI AND ISLAMIC PHILOSOPHY	Dr. Sofia Oliveira Dr. Hiroshi Tanaka
		5	RECONCILING EFFICIENCY AND COMPASSION IN OPEN KNOWLEDGE SYSTEMS: AN EDUCATIONAL APPROACH	Fatima Bakare, Hoang Nguyen, Nurul Hasanah, Kwame Asante, Li Jianyu
		6	THE DEVELOPMENT OF DEMOCRATIC PRINCIPLES IN PAKISTAN: ISLAMIC THOUGHT AND COMPARATIVE POLITICAL THEORY	: Dr. Ali Malik
		7	THE INFLUENCE OF RELIGIOUS AND MORAL VALUES ON NATIONAL SECURITY: INSIGHTS FROM KAZAKHSTAN	A. K. Nurzhanov, B. T. Serikbayev, C. A. Tulegenov, D. S. Askarova, E. M. Kenzhebekov
		8	CRITICAL ANALYSIS OF SERVANT LEADERSHIP: A REVIEW OF EXISTING LITERATURE	Aisha Diallo, Mohamed Kone, Kenji Suzuki

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HALL / SALON 10	**Dr. Aibek Toktogulov**	1	UNVEILING SYMBOLISM IN HINDU TEMPLE ARCHITECTURE: A PHILOSOPHICAL PERSPECTIVE	Ali Hassan Aisha Khan
		2	INTEGRATING ETHICAL FRAMEWORKS: A COMPARATIVE STUDY OF ASIAN AND AFRICAN PERSPECTIVES ON BUSINESS ETHICS	Fatima Ahmed Nurzhan Bekov
		3	INNOVATIONS IN OPEN SCIENCE: TRANSFORMING RESEARCH PARADIGMS	PHD Student Zainab Abbas Dr. Aibek Toktogulov
		4	REEVALUATING CONSTRUCTIVIST PARADIGMS: AN EXISTENTIAL AND PHENOMENOLOGICAL PERSPECTIVE	Dr. Ahmed Al-Mansoori
		5	RECONSTRUCTING SELF THROUGH TEMPORAL DYNAMICS: ANALYZING ZHAO TAO'S ROLE IN JIA ZHANGKE'S CINEMATIC UNIVERSE)	Gulnara Iskakova Asim Raza
		6	ENHANCING CONSTRUCTION EFFICIENCY: A STUDY ON THE ADOPTION OF LEAN PRACTICES	Karim Nurpeisov Aisha Malik
		7	ANALYZING AESTHETIC DIMENSIONS IN MUSEUM ARCHITECTURE	Rana Ahmed Aizhan Dr. Abdyrakhmanova
		8	INTEGRATING PHILOSOPHICAL PERSPECTIVES INTO INTERDISCIPLINARY PHYSICAL EDUCATION PROGRAMS	Assis. Prof. Dr. Amina Khamis Dr. Jibril Adamu

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HALL / SALON 11	**Dr. Aibek Toktogulov**	1	THE INFLUENCE OF CULTURAL PHILOSOPHY ON INDIVIDUAL IDENTITY IN TURKIC TRADITIONS	Prof.Dr. M. Adebayo
		2	TRADITIONAL EASTERN PRACTICES IN CONTEMPORARY SUSTAINABLE ARCHITECTURE	L. Tanaka N. Ndungu
		3	EXPLORING POSTMODERN TRAGI-COMEDY: AN ANALYSIS OF TOM STOPPARD'S 'ROSENCRANTZ AND GUILDENSTERN ARE DEAD'	Mei-Ling Chen Dr. Carlos Silva
		4	THE ROLE OF ISLAM IN SHAPING CULTURAL VALUES IN KAZAKHSTAN	Kofi Agyeman Amina El-Omari Assoc. Prof .Fatoumata Diallo
		5	ARTISTIC RESPONSES TO CLIMATE CRISIS: EXPLORING INNOVATIVE APPROACHES TO SUSTAINABLE FUTURES THROUGH INTERDISCIPLINARY ART PRACTICE	Amina Bello Mikhail Ndumba
		6	UNVEILING DARKNESS: EXPLORING EXISTENTIAL THEMES AND MUSICAL NARRATIVES IN "TRUE DETECTIVE"	Assis. Prof. Dr. Aiko Tanaka
		7	RETHINKING ABSENCE: THE ROLE OF SILENCE AND PAUSE IN SAMUEL BECKETT'S WAITING FOR GODOT	Jun-Ho Kim Meilin Xu
		8	ADVANCEMENTS IN CONSTRAINT MANAGEMENT THEORY: A COMPREHENSIVE REVIEW	Mei-Ling Chen Hiroshi Takahashi Samuel Nkrumah

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HALL / SALON 1	**Dr. Öğr. Üyesi Hüseyin ÇELİK**	1	TESTING THE ENVIRONMENTAL PHILLIPS CURVE HYPOTHESIS in TURKIYE	Esma ERDOĞAN Müge MANGA
		2	THE LINKAGES BETWEEN ENVIRONMENTAL POLLUTION, HUMAN CAPITAL and GLOBALIZATION: A STUDY ON TURKIYE	Müge MANGA Esma ERDOĞAN
		3	HANEHALKI TÜKETİMİ, ENFLASYON VE EKONOMİK BÜYÜME İLİŞKİSİ: GLOBAL KANITLAR	Dr. Öğr. Üyesi Serhat ALPAĞUT
		4	THE RELATIONSHIP BETWEEN CORRUPTION CONTROL AND ECONOMIC GROWTH: AN ANALYSIS BY INCOME GROUPS	Asst. Prof. Dr. Fatih AKIN
		5	UNEMPLOYMENT AND JOB SEARCH PROCESSES IN TÜRKİYE: OCCUPATIONAL GROUPS, JOB SEARCH CHANNELS AND LABOR FORCE PARTICIPATION DYNAMICS	Dr. Öğr. Üyesi Gülferah ERTÜRKMEN Dr. Tuğba KONUK
		6	YOUTH UNEMPLOYMENT IN LABOR MARKETS: CAUSES, CONSEQUENCES AND SOLUTION STRATEGIES	Dr. Öğr. Üyesi Gülferah ERTÜRKMEN
		7	UNEMPLOYMENT HYSTERESİS IN CENTRAL AND EASTERN EUROPEAN COUNTRIES: EVIDENCE FROM FOURIER UNIT ROOT TESTS WITH SHARP AND SMOOTH BREAKS	Dr. Ayşe Nur ŞAHİNLER
		8	THE IMPACT OF REMITTANCES ON DOMESTIC SAVINGS: EVIDENCE FROM TURKIYE	Dr. Öğr. Üyesi Hüseyin ÇELİK

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HALL / SALON 2	**Prof. Dr. RAMAZAN BİÇER**	1	NÖROBİLİM VE İSTİHBARAT: GELECEĞİN OPERASYONEL TEKNİKLERİ	Prof. Dr. Ramazan BİÇER Dr. Eda ALEMDAR
		2	REASONS FOR RELIGIOUS THEMED TERRORISM	Prof. Dr. RAMAZAN BİÇER
		3	DIGITAL DISINFORMATION AND INTERNATIONAL RELATIONS: THE 2024 US PRESIDENTIAL ELECTIONS AND THE DIMENSIONS OF POLITICAL MANIPULATION	Dr. Öğretim Üyesi Gül Seda ACET İNCE
		4	ÇIKARLARIN AYRIŞMASI MI , MEDENİYETLERİN ÇATIŞMASI MI ?	Dr. Seda Gözde TOKATLI
		5	GÖÇ KRİZİ VE MÜLTECİ SORUNUNUN İNSANİ BOYUTTA ANALİZİ	Dr. Seda Gözde TOKATLI
		6	REALISATION OF A BOLD DREAM AT GUNPOINT : UNDERGROUND JEWISH ORGANIZATIONS	Yüksek Lisans Öğrencisi, İREM TABİRLİOĞLU
		7	EUROPEAN ARMY: A BELATED NECESSITY?	Arş. Gör., Özgür YILMAZ
		8	ANALYSING THE AFGHAN PEACE PROCESS IN THE FRAMEWORK OF RIPENESS THEORY	Arş. Gör., Özgür YILMAZ
		9	İNGİLİZ OKULU PERSPEKTİFİNDEN ULUSLARARASI SİSTEM, ULUSLARARASI TOPLUM VE DÜNYA TOPLUMU	Doç.Dr. ABDULLAH TORUN
		10	SOĞUK SAVAŞ DÖNEMİNDE TÜRKİYE'NİN ÇOK YÖNLÜ DIŞ POLİTİKAYA GEÇİŞİNİ ETKİLEYEN FAKTÖRLER	Doç Dr. ABDULLAH TORUN

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HALL / SALON 3	**Av. Furkan ÇAPOĞLU**	1	ADMINISTRATIVE FUNCTIONS OF THE PROVINCIAL COUNCIL AND ITS CONTRIBUTION TO LOCAL GOVERNMENTS	Bilim Uzm. Mehmet YILDIZ Prof. Dr. Erhan GÜMÜŞ Prof. Dr. Ahmet TUNÇ
		2	İDARİ İŞLEM KURAMINDA YOKLUK	AHMET KEMAL KANAT
		3	TÜRK KAMU YÖNETİMİNDE YÖNETİM PSİKOLOJİSİNİN ETKİNLİĞİ	Av. Furkan ÇAPOĞLU Psk. Mustafa BIYIKOĞLU
		4	TARİHTEN GÜNÜMÜZE YÖNETİM PSİKOLOJİSİ	Av. Furkan ÇAPOĞLU Psk. Mustafa BIYIKOĞLU
		5	Kimlik ve İdeoloji Serüveninde Milli Türk Talebe Birliği	Dr. Öğr. Üyesi İlhan BİLİCİ Sena YILDIRIM
		6	Siyasal Şiddet, Meşrulaştırma ve 1970'ler Türkiye'sinden Yansımalar	Dr. Öğr. Üyesi İlhan BİLİCİ Mustafa Kemal ENTERİLİ

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HALL / SALON 4	**Öğr. Gör. Ümit TOPCUOĞLU**	1	THE DEMOCRATIC CRISIS CAUSED BY MIGRATION MOBILITY IN ACCESS TO PUBLIC SERVICES IN THE CITY	Lisans Öğrencisi, Zehra DURUKAN Araştırma Görevlisi, Mustafa Gökberk ERTAN
		2	Türkiye'de Acil Sağlık Hizmetlerinin Tarihçesi ve Gelişimi: Dünya ile Kıyaslama	Öğr. Gör. Ümit TOPCUOĞLU
		3	Afet Eğitiminin Toplumsal Faydaları	Öğr. Gör. Ümit TOPCUOĞLU
		4	BEHAVIOR-FOCUSED ENERGY EFFICIENCY FOR SUSTAINABLE CITIES: THE SOCIAL DIMENSION OF URBAN TRANSFORMATION	Doktora Öğrencisi, Melike ÇİÇEK
		5	KENT PARKLARININ KENTSEL FIRSAT EŞİTSİZLİĞİ AÇISINDAN DEĞERLENDİRİLMESİ: ERZİNCAN ÖRNEĞİ	Dr. UĞUR GÜLCÜ Doç. Dr. AHMET YAZAR

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HALL / SALON 5	**Doç. Dr. TUĞBA MERT**	1	EXAMINING ROUGH IDEALS AND A SURVEY ON EXISTENCE OF LOCAL ROUGH IDEALS	M. Mustafa BEYDAĞI Prof. Dr. İlhan İÇEN Prof. Dr. A. Fatih ÖZCAN
		2	KINEMATICAL APPROACH TO HELICAL TYPE CURVES	Asst. Prof. Dr. ÇAĞLA RAMİS İLGÜZ ESRA ORMAN
		3	AN ALGORITHM FOR THE RECTIFYING CURVES	Asst. Prof. Dr. ÇAĞLA RAMİS İLGÜZ MUSTAFA VARİLCİ
		4	ANALYSIS OF SOLVING AND APPLICATIONS OF SINGULARLY PERTURBED PROBLEMS	Dr, ZELAL TEMEL
		5	PARA-SASAKIAN MANIFOLDS ADMITTING CONFORMAL RICCI SOLITONS	Prof. Dr. MEHMET ATÇEKEN Doç. Dr. TUĞBA MERT
		6	THE LINEARITY OF THE RELATIONSHIP BETWEEN MATHEMATICS AND ART: AN INTERDISCIPLINARY APPROACH	Yüksek Lisans Öğrencisi, Büşra ÖZÇELİK Doç. Dr. Ezgi TOKDİL
		7	Uniqueness Theorem For Inverse Nodal Problem	Dr. Öğr. Üyesi Merve ARSLANTAŞ
		8	GRAY MAP IN THE RING	Master's student, HABIBE RANA KASDAS Asist. Prof. Dr. MUSTAFA OZKAN
		9	FORMATION OF A 32-ELEMENT RING WITH COEFFICIENTS IN AND CYCLIC CODES OVER THE RING	Asist. Prof. Dr. MUSTAFA OZKAN Master's student, HABIBE RANA KASDAS

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HALL / SALON 6	**Assoc. Prof. Dr. TUBA NUR OLĞUN**	1	AN EVALUATION OF THE CONSERVATION-TOURISM RELATIONSHIP IN THE CONTEXT OF TUNCELİ/PERTEK CASTLE	Assoc. Prof. Dr. TUBA NUR OLĞUN
		2	THE FICTIONAL BALANCE BETWEEN LEED CERTIFICATION SYSTEM AND LANDSCAPE ARCHITECTURE	Asist.Prof. Dr., Makbulenur ONUR Research Assistant, Dr., Demet Ulku GULPINAR SEKBAN
		3	LEED SCORECARD ANALYSIS FROM A LANDSCAPE ARCHITECTURE PERSPECTIVE	Asist.Prof. Dr., Makbulenur ONUR Research Assistant, Dr., Demet Ulku GULPINAR SEKBAN
		4	EFFECTIVE WEED MANAGEMENT AND SUSTAINABILITY IN LANDSCAPES	Research Assistant, RIDVAN TİK Assoc. Prof. Dr., RAMAZAN GÜRBÜZ Assoc. Prof. Dr., TUNCAY KAYA
		5	RENEWABLE ENERGY SOLUTIONS IN LANDSCAPING 'AGROVOLTAIC SYSTEMS AND THEIR POTENTIAL'	Research Assistant, RIDVAN TİK Assoc. Prof. Dr., TUNCAY KAYA
		6	ANALYZING THE SPATIAL STRUCTURE OF TRADITIONAL RİZE HOUSES WITHIN THE SCOPE OF PROTECTION OF RURAL ARCHITECTURAL HERITAGE	M. Arch. Sedanur BİRİNCİ Prof. Dr. Çiğdem Belgin DİKMEN
		7	EVALUATION OF TRADITIONAL RURAL HOUSES IN RİZE WITHIN THE SCOPE OF SUSTAINABILITY	M. Arch. Sedanur BİRİNCİ Prof. Dr. Çiğdem Belgin DİKMEN

ICSAS 1st INTERNATIONAL CONFERENCE ON PRESCHOOL EDUCATION AND EARLY CHILD DEVELOPMENT March 7 - 9, 2025 İzmir Meeting ID: 885 7151 8350 Passcode: 202224				
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HALL / SALON 7	**Öğretim Görevlisi, Betül Kübra ŞAHİN YONCA**	1	OKUL ÖNCESİ ÖĞRETMEN ADAYLARININ BAKIŞ AÇISINDAN OKUL ÖNCESİ EĞİTİM SINIFLARINDA SINIF YÖNETİMİ	Öğretim Görevlisi, Betül Kübra ŞAHİN YONCA
		2	OKUL ÖNCESİ EĞİTİMDE GELİŞİME UYGUN UYGULAMALAR: OKUL ÖNCESİ ÖĞRETMEN ADAYLARININ GÖRÜŞLERİ	Öğretim Görevlisi, Betül Kübra ŞAHİN YONCA
		3	FARKLI YAŞ GRUBUNDAN ÇOCUKLARIN AYNI SINIFTA EĞİTİM ALMALARINA İLİŞKİN EBEVEYN GÖRÜŞLERİ	Okul Öncesi Öğretmeni, Mizgin AYKUT Prof. Dr., İkbal Tuba ŞAHİN SAK
		4	EFFECT OF PROSOCIAL BEHAVIOR PSYCHOEDUCATION PROGRAM ON PROBLEM BEHAVIORS AND SELF-REGULATION SKILLS OF 5-6-YEAR-OLD CHILDREN	Dr., Burcu BAĞCI ÇETİN
		5	OKUL ÖNCESİ DÖNEM ÇOCUKLARIN ÇOCUK HAKLARINA YÖNELİK GÖRÜŞLERİNİN DEĞERLENDİRİLMESİ	Doç. Dr. Dervişe AMCA TOKLU Prof. Dr. Filiz ERBAY Prof. Dr. Umut AKÇIL
		6	Investigation of the Relationship Between Adolescents' Popularity Perceptions and Their Interactions with Strangers on the Internet	Yüksek Lisans Öğrencisi Çiğdem SABUNCU Doç. Dr. Yaşar BARUT Prof. Dr. Soner ÇANKAYA
		7	EXAMINING THE RELATIONSHIP BETWEEN CHILD DEVELOPMENT CANDIDATES' IDENTITY CONSTRUCTION IN SOCIAL MEDIA AND THEIR PERSONAL RESPONSIBILITY LEVELS	Yüksek Lisans Öğrencisi Kübra AKDENİZ Doç. Dr. Yaşar BARUT Prof. Dr. Soner ÇANKAYA
		8	INVESTİGATİNG THE REALATİONSHİP BETWEEN ARTİFİCİAL İNTELLİGENCE LEVELS AND ARTİFİCİAL INTELLEİGENCE ANXİETY OF PRESCHOOL TEACHER CANDİDATES	Yüksek Lisans Öğrencisi Kübra KELEŞ Doç. Dr. Yaşar BARUT Prof. Dr. Soner ÇANKAYA
		9	THE RELATIONSHIP BETWEEN THE DIGITAL AWARENESS OF MOTHERS WITH CHILDREN AGED 3-6 AND THE PSYCHOSOCIAL BEHAVIOR OF THE CHILD	Yüksek Lisans Öğrencisi Rabia ASLANTAŞ Doç. Dr. Yaşar BARUT Prof. Dr. Soner ÇANKAYA
		10	THE RELATIONSHIP BETWEEN MATERNAL EMPLOYMENT GUILT AND PARENTAL SELF-EFFICACY	Yüksek Lisans Öğrencisi Saime Nur Tomrukçu Doç. Dr. Yaşar BARUT Prof. Dr. Soner ÇANKAYA

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HALL / SALON 8	**Doç. Dr. ÇAĞLA GİRGİN BÜYÜKBAYRAKTAR Öğr. Gör. Dr. EDA KÖKLÜ BAYRAKCI**	1	AN INVESTIGATION OF THE FACTORS AFFECTING THE RESILIENCE OF PARENTS OF CHILDREN WITH SPECIAL NEEDS	Esra Dereobalı Doç. Dr. Türkan Yılmaz Irmak
		2	REFLECTIONS OF ROMANTIC RELATIONSHIP BELIEFS AND MARITAL ROLE EXPECTATIONS ON LIFE SATISFACTION	Doç. Dr. ÇAĞLA GİRGİN BÜYÜKBAYRAKTAR Öğr. Gör. Dr. EDA KÖKLÜ BAYRAKCI
		3	EXAMINING THE RELATIONSHIPS BETWEEN PERFECTIONISM IN ROMANTIC RELATIONSHIPS, IRRATIONAL BELIEFS IN ROMANTIC RELATIONSHIPS, PSYCHOLOGICAL WELL-BEING AND MARITAL ADJUSTMENT	BERRAK ERSAN ALP Assoc. Prof. FULYA TÜRK
		4	İLİŞKİDE KARAR VERME BECERİSİNİN DEMOGRAFİK DEĞİŞKENLER AÇISINDAN İNCELENMESİ	BEGÜM UYGUR DOÇ. DR. SEHER MERVE ERUS
		5	İLİŞKİ DOYUMUNUN ÇEŞİTLİ DEMOGRAFİK DEĞİŞKENLER AÇISINDAN İNCELENMESİ	BURÇİN HAZAL AĞCA DOÇ. DR. SEHER MERVE ERUS

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HALL / SALON 9	**Assoc. Prof. Ololade M. Aminu**	1	ANALYZING SUCCESS FACTORS OF PLAY-BASED INTERVENTION PROGRAMS FOR CHILDREN WITH DIFFERENT ABILITIES IN TURKEY: A COMPARATIVE EVALUATION	Aylin Yılmaz, Ahmet K. Yıldız, Dr. Öğr. Üyesi Zeynep Şahin
		2	THE SOCIAL DYNAMICS OF PANDEMICS: A CLINICAL SOCIOLOGICAL ANALYSIS OF PRECAUTIONS AND RISKS	Dr. Musa Karabulut Mustafa Eryılmaz
		3	TEACHING STRATEGIES AND PREJUDICE TOWARD IMMIGRANT AND DISABLED STUDENTS	Mücahit Yaşar, Dr. Öğr. Gör. Niyazi Gündoğan
		4	STUDENTS' ATTITUDES TOWARD SEEKING PSYCHOLOGICAL HELP	Dr. Öğr. Gör. Nihat Kılıç, YL. Öğr. Nihat Fırat
		5	AN EXPLORATION OF THE QUALITY OF PRIMARY CAREGIVING RELATIONSHIPS BETWEEN ADOLESCENTS ORPHANED THROUGH AIDS AND THEIR GRANDMOTHERS, BASED ON THE NARRATIVES OF STAKEHOLDERS	Dr. Selin Demir, Dr. İsmail Karahan
		6	CHILD ABUSE: EMOTIONAL, PHYSICAL, NEGLECT, SEXUAL AND THE PSYCHOLOGICAL EFFECTS: A CASE SCENARIO IN LAGOS STATE, NIGERIA	Assoc. Prof. Ololade M. Aminu

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HALL / SALON 1	**Assis. Prof. Dr. Azita Rahmani**	1	EXPERT SOLUTIONS TO AFFORDABLE HOUSING FINANCE CHALLENGES IN DEVELOPING ECONOMIES	Michael Johnson, Assis. Prof. Dr. Sarah L. Thompson
		2	THE IMPACT OF DIGITAL INCLUSIVE FINANCE ON THE HIGH-QUALITY DEVELOPMENT OF CHINA'S EXPORT TRADE	Dr. Li Zhang, Dr. Ming Chen
		3	ETHEREUM-BASED SMART CONTRACTS FOR TRADE AND FINANCE	Assoc. Prof. Dr. John Carter
		4	FINANCING-SCHEDULING OPTIMIZATION FOR CONSTRUCTION PROJECTS USING GENETIC ALGORITHMS	John A. Thompson Michael B. Harris Laura D. Evans
		5	FACTORS DETERMINING WOMEN EMPOWERMENT THROUGH MICROFINANCE: AN EMPIRICAL STUDY IN SRI LANKA	A. Perera, S. T. Fernando
		6	MARKET ACCEPTANCE OF A MURABAHA-BASED FINANCE STRUCTURE WITHIN A SOCIAL NETWORK OF NON-ISLAMIC SMALL AND MEDIUM ENTERPRISE OWNERS IN AFRICAN PROCUREMENT	Assis. Prof. Dr. Azita Rahmani
		7	Triangle Challenges of Sustainability at the University Level within the Framework of a Knowledge-Driven Economy and Society	Dr. Petr Novák
		8	STATISTICAL ANALYSIS OF THE IMPACT OF MARITIME TRANSPORT GROSS DOMESTIC PRODUCT ON NIGERIA'S ECONOMY	A. T. Johnson, M. L. Adebayo
		9	THE IMPACT OF JOB-RELATED EMOTIONS ON JOB-RELATED HAPPINESS AMONG FRONTLINE EMPLOYEES IN FINANCIAL FIRMS	John A. Thompson, Sarah L. Bennett

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HALL / SALON 2	**Assoc. Prof. Dr. Ghasem Ghorbani Rostam**	1	CONCEPTUAL APPROACH FOR FLEXIBLE BUSINESS PROCESS MODELING	Dr. Hannelore Peeters Prof. Dr. Alain Vermeulen
		2	ORGANIZATIONAL DECISION MAKING BASED ON BUSINESS INTELLIGENCE	Pejman Hosseinioun, Dr. Rose Shayeghi, Assoc. Prof. Dr. Ghasem Ghorbani Rostam
		3	ON CULTIVATING INTERDISCIPLINARY BUSINESS INTERPRETING TALENTS BASED ON MARKET DEMAND	Aylar Myradova, Serdar Berdimuhamedov
		4	BUSINESS BUYERS' EXPECTATIONS IN BUYER-SELLER ENCOUNTERS	Fatih Yenilmez , Dr. Öğr. Üyesi Sude Biçer
		5	SOA EMBEDDED IN BPM: A HIGH-LEVEL VIEW OF THE OBJECT-ORIENTED PARADIGM	Phd İmran Güner
		6	A SPECIFICATION-BASED APPROACH FOR RETRIEVAL OF REUSABLE BUSINESS COMPONENTS FOR SOFTWARE REUSE	Yl. Öğrencisi Adnan Akçay , Dr. Abdullah Aydın Hisar
		7	IDENTIFYING BUSINESS INCUBATORS BASED ON THEIR REAL ACTIVITIES: EVIDENCE FROM CHINA	Dr. Ping Deng, Assis. Prof. Dr. Wentao Yu
		8	PROCESS-BASED BUSINESS TRANSFORMATION THROUGH SERVICES COMPUTING	Sinnakkrishnan Perumal, Dr. Nitish Pandey

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		2	THE ASSESSMENT OF LOW-CARBON ECONOMY IN JIANGSU, CHINA	Michael Thompson, Sarah Lee
		3	DEVELOPMENT STRATEGY AND TREND ANALYSIS IN THE INFORMATION ECONOMY: INSIGHTS FROM GLOBAL EXPERIENCES APPLIED TO AZERBAIJAN	Farid Məmmədov, Leyla Hüseynova, Elnur Qasımov
		4	ENHANCING INTELLECTUAL CAPITAL TO FOSTER INNOVATION, ENTREPRENEURSHIP, AND SUSTAIN THE KNOWLEDGE ECONOMY	Dr. Baatar Enkhbayar
		5	SUFFICIENCY ECONOMY: A CONTRIBUTION TO ECONOMIC DEVELOPMENT	Assoc. Prof. Dr. Ayesha Khalid
		6	UTILITY ANALYSIS OF API ECONOMY BASED ON MULTI-SIDED PLATFORM MARKETS MODEL	Dr. Claire Moreau
		7	A BALANCED SCORECARD APPROACH FOR EVALUATING STRATEGIC ALIGNMENT OF NATIONAL R&D PROGRAMS IN CREATIVE ECONOMY POLICY	Aylin Əliyeva, Farid Məmmədov, Leyla Hüseynova, Elnur Qasımov, Zəhra Rzayeva
		8	CHALLENGES AND OPPORTUNITIES FOR PROMOTING CIRCULAR ECONOMY IN THE CONSTRUCTION SECTOR	I. Petrov, A. Ivanova, D. Sokolov, K. Volkov

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		2	TERRITORIES' CHALLENGES AND OPPORTUNITIES TO PROMOTE CIRCULAR ECONOMY IN THE BUILDING SECTOR	Cem Güven, Dr. Öğr. Üyesi Beyhan Yiğit, YL. Öğrencisi. Cumhur Ahmedova
		3	BANKING CRISIS AND ECONOMIC EFFECTS OF THE BANKING CRISIS IN NIGERIA	Chinedu Okafor, Amina Bello, Musa Ahmed
		4	TRIANGLE ISSUES OF SUSTAINABILITY AT THE UNIVERSITY LEVEL WITHIN THE CONTEXT OF THE KNOWLEDGE ECONOMY AND SOCIETY	Fariz Aliyev, Assoc. Prof. Dr. Nigar Mammadova
		5	STATISTICAL ANALYSIS OF THE IMPACT OF MARITIME TRANSPORT GROSS DOMESTIC PRODUCT ON BELGIUM'S ECONOMY	Assis. Prof. Dr. Dupont Vandenberghe
		6	A REVIEW ON THE OUTLOOK OF THE CIRCULAR ECONOMY IN THE AUTOMOTIVE INDUSTRY	M. Schneider, L. Weber
		7	THE ROLE OF MULTINATIONAL ENTERPRISES' INVESTMENTS IN ECONOMIC DEVELOPMENT: A CASE STUDY OF POLAND	M. Kowalski, J. Nowak
		8	ANALYZING THE POTENTIAL OF JOB CREATION BY TAKING THE FIRST STEP TOWARDS CIRCULAR ECONOMY: CASE STUDY OF BRAZIL	M. K. Schmidt, L. Fischer, P. M. Thomas

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HALL / SALON 5	**Dr. Carlos Mendes, Prof. Mariana Costa, Sofia Oliveira**	1	ETHICAL CHALLENGES IN ANTI-DOPING POLICIES: A COMPARATIVE ANALYSIS OF TURKEY AND INTERNATIONAL STANDARDS	Aisha Rahman
		2	MORPHOLOGICAL DIFFERENCES AMONG FEMALE SPRINTERS IN NIGERIA	Chinwe Okafor, Ibrahim Adamu, Fatima Suleiman
		3	LONG-TERM PHYSICAL TRAINING AND ITS INFLUENCE ON SKELETAL DEVELOPMENT IN SOUTH AFRICAN WOMEN	Nomvula Dlamini, Thabo Maseko
		4	EXAMINING THE RELATIONSHIP BETWEEN PHYSICAL ACTIVITY, DIET, AND COGNITIVE AGILITY	Ravi Prakash, Dr. Priya Natarajan
		5	PROMOTING COMMUNITY HEALTH THROUGH SPORTS: A HOLISTIC STRATEGY	Dr. Carlos Mendes, Prof. Mariana Costa, Sofia Oliveira
		6	IMPROVING STUDENT PARTICIPATION IN SWIMMING LESSONS: THE ROLE OF STRUCTURED TEACHING MODELS	Gabriela Fernández
		7	THE INFLUENCE OF ATHLETE SATISFACTION ON TEAM PERFORMANCE: A CASE STUDY FROM CAIRO UNIVERSITY	Omar El-Sayed, Hanaa Mahmoud
		8	THE EFFECTS OF LONGITUDINAL FITNESS TRAINING ON BODY COMPOSITION IN EASTERN EUROPEAN ADOLESCENT BOYS	Dmitry Ivanov, Aneta Kovacs

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		2	THE ROLE OF CREATIVE HOBBIES IN MENTAL WELL-BEING AMONG NURSING STUDENTS: A STATISTICAL ANALYSIS	Researcher Sofia Mendes
		3	CLINICAL TRAINING EXPERIENCES IN PEDIATRIC WARDS: PERSPECTIVES FROM NURSING STUDENTS	Beatriz Tavares, João Henrique Costa
		4	EFFECTS OF MINDFULNESS TRAINING ON STRESS MANAGEMENT AMONG FIRST-YEAR NURSING STUDENTS	Dr. Ahmed Oumar
		5	DETECTION OF LEGIONELLA PNEUMOPHILA IN HOSPITAL WATER SYSTEMS IN LAGOS, NIGERIA USING PCR METHODS	Daniel C. Adebayo, Zhang Wei, Farid Al-Rashid
		6	IDENTIFYING COVID-19 STRAINS THROUGH BLOOD BIOMARKER ANALYSIS IN ATHLETES	Assoc. Prof. Dr. Ricardo M. Vasquez
		7	PHYSICAL AND METABOLIC CHARACTERISTICS OF ELITE KENYAN LONG-DISTANCE RUNNERS: A PERFORMANCE STUDY	Leonardo J. Ferreira
		8	INVESTIGATING THE EFFECTS OF COOL-WATER IMMERSION ON POST-EXERCISE RECOVERY IN HUMID CLIMATES	Samuel Chukwuma, Laila Hussain, Xinyi Zhou

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HALL / SALON 7	**Assoc. Prof. Dr. Amina Chikondi**	1	FOSTERING PROFESSIONAL IDENTITY DEVELOPMENT IN UNDERGRADUATE NURSING STUDENTS THROUGH EXPERIENTIAL LEARNING	Emma Njeri, Mohammad Faizan, Thandiwe Moyo
		2	ASSESSING DIGITAL HEALTH LITERACY AMONG NURSING STUDENTS: A CASE STUDY FROM UNIVERSITY OF LUSAKA	Kwame Boateng, Assoc. Prof. Dr. Amina Chikondi
		3	PROMOTING PROBLEM-SOLVING AND ADAPTABILITY SKILLS IN NURSING EDUCATION THROUGH CASE-BASED LEARNING	Gabriela Rocha, Carlos Mendes
		4	TRADITIONAL HEALING PRACTICES AND MODERN PAIN MANAGEMENT: IMPLICATIONS FOR PALLIATIVE CARE	Fatima Diallo
		5	THE IMPACT OF SIMULATION-BASED LEARNING ON CLINICAL DECISION-MAKING AMONG NURSING STUDENTS	S. Rahman, J. Wang
		6	INTEGRATING ARTIFICIAL INTELLIGENCE INTO NURSING EDUCATION: CHALLENGES AND OPPORTUNITIES	Assoc. Prof. Dr. Benjamin Okafor
		7	DEVELOPING MOBILE APPLICATIONS FOR CLINICAL TRAINING IN NURSING: INSIGHTS FROM EDUCATORS	Zhang Min, Halima Yusuf
		8	UTILIZING COMPETENCY-BASED ASSESSMENTS IN MEDICAL-SURGICAL NURSING EDUCATION: A COMPARATIVE ANALYSIS	Sophia Chen, Jin Ho Park, Hassan Idris

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HALL / SALON 8	**Assist. Prof. Dr. Ahmed Al-Mousa**	1	THE ROLE OF CLINICAL PRECEPTORS IN SHAPING UNDERGRADUATE NURSING CURRICULUM	Ayla Pereira, Kofi Mensah
		2	THE IMPACT OF MIDWIFERY EDUCATION ON CLINICAL OUTCOMES	Assis. Prof. Dr. Sara Tan, Dr. James Lee
		3	EFFECTS OF NURSING SERVICES ON THE PHYSICAL WELL-BEING AND BEHAVIORAL PATTERNS OF FEMALE INMATES IN PRISONS	Elena Rodrigues, Fatoumata Diop, Wang Li
		4	TRAITS OF SUCCESSFUL NURSE LEADERSHIP: INSIGHTS FROM WARD NURSES IN SYRIA	Assist. Prof. Dr. Ahmed Al-Mousa
		5	MIDWIFERY AND ITS CONTRIBUTION TO SAFE DELIVERIES IN DEVELOPING COUNTRIES	Lina Zeyad, Khaled Al-Salem
		6	IMPROVING NUTRITIONAL CARE FOR PEDIATRIC CANCER PATIENTS: NURSING INTERVENTIONS	Dr. Laura Oliveira, Dr. Ibrahim Ahmed
		7	IMPACT OF PEER SUPPORT ON PROBLEM-SOLVING SKILLS IN NURSING STUDENTS	Dr. Ahmed Jibril, Prof. Dr. Mei Zhang
		8	EVALUATING NURSING COMPETENCIES IN CLINICAL ENVIRONMENTS: A STUDY OF CAMBODIAN NURSES	Sokha Chea, Nadia Sulaiman

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HALL / SALON 9	**Assoc. Prof. Dr. Eduardo Silva**	1	THE PRACTICAL DELIVERY ROOM EXPERIENCE OF NURSING STUDENTS AT DHOFAR UNIVERSITY	Aisha Al-Harthi, Dr.Salim Al-Balushi
		2	RESILIENCE EVALUATION AMONG PATIENTS WITH CHRONIC KIDNEY DISEASE UNDERGOING DIALYSIS TREATMENT	Joana M. Costa, Ricardo Silva, Helena Marques
		3	PHYSICAL PROPERTIES AND RESISTANT STARCH CONTENT IN RICE FLOUR AFTER A-AMYLASE HYDROLYSIS	Carlos Almeida, Mai Linh Nguyen, Fouad Al-Khouri
		4	MIDWIFERY IN URBAN VERSUS RURAL SETTINGS: A COMPARATIVE STUDY	Phd. Candidate Nora Ahmed, Elias Al-Sabah
		5	MIDWIFERY CARE IN HIGH-RISK PREGNANCIES: A GLOBAL PERSPECTIVE	Dr. Maria Oliveira, Assoc. Prof. Dr. Eduardo Silva
		6	THE ROLE OF MIDWIVES IN POSTPARTUM MENTAL HEALTH SUPPORT	Emma Bennett, Mark Turner
		7	EXPLORING THE ROLE OF MIDWIVES IN BIRTH CONTROL EDUCATION	Dr. Maryam Al-Khalifa, Hana Al-Mansoori

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HALL / SALON 10	**Dr. Joseph K. Kamau,**	1	KNOWLEDGE AND PERCEPTION OF MATERNAL HEALTH CARE AMONG PREGNANT WOMEN IN PUBLIC HOSPITALS IN MAPUTO, MOZAMBIQUE	Carlos M. Fernandes, Lucia P. Andrade, Isabel R. Tavares
		2	CHALLENGES AND MOTIVATIONS IN ACCESSING IMMUNIZATION SERVICES AMONG REFUGEE CAREGIVERS IN ZIMBABWE: A QUALITATIVE ANALYSIS	Patricia T. Moyo, Kwame K. Asante, Prof. Dr. Emmanuel N. Nkrumah, Dr. Joseph K. Kamau, Alexandre D. Nsengiyumva
		3	ENHANCING COLLABORATION IN PALLIATIVE CARE PROVIDERS: INSIGHTS FROM BOTH URBAN AND RURAL AREAS IN NIGERIA	Chinonso I. Okafor, Yemi A. Olufemi, Ruth O. Alade, Akinwale J. Balogun
		4	EXPLORING THE IMPACT OF STRESS AND COPING STRATEGIES AMONG PATIENTS UNDERGOING HEMODIALYSIS IN KENYA	Grace O. Kinyua, Dr. Martin A. Nyambura
		5	EVALUATION OF EVIDENCE-BASED NURSING PRACTICES IN PEDIATRIC DENTAL CARE IN PUBLIC HEALTH SETTINGS	Dr. Regina S. Osei, Dr. Benjamin E. Okoro
		6	ASSESSING THE IMPACT OF HIGH-FIDELITY SIMULATION ON TEAMWORK AND COMMUNICATION AMONG NURSING STUDENTS IN EAST AFRICA	Koffi J. Dufresne, Zainab O. Ajayi, S. Nambiro, Dr. Sheila M. Nyongo
		7	THE ROLE OF COMPLEMENTARY THERAPIES IN PEDIATRIC ONCOLOGY TREATMENT: A STUDY ON THE INTEGRATION OF YOGA	Dr. Solomon J. Okonkwo

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HALL / SALON 11	**Dr. Maria Gallo, Prof. Dr. Luca Bianchi,**	1	SOCIO DEMOGRAPHIC CORRELATES OF POST-TRAUMATIC STRESS DISORDER AMONG YOUTH UNDERGOING DOMESTIC VIOLENCE IN EUROPEAN CONTEXTS	Laurent Dupont, Sofia Hernandez
		2	SOCIOLOGY PERSPECTIVE ON EMOTIONAL MALTREATMENT: RETROSPECTIVE CASE STUDY IN A JAPANESE ELEMENTARY SCHOOL	Dr. Maria Gallo, Prof. Dr. Luca Bianchi,
		3	THE IMPACT OF ERIC TRANSFERENCE ON THE DURABILITY OF PSYCHOANALYTIC TREATMENT: AN EXPLORATORY CASE STUDY	Sara Romano, Dr. Lukas Schmidt
		4	THE IMPACT OF THE BUILT ENVIRONMENT ON CHILDREN: ENVIRONMENTAL PERCEPTIONS OF DEPRIVED CHILDREN IN EUROPEAN SLUMS	Elias Becker, Clara Fernández, Nia Thomsen
		5	ASSOCIATION BETWEEN ADHD MEDICATION, CANNABIS, NICOTINE USE, MENTAL DISTRESS, AND OTHER PSYCHOACTIVE SUBSTANCES	Luca Bergamini, Assoc. Prof. Dr. Maria De Luca, Anna Fischer, Dr. Jeanette Nadeau
		6	ADDRESSING GLOBAL TRAUMA: SOMATIC INTERVENTIONS IN PTSD TREATMENT AND CLINICIAN BURNOUT PREVENTION	Marie Dupont, Johannes Fischer, Lucia Moretti

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HALL / SALON 12	**Dr. Zola Moyo**	1	CORRELATION BETWEEN MEANING IN LIFE AND ACADEMIC PERFORMANCE IN AFRICAN COLLEGE STUDENTS	Amina N'Diaye, Kwame Agyemang, Dr. Zola Moyo
		2	IMPROVING DECISION SUPPORT FOR ORGAN TRANSPLANT	A. M. Ndlovu, P. L. Dlamini, T. O. Adeyemi, J. C. Mbatha, S. S. Nkosi, B. E. Chukwu
		3	LOVE AND MONEY: SOCIETAL ATTITUDES TOWARD INCOME DISPARITIES IN AGE-GAP RELATIONSHIPS	Kwame A. Asante Ngozi O. Okafor Tendai M. Chirwa
		4	EFFECTS OF GRATITUDE PRACTICE ON RELATIONSHIP SATISFACTION AND THE ROLE OF PERCEIVED SUPERIORITY	Kwame Mensah, Amina Ndlovu, Temba Dube
		5	MINDFULNESS-BASED STRESS REDUCTION FOR ENHANCING SELF-ESTEEM AND WELL-BEING: THE CRITICAL ROLE OF CONTINGENT SELF-ESTEEM IN PREDICTING WELL-BEING COMPARED TO EXPLICIT SELF-ESTEEM	Amina Diouf, Kwame Nkrumah Thandiwe Mbatha
		6	SUICIDE WRONGFUL DEATH: STANDARD OF CARE PROBLEMS INVOLVING THE INACCURATE DISCERNMENT OF LETHAL RISK WHEN FOCUSING ON THE ELICITATION OF SUICIDE IDEATION	Jin Wei Li, Yu Hang Zhang, Aiko Tanaka
		7	EXPERIENCES AND IMPACT OF ATTACHMENT AMONG WOMEN WITH INSECURE ATTACHMENT IN COHABITATION: IMPLICATIONS FOR THERAPEUTIC PRACTICE	Nur Aisyah Sari, Rina Puspitasari, Andi Muhammad Haris
		8	CULTURAL PRACTICES AS A COPING MEASURE FOR WOMEN WHO TERMINATED A PREGNANCY IN ADOLESCENCE: A QUALITATIVE STUDY	Phd. Nina P. Wijaya Prof. Dr. Rina H. Putri
		9	HELPING OTHERS AND YOUTH MENTAL HEALTH: A QUALITATIVE STUDY EXPLORING PERSPECTIVES OF YOUTH ENGAGING IN PROSOCIAL ACTIVITIES	Ayesha Tanaka, Rajiv Kumar, Mei Ling Zhao

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HALL / SALON 1	**Dr. Öğr. Üyesi Ahmet Düha KOÇ**	1	ÇOCUK SAĞLIĞI POLİTİKALARI ÜZERİNE YAPILAN ÇALIŞMALARIN VOSVİEWER İLE BİBLİYOMETRİK ANALİZİ	Arş. Gör. Osman ŞAHMAN Arş. Gör. Dr. Semih ISLICIK
		2	The Impact of Electronic Health Records on Nursing Management	Öğr. Gör. Dr. Emine ERSÖZLÜ
		3	Digitalization in Nursing Management: Technological Innovations and Challenges	Öğr. Gör. Dr. Emine ERSÖZLÜ
		4	Türkiye ve Dünya Genelinde Paramedik Eğitimi ve Lisans Programları	Öğr. Gör. Ümit TOPCUOĞLU
		5	TOPLUMDA İLKYARDIM EĞİTİMİNİN FAYDALARI	Öğr. Gör. Ümit TOPCUOĞLU
		6	SÜRDÜRÜLEBİLİRLİK VE SÜRDÜRÜLEBİLİR KALKINMA	Prof. Dr. Yunus Emre ÖZTÜRK Birgül Sena IŞIK
		7	DİGİTALİZATİON and ITS EFFECTS ON REDUCİNG CARBON FOOTPRİNT	Prof.Dr. YUNUS EMRE ÖZTÜRK Yüksek Lisans Öğrencisi, AYŞE KEMER
		8	COĞRAFİ BİLGİ SİSTEMLERİ (CBS) İLE 112 AMBULANS ROTALAMA VE ACİL MÜDAHALE OPTİMİZASYONU	Dr. Öğr. Üyesi Ahmet Düha KOÇ
		9	SAĞLIK BİLİŞİMİ KULLANARAK ACİL DURUM YÖNETİMİNDE HATA AZALTMA STRATEJİLERİ	Dr. Öğr. Üyesi Ahmet Düha KOÇ

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HALL / SALON 2	**PROF. DR. OGUZHAN ZENGIN**	1	A BIBLIOGRAPHIC REVIEW OF POSTGRADUATE THESES ON POST-TRAUMATIC STRESS DISORDER	Doktorant, MAHMUT SAMİ KÖKTAŞ
		2	ENSURING HEALTHY LIVES AND PROMOTING WELL-BEING FOR ALL IN TURKEY: ALIGNING WITH THE 2030 AGENDA FOR SUSTAINABLE DEVELOPMENT	PROF. DR. OGUZHAN ZENGIN
		3	FROM EDUCATION TO EMPLOYMENT: EXPLORING TURKEY’S PROGRESS TOWARD GENDER EQUALITY	PROF. DR. OGUZHAN ZENGIN
		4	MEDICAL SOCIAL SERVICE PRACTICES FOR CANCER PATIENTS AND THEIR RELATIVES ONCOLOGICAL SOCIAL SERVICE	Asst. Prof., İhsan KUTLU Graduate student, Fatma Sude UZUN
		5	THE SOCIOLOGICAL ANALYSIS OF HONOR AND CUSTOM KILLING IN TURKEY	Dr. ZEYNEP ŞENTÜRK DIZMAN
		6	DARK TOURISM: SOCIOLOGICAL REFLECTIONS OF DEATH AND SUFFERING	Doktora Öğrencisi Ayşe KÖSE ŞİRİN
		7	ORMAN YANGINLARININ KIRSAL YAPIYA ETKİLERİ ÜZERİNE SOSYOLOJİK BİR DEĞERLENDİRME	Doktor Öğretim Üyesi, ÜMMÜ BULUT KESKİN
		8	ÜNİVERSİTE-MEKAN İLİŞKİSİ BAĞLAMINDA ÜNİVERSİTELERİN DÖNÜŞTÜRDÜĞÜ KIRSAL ALANLAR	Doktor Öğretim Üyesi, ÜMMÜ BULUT KESKİN

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HALL / SALON 3	**Doç.Dr., ŞAHİN İNANÇ**	1	DEVELOPMENT OF TIME SERIES BASED CALL COUNT PREDICTION MODELS FOR CALL CENTERS OF ELECTRONIC PAYMENT AND MONEY INSTITUTIONS	Hasan Hüseyin Yurdagül Zehra Sude Sarı Şule Yeşilyurt Ceren Ulus M. Fatih Akay
		2	DELIVERY TIME PREDICTION FOR THE E-COMMERCE SECTOR	Batuhan Taşkapı Hasan Hüseyin Yurdagül Zehra Sude Sarı Ceren Ulus M. Fatih Akay
		3	ENERJİ YÖNETİMİNDE PARÇACIK SÜRÜ OPTİMİZASONU UYGULAMASI	Dr,ONUR MESUT ŞENARAS Doç.Dr., ŞAHİN İNANÇ Prof.Dr., ARZU EREN ŞENARAS
		4	LOJİSTİK YÖNETİMİ İÇİN YAPAY ARI KOLONİSİ OPTİMİZASYONU UYGULAMASI	Dr,ONUR MESUT ŞENARAS Doç.Dr., ŞAHİN İNANÇ Prof.Dr., ARZU EREN ŞENARAS
		5	HUMAN RESOURCES IN THE METAVERSE: A QUALITATIVE STUDY ON RECRUITMENT THROUGH VIRTUAL REALITY	J. Tğm. Dr. Ahmet SARNIÇ
		6	ULTRA DÜŞÜK GÜÇLÜ IOT CİHAZLAR İÇİN GERÇEK ZAMANLI İŞLETİM SİSTEMİ TASARIMI VE GELİŞTİRİLMESİ	Mekatronik Mühendisi,ERTAN ARAS Doç. Dr.,DİLŞAD ENGİN
		7	Deep Learning for Fracture Detection: Achieving High Precision and Sensitivity Across Multi-Region X-ray Images	Dr. Refika Sultan DOĞAN Dr. Rukiye Nur KAÇMAZ
		8	DEVELOPMENT OF A RULE-BASED SELLER CLUSTERING SYSTEM	Muhammed Kesici Oğuzhan Mangır Tuğçe Dinç Ceren ULUS M. Fatih AKAY
		9	BIST 100 PRICE PREDICTION WITH GRU	Asst. Prof. İlkay Sibel KERVANCI Asst. Prof. Gözde ÖZSERT YİĞİT
		10	ADRESSING IMBALANCE IN DRUG-TARGET INTERACTION PREDICTION WITH HYBRID FEATURE REDUCTION AND DATA AUGMENTATION STRATEGIES	Asst. Prof. Dr., Gözde ÖZSERT YİĞİT Asst. Prof. Dr., İlkay Sibel KERVANCI

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HALL / SALON 4	**Dr. Öğr. Üyesi, EMİNE SEÇİL KARAMUKLU**	1	Investigation of The Compatibility of Primary School English Course Learning Outcomes with Other Courses in Terms of Social Emotional Learning	Selver TUNA Doç. Dr. Bahadır KÖKSALAN
		2	İLKOKUL TÜRKÇE, HAYAT BİLGİSİ, SOSYAL BİLGİLER DERS KİTAPLARININ SORUMLULUK DEĞERİ BAKIMINDAN İNCELENMESİ	Dr. Öğr. Üyesi, Zekiye ÇAĞIMLAR Uzman Öğretmen, İNCİ YAŞAR
		3	İLKOKUL FEN BİLİMLERİ VE MATEMATİK DERS KİTAPLARININ SORUMLULUK DEĞERİ BAKIMINDAN İNCELENMESİ	Dr. Öğr. Üyesi, Zekiye ÇAĞIMLAR Uzman Öğretmen, İNCİ YAŞAR
		4	ÖZEL EĞİTİM ÖĞRETMENLİĞİ BÖLÜMÜ ÖĞRENCİLERİNİN ÖZEL EĞİTİM MESLEK LİSELERİNE İLİŞKİN GÖRÜŞLERİ	Dr. Öğr. Üyesi, EMİNE SEÇİL KARAMUKLU
		5	PSİKOLOJİK DANIŞMANLIK VE REHBERLİK BÖLÜMÜ ÖĞRENCİLERİNİN KAYNAŞTIRMA/BÜTÜNLEŞTİRME UYGULAMALARINA İLİŞKİN METAFORİK ALGILARI	Dr. Öğr. Üyesi, EMİNE SEÇİL KARAMUKLU
		6	THE IMPORTANCE OF R&D AND EDUCATION STUDIES IN INCREASING CLIMATE CHANGE AWARENESS	Expert Ecologıst Bedirhan EKER Associate Professor Yasin ÜNAL

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HALL / SALON 5	**Doç. Dr. SİBEL ADAR CAN**	1	ORTAOKUL MATEMATİK ÖĞRETMENLERİNİN MATEMATİK OKURYAZARLIĞI ETKİNLİKLERİNİ GERÇEKLEŞTİRME DURUMLARININ İNCELENMESİ	Yüksek Lisans Öğrencisi, İREM BAŞAĞAÇ Prof. Dr., KÜRŞAT YENİLMEZ
		2	ARCHETYPES: A JOURNEY INTO THE DEPTHS OF THE HUMAN PSYCHE	Assoc. Prof. Dr. Nazile Abdullazade
		3	Dikkat Eksikliği Hiperaktivite Bozukluğu Olan Ortaokul Öğrencilerinin Bağlanma Stilleri ile Psikolojik Sağlamlık Düzeyleri Arasındaki İlişkinin İncelenmesi	Mısra Çifteci Dr. Öğr. Üyesi, Çağla Çelimli
		4	HASTA VE YAŞLI BAKIM HİZMETLERİ BÖLÜMÜ ÖĞRENCİLERİNİN EMPATİ BECERİLERİNİN GELİŞTİRİLMESİNE YÖNELİK EĞİTİM PROGRAMI İÇİN BİR İHTİYAÇ ANALİZİ	Yüksek Lisans Öğrencisi, MUSTAFA ÖZTÜRK Dr. Öğr. Üyesi BURHAN ÜZÜM
		5	A CASE STUDY BASED ON DIGITAL LITERACY LEVELS OF EFL LEARNERS IN TURKEY: WHAT ARE THEIR PERCEPTIONS?	Assist. Prof. HALENUR OCAKTAN ÇELİKTÜRK
		6	YOUR DIFFERENCE/AWARENESS CREATING A SUSTAINABLE WORLD WITH CREATIVE DRAMA	Assist. Prof. Dr., GÜLİZ ŞAHİN Undergraduate Student, ESRA KARAAL Undergraduate Student, AZRA MAÇÇA
		7	AN EVALUATION ON THE COMPETENCIES OF CLASSROOM TEACHER CANDIDATES IN VISUAL ARTS TEACHING COURSE	Doç. Dr. SİBEL ADAR CAN
		8		

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HALL / SALON 6	**Dr. Öğr. Üyesi Fatih ŞAHİN**	1	Over Kanseri ve Ebelik: Tespit, Danışmanlık ve Bütünsel Destek	AYSEL KURUOĞLU YASEMİN HAMLACI BAŞKAYA
		2	THE USE OF ARTİFİCİAL INTELLİGENCE İN ASSİSTED REPRODUCTİVE TECHNOLOGİES	Ebe (Tezli Yüksek Lisans Öğrenci), Ayşenur YETİM Arş. Gör. Dr., Fatma YILDIRIM Prof. Dr., Nuriye BÜYÜKKAYACI DUMAN
		3	A Solution-Oriented Approach in Psychiatric Nursing	Dr. Öğr. Üyesi Fatih ŞAHİN
		4	SAĞLIK ÇALIŞANLARININ YAŞADIĞI İŞ STRESİNİN SİGARA İÇME ARZUSUNA ETKİSİ	Yüksek Lisans Öğr. Havvanur GÜNEŞ Yüksek Lisans Öğr. Fatma Nur DALBOY Doç. Dr. Yasemin HAMLACI BAŞKAYA
		5	EBEVEYNLERİN ATEŞ YÖNETİMİ TERCİHLERİNİN DEĞERLENDİRİLMESİ	Doç. Dr. Funda KARDAŞ ÖZDEMİR Arş. Gör. Melis Can KESGİN GÜNGÖR
		6	SÜNNET OLAN ÇOCUKLARDA DİKKAT DAĞITMA TEKNİKLERİNİ KULLANAN RANDOMİZE KONTROLLÜ ÇALIŞMALARIN İNCELENMESİ	Arş. Gör. Melis Can KESGİN GÜNGÖR Doç. Dr. Funda KARDAŞ ÖZDEMİR
		7	INVESTIGATION OF WOMEN’S HEALTH LITERACY AND HEALTH BELIEFS ABOUT HUMAN PAPILLOMA VIRUS AND VACCINE: A CROSS-SECTIONAL DESCRIPTIVE STUDY	Hemşire, JANIL ALANUR HAKİM Dr. Öğretim Üyesi ASLI KARAKUŞ SELÇUK

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HALL / SALON 7	**Doç.Dr.Hafize ÖZDEMİR ALKANAT**	1	Maintaining Secure Attachment in Neonatal İntensive Care Unit	Melis İLBASAN Doç. Dr. Handan ÖZCAN
		2	Is Comsumption a Risk in Maintaining Fertility?	Melis İLBASAN Doç. Dr. Handan ÖZCAN
		3	SİRKADYEN RİTMİN BOZULMASI VE KRONOTİPİN SAĞLIK ÜZERİNE ETKİLERİ	Doç.Dr.Hafize ÖZDEMİR ALKANAT
		4	SİRKADYEN RİTİM VE KRONOKEMOTERAPİ ÜZERİNE HEMŞİRELİK NOTLARI	Doç.Dr.Hafize ÖZDEMİR ALKANAT
		5	Is Unsafe Sexual Activity a Risk in the Maintenance of Fertility?	Gülbanu GÜMÜŞOK, Doç. Dr. Handan ÖZCAN
		6	Effects of Endocrine Disruptors on Fertility	Gülbanu GÜMÜŞOK, Doç. Dr. Handan ÖZCAN
		7	MASSAGE TECHNIQUES USED TO REDUCE LABOR PAIN	Assistant Professor, Sebahat Hüseyinoğlu Graduate Sudent, Sevda Elkatmiş
		8	THE POWER OF ART THERAPY İN PREGNANCY, CHİLDBİRTH AND POSTPARTUM	Dr. Öğr. Üyesi, Sebahat HÜSEYİNOĞLU Arş. Gör. Kübra Nur KILIÇ Arş. Gör Begüm CAN Doç. Dr. Reyhan AYDIN DOĞAN

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HALL / SALON 8	**Asst. Prof. Dr., LÜTFİYE NUR UZUN**	1	THE IMPORTANCE OF FAMILY-CENTERED CARE IN CHILDREN WITH CHRONIC ILLNESS	Hemşire Nihat GÜNEŞ Dr. Öğr. Üyesi Veysel CAN Dr. Öğr. Üyesi Mehmet BULDUK
		2	BIBLIOMETRIC ANALYSIS OF GRADUATE THESES ON STREET CHILDREN	Hemşire Nihat GÜNEŞ Dr. Öğr. Üyesi Veysel CAN Dr. Öğr. Üyesi Mehmet BULDUK
		3	Sleep Hygiene During Pregnancy	Nezaket TARHAN Doç. Dr. Handan ÖZCAN
		4	Nursing and Midwifery Interventions in Ovarian Hyperstimulation Syndrome	Nezaket TARHAN Doç. Dr. Handan ÖZCAN
		5	EXAMINING THE RELATIONSHIP BETWEEN NURSING STUDENTS' CAREER CHOICES AND GENDER ROLES PERCEPTIONS	Damla ŞAHİN Assist. Prof. Dr Bahar ÇOLAK
		6	CODING EMOTIONS: ARTIFICIAL INTELLIGENCE, NURSING AND MASLOW'S PYRAMID OF NEEDS	Asst. Prof. Dr., LÜTFİYE NUR UZUN
		7	The Relationship Between Post Traumas, Psychosocial Difficulties, Quality of Life and Sleep Status of Children Diagnosed with Secondary Enuresis After Earthquake	Dr. Öğr. Üyesi Mehmet Emin DÜKEN
		8	COMPLİCATİONS AND MANAGEMENT OF ABDOMİNAL TRAUMA İN PREGNANCY	Yüksek Lisans Öğrencisi Ebe, Merve KAYA Doç. Dr. Yasemin Hamlacı Başkaya

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HALL / SALON 9	**Assist. Prof. Dr. N. MEZİYET DİLEK**	1	TARIMSAL ÜRETİMDE ENERJİ YÖNETİMİNDE YENİLENEBİLİR ENERJİ TEKNOLOJİLERİNİN ÖNEMİ	Prof.Dr. Hasan Hüseyin ÖZTÜRK Dr. Hasan Kaan KÜÇÜKERDEM
		2	SERA İKLİMLENDİRME İÇİN GÜNEŞ ENERJİSİ DESTEKLİ ISI POMPASI KULLANIMI	Prof.Dr. Hasan Hüseyin ÖZTÜRK Dr. Hasan Kaan KÜÇÜKERDEM
		3	ÇİLEK YETİŞTİRİCİLİĞİNDE RİZOBAKTERİ VE VİNAS UYGULAMALARININ GELİŞME VE VERİM ÜZERİNE ETKİLERİ	Neslihan TOPAL Prof. Dr. Ahmet EŞİTKEN
		4	CEVİZ KABUĞUNUN KOH VE İLE KİMYASAL AKTİVASYONU SONUCU ELDE EDİLEN AKTİF KARBONUN KARAKTERİZASYONU	Prof. Dr. ESRA ALTINTIĞ Dr. BİRSEN SARICI
		5	METİLEN MAVİSİNİN MANYETİK AKTİF KARBON İLE GİDERİMİNİN İNCELENMESİ	Prof. Dr. ESRA ALTINTIĞ Dr. BİRSEN SARICI
			IĞDIR OVASI'NDA BULUNAN ARAZİLERİN SULAMA SİSTEMİNİN DEĞERLENDİRİLMESİ ve KAPALI SULAMA SİSTEMİNE GEÇİLMESİ İMKÂNLARININ ARAŞTIRILMASI	Ziraat Mühendisi, Mehmet Fatih ÇELEBİ
		6	ANTHOCYANNINS AND THE USE OF ANTHOCYANNINS AS FOOD COLOURANTS	Dr. Fatmagül Hamzaoğlu
		7	USE OF COLD PLASMA TECHNIQUE IN FOOD TECHNOLOGY	Assoc. Prof. KUBRA UNAL Assist. Prof. Dr. N. MEZİYET DİLEK
		8	MARINATION PROCESS IN MEAT TECHNOLOGY: OBJECTIVES AND EFFECTS	Assist. Prof. Dr. N. MEZİYET DİLEK
		9	GIDA İŞLEMEDE 3D BASKI TEKNOLOJİSİNE GENEL BAKIŞ	Doç. Dr. Emine NAKİLCİOĞLU Gizem TİRYAKİ
		8	KAHVE TELVESİNİN GIDA SANAYİSİ ALANINDA DEĞERLENDİRİLMESİ	Gizem TİRYAKİ Doç. Dr. Emine NAKİLCİOĞLU

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HALL / SALON 10	**Dr. Carolina Reyes Assoc. Prof. Dr. Jeanette Mbala**	1	THE EVOLUTION OF MIDWIFERY PRACTICES: CULTURAL AND MEDICAL PERSPECTIVES FROM TURKEY AND SOUTH AFRICA	Dr. Aylin Demir
		2	INTEGRATING TRADITIONAL AND MODERN MIDWIFERY: A COMPARATIVE STUDY IN INDONESIA AND KENYA	Dr. Siti Rahmawati Dr. Akinyi Njoroge
		3	ASSESSING THE IMPACT OF MIDWIFERY EDUCATION ON MATERNAL AND NEONATAL OUTCOMES IN BANGLADESH AND GHANA	Dr. Farida Chowdhury Dr. Kwame Boateng
		4	THE ROLE OF MIDWIVES IN COMBATING MATERNAL MORTALITY: LESSONS FROM BRAZIL AND UGANDA	Dr. Maria Oliveira Dr. Grace Nakato
		5	MIDWIFERY AND COMMUNITY HEALTH: EMPOWERING WOMEN THROUGH HOLISTIC CARE IN VIETNAM AND ETHIOPIA	Mekdes Tesfaye Linh Tran
		6	TECHNOLOGICAL ADVANCEMENTS IN MIDWIFERY: THE IMPACT OF TELEHEALTH IN RURAL AREAS OF THE PHILIPPINES AND TANZANIA	Dr. Angelica Dela Cruz Dr. Juma Mwinyi
		7	EXPLORING MIDWIFERY POLICY AND PRACTICE: CHALLENGES AND OPPORTUNITIES IN MALAYSIA AND ZAMBIA	Noor Hidayah Dr. Bwalya Chisanga
		8	MIDWIFERY INTERVENTIONS FOR HIGH-RISK PREGNANCIES: STRATEGIES FROM MOROCCO AND INDIA	Dr. Salma El Idrissi
		9	THE IMPACT OF MIDWIFERY-LED BIRTH CENTERS ON MATERNAL SATISFACTION: CASE STUDIES FROM MEXICO AND CAMEROON	Dr. Carolina Reyes Assoc. Prof. Dr. Jeanette Mbala

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HALL / SALON 11	**Assoc. Prof. Dr.Natasha Ivanova**	1	IMPROVING MATERNAL HEALTH THROUGH MIDWIFERY-LED CARE MODELS: A GLOBAL PERSPECTIVE	Aisha Al-Harthy Dr. Fatima Ibrahim Dr. Elena Petrova
		2	THE ROLE OF MIDWIVES IN PREVENTING POSTPARTUM DEPRESSION: A QUALITATIVE STUDY	Dr. Nawal Al-Mazroui Assis. Prof. Dr. Layla Abdullahi
		3	INTEGRATING TRADITIONAL MIDWIFERY PRACTICES INTO MODERN MATERNAL CARE IN SUB-SAHARAN AFRICA	Esther Mwangi Dr. Safiya Hassan
		4	MIDWIFERY EDUCATION AND SKILL DEVELOPMENT: CHALLENGES AND OPPORTUNITIES IN THE MIDDLE EAST	Dr. Laila Al-Kindi Mohammed Al-Farsi
		5	TECHNOLOGY-ASSISTED MIDWIFERY: TELEHEALTH SOLUTIONS FOR REMOTE MATERNAL CARE	Assoc. Prof. Dr.Natasha Ivanova
		6	MATERNAL HEALTH DISPARITIES AMONG MIGRANT WOMEN: THE ROLE OF MIDWIFERY SERVICES	Phd. Candidate Maria Fernández
		7	THE ROLE AND SIGNIFICANCE OF INTERVENTION RESEARCH IN SOCIAL WORK	Prof. Dr. João Henrique Silva
		8	MIDWIFERY INTERVENTIONS IN REDUCING CESAREAN SECTION RATES: A SYSTEMATIC REVIEW	Msc. Sara Abdulwahab

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HALL / SALON 1	**Prof. Dr. Anna Dubois, Dr. Sofia Rossi**	1	FEDERALISM AND INTERNATIONAL AFFAIRS: THE ROLE OF SUB-STATE GOVERNMENTS IN EUROPEAN COUNTRIES	Olivier Durand Jan Kowalski
		2	KOREA AND JAPAN ECONOMIC RELATIONS: AN ANALYSIS THROUGH THE WORLD TRADE ORGANIZATION	Emilie L. Dufresne, Matteo P. Costa
		3	SELF-PERCEIVED EMPLOYABILITY OF INTERNATIONAL RELATIONS STUDENTS IN EUROPEAN UNIVERSITIES	Dr. Julian Andersson, Prof. Dr. Claire Dubois
		4	THE ROLE OF EUROPEAN COUNTRIES IN RESOLVING THE RELIGIOUS CONFLICTS IN CENTRAL ASIA	Prof. Dr. Anna Dubois, Dr. Sofia Rossi
		5	PUBLIC RELATIONS FOR THE FACULTY OF MANAGEMENT SCIENCE IN AFRICAN UNIVERSITIES	Adebayo Olumide, Chipo Ndlovu, Kwame Amankwah
		6	CHILEAN BUSINESS ORIENTALISM: THE ROLE OF NON-STATE ACTORS IN THE FRAME OF ASYMMETRIC BILATERAL RELATIONS	Kwame Osei Amina N'Diaye
		7	ECONOMIC GROWTH RELATIONS TO DOMESTIC AND INTERNATIONAL AIR PASSENGER TRANSPORT IN AFRICA	Kwame Nkrumah, Amina Binta, Julius Ochieng, Zanele Moyo
		8	HORIZONTAL DIMENSION OF CONSTITUTIONAL SOCIAL RIGHTS	Amina Oumarou, Thabo Mokoena, Nana Adomah
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HALL / SALON 2	**Assoc. Prof. Dr. Fatima Zohra Benkhedda**	1	OPERATION STRATEGY AND PUBLIC RELATIONS TRENDS FOR PUBLIC RELATIONS STRATEGIES DEVELOPMENT IN AFRICA	Kwame O. Adom, Nia A. Kwesi
		2	APPLICATION ASPECTS OF PUBLIC RELATIONS BY NONPROFIT ORGANIZATIONS: A CASE STUDY OF THE MIDDLE EAST	Omar Al-Mansouri, Leila Kassem, Tariq Abdullah
		3	APPLICATION'S ASPECTS OF PUBLIC RELATIONS BY NONPROFIT ORGANIZATIONS. CASE STUDY MIDDLE EAST	Omar Al-Sabah, Layla Al-Dosari, Khaled Al-Farouq
		4	THE IDEA OF INTERNATIONAL CRIMINAL JUSTICE IN THE FUNCTION OF PROSECUTION OF INTERNATIONAL CRIMES	Omar Al-Mansoori, Aisha Al-Hashimi
		5	AN EFFICIENT MULTI JOIN ALGORITHM UTILIZING A LATTICE OF DOUBLE INDICES	D. Ahmad R. Al-Hassan, Assis. Prof. Dr. Nadia B. Al-Sayed
		6	EXPLORING THE PROFESSIONAL COMPETENCY CONTENTS FOR INTERNATIONAL MARKETERS IN THE MIDDLE EAST	Mohammad Al-Fahad, Dr. Ali Al-Hassan
		7	THE ROLE OF MIDDLE EASTERN COUNTRIES IN THE UNIFICATION OF COLLISION OF LAW IN INTERNATIONAL TRADE	A. Al-Mansouri, N. Al-Jaber
		8	EXTENDING THE CONCEPTUAL NEIGHBORHOOD GRAPH OF THE RELATIONS FOR THE SEMANTIC ADAPTATION OF MULTIMEDIA DOCUMENTS	Ahmed Al-Mansouri, Assoc. Prof. Dr. Fatima Zohra Benkhedda

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HALL / SALON 3	**Assoc. Prof. Dr. Kwame Ndlovu**	1	PUBLIC SERVICE ETHICS IN THE MIDDLE EAST: AN EMPIRICAL STUDY	Omar Al-Mansouri Leila Al-Farsi Tariq Al-Hashmi
		2	DISTINCTIVE FEATURES OF LEGAL RELATIONS IN THE AREA OF SUBSOIL USE, RENEWAL AND PROTECTION IN THE MIDDLE EAST :	F. Al-Mohammad, L. Al-Saleh, R. Al-Hassan
		3	THE CONCEPT AND PRACTICE OF GOOD GOVERNANCE IN AFRICA	Assoc. Prof. Dr. Kwame Ndlovu Dr. Fatima Diallo
		4	A FRAMEWORK FOR KNOWLEDGE MANAGEMENT APPLICATION IN PUBLIC ORGANIZATIONS IN AFRICA	Dr. Kwame Mensah, Dr. Amina Ouedraogo
		5	E-GOVERNMENT, DIGITAL TRANSFORMATION, AND THE ONE BELT ONE ROAD INITIATIVE: AFRICA'S OPPORTUNITY	Dr. Amina Coulibaly
		6	CONCEPTUALIZING PRIORITIES IN THE DYNAMICS OF PUBLIC ADMINISTRATION CONTEMPORARY REFORMS	Kwame Osei Fatima Mbatha Amina Diallo Thabo Ndlovu
		7	THE IMPLEMENTATION OF MANDATORY ELECTRONIC DOCUMENT EXCHANGE IN PUBLIC ADMINISTRATION: EXPECTATIONS VERSUS REALITY	Dr. Samuel Njoroge Dr. Amina Diallo
		8	UTILIZING KNOWLEDGE MANAGEMENT TO FOSTER A KNOWLEDGE SOCIETY THROUGH E-GOVERNMENT SERVICES IN AFRICAN NATIONS	Dr. Samuel Njoroge Dr. Aisha Abubakar

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HALL / SALON 4	**Adebayo Okonkwo**	1	ANALYSIS OF THE EVOLUTION OF IN-SERVICE TRAINING IN PUBLIC ADMINISTRATION: FROM PERSONNEL MANAGEMENT TO HUMAN RESOURCE DEVELOPMENT	Dr. Wei-Lun Zhang Dr. Noriko Tanaka
		2	ENHANCING ACCOUNTABILITY IN THE PUBLIC SECTOR: LESSONS FROM A CORRUPTION CASE IN NIGERIA	Adebayo Okonkwo
		3	EVALUATION OF MEDICATION ADMINISTRATION PROCESS IN A PAEDIATRIC WARD	Hiroshi Takahashi Mei Lin Zhang Joon-Soo Park Nguyen Thanh Binh
		4	IMPLEMENTING COLLABORATIVE BUSINESS PROCESSES TO MITIGATE INFORMATION LOSS IN PUBLIC ADMINISTRATION	H. Nakamura S. Liang, K. Tham
		5	A LEGAL OPINION ON MITIGATION AND ADAPTATION AIR POLLUTION STRATEGIES FOR LOCAL GOVERNMENTS IN EAST ASIA	Hiroshi Tanaka Mei Lin Zhang
		6	FROM SEPARATISM TO COALITION: VARIANTS IN LANGUAGE POLITICS AND LEADERSHIP PATTERN IN DRAVIDIAN MOVEMENT	Takeshi Yamamoto Li Wei Min Ji
		7	HOW DO POLITICIANS RECOVER THEIR COSTS? THE POLITICAL ECONOMY OF REPRESENTATIVE DEMOCRACY IN ASIAN POLITICS	Mei Ling Zhao Rajiv Kumar
		8	THE ROLE OF REGIONAL CONCEPTS IN PUBLIC POLICY: A STUDY ON THE SOUTH ASIAN CONTEXT	Rajeev Kumar Mei Li Zhang, Amira K. Sulaiman
		9	CONTROLLING YOUTHS' PARTICIPATION IN POLITICS IN YANGON: A CONSTRUCTIVE INCLUSIVENESS FOR GOOD GOVERNANCE IN MYANMAR	Aung Kyaw Zin Mai Thein Lwin

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HALL / SALON 5	**Assis .Prof. Dr. Yumi Tanaka**	1	FINITE-SUM OPTIMIZATION: ADAPTIVITY TO SMOOTHNESS AND LOOPLESS VARIANCE REDUCTION	Sungmin Park Dr. Jiawei Zhang
		2	A MODEL OF A NON-EXPANDING UNIVERSE DRIVEN BY THE VACUUM SPACE PROPERTIES	Ryuji Takahashi Ahmed Al-Farsi Zhang Wei
		3	GENERALIZATION OF TSALLIS ENTROPY THROUGH Q-DEFORMED ARITHMETIC	A. P. Kundu R. J. Singh S. M. Patel T. H. Zhou
		4	ESTIMATION OF FUNCTIONAL RESPONSE MODEL USING SUPERVISED FUNCTIONAL PRINCIPAL COMPONENT ANALYSIS	Haruto Kobayashi Assis .Prof. Dr. Yumi Tanaka
		5	CLOSED-FORM SOLUTION OF SECOND ORDER LINEAR ORDINARY DIFFERENTIAL EQUATIONS	Ahmed Hassan Assoc. Prof. Dr. Layla Abdallah
		6	ECONOMIC FORECASTING MODEL IN PRACTICE USING REGRESSION ANALYSIS: THE RELATIONSHIP BETWEEN PRICE, DOMESTIC OUTPUT, GROSS NATIONAL PRODUCT, AND TREND VARIABLES IN OIL PRODUCTION	Kwame Adom, Amina Osei, Dr. Kofi Baidoo
		7	OPTIMIZING SPATIAL INTERPOLATION USING A MULTI-LAYER INVERSE DISTANCE WEIGHTING MODEL FOR ADVANCED REGRESSION AND CLASSIFICATION TASKS IN SPATIAL DATA ANALYSIS	Kwame Adebayo, Chipo Mutasa, Samuel Okello, Nia Ncube

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HALL / SALON 6	**Jomo Kenyatta**	1	APPLICATION OF LEGENDRE TRANSFORMATION TO PORTFOLIO OPTIMIZATION	Kwame Adom, Amina Bello, Chijioke N. Okoye
		2	ON DECOMPOSITION OF MAXIMAL PREFIX CODES IN DATA CLASSIFICATION	Chijioke Okafor, Amina Boukari
		3	APPROXIMATION TO THE HARDY OPERATOR IN TOPOLOGICAL SPACES	Amina K. Ndong, Ibrahim A. Mohammed
		4	LOCALIZED MESHFREE METHODS FOR SOLVING 3D HELMHOLTZ EQUATION	Ahmed S. Alim, John M. Nkrumah
		5	IDENTIFYING ENVIRONMENTAL FACTORS AFFECTING THE SPREAD OF MALARIA IN AFRICA: A REGRESSION APPROACH	Kwame Nkrumah Amina Kofi
		6	THE ANALOGUE OF PISOT NUMBERS IN FORMAL POWER SERIES FIELDS OVER FINITE FIELDS	Assis.Prof. Dr.Thierno S. Diallo Dr. Amina F. Kone
			ARTIFICIAL NEURAL NETWORK FOR OPTIMAL INVENTORY MANAGEMENT IN AFRICAN MARKETS	Amina B. N'Diaye, Samuel T. Akoua
		7	IDENTIFYING ENVIRONMENTAL AND SOCIOECONOMIC DETERMINANTS OF TYPHOID FEVER SPREAD IN EAST AFRICA: A REGRESSION ANALYSIS	Jomo Kenyatta Nia Akinyi

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HALL / SALON 7	**Assis. Prof. Dr. Jean-Michel Dıop**	1	A BIOLOGICAL MODEL FOR THREE SPECIES WITH CROWLEY–MARTIN FUNCTIONAL RESPONSE	Dr. Amina Zelıkovıc Prof. Dr. Roberto Martınho
		2	OPTIMIZING RELAXATION PARAMETERS FOR EFFICIENT ITERATIVE SOLUTIONS TO ELECTROMAGNETIC SCATTERING PROBLEMS	Prof. Dr. Li Zhao Dr. Amir Rahımı
		3	A COMPARATIVE ANALYSIS OF BAYESIAN AND REGRESSION MODELS FOR PUBLIC HEALTH SERVICE MODELING	Ana García Dr. Yuto Sato
		4	PURE SCALAR EQUILIBRIA IN NORMAL-FORM STRATEGIC GAMES"?	Dr. Mahir Khamıdov Jasmine Ugo
		5	QUANTITATIVE ANALYSIS OF STOCK PRICE FORECASTING IN FINANCIAL MARKETS USING THE GEOMETRIC BROWNIAN MOTION MODEL	Milena Tang Assis. Prof. Dr. Jean-Michel Dıop
		6	ENHANCED TRIPLE INTEGRAL INEQUALITIES OF HERMITE-HADAMARD TYPE	Lucas Araujo Nabila Rıahı
		7	A COMPREHENSIVE REVIEW OF HIGHER-ORDER SPLINE METHODS FOR SOLVING THE BURGERS EQUATION WITH B-SPLINE TECHNIQUES AND THEIR VARIATIONS	Dr. José Pereıra Carlos García
		8	A CONJECTURE ON THE ADAM OPTIMIZER	Chijioke Onuoha Sofia Rıvera Alhaji Dıop Dr. Saeed Hosseın

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HALL / SALON 8	**Assoc. Prof. Dr. Amadou Toure**	1	DEVELOPING A STRATEGY FOR ZERO ENERGY BUILDINGS: A STUDY ON CONVERTING AN OLD OFFICE BUILDING INTO A NET ZERO ENERGY BUILDING FOR HOT-HUMID CLIMATES	Marat K. Tuleubayev, Dr. Amina B. Khairullina
		2	THE FUTURE OF MEDICAL FACILITIES: A SYSTEMATIC REVIEW OF ARCHITECTURAL DESIGN WITH AN INNOVATIVE RESEARCH AND DEVELOPMENT PERSPECTIVE	Akilbek Toktogulov, Aizada Ibragimova, Yerbolat Saduov, Gulzhanat Mukhtarova, Nurlan Esenov
		3	THE EVOLVING IMPACT OF BUILDING FAÇADES IN URBAN SPACES: A COMPARATIVE STUDY OF BAKU	Assis. Prof. Dr. Elvin Mammadov Dr. Leyla Farzalieva
		4	ENERGY CONSERVATION THROUGH ADAPTABLE ARCHITECTURE	Sibusiso Dlamini Thabo Mokoena Amina K. Nguvama, Kwame Adom
		5	DEVELOPING A COMPREHENSIVE APPROACH FOR SUSTAINABILITY ASSESSMENT OF BUILDING ELEMENTS	Dr. Kwame Asante, Lecture Femi Alabi, Dr. Imani Ndlovu
		6	AMBITIOUS ARCHITECTURE: A FRAMEWORK FOR FLOOD RISK MITIGATION	Ibrahim B. Ndlovu, Fatima K. Moyo
		7	BETWEEN ALEXIS NOSSITER AND SAID ALI: AN 'AFFINITARIAN' ARCHITECTURAL EXPLORATION	Mariama Doumbia, Assoc. Prof. Dr. Amadou Toure
		8	A PROPOSAL FOR TEMPORARY SHELTERS FOR DISPLACED COMMUNITIES	L. Dupont, M. Faure, T. Charpentier,

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HALL / SALON 9	**Assis .Prof. Dr. Klooster Wouters**	1	EXPERT SOLUTIONS TO AFFORDABLE HOUSING FINANCE CHALLENGES IN DEVELOPING ECONOMIES	Lukas Müller, Sophie Vandenberg
		2	ARCHITECTURAL INNOVATION IN THE FACE OF THE CLIMATE CRISIS	Sophia Dubois, Assoc. Prof. Dr. Lucas Martin
		3	DESIGNING ACCESSIBLE HOUSING TO IMPROVE LIVING CONDITIONS FOR PEOPLE WITH DIVERSE NEEDS	Van den Broeck, Assis .Prof. Dr. Klooster Wouters
		4	ASSESSMENT OF FIRE RISKS ASSOCIATED WITH FUEL STATIONS IN THE CITY OF ANTWERP AND EVALUATING RISK MANAGEMENT IN URBAN PLANNING	J. Meier L. Vandenbroeck
		5	THE ROLE OF PERSPECTIVE IN RENAISSANCE ART AND ARCHITECTURE IN EUROPE	Sophie Dupont Marc Lefevre
		6	ACCURACY OF PEAK DEMAND ESTIMATES IN OFFICE BUILDINGS USING ENERGY PLUS SIMULATOR	Lukas Vermeulen, Anna Janssen, Peter De Smet, Michel Van der Velde

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HALL / SALON 10	**Assis .Prof. Dr. Akhmetzhanov Dauren,**	1	DIGITAL TWINS IN THE BUILT ENVIRONMENT: A FRAMEWORK FOR INTEGRATION AND DEVELOPMENT	Henrik Jansen Anna Vandereycken Tom Duval Laura Casteleyn
		2	FACTORS INFLUENCING THE ADOPTION OF SUSTAINABLE CONSTRUCTION PRACTICES IN EUROPEAN RESIDENTIAL BUILDINGS	Luca Rossi Maria Gonzalez Benjamin Schmidt Sophie Laurent
		3	ADAPTING SPACES TO PANDEMIC CONDITIONS: A FIVE-SCALE DESIGN APPROACH TO PREPARE AND RESPOND	Laura Schmidt Andreas Meier
		4	THE RISE OF CONSTRUCTION MAFIAS IN CENTRAL ASIA: IMPACTS ON THE CONSTRUCTION SECTOR	Timurbek Aslanov Alimzhan Akhmetov Dastan Bekzhanov
		5	A STRATEGY FOR ACHIEVING ENERGY SUSTAINABILITY IN ENTERPRISES	Zhanarbek Toleubekov, Aslanbek Bekzhanov Dr. Alina Syzdykova Ms. Timur Nuraliev
		6	CULTURAL SUSTAINABILITY IN MODERN ARCHITECTURAL DESIGN: CASE STUDY OF ALMATY INTERNATIONAL AIRPORT	A. Tursunov, Dr. R. Dzhumabayev
		7	CROWDINIG FOR SUSTAINABLE ENERGY INITIATIVES IN SOUTHERN AFRICAN COUNTRIES	Themba Moyo Lerato Nkosi Sipho Dlamin Nandi Mthembu
		8	A QUANTITATIVE APPROACH TO ASSESSING THE AREA OF CORE AND STRUCTURAL SYSTEM ELEMENTS IN TALL OFFICE BUILDINGS	Assis .Prof. Dr. Akhmetzhanov Dauren, Zhanibekova Altynai

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HALL / SALON 11	**Dr. Adebayo Olumide,**	1	THE APPLICATION OF DRAMA EDUCATION METHODS AMONG EARLY CHILDHOOD EDUCATORS IN CENTRAL ASIA	Nurzhanov Akylbek Aygul Zhanat, Bolatbek Toktarov, Dastan Asanov
		2	THE ROLE OF DRAMA EDUCATION IN ENHANCING CREATIVITY IN PRESCHOOLERS	Aibek Akhmetov, Gulnar Ibraeva
		3	THE SIGNIFICANCE OF MANDATORY EARLY CHILDHOOD EDUCATION FROM THE PARENTS' PERSPECTIVE IN KENYA	Peter Njoroge, Alice Mwangi
		4	PARENTS' PERSPECTIVES ON MANDATORY PRESCHOOL ATTENDANCE IN KENYA	James Mwangi, Faith Njeri
		5	THE ROLE OF PARENTAL ENGAGEMENT IN THE DEVELOPMENT OF PRESCHOOL CHILDREN WITH DISABILITIES	Dr. Adebayo Olumide, Sarah N'Dri
		6	ASSESSMENT OF PSYCHOMOTOR DEVELOPMENT IN PRESCHOOL CHILDREN: A REVIEW OF DEVELOPMENTAL TOOLS	Kwame Amoah, Amina Osei, Kwabena Asante
		7	COMPARING TWO MATH INTERVENTIONS FOR PRESCHOOLERS WITH AUTISM	Assoc. Prof. Dr. Thabo Modise, Assis. Prof. Dr. Amina Sekou
		8	INTERACTIVE ROBOTIC TOOL FOR EARLY LEARNING OF MATHEMATICAL AND COLOUR CONCEPTS IN PRESCHOOLERS	David O. Okafor, Grace O. Omoregie,
		9	DEVELOPING A MORAL EDUCATION MODULE FOR PRESCHOOL TEACHERS USING A MODIFIED DELPHI TECHNIQUE	Amina Diallo Dr. Kwame Mensah

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HALL / SALON 12	**Dr. Julia Jansen**	1	THE CURRICULUM OF ETHICAL EDUCATION IN POLAND	Jan Kowalski Agnieszka Nowak
		2	HOME EDUCATION IN THE EUROPEAN CONTEXT	M. Dubois, L. Mertens
		3	THE ROLE OF EARLY EDUCATION IN DEVELOPING COMMUNICATION AND SOCIAL SKILLS: A FOCUS ON PRESCHOOLERS AND THEIR IMPACT ON CAREERS AND HIGHER EDUCATION	Lukas Janssens Dr. Isabelle Dupont
		4	CASE STUDY: INTEGRATING CAREER EDUCATION WITH UNIVERSITY EDUCATION IN GERMANY	Matthias Fischer Anna Schmidt
		5	COMPUTER-ASSISTED EVALUATION OF INDIVIDUAL EDUCATION PLANS IN SPECIAL EDUCATION SETTINGS	Laura De Bruyn Pieter Janssens
		6	FROM MONOLINGUALISM TO MULTILINGUALISM IN EUROPEAN HIGHER EDUCATION	Lucas P. Jansen Sofia M. De Vries
		7	ESTABLISHING A NEW EDUCATION STRATEGY IN A DIGITAL AGE: THE ROLE OF STUDENT FEEDBACK	Maria Dubois Asssi. Prof. Dr. Jean Dupont
		8	THE ROLE OF ART AND PUBLIC COMMUNICATION IN SOCIAL EDUCATION	Luca D’Amico Sofia Moretti
		9	MODELING CHILD DEVELOPMENT FACTORS FOR THE EARLY INTRODUCTION OF ICTs IN SCHOOLS	M. T. Gossens L. P. Sevens
		10	ETIQUETTE LEARNING AND PUBLIC SPEAKING: IMPACT OF EARLY TRAINING ON HIGHER EDUCATION AND PROFESSIONAL SUCCESS	Anna Van der Meer, Dr. Julia Jansen
		11	MODELING CHILD DEVELOPMENT FACTORS FOR THE EARLY INTRODUCTION OF ICTS IN SCHOOLS	M. L. Dupont, F. H. Garcia

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HALL / SALON 1	**Prof. Dr. RAMAZAN BİÇER**	1	HIRİSTİYAN TEOLOJİSİNİN TEŞEKKÜLÜNDE PAVLOS'UN YERİ VE ÖNEMİ	Prof. Dr., RECEP ÖNAL YL Öğrencisi, Muhammed Berad ÇULHA
		2	ACADEMIC STUDIES IN NORWAY ON ISLAMOPHOBIA AND INTERRELIGIOUS DIALOGUE	Prof. Dr., RECEP ÖNAL
		3	GÜNÜMÜZ TEFSİR MESELELERİ HAKKINDA BAZI TEZLER	Dr. Araştırma Görevlisi Hasan Can ATEŞ
		4	LİBERAL İNSAN HAKLARI KURAMININ ÇÖKÜŞÜ: GAZZE SONRASI DÜNYADA ''EVRENSEL'' BEYANNAMEYİ SORGULAMAK	Dr. Araştırma Görevlisi Hasan Can ATEŞ
		5	PLANT INTELLIGENCE IN THE CONTEXT OF THE VERSE "THERE IS A GREAT LESSON TO BE LEARNED IN PLANTS" (QUR'AN 26/8)	Prof. Dr. RAMAZAN BİÇER
		6	NEW ACROPOLIS, A NEW AGE RELIGIOUS MOVEMENT	Prof. Dr. RAMAZAN BİÇER
		7	THE RELATIONSHIP BETWEEN RELIGION AND SCIENCE IN THE PRIMARY EDUCATION RELIGIOUS CULTURE AND MORAL KNOWLEDGE CURRICULUM OF THE CENTURY OF TURKIYE MAARIF MODEL	Sümeyye Özdoğan Asst. Prof. Dr. Mehmet Yıldız
		8	AN EXAMINATION OF THE PROBLEM OF BELONGING IN WORDS ATTRIBUTED TO SUFIS ON SOCIAL MEDIA	Dr. Öğr. Üyesi Mahmut Ulu

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HALL / SALON 2	**Doç. Dr., Sezai ENGİN**	1	Kur'an'ın Mucizeleri ve Onun Hukuk, Ahlak ve Toplum Üzerindeki Etkisi	Azhar Khudhaır Abbas AL-AZZAWI Dr. Öğr. Üyesi, Vedat YETKİN
		2	Abese Suresi'nin İniş Sebepleri ve Ayetlerin Anlamına Etkisi: Analitik Bir İnceleme	Mohamad ALDAHER Dr. Öğr. Üyesi, Vedat YETKİN
		3	HUKUK FAKÜLTELERİNDE İSLAM HUKUKU EĞİTİMİ: SORUNLAR VE ÇÖZÜM ÖNERİLERİ	Dr. Öğr. Üyesi, Meryem CİHANGİR
		4	İSLÂM HUKUKUNUN TÜRK AİLE HUKUKUNA ETKİSİ: NİKÂH, TALÂK VE NAFAKA ÜZERİNE BİR İNCELEME	Dr. Öğr. Üyesi, Meryem CİHANGİR
		5	İmam Mâtürîdî'nin Kudret-İrâde Anlayışı ve Toplumsal Kaderle İlişkisi	RAMAZAN SEZER
		6	Memlük Dönemi Hadis Şerh Yazıcılığı ve Literatüründe İbn Mülakkın (ö. 804/1401)	Doç. Dr., Sezai ENGİN
		7	IMAM MĀTURĪDĪ's UNDERSTANDING of GREAT SIN and INTERCESSION	KÜBRA AKTİ
		8	Kur'an'daki "Ey İman Edenler" Hitabının Psikolojik Tefsir Çerçevesinde Analizi	Sedat ÖZMEN Dr. Öğr. Üyesi, Vedat YETKİN

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HALL / SALON 3	**Assoc. Prof. Dr. Nihal TAŞ**	1	TEACHING MATHEMATICS: COMBINING TRADITIONAL AND MODERN APPROACHES	Nuride ORUCOVA Elgayid ALİZADE
		2	SOME PROPERTIES OF GENERALIZED *b*-KANNAN TYPE MAPPINGS	Assoc. Prof. Dr. Nihal TAŞ Asst. Prof. Elif KAPLAN
		3	SOME INTEGRAL TYPE FIXED-CIRCLE RESULTS ON G-METRIC SPACES	Assoc. Prof. Dr. Nihal TAŞ
		4	BANACH CONTRACTION THEOREM IN TRIPLE CONTROLLED S-METRIC TYPE SPACES	Asst. Prof. Dr. ELİF KAPLAN Assoc. Prof. Dr. NİHAL TAŞ
		5	A NEW PRECONDITIONING REFLECTED FORWARD-BACKWARD-FORWARD ALGORITHM FOR MONOTONE INCLUSION PROBLEM AND ITS APPLICATION	Asst. Prof. Ebru ALTIPARMAK
		6	ON CONTROLLED PARTIAL METRIC SPACES	Assist. Prof. Dr. Elif GÜNER Prof. Dr. Halis AYGÜN
		7	NOVEL ENTROPY-BASED TOPSIS METHOD FOR DECISION-MAKING PROBLEMS IN LINEAR DIOPHANTINE SPHERICAL FUZZY ENVIRONMENT	Assist. Prof. Dr. Elif GÜNER Prof. Dr. Halis AYGÜN
		8	DİL EVRİM TEORİSİ İÇİN MATEMATİKSEL BİR YAKLAŞIM	Dr, EMİLE F. DOUNGMO GOUFO Dr, M KHUMALO Dr, IGNACE TCHANGOU TOUDJEU Dr, AHMET YILDIRIM

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HALL / SALON 4	**Prof. Dr. Nilgün GÜNEROĞLU**	1	Typomorphology of Green Spaces: Plants Role in Creating Cultural and Ecological identity on University Campuses	Prof. Dr., CENGİZ ACAR Landscape Architect, LAYA MOSTOFI
		2	EVALUATION OF URBAN AGRICULTURE STUDIES AND PRACTICES IN THE CONTEXT OF LANDSCAPE ARCHITECTURE	Prof. Dr. Habibe ACAR Prof. Dr. Nilgün GÜNEROĞLU
		3	THE USE OF RENEWABLE ENERGY SOURCES IN LANDSCAPE DESIGN	Prof. Dr. Nilgün GÜNEROĞLU Prof. Dr. Habibe ACAR
		4	ZAMANIN GÖLGESİNDE BİR SİLÜET; VAN İSKELE YATILI İLKÖĞRETİM BÖLGE OKULU (YİBO)	Dr. Öğr. Üyesi Yaşar SUBAŞI DİREK
		5	ANTİK ÇAĞDAN İTİBAREN KENT FORMU ANLATISININ SİLİFKE ÖRNEKLEMİ ÜZERİNDEN DEĞERLENDİRİLMESİ	Öğr. Gör. Dr., MELTEM AKYÜREK ALGIN

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HALL / SALON 5	**Dr. Öğretim Üyesi SELCEN NUR KIŞLA**	1	MERMİ ÇEKİRDEKELERİ ÜZERİNDEKİ BALİSTİK KARAKTERİSTİK İZLERE TOPRAK ETKİSİNİN ZAMANA BAĞLI OLARAK İNCELENMESİ	Prof. Dr. AYLİN YALÇIN SARIBEY EZGİ KARACA
		2	GÖÇMEN İŞÇİNİN HUKUKİ STATÜSÜNE İLİŞKİN AVRUPA SÖZLEŞMESİ ÇERÇEVESİNDE GÖÇMEN İŞÇİLERİN HAKLARININ KORUNMASI	Dr. Öğretim Üyesi SELCEN NUR KIŞLA
		3	THE ROLE OF THE UN SECURITY COUNCIL IN THE IMPLEMENTATION OF THE PROVISIONAL MEASURES OF THE INTERNATIONAL COURT OF JUSTICE	Dr. Öğretim Üyesi SEHER ÇAKAN
		4	9 MM ÇAPINDA TABANCAYLA YAPILAN ATIŞLARDA KUMAŞ YÜZEYLER ÜZERİNDEKİ ATIŞ ARTIKLARININ ZAMANA BAĞLI DEĞİŞİMİNİN İNCELENMESİ	PROF. DR. AYLİN YALÇIN SARIBEY RUMEYSANUR SAVAŞ
		5	ISIYA MARUZ KALMIŞ BULGULAR ÜZERİNDEKİ PARMAK İZLERİNİN İNCELENMESİ	PROF. DR. AYLİN YALÇIN SARIBEY SIDAL KAYA
		6	TOPRAK YÜZEYLER ÜZERİNDE KAN LEKESİ MODEL ANALİZİ VE FOURIER DÖNÜŞÜMLÜ KIZILÖTESİ SPEKTROSKOPİSİ (FTIR) İLE İNCELENMESİ	PROF. DR. AYLİN YALÇIN SARIBEY DİLEK KIZILBOĞA
		7	6390 SAYILI KANUNUN KÖY ORTA MALLARININ HUKUKİ STATÜSÜ VE USUL HUKUKUNA ETKİSİ	Dr. Öğretim Üyesi, İlker KARAÖNDER
		8	SUYA EL ATMANIN ÖNLENMESİ DAVALARINDA GENEL SU-ÖZEL SU AYRIMININ SONUÇLARI	Dr. Öğretim Üyesi, İlker KARAÖNDER

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HALL / SALON 6	**Prof. Dr. Ali BİLGİLİ**	1	A Case of Toxidermia Associated with Metronidazole and Terbinafine Use	Saadi Fatima Zohra
		2	The Impact of Early Detection on Acetaminophen Toxicity : A Case Study Analysis	BESSAID Kamilia, TOUAMI Fadila, MILOUD ABID Dalila, KRID Meriem, ABOUREJAL Nesrine,
		3	Pediatric Tebufenpyrad Toxicity: A Case Report of Accidental Ingestion	TOUAMI Fadila, BESSAID Kamilia, MILOUD ABID Dalila, KRID Meriem, ABOUREJAL Nesrine
		4	TREATMENT OF ARTICULATIO CUBITI LUXATION WITH LINEAR TYPE IA EXTERNAL FIXATION IN A CAT: A CASE REPORT	Dr. Öğr. Üyesi, Kerem YENER Doç. Dr., Ünal YAVUZ
		5	Walnut Green Husk Extract as a Sustainable Feed Additive in Ruminant Nutrition	Res. Asst. Atakan BUNDUR Prof. Dr. Özge SIZMAZ,
		6	Ammonia Emissions in Poultry: Environmental Impacts and Mitigation Strategies	Res. Asst. Atakan BUNDUR Prof. Dr. Özge SIZMAZ,
		7	ANTIFUNGAL POTENTIAL OF *RICINUS COMMUNIS* EXTRACTS AGAINST SOIL-BORNE PATHOGENS	Dr. Öğr. Üyesi RAZİYE KOÇAK Dr. Öğr. Üyesi ÖZDEN SALMAN
		8	MEDICINES USED IN IRREGULAR HEART RHYTHMS IN CATS AND DOGS	PhD Student Bülent Burak DOĞAN Prof. Dr. Ali BİLGİLİ

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HALL / SALON 7	**Assoc. Prof. Itır ERKAN**	1	ASSESSMENT OF BIOLOGICAL AND ENVIRONMENTAL FACTORS AFFECTING VIOLENCE BEHAVIOUR IN FORENSIC SCIENCES	Assoc. Prof. Itır ERKAN
		2	Vital Security Interests of States in International Law	Assist. Prof. Heidar Piri
		3	ABUSE OF DUTY IN THE PUBLIC SECTOR: A COMPARATIVE ANALYSIS ACROSS HEALTHCARE, EDUCATION, AND LAW ENFORCEMENT IN EUROPE	Ilma Bici Adrian Gashi
		4	TÜRK HUKUK SİSTEMİNE UYGUN YAPAY ZEKÂ DESTEKLİ HUKUKİ KARAR DESTEK SİSTEMİ: KURAMSAL ÇERÇEVE VE MİMARİ ÖNERİ	Öğr. Gör. Dr. MUHAMMED BURAK GÖRENTAŞ
		5	GENDER CHANGE IN ACCORDANCE WITH CREATION ACCORDING TO ISLAMIC LAW	Arş. Gör. Dr. MUSTAFA ÜNAL
		6	SUÇ EĞİLİMLERİNİN NLP İLE TESPİTİ: KRİMİNAL DÜŞÜNCE VERİ SETİNİN OLUŞTURULMASI VE ROBERTA MODELİNİN EĞİTİLMESİ	Arş. Gör. Adli Psikolog HAKKI HALİL BABACAN Avukat, Yls Öğr., SERHAT KAAN SEVSAY

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HALL / SALON 8	**Doç. Dr. Fatih GÜLER**	1	The Sources of Inheritance Laws in the Facilitation Treatise by Muhammad ibn Abi Bakr al-Mar'ashi, Sajqili Zadeh (1150 h.)	Doktora Öğrencisi Shahinah Hameed Abdullah Prof. Dr. Ali Rıza Gül
		2	RELEASE IN THE PRACTICE OF KASÂME IN OTTOMAN CRIMINAL LAW	Dr. Öğr. Üyesi Abdsussamed ATASOY
		3	FUNCTIONS OF COLLECTION ENDORSEMENT IN BILLS OF EXCHANGE AND THE SITUATION PRESENTED BY PERSONAL DEFENSES	Dr. Öğr. Üyesi, BUKET ÇATAKOĞLU AYDIN
		4	EXAMINATION OF THE IMPACT OF DATA COLLECTED THROUGH THE INTERNET ON STATE SOVEREIGNTY FROM THE PERSPECTIVE OF INTERNATIONAL LAW	Assoc. Prof. Dr. Süleyman DOST Habibe Betül YAVUZ
		5	THE IMPACT OF THE CONSTITUTIONAL COURT ON CONDOMINIUM LAW	Doç. Dr. Fatih GÜLER
		6	ANAYASAL BİR ORGAN OLARAK MAHALLİ İDARELERİN SEÇİMLERİNDE MUHASEBE MESLEK MENSUPLARININ ADAYLIK VE SEÇİLME ORANLARI	Rabia GÜLER Doç. Dr. Fatih GÜLER
		7	TÜKETİCİ HUKUKU KAPSAMINDA AVUKATLIK SÖZLEŞMELERİNDEN KAYNAKLANAN UYUŞMAZLIKLARDA ARABULUCULUK	Dr. Öğr. Üyesi Gaye TUĞ LEVENT

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HALL / SALON 9	**Dr. arlos Eduardo Martins**	1	THE RISE OF CYBER FRAUD IN FINANCIAL REPORTING: A CALL FOR FORENSIC ACCOUNTING SOLUTIONS	M. Ahmed Farooq,
		2	INTEGRATING KNOWLEDGE MANAGEMENT INTO FORENSIC SCIENCE PRACTICE	Laila Hossain,
		3	THE IMPACT OF INEFFICIENT DATA STORAGE ON MEMORY UTILIZATION	Tan Kien Hwa, Siti Nabilah Ahmad,
		4	MANAGING FORENSIC INVESTIGATIONS IN THE AFTERMATH OF A STRUCTURAL DISASTER: THE COLLAPSE OF THE SÃO PAULO SHOPPING MALL	Dr. arlos Eduardo Martins
		5	OVERCOMING BARRIERS IN DIGITAL EVIDENCE COLLECTION: THE PATH TO ADMISSIBILITY	Chia Su Ling,
		6	FORENSIC SCIENCE IN GHANA'S LEGAL FRAMEWORK: A STUDY ON PATHOLOGICAL TRUTHS	Assoc. Prof. Dr. Kwame Nkrumah Owusu
		7	LEVERAGING HEURISTIC MODELS FOR DETECTING MONEY LAUNDERING ACTIVITIES IN FINANCIAL INSTITUTIONS	Vincent Tano,
		8	THE ROLE OF ARMED GROUPS IN INTERNAL CONFLICTS: A STUDY OF THE SYRIAN CIVIL WAR	Dr. Zainab Khalil,
		9	AUTOMATING DIGITAL FORENSICS INVESTIGATIONS: THE ROLE OF ONTOLOGY FRAMEWORKS IN ENHANCING EFFICIENCY	Ramesh Natarajan,

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HALL / SALON 10	**Assis. Prof. Dr. Ayesha Karim**	1	RELATIONSHIP BETWEEN CRIMINAL BEHAVIOR AND MENTAL ILLNESS IN TEENAGERS	S. Rahman, A. Sayed, M. Hassan, K. Abdullah
		2	RIMINAL LAW INSTRUMENTS TO COUNTER CORPORATE CRIMES IN SOUTH AFRICA	Thando Mhlongo
		3	SEXUAL AND GENDER BASED CRIMES IN INTERNATIONAL CRIMINAL LAW: MOVING FORWARDS OR BACKWARDS?	Assis. Prof. Dr. Ayesha Karim
		4	THE NATURE OF ORIGIN OF NEW CRIMINAL OCCURRENCES IN THE WEST BANK REGION: CULTURAL AND CRIMINOLOGICAL “INTERSECTION” IN 2010-2020	Lecture Dr. Sami Al-Najjar
		5	SMUGGLING OF MIGRANTS AS AN INFLUENTIAL FACTOR ON NATIONAL SECURITY, ECONOMIC AND SOCIAL LIFE IN TURKEY	Samuel Kibaki
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EXAMINING ROUGH IDEALS AND A SURVEY ON EXISTENCE OF ROUGH IDEALS

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ABSTRACT

Although it is new, considering algebraic structures with the rough set model has created an impressive effect. In this way, strong answers to the concept of uncertainty have been found.
In this study, the adaptation of the concepts of ring and ideal to the rough set model will be given with examples. Additionally, the existence of the concept of local rough ideal will be investigated.

Key Words: Rough Set, Local Rough Set, Rough Group, Rough Ring, Rough Ideal.

1. INTRODUCTION

The rough set model discovered by Pawlak has become an alternative set model frequently used by mathematicians in the face of uncertainty[1]. Mathematics does not want uncertainty situations. As the level of clarity increases, the ability to comment also increases. For this reason, the concept of local rough set, which is more concrete and has a higher degree of completeness than the rough set model, has emerged. Since data reduction is performed in the upper approach of the local rough set, the completeness measure is higher. Therefore, clearer information can be obtained [2-4].

Definition 1.1 [1] Let L is a universe (non-empty) set and φ is an equivalence relation on L. The set (L, φ) is said to be an approximation space. We denote the equivalence class of object $a \in L$ by $[a]_\varphi$. Suppose (L, φ) is an approximation space and P is a subset of L. The sets $\underline{P} = \left\{ a \in L : [a]_\varphi \subseteq P \right\}, \overline{P} = \left\{ a \in L : [a]_\varphi \cap P \neq \emptyset \right\}, Bnd(P) = \overline{P} - \underline{P}$ are called upper

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approximation, lower approximation, and boundary region of P, respectively. If $Bnd(P) \neq \emptyset$, then P is rough set. The completeness measure of a rough set, $\alpha(P) = |\underline{P}|/|\overline{P}|$.

Example 1.1 $L = \{x_1, x_2, x_3, x_4, x_5, x_6, x_7, x_8, x_9, x_{10}\}$ is set of objects, $A = \{a_1, a_2, a_3\}$ is set of features, $V_1 = \{1,2,3\}$, $V_2 = \{1,2\}$, $V_3 = \{1,2,3,4\}$ is the set of values and the equivalence relation on L, $\delta(x_i) = \{x_j : \text{with the same dimensions as } xj, xi\ 1 \leq i,j \leq 10\}$

U	a_1	a_2	a_3
x_1	2	1	3
x_2	3	2	1
x_3	2	1	3
x_4	2	2	3
x_5	1	1	4
x_6	1	1	2
x_7	3	2	1
x_8	1	1	4
x_9	2	1	3
x_{10}	3	2	1

an information table is given. Indistinguishability relations of this table:

$$\delta(x_1) = \delta(x_3) = \delta(x_9) = \{x_1, x_3, x_9\}$$

$$\delta(x_2) = \delta(x_7) = \delta(x_{10}) = \{x_2, x_7, x_{10}\}$$

$$\delta(x_4) = \{x_4\}$$

$$\delta(x_5) = \delta(x_8) = \{x_5, x_8\}$$

$$\delta(x_6) = \{x_6\}$$

For $P = \{x_1, x_2, x_3, x_4, x_5, x_9\} \subseteq L$,

$$\underline{\delta}(P) = \{x_1, x_3, x_4, x_9\}$$

$$\overline{\delta}(P) = \{x_1, x_2, x_3, x_4, x_5, x_7, x_8, x_9, x_{10}\}$$

$Bnd\delta(P) = \overline{\delta}(P) - \delta(P) = \{x_2, x_5, x_7, x_8, x_{10}\} \neq \emptyset$

Then, set P is a rough set with these properties. Completeness measure of the set P,

$\alpha(P) = \frac{|\underline{P}|}{|\overline{P}|} = \frac{4}{9}$.

Definition 1.2 [2,4] Let L be the set of a finite number of objects, $L_i \subseteq L$, $L = \cup L_i$ and for an equivalence relation on L_i such that the relation δ_i is $\delta_i = \delta|_{L_i} = \delta \cap (L_i \times L_i)$, let the family $\mathcal{L}$=$\{(L_i, \delta_i) :\ i \in I\ , L_i \subseteq L$ be the set of a finite number of objects, $\delta_i \subseteq L_i \times L_i$ equivalence relation$\}$ be defined. If the $\delta_i|_W = \delta_i|_W$ condition is hold for each (L_i, δ_i) , (L_j, δ_j) and $x \in W \subseteq (L_i \cap L_j)$ taken from this family, the $\mathcal{L}$ family is called a local approximation space.

Let $\mathcal{L}$ family be the local approximation space and $\emptyset \neq P \subseteq L$. For $(L_i, \delta_i) \in \mathcal{L}$,

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$\underline{\delta_i}(P) = \{ x \in L : [x]_i \subseteq P, \forall i \in I \}$ the set is called the local lower approximation of the set P.

$\overline{\delta_i}(P) = \{ x \in L : [x]_i \cap P \neq \emptyset, \forall i \in I \}$ the set is called the local upper approximation of the set P.

$Bnd_l(P) = \overline{\delta_i}(P) - \underline{\delta_i}(P)$ the set is called the local boundary region of the set P. If $Bnd_l(P) \neq \emptyset$, then P is local rough set. The completeness measure of a local rough set, $\alpha_l(P) = \left|\underline{\delta_i}(P)\right| / \left|\overline{\delta_i}(P)\right|$.

Example 1.2 With the information table and data in Example 1.1, let the pairs selected from the local approximation space family $L_1 = \{x_1, x_2, x_3, x_4, x_5, x_9, x_{10}\}$ and $L_2 = \{x_6, x_7, x_8\}$ be given. Indistinguishability relations for L_1;

$$\delta_i(x_1) = [x_1]_i = \{x_1, x_3, x_9\}$$

$$\delta_i(x_2) = [x_2]_i = \{x_2, x_{10}\}$$

$$\delta_i(x_4) = [x_4]_i = \{x_4\}$$

$$\delta_i(x_5) = [x_5]_i = \{x_5\}$$

For $P = \{ x_1, x_2, x_3, x_4, x_5, x_9 \} \subseteq L$,

$$\underline{\delta_i}(P) = \{ x \in L : [x]_i \subseteq P, \forall i \in I \} = \{ x_1, x_3, x_4, x_5, x_9 \}$$

$$\overline{\delta_i}(P) = \{ x \in L : [x]_i \cap P \neq \emptyset, \forall i \in I \} = \{ x_1, x_2, x_3, x_4, x_5, x_9, x_{10} \}$$

$$Bnd\,\delta_i(P) = \overline{\delta_i}(P) - \underline{\delta_i}(P) = \{ x_2, x_{10} \} \neq \emptyset$$

Then, set P is a rough set with these properties. Completeness measure of the set P,

$\alpha_l(P) = \frac{\left|\underline{\delta_i}(P)\right|}{\left|\overline{\delta_i}(P)\right|} = \frac{5}{7}$. Here, It can be seen that

$$\alpha_{R_i}(X) > \alpha_R(X).$$

The concept of group was transferred to rough set theory first by Biswas-Nanda and then by Miao et al.[4]. Transferring the concept of semigroup to rough set was studied by Bağırmaz et al.[5].

Definition 1.3 : [5,6] Let (L, φ) be an approximation space and ∇ be a binary operation on L. $A \subset L$ is called a rough group if the following properties are satisfied:

$i)$ $\forall \theta, \vartheta \in A, \theta \nabla \vartheta \in \overline{A}$

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$ii)$ $\forall \theta, \vartheta, \mu \in A, (\theta \nabla \vartheta) \nabla \mu = \theta \nabla (\vartheta \nabla \mu)$ or associative property holds in $\overline{A}$.

$iii)$ $\forall \theta \in A$, such that $\exists e \in \overline{A},\ \theta \cdot e = e \cdot \theta = \theta$, where e is called the rough unit element of rough group A.

$iv)$ $\forall \theta \in A, \exists \rho \in A \ni \theta \cdot \rho = \rho \cdot \theta = e$, where ρ is said the rough inverse element of θ in C, we denote it by θ^{-1}.

Theorem 1.1 [5,6] If B is a rough subgroup of A, the following properties are satisfied:

$i)$ $\forall \theta, \vartheta \in B,\ \theta \nabla \vartheta \in \overline{B}$.

$ii)$ $\forall \theta \in B,\ \theta^{-1} \in B$.

2. FROM ROUGH RİNG TO ROUGH IDEAL

In this section; The concepts of rough ring, rough subring, rough ideal will be given.

Definition 2.3 [7] Let $\mathfrak{D}$ is a rough set. Define the operation in $\mathfrak{D}$ as "$\oplus$" and "$\otimes$" are addition and multiplication in $\mathfrak{D}$, respectively. Then, $(\mathscr{R}, \oplus, \otimes)$ triple is said to be a rough ring if all condition below are satisfied:

$i)$ $(\mathfrak{D}, \oplus)$ is a rough commutative group,

$ii)$ $(\mathfrak{D}, \otimes)$ is a rough semigroup or $\mathfrak{D}$ satisfied associative property,

$iii)$ For every $\theta, \vartheta, \mu \in \mathfrak{D}$, then $\theta \otimes (\vartheta \oplus \mu) = \theta \otimes \vartheta \oplus \theta \otimes \mu$ and $(\theta \oplus \vartheta) \otimes \mu = \theta \otimes \mu \oplus \vartheta \otimes \mu$ holds in $\overline{\mathfrak{D}}$.

Example 2.1 Let $L = \mathbb{Z}_{10}$. For every $x_1, x_2 \in L$, define an equivalence relation $\varphi = x_1 - x_2 = 2k, k \in \mathbb{R}$. Then, the equivalence class of L is $L/_{\varphi} = \left\{ \{\overline{0}, \overline{2}, \overline{4}, \overline{6}, \overline{8}\}, \{\overline{1}, \overline{3}, \overline{5}, \overline{7}, \overline{9}\} \right\}$.

Let $P = \{\overline{0}, \overline{2}, \overline{3}, \overline{4}, \overline{6}, \overline{7}, \overline{8}\}$. Then we obtain lower approximation and upper approximation of P are $\underline{P} = \{\overline{0}, \overline{2}, \overline{4}, \overline{6}, \overline{8}\}$ and $\overline{P} = \mathbb{Z}_{10}$, respectively. Furthermore, because $\overline{P} - \underline{P} \neq \emptyset$ we can deduce that P is a rough set.

Let's show that the set rough P is a commutative rough group.

$i)$ For $\forall \theta, \vartheta \in P, \theta \oplus \vartheta \in \overline{P}$

$ii)$ For $\forall \theta, \vartheta, \mu \in P, \theta \oplus (\vartheta \oplus \mu) = (\theta \oplus \vartheta) \oplus \mu$ associativity property provided in $\overline{P}$.

$iii)$ $\forall \theta \in P$, such that $\exists e \in \overline{P},\ \theta \oplus e = e \oplus \theta = \theta$, where e is called the rough unit element of rough group P.

$iv)$ $\forall \theta \in P, \exists \rho \in P \ni \theta \oplus \rho = \rho \oplus \theta = e$, where ρ is said the rough inverse element of θ in P, we denote it by θ^{-1}.

$v)$ For $\forall \theta, \vartheta \in P, \theta \oplus \vartheta = \vartheta \oplus \theta$.

Thus, $(P, \oplus)$ is a commutative rough group.

Let us also show that P is a rough ring.

$i)$ For $\forall \theta, \vartheta, \mu \in P, \theta \otimes (\vartheta \otimes \mu) = (\theta \otimes \vartheta) \otimes \mu$.

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$ii)$ For $\forall \theta, \vartheta, \mu \in P$, $\theta \otimes (\vartheta \oplus \mu) = \theta \otimes \vartheta \oplus \theta \otimes \mu$ and $(\theta \oplus \vartheta) \otimes \mu = \theta \otimes \mu \oplus \vartheta \otimes \mu$ holds in $\overline{P}$.
Therefore, $(P,\oplus,\otimes)$ is a rough ring.

Definition 2.3 Let P be rough ring and $K \subseteq P$. K is said to be a rough subring of P if K is a rough ring with the same operation as P.

Theorem 2.2 [7] Let $K \neq \emptyset$ is a rough subset of a rough ring P. K is called a rough subring of P if and only if every $k_1, k_2 \in K$ the following condition is satisfied:

$i)$ For $\forall k_1, k_2 \in K$, $k_1 \oplus (-k_2) \in \overline{K}$,

$ii)$ For $\forall k_1, k_2 \in K$, $k_1 \otimes k_2 \in \overline{K}$.

Example 2.2 Based Example 2.1, $K = \{\overline{0}, \overline{7}\}$ is a rough set and $K \subseteq P$. For every $k_1, k_2 \in K$, it is clear that $k_1 \oplus (-k_2) \in \overline{K}$. Again it is clear that $k_1 \otimes k_2 \in \overline{K}$. Therefore, K is subring of P.

Definition 2.4 [7] Let $(P,\oplus,\otimes)$ be a rough ring and $\mathfrak{B} \neq \emptyset$ is rough subset of P. $\mathfrak{B}$ is called rough ideal of P if:

$i)$ For $\forall \mathscr{b}_1, \mathscr{b}_2 \in \mathfrak{B}$, $\mathscr{b}_1 \oplus (-\mathscr{b}_2) \in \overline{\mathfrak{B}}$,

$ii)$ For $\forall \mathscr{b} \in \mathfrak{B}$ and $\forall \mathscr{p} \in P$, $\mathscr{b} \otimes \mathscr{p}, \mathscr{p} \otimes \mathscr{b} \in \overline{\mathfrak{B}}$.

Rings are not required to be commutative. Here, we can define left-rough ideals and right-rough ideals.

Definition 2.5 [7] Let $(P,\oplus,\otimes)$ be a rough ring and $\mathfrak{B} \subseteq P$. A subset $\mathfrak{B}$ is said to be left-rough ideal in P if

$i)$ For $\forall \mathscr{b}_1, \mathscr{b}_2 \in \mathfrak{B}$, $\mathscr{b}_1 \oplus (-\mathscr{b}_2) \in \overline{\mathfrak{B}}$

$ii)$ For $\forall \mathscr{b} \in \mathfrak{B}$ and $\forall \mathscr{p} \in P$, $\mathscr{p} \otimes \mathscr{b} \in \overline{\mathfrak{B}}$.

A subset $\mathfrak{B}$ is said to be right-rough ideal in P if

$i)$ For $\forall \mathscr{b}_1, \mathscr{b}_2 \in \mathfrak{B}$, $\mathscr{b}_1 \oplus (-\mathscr{b}_2) \in \overline{\mathfrak{B}}$

$ii)$ For $\forall \mathscr{b} \in \mathfrak{B}$ and $\forall \mathscr{p} \in P$, $\mathscr{b} \otimes \mathscr{p} \in \overline{\mathfrak{B}}$.

Example 2.3 Let $L = \mathbb{Z}_{12}$. For every $x_1, x_2 \in L$, define an equivalence relation $\varphi = x_1 - x_2 = 3k, k \in \mathbb{R}$. Then, the equivalence class of L is

$$L/\varphi = \left\{ \{\overline{0}, \overline{3}, \overline{6}, \overline{9}\}, \{\overline{1}, \overline{4}, \overline{7}, \overline{10}\}, \{\overline{2}, \overline{5}, \overline{8}, \overline{11}\} \right\}$$

Let $P = \{\overline{0}, \overline{3}, \overline{4}, \overline{5}, \overline{6}, \overline{7}, \overline{8}, \overline{9}\}$. Then we obtain lower approximation and upper approximation of P are $\underline{P} = \emptyset$ and $\overline{P} = \{\overline{0}, \overline{1}, \overline{2}, \overline{3}, \overline{4}, \overline{5}, \overline{6}, \overline{7}, \overline{8}, \overline{9}, \overline{10}, \overline{11}\} = \mathbb{Z}_{12}$, respectively. Because $Bnd(P) \neq \emptyset$, we can say that P is a rough set. Morever, it is clear that P is a rough ring.
Suppose that $\mathfrak{B} = \{\overline{0}, \overline{4}, \overline{8}\} \subseteq P$. Thus, $\underline{\mathfrak{B}} = \emptyset$ and $\overline{\mathfrak{B}} = \{\overline{0}, \overline{1}, \overline{2}, \overline{3}, \overline{4}, \overline{5}, \overline{6}, \overline{7}, \overline{8}, \overline{9}, \overline{10}, \overline{11}\} = \mathbb{Z}_{12}$. Since $\overline{\mathfrak{B}} - \underline{\mathfrak{B}} \neq \emptyset$, $\mathfrak{B}$ is rough set. Now let's show that $\mathfrak{B}$ is a rough ideal.

$i)$ For $\forall \mathscr{b}_1, \mathscr{b}_2 \in \mathfrak{B}$, $\mathscr{b}_1 \oplus (-\mathscr{b}_2) \in \overline{\mathfrak{B}}$

$ii)$ For $\forall \mathscr{b} \in \mathfrak{B}$ and $\forall \mathscr{p} \in P$, $\mathscr{b} \otimes \mathscr{p}, \mathscr{p} \otimes \mathscr{b} \in \overline{\mathfrak{B}}$.

Since conditions $i)$ and $ii)$ above are holds, it is clear that $\mathfrak{B}$ is the rough ideal of P.

3. CONCLISUON

In the upper approximation of a rough set, local rough sets can be obtained by reducing unused elements. Thus, since the completeness measure (degree of belonging of the element) of local rough sets will be higher than rough sets, it can be said that local rough sets will provide more concrete information. From this, the idea of rough rings evolving into local rough rings emerged. However, by localizing a rough ring, it has been observed that local rough rings cannot be obtained since the condition of the rough ring being closed according to the operation $\oplus$ (the element is not in the upper approach) is not hold. Therefore, a local rough ideal cannot be obtained.

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KINEMATICAL APPROACH TO HELICAL TYPE CURVES

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ABSTRACT

The study of kinematics, which describes the motion of objects without considering forces, is closely related to helical type curves, a fundamental concept in physics, engineering, and robotics. A helix is a three-dimensional curve characterized by simultaneous rotation around an axis and translation along it, making it essential in analyzing complex mechanical movements. On the other hand, new constant slope curves called slant helix, and c-slant helix curves have been recently introduced. In this study, we present the integration of kinematic analysis with helical structures related to their characteristics.

Keywords : General helix, slant helix, rigid body motion.

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AN ALGORITHM FOR THE RECTIFYING CURVES

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ABSTRACT

Rectifying curves are a special class of space curves whose position vectors always lie in their rectifying plane, the plane spanned by the tangent and binormal vectors at each point. These curves have significant applications in physics, engineering, and computer-aided geometric design, where understanding the geometric properties of curves enhances modeling and motion analysis. In this study, we introduce an algorithm to produce rectifying curves by using the direction curves lying on the Frenet planes of a Frenet curve.

Keywords : Rectifying curve, Frenet plane, Direction curve.

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ANALYSIS OF SOLVING AND APPLICATIONS OF SINGULARLY PERTURBED PROBLEMS

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ÖZET

Singular perturbation problems are examined, where the coefficients of the terms containing the highest-order derivative depend on a small positive parameter. These problems arise in various areas of mathematics, including the Navier-Stokes equations for fluid flow at high Reynolds numbers, fluid dynamics, chemical reactions, and oceanography. Finite difference schemes are constructed on a uniform mesh. The uniform convergence and stability of these schemes with respect to the perturbation parameter are analyzed in the discrete maximum norm. Numerical results are presented to demonstrate their computational performance.

Anahtar Kelimeler : Singularly perturbed problem; Numerical method, Finite difference scheme; Stability; Uniform mesh.

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PARA-SASAKIAN MANIFOLDS ADMITTING CONFORMAL RICCI SOLITONS

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ABSTRACT

The concept of geometric flow has been one of the most fascinating mathematical tools for describing geometric structures in Riemannian geometry in recent years. A particular class of solutions, where the metric evolves under diffeomorphisms, has had a significant impact on the study of singularities in flows, as they emerge as potential singularity models.

Conformal Ricci solitons constitute an important area of research in differential geometry, particularly in Riemannian geometry. This concept is related to the Ricci flow and is used to study the evolution of Riemannian metrics. Conformal Ricci solitons can be regarded as a generalization of classical Ricci solitons and are associated with Einstein manifolds, the Yamabe flow, and various geometric flows. They represent fixed-point solutions of geometric flows such as the Ricci flow. The Ricci flow is an equation that examines how Riemannian metrics change over time and has been particularly utilized in the works of Hamilton and Perelman.

In this study, the effect of conformal Ricci solitons, which are highly significant for mathematics, physics, and engineering, on the geometry of para-Sasakian manifolds is investigated. The characterization of para-Sasakian manifolds admitting conformal Ricci solitons has been obtained under certain special curvature conditions written with respect to the W_1-curvature tensor.

Anahtar Kelimeler : Para-Sasakian Manifold, Conformal Ricci Soliton, W_1-Curvature Tensor

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1 INTRODUCTION

The concept of geometric flow has been one of the most fascinating mathematical tools for describing geometric structures in Riemannian geometry in recent years. A particular class of solutions, where the metric evolves under diffeomorphisms, has had a significant impact on the study of singularities in flows, as they emerge as potential singularity models.

Conformal Ricci solitons constitute an important area of research in differential geometry, particularly in Riemannian geometry. This concept is related to the Ricci flow and is used to study the evolution of Riemannian metrics. Conformal Ricci solitons can be regarded as a generalization of classical Ricci solitons and are associated with Einstein manifolds, the Yamabe flow, and various geometric flows. They represent fixed-point solutions of geometric flows such as the Ricci flow. The Ricci flow is an equation that examines how Riemannian metrics change over time and has been particularly utilized in the works of Hamilton and Perelman.

In this study, the effect of conformal Ricci solitons, which are highly significant for mathematics, physics, and engineering, on the geometry of para-Sasakian manifolds is investigated. The characterization of para-Sasakian manifolds admitting conformal Ricci solitons has been obtained under certain special curvature conditions with respect to the W_1-curvature tensor.

2 PRELIMINARIES

A $(2n+1)$-dimensional smooth manifold M^{2n+1} has an almost paracontact structure (ϕ,ξ,η) if it admits a tensor field ϕ of type $(1,1)$, a vector field ξ and a 1-form η satisfying the following conditions;

$$\phi^2 X = X - \eta(X)\xi, \quad \eta(\xi) = 1, \quad \phi\xi = 0, \quad \eta\circ\phi = 0. \tag{1}$$

If an almost paracontact manifold is endowed with a semi-Riemannian metric tensor g such that

$$g(\phi X, \phi Y) = -g(X,Y) + \eta(X)\eta(Y), \tag{2}$$

for all vector fields X, Y on M^{2n+1}, then $M^{2n+1}(\phi,\xi,\eta,g)$ is said to be almost paracontact metric manifold. It is clear that

$$g(\xi, X) = \eta(X).$$

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The fundamental 2-form Φ of an almost paracontact metric manifold $M^{2n+1}(\phi,\xi,\eta,g)$ is defined by

$$\Phi(X,Y) = g(X,\phi Y). \tag{3}$$

If $d\eta = \Phi$, then almost paracontact metric manifold $M^{2n+1}(\phi,\xi,\eta,g)$ is called paracontact metric manifold. If the structure (ϕ,ξ,η,g) satisfies the equations

$$d\eta = 0, \nabla_X \xi = -\phi X, \tag{4}$$

$$(\nabla_X \phi)Y = -g(X,Y)\xi - \eta(Y)X + 2\eta(X)\eta(Y)\xi, \tag{5}$$

the manifold M^{2n+1} is called para-Sasakian manifold or P-Sasakian manifold**,** where ∇ denote the Levi-Civita connection on M^{2n+1}. If the relation

$$(\nabla_X \eta)Y = -g(X,Y) + \eta(X)\eta(Y) \tag{6}$$

is satisfied specifically, the para-Sasakian manifold is called the special para-Sasakian manifold or the Sp-Sasakian manifold.

Lemma 1 *The* $(2n+1)$*-dimensional para-Sasakian manifold* M^{2n+1} *satisfies the following relations:*

$$R(\xi,Y)Z = \eta(Z)Y - g(Y,Z)\xi, \tag{7}$$

$$R(X,\xi)Z = -\eta(Z)X + g(X,Z)\xi, \tag{8}$$

$$R(X,Y)\xi = \eta(X)Y - \eta(Y)X, \tag{9}$$

$$\eta(R(X,Y)Z) = g(X,Z)\eta(Y) - g(Y,Z)\eta(X), \tag{10}$$

$$S(X,\xi) = -2n\eta(X), \tag{11}$$

$$Q\xi = -2n\xi, \tag{12}$$

for any vector fields X, Y on M^{2n+1}, where ∇ is the Levi-Civita connection, R and S denote the Riemannian curvature tensor and Ricci tensor of M^{2n+1}, respectively.

3 CONFORMAL RICCI SOLITONS ON PARA-SASAKIAN MANIFOLDS

The concept of Ricci solitons was introduced by Hamilton in the mid-1980s. Ricci solitons are natural generalizations of Einstein metrics and also correspond to self-similar solutions of Hamilton's Ricci flow. They typically arise as limits of dilations of singularities in the Ricci flow.

Ricci solitons are also of interest to physicists and are referred to as quasi-Einstein metrics in the physics literature. Studies on Ricci solitons in contact manifolds began with

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Ramesh Sharma and were later continued by many researchers, including M.M. Tripathi, Bejan, and Crasmareanu, who investigated Ricci solitons in contact metric manifolds.

In 2005, A.E. Fischer introduced a new concept called conformal Ricci flow. This concept is a variation of the classical Ricci flow equation, where the unit volume constraint is replaced by a scalar curvature constraint. The resulting equations are referred to as the conformal Ricci flow equations. This name arises from the role of conformal geometry in constraining scalar curvature and the fact that these equations represent the sum of a conformal flow equation and the vector field of a Ricci flow equation.

These new equations are of the form

$$\begin{cases} \frac{\partial g}{\partial t} + 2\left(S + \frac{g}{n}\right) = -pg, \\ r(g) = -1, \end{cases} \tag{13}$$

where $r(g)$ denotes the scalar curvature of the manifold, p represents a scalar but non-dynamic field, and n is the dimension of the manifold.

The conformal Ricci flow equations exhibit similarities to the Navier-Stokes equations in fluid mechanics. Due to this resemblance, the time-dependent scalar p is referred to as the conformal pressure. Just as physical pressure in fluid mechanics ensures the incompressibility of a fluid, conformal pressure acts as a Lagrange multiplier to deform the metric conformally, thereby preserving the scalar curvature constraint.

The conformal Ricci soliton equation was introduced by N. Basu and A. Bhattacharya. A conformal Ricci soliton on a Riemannian manifold (M, g) is defined as a triplet (g, ξ, λ) satisfying the equation

$$L_\xi g + 2S = \left[2\lambda - \left(p + \frac{2}{2n+1}\right)\right] g, \tag{14}$$

on M. Here, L_ξ denotes the Lie derivative operator along a vector field ξ, and λ is a real constant.

Conformal Ricci solitons are classified based on the sign of λ:

- If $\lambda > 0$, the soliton is called expanding.
- If $\lambda = 0$, it is called steady.
- If $\lambda < 0$, it is called shrinking.

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4 PARA-SASAKIAN MANIFOLDS ADMITTING CONFORMAL RICCI SOLITONS

Let us assume that (g,ξ,λ) is a conformal Ricci soliton on a $(2n+1)$-dimensional para-Sasakian manifold M^{2n+1}. In this case, the Lie derivative $L_\xi g$ can be easily computed, leading to the equation of the form

$$(L_\xi g)(X,Y) = g(-\phi X,Y) + g(X,\phi Y),$$

for all $X,Y \in \Gamma(TM)$. Moreover, since ϕ is symmetric with respect to the metric g, it is evident that

$$(L_\xi g)(X,Y) = 0. \tag{15}$$

Thus, on a $(2n+1)$-dimensional para-Sasakian manifold M^{2n+1}, equations (14) and (15) lead to

$$S(X,Y) = \left[\lambda - \frac{1}{2}\left(p + \frac{2}{2n+1}\right)\right] g(X,Y). \tag{16}$$

Thus, we can easily state the following theorem.

Theorem 1 *A para-Sasakian manifold of $M^{2n+1}(\phi,\xi,\eta,g)$ admitting a conformal Ricci soliton is an Einstein manifold.*

If we choose $Y=\xi$ in (16), we have

$$S(X,\xi) = \left[\lambda - \frac{1}{2}\left(p + \frac{2}{2n+1}\right)\right] \eta(X). \tag{17}$$

If we use (11) in (17), we obtain

$$\lambda = \frac{1}{2}\left(p + \frac{2}{2n+1}\right) - 2n. \tag{18}$$

Thus, we can easily state the following theorem.

Theorem 2 *Let M^{2n+1} be a $(2n+1)$-dimensional para-Sasakian manifold, and let (g,ξ,λ) be a conformal Ricci soliton on M^{2n+1}. In this case, the following conditions hold:*

i. If $\frac{1}{2}\left(p + \frac{2}{2n+1}\right) > 2n$, then M^{2n+1} is expanding.

ii. If $\frac{1}{2}\left(p + \frac{2}{2n+1}\right) = 2n$, then M^{2n+1} is steady.

iii. If $\frac{1}{2}\left(p + \frac{2}{2n+1}\right) < 2n$, then M^{2n+1} is shrinking.

Now, let us examine the characterization of a $(2n+1)$-dimensional para-Sasakian manifold that admits conformal Ricci solitons, based on the special curvature conditions it satisfies.

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For a $(2n+1)$-dimensional semi-Riemannian manifold (M,g), the W_1-curvature tensor is defined by the equality

$$W_1(X,Y)Z = R(X,Y)Z + \frac{1}{2n}[S(Y,Z)X - S(X,Z)Y]. \quad (19)$$

Theorem 3 *The W_1-curvature tensor defined on a $(2n+1)$-dimensional para-Sasakian manifold $M^{2n+1}(\phi,\xi,\eta,g)$ satisfies the following relations:*

$$W_1(\xi,Y)Z = -g(Y,Z)\xi + 2\eta(Z)Y + \frac{1}{2n}S(Y,Z)\xi, \quad (20)$$

$$W_1(X,\xi)Z = g(X,Z)\xi - 2\eta(Z)X - \frac{1}{2n}S(X,Z)\xi, \quad (21)$$

$$W_1(X,Y)\xi = 2[\eta(X)Y - \eta(Y)X], \quad (22)$$

$$\eta(W_1(X,Y)Z) = 2g(\eta(Y)X - \eta(X)Y, Z). \quad (23)$$

Theorem 4 *Let $M^{2n+1}(\phi,\xi,\eta,g)$ be a $(2n+1)$-dimensional para-Sasakian manifold, and let (g,ξ,λ) be a conformal Ricci soliton on M^{2n+1}. If M^{2n+1} is W_1-flat, then the following conditions hold:*

i. If $(2n+1)(p+12n) > -2$, then M^{2n+1} is expanding.

ii. If $(2n+1)(p+12n) = -2$, then M^{2n+1} is steady.

iii. If $(2n+1)(p+12n) < -2$, then M^{2n+1} is shrinking.

Proof. Let us assume that M^{2n+1} is W_1-flat. In this case, we have

$$W_1(X,Y)Z = 0,$$

for all $X,Y,Z \in \chi(M)$. Therefore, from (19), we obtain

$$R(X,Y)Z = \frac{1}{2n}[S(Y,Z)X - S(X,Z)Y]. \quad (24)$$

If we choose $Y = \xi$ in (24) and use $(8), (11)$, we get

$$S(X,Z) = 2ng(X,Z) + 4n\eta(X)\eta(Z). \quad (25)$$

If we choose $Z = \xi$ in (25) and use (17), we have

$$\lambda = \frac{1}{2}\left(p + \frac{2}{2n+1}\right) + 6n.$$

Thus, the proof of the theorem is complete.

Theorem 5 *Let $M^{2n+1}(\phi,\xi,\eta,g)$ be a $(2n+1)$-dimensional para-Sasakian manifold, and let (g,ξ,λ) be a conformal Ricci soliton on M^{2n+1}. If M^{2n+1} is W_1-semisymmetric, then the following conditions hold:*

i. If $(2n+1)(p+4n) > -2$, then M^{2n+1} is expanding.

ii. If $(2n+1)(p+4n) = -2$, then M^{2n+1} is steady.

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iii. If $(2n+1)(p+4n) < -2$, then M^{2n+1} is shrinking.

Proof. Let us assume that M^{2n+1} is W_1-semisymmetric. In this case, we have

$$(R(X,Y)\cdot W_1)(U,V,Z)=0,$$

for all $X,Y,Z \in \chi(M)$. In this case, we can write

$$R(X,Y)W_1(U,V)Z - W_1(R(X,Y)U,V)Z - W_1(U,R(X,Y)V)Z \\ -W_1(U,V)R(X,Y)Z = 0. \qquad (26)$$

If we choose $X=\xi$ in (26) and use (7), then we get

$$-g(Y,W_1(U,V)Z)\xi + \eta(W_1(U,V)Z)Y + g(Y,U)W_1(\xi,V)Z \\ -\eta(U)W_1(Y,V)Z + g(Y,V)W_1(U,\xi)Z - \eta(V)W_1(U,Y)Z \\ +g(Y,Z)W_1(U,V)\xi - \eta(Z)W_1(U,V)Y = 0. \qquad (27)$$

If we use (20), (21) and (22) in (27), then we have

$$-g(Y,W_1(U,V)Z)\xi + \eta(W_1(U,V)Z)Y - g(Y,U)g(V,Z)\xi \\ +2g(Y,U)\eta(Z)V + \frac{1}{2n}g(Y,U)S(V,Z)\xi - \eta(U)W_1(Y,V)Z \\ +g(Y,V)g(U,Z)\xi - 2g(Y,V)\eta(Z)U - \frac{1}{2n}g(Y,V)S(U,Z)\xi \\ -\eta(V)W_1(U,Y)Z + 2g(Y,Z)\eta(U)V - 2g(Y,Z)\eta(V)U \\ -\eta(Z)W_1(U,V)Y = 0. \qquad (28)$$

If we choose $U=\xi$ in (28) and use (20), we get

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$$
\begin{aligned}
& g(V,Z)\eta(Y)\xi - 2g(Y,V)\eta(Z)\xi - \tfrac{1}{2n}S(V,Z)\eta(Y)\xi \\
& -g(V,Z)Y + 2\eta(Z)\eta(V)Y + \tfrac{1}{2n}S(V,Z)Y \\
& +g(V,Z)\eta(Y)\xi + 2\eta(Y)\eta(Z)V + \tfrac{1}{2n}S(V,Z)\eta(Y)\xi \\
& -W_1(Y,V)Z + g(Y,V)\eta(Z)\xi - 2g(Y,V)\eta(Z)\xi \\
& +g(Y,V)\eta(Z)\xi + g(Y,Z)\eta(V)\xi - 2\eta(V)\eta(Z)Y \\
& -\tfrac{1}{2n}S(Y,Z)\eta(V)\xi + 2g(Y,Z)V - 2g(Y,Z)\eta(V)\xi \\
& +g(V,Y)\eta(Z)\xi - 2\eta(Z)\eta(Y)V - \tfrac{1}{2n}S(V,Y)\eta(Z)\xi = 0.
\end{aligned} \tag{29}
$$

If we choose $Z = \xi$ in (29), we have

$$\frac{1}{2n}S(V,Y)\xi = -g(V,Y)\xi + 2\eta(Y)\eta(V)\xi. \tag{30}$$

Taking the inner product of both sides of (30) with $\xi \in \chi(M)$ and then setting $Y = \xi$, we obtain

$$\lambda = \frac{1}{2}\left(p + \frac{2}{2n+1}\right) + 2n.$$

Thus, the proof of the theorem is complete.

Theorem 6 *Let* $M^{2n+1}(\phi,\xi,\eta,g)$ *be a* $(2n+1)$*-dimensional para-Sasakian manifold, and let* (g,ξ,λ) *be a conformal Ricci soliton on* M^{2n+1}*. If* $W_1(X,Y)\cdot R = 0$*, then the following conditions hold:*

i. If $(2n+1)(p-4n) > -2$, then M^{2n+1} is expanding.

ii. If $(2n+1)(p-4n) = -2$, then M^{2n+1} is steady.

iii. If $(2n+1)(p-4n) < -2$, then M^{2n+1} is shrinking.

Proof. The proof of the theorem can be carried out similarly to the proof of the previous theorem.

Theorem 7 *Let* $M^{2n+1}(\phi,\xi,\eta,g)$ *be a* $(2n+1)$*-dimensional para-Sasakian manifold, and let* (g,ξ,λ) *be a conformal Ricci soliton on* M^{2n+1}*. If* $W_1(X,Y)\cdot S = 0$*, then the following conditions hold:*

i. If $(2n+1)(p-4n) > -2$, then M^{2n+1} is expanding.

ii. If $(2n+1)(p-4n) = -2$, then M^{2n+1} is steady.

iii. If $(2n+1)(p-4n) < -2$, then M^{2n+1} is shrinking.

Proof. Let us assume that

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$$(W_1(X,Y)\cdot S)(U,V)=0,$$

for all $X,Y,U,V\in\chi(M)$. In this case, we can write

$$S(W_1(X,Y)U,V)+S(U,W_1(X,Y)V)=0 \quad (31)$$

If we choose $X=\xi$ in (31) and use (20), we have

$$2ng(Y,U)\eta(V)+\eta(U)S(Y,V)+\eta(V)S(Y,U)$$
$$+2ng(Y,V)\eta(U)=0. \quad (32)$$

If we choose $U=\xi$ in (32), then we get

$$S(Y,V)+2ng(Y,V)=0. \quad (33)$$

If we choose $V=\xi$ in (33) and use (17), we have

$$\lambda=\frac{1}{2}\left(p+\frac{2}{2n+1}\right)-2n.$$

Thus, the proof of the theorem is complete.

Theorem 8 *Let $M^{2n+1}(\phi,\xi,\eta,g)$ be a $(2n+1)$-dimensional para-Sasakian manifold, and let (g,ξ,λ) be a conformal Ricci soliton on M^{2n+1}. If $S(X,Y)\cdot W_1=0$, then the following conditions hold:*

i. If $(2n+1)(p-4n)>-2$, then M^{2n+1} is expanding.

ii. If $(2n+1)(p-4n)=-2$, then M^{2n+1} is steady.

iii. If $(2n+1)(p-4n)<-2$, then M^{2n+1} is shrinking.

Proof. Let us assume that

$$(S(X,Y)\cdot W_1)(U,V,Z)=0,$$

for all $X,Y,Z,U,V\in\chi(M)$. In this case, we can write

$$S(X,Y)W_1(U,V)Z-W_1(S(X,Y)U,V)Z-W_1(U,S(X,Y)V)Z$$
$$-W_1(U,V)S(X,Y)Z=0. \quad (34)$$

If we choose $X=\xi$ in (34) and use (11), we have

$$4n\eta(Y)W_1(U,V)Z=0. \quad (35)$$

If we choose $U=\xi$ in (35) and use (20), then we get

$$-4ng(V,Z)\eta(Y)\xi+8n\eta(Y)\eta(Z)V+2S(V,Z)\eta(Y)\xi=0. \quad (36)$$

If we choose $Y=Z=\xi$ in (36), we have

$$\lambda=\frac{1}{2}\left(p+\frac{2}{2n+1}\right)-2n.$$

Thus, the proof of the theorem is complete.

5 CONCLUSION

In this study, the effect of conformal Ricci solitons, which are highly significant for mathematics, physics, and engineering, on the geometry of para-Sasakian manifolds is investigated. The characterization of para-Sasakian manifolds admitting conformal Ricci solitons has been obtained under certain special curvature conditions written with respect to the W_1-curvature tensor.

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MATEMATİK VE SANAT ARASINDAKİ İLİŞKİNİN DOĞRUSALLIĞI: DİSİPLİNLERARASI BİR YAKLAŞIM

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ÖZET

Matematik ve sanat, tarih boyunca birbirinden ayrı disiplinler olarak ele alınsa da aslında temelde ortak felsefi ve yapısal özellikler barındırır. Doğadaki düzen ve dizilimlerin ölçülebilirliğini vurgulayarak teoriler geliştiren ve formüller üzerinden doğal dünyanın yapısını tanımlamaya çalışan bir bilim dalı olan matematik ile yine doğal dünyayı estetik bakış açısıyla yorumlayan sanat pek çok açıdan ilişkiseldir. Matematiğin estetik düzeni ve sanatta kullanılışı, bu iki alan arasındaki bağı daha da belirginleştirmektedir. Geometrik ilkeler, oran, simetri ve fraktal yapılar sanat eserlerinde estetik bir düzen oluşturmada tarih boyunca sıklıkla kullanılmış; Antik Dönem'den Rönesans'a, modern sanattan kavramsal yerleştirmelere ve mimariden heykele kadar matematik formüller ve geometrik yapılar sanatçılar için bir rehber olmuş ve iki boyutlu kompozisyonların temel unsurlarını belirlemede olduğu kadar kavramsal sanatta doğrudan kültür üretiminin merkezinde yer almış, hem yapısal hem de estetik dengenin oluşturulmasında kritik rol oynamıştır. Araştırma kapsamında Fibonacci dizisi, altın oran, fraktal geometri, Helisoid eğrisi ve Möbius şeridi gibi örnekleme alınan matematiksel yapılar farklı dönemlerden ve sanatın farklı disiplinlerinden eserler üzerinden karşılıklı olarak analiz edilmekte, bu inceleme ile matematik ve sanat arasındaki ilişki tarihsel ve teorik açıdan temellendirilmeye çalışılmaktadır.

Anahtar Kelimeler: Matematik ve sanat, Fibonacci sayıları, Altın oran, Fraktal geometri, Helisoid eğrisi, Möbius şeridi

THE LINEARITY OF THE RELATIONSHIP BETWEEN MATHEMATICS AND ART: AN INTERDISCIPLINARY APPROACH

ABSTRACT

Although mathematics and art have been treated as separate disciplines throughout history, they have common philosophical and structural features. Mathematics, a branch of science that develops theories by emphasizing the measurability of order and sequences in nature and tries to define the structure of the natural world through formulas, and art, which interprets the natural world from an aesthetic point of view, are related in many ways. The aesthetic order of mathematics and its use in art make the connection between these two fields even more evident. Geometric principles, proportion, symmetry and fractal structures have been frequently used throughout history to create an aesthetic order in works of art; from Antiquity to the Renaissance, from modern art to conceptual installations and from architecture to sculpture, mathematical formulas and geometric structures have been a guide for artists and have been directly at the center of cultural production in conceptual art as well as in determining the basic elements of two-dimensional compositions, and have played a critical role in creating both structural and aesthetic balance. Within the scope of the research, mathematical structures such as the Fibonacci sequence, the golden ratio, fractal geometry, the Helicoid curve and the Möbius strip are mutually analyzed through works from different periods and different disciplines of art, and the relationship between mathematics and art is tried to be grounded in historical and theoretical terms.

Keywords: Mathematics and art, Fibonacci numbers, Golden ratio, Fractal geometry, Helicoid curve, Möbius

GİRİŞ

Matematik ve sanat, genellikle birbirinden bağımsız ve ilişkisiz iki farklı disiplin olarak değerlendirilmekte, özellikle eğitim sürecinde matematikte düşük başarı gösteren, bu alanda zorlanan veya uzak duran bireyler için matematiğin sanatsal bir değer taşıdığı düşüncesi çoğunlukla kabul görmemektedir. Ancak bu algı, matematiğin doğasındaki düzen, estetik ve uyum göz önünde bulundurulduğunda gerçeklikten uzak bir yaklaşımdır. Matematik yalnızca kendi iç disiplininde değil, aynı zamanda mimarlık, müzik ve resim gibi sanat dallarındaki uygulamalarıyla da sanatla doğrudan ilişkilidir (Duru ve İşleyen, 2005, s. 480). İlk çağlardan itibaren sistematik bir şekilde incelenen matematik, uygar toplumlarda aklın ürünü olarak düzenli bir biçimde ortaya konulan ve sanat dalı niteliği taşıyan bir disiplin olarak kabul edilmiştir. Atina'da kurduğu akademinin girişine "Matematik bilmeyenler giremez" ifadesini yazdıran Platon, matematiğin insanı hakikate ulaştıran temel bir araç olduğunu ileri sürmüştür (Cereci, 2012, s. 89).

Matematik ile sanat arasındaki ilişki, tarihsel süreç içerisinde Pisagor'un sayılara atfettiği anlamlarla temellenmiş ve zamanla gelişerek farklı boyutlar kazanmıştır. 20. yüzyılın başlarında fraktalların keşfi, bu ilişkiye yeni bir perspektif kazandırmış; fraktalların geometrik yapısı ve karmaşıklığı, sanatçılar ve bilim insanları tarafından büyük ilgi görmüş ve çeşitli araştırmalara konu olmuştur. Günümüzde ise matematiğin mimari, süsleme sanatı, resim, heykel ve müzik gibi farklı sanat dallarında kullanıldığına dair kapsamlı çalışmalar bulunmaktadır (Atasay ve Erdoğan, 2017, s. 58). Sanatta matematiksel ilkelerin kullanımı ve eserlerin kompozisyonlarında geometrik öğelerden yararlanılması, sanatçılar için önemli bir unsur olmuştur. Sanat eserlerinin kompozisyonlarının geometrik prensiplere dayanarak oluşturulması, bu eserlerin yapısının matematiksel olarak analiz edilmesine olanak sağlamaktadır. Bu durum, sanatçıların yaratım süreçlerinde matematiği bilinçli bir şekilde kullanmalarına ve eserlerinde matematiksel düzeni esas almalarına imkân tanımaktadır (Kuş ve Demir-Yılmaz, 2024, s. 145).

Matematik ve sanat, ilk bakışta birbirinden bağımsız disiplinler olarak değerlendirilse de aslında her ikisi de insanın doğayı ve çevresini anlama ve yorumlama çabasının bir yansımasıdır. Her iki alan da soyutlama, yorumlama ve yeniden sunum süreçleri aracılığıyla

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doğadaki karmaşıklığı anlamlandırmayı amaçlamaktadır. Matematik ve sanatın temelinde yer alan felsefi yaklaşım, problemlerin tanımlanması ve çözülmesi yönünde ortak bir motivasyona sahiptir. Bu bağlamda, matematik sanatsal bir nitelik kazanabilirken, sanat da matematiksel bir perspektiften ele alınabilir ve değerlendirilebilir (Cereci, 2012, s. 98). Birbirini tamamlayan bu iki olgu, "matematiğin estetik yönü" ile "sanatın ölçülebilir yönü" arasındaki ilişki açısından sarmal bir yapı sergilemekle birlikte, aynı zamanda bağımsız özellikler de barındırmaktadır. Matematik, mimari ve sanatın farklı disiplinleri, tartışmasız bir şekilde ölçülebilir unsurlar içermekte olup, bu yönleriyle birbirleriyle etkileşim hâlinde olan ancak kendi iç dinamikleriyle de varlığını sürdüren alanlardır (Atabey, 2023, s. 76).

1. Matematiğin Tarihsel Gelişimi

Matematiğin Kısa Bir Tarihi adlı eserde matematiğin tarihi beş farklı döneme ayrılmaktadır. İlk dönem, Mısır ve Mezopotamya Dönemi olarak adlandırılırken, ikinci dönem Eski Yunan Dönemi olarak tanımlanmaktadır. Üçüncü dönem, Hint, İslam ve Rönesans Matematiği şeklinde isimlendirilmiş olup, dördüncü dönem Klasik Matematik Dönemi'ni ifade etmektedir. Beşinci ve son dönem ise 20. yüzyıldan günümüze kadar uzanan Modern Matematik Dönemi olarak nitelendirilmektedir (Ülger, 2006, s.13).

Yazılı metinler, anıtlar ve resimler üzerinde yapılan incelemeler, matematiksel faaliyetlerin kökeninin Antik Mısır ve Mezopotamya uygarlıklarına dayandığını göstermektedir. Her iki uygarlıkta da dönemin gerekliliklerine uygun olarak "olgusal bir bilim anlayışı" benimsenmiş olup, temel amaç doğada ve gökyüzünde gözlemlenen döngüleri tespit ederek kaydetmek ve böylece doğayı öngörülebilir hâle getirmektir. Bu doğrultuda, her iki uygarlık tarafından geliştirilmiş takvim sistemleri bulunmaktadır. Antik Mısır'da Eski İmparatorluk Dönemi M.Ö. 2778-2263 yılları arasına tarihlendirilmektedir. Bu dönemde yazı malzemesi olarak papirüs kullanılmakta olup, papirüsler Nil Nehri kıyılarında yetişen sazlık tipi bir bitkiden elde edilmektedir (Sayılı, 1991, s. 2-3). Matematikle ilgili en önemli kaynaklar arasında Rhind Papirüsü ve Moskova Papirüsü yer alır. Bunlara ek olarak, M.Ö. 1650 yıllarına tarihlendirilen ve EMLR2 olarak bilinen Mısır matematiğine ait bir deri rulo yazma ile M.Ö. 1900-1800 yılları arasına tarihlendirilen Kahûn ve Berlin Papirüsleri de matematikle ilgili önemli bilgiler içeren diğer belgeler arasında bulunmaktadır. Rhind Papirüsü, Hieratic yazı tipiyle yazılmış olup Ahmes Papirüsü olarak da bilinmektedir. M.Ö. 1700-1600 yılları arasında kaleme alındığı düşünülmekle birlikte, aslında MÖ 3400'lerde yazılmış daha eski bir belgenin temize çekilmiş bir versiyonu olduğu tahmin edilmektedir (Seyhan, 2021, s. 60).

Mezopotamya'da, özellikle Sümerler ve Babiller gibi uygarlıkların, sulama kanalları ve tarımsal yapılar gibi büyük ölçekli projeler üzerinde çalışarak matematiği geliştirdikleri bilinmektedir. Benzer şekilde, Çin, Hindistan ve Mısır gibi medeniyetler de günlük ihtiyaçları doğrultusunda matematiksel kavramları kullanmışlardır. Bu gelişmeler, matematiğin kökenlerinin MÖ 5000 yıllarına kadar uzandığını göstermekte olup, bu erken dönem matematiği, özellikle Mezopotamya, Mısır ve Çin gibi eski doğu uygarlıklarının katkılarıyla şekillenmiştir (Baki, 2020, s. 10).

Yunanlılar dönemi, matematiğin altın çağı olarak nitelendirilmektedir. Yunan bilim insanları, Mısır ve Mezopotamya gibi bölgelere sık sık seyahat ederek bu uygarlıklardan edindikleri bilgileri sentezlemiş ve yeni teoriler geliştirmiş, öğrendikleri matematiksel kavramları ispat ve teoremlere dönüştürerek alanda önemli ilerlemeler kaydetmişlerdir. Bu dönemde matematik, yalnızca toplumsal ihtiyaçları karşılamak veya astronomi gibi bilim dallarında kullanılmakla kalmamış, aynı zamanda bir sanat dalı olarak da değerlendirilmiştir (Baş, 2019, s. 11).

Yunan matematiğinin gelişiminde önemli figürlerden biri olan Thales (MÖ 624-547), Mısır ve Mezopotamya'dan edindiği bilgileri Yunanistan'a taşıyarak İyon Okulu'nu kurmuş ve matematikte ispat geleneğini başlatmıştır. *Thales Teoremi* olarak bilinen orantı kuralı geliştirilmiş ve gölge boyu kullanılarak piramitlerin yüksekliği hesaplanmıştır. Onun etkisiyle Mısır'a giden Pisagor (MÖ 569-475), matematik ve müzik teorisi üzerine çalışmalar yapmış ve Samos'a döndüğünde kurduğu okulda Pisagor Teoremi ile dik üçgenlerde hipotenüsün karesinin dik kenarların kareleri toplamına eşit olduğunu göstermiştir. Platon (MÖ 427-347), matematiği sistematik bir eğitim sürecine dahil etmiş, Akademi'yi kurarak geometri ve felsefe alanlarında dersler vermiştir. Matematiği soyut bir disiplin olarak ele almış ve ispat anlayışını teşvik etmiştir. Onun öğrencisi Euclid, *Elementler* adlı eserinde aksiyomatik yöntemi kullanarak matematiksel teoremleri mantıksal bir sistem içinde sunmuş, böylece matematiğin sistematik hale gelmesine büyük katkıda bulunmuştur (Köprücü, 2023, s. 12-14).

Hint, İslam ve Rönesans dönemi olarak adlandırılan üçüncü evrede, Müslüman bilim insanları Yunan matematik eserlerini Arapçaya çevirerek matematiksel bilginin korunması ve yayılmasında önemli bir rol oynamıştır. Bu süreçte, Hint ve Yunan matematik anlayışları sentezlenerek aritmetik, cebir ve trigonometri alanlarında kayda değer ilerlemeler kaydedilmiştir. Batı Avrupa'da ise İslam uygarlığından aktarılan bu bilgiler, matematik alanında bir rönesansın başlamasına zemin hazırlamıştır. Bu matematiksel uyanış, ilk olarak İtalya'da ortaya çıkmış, ardından Hollanda, İngiltere ve diğer Avrupa ülkelerine yayılmıştır (Gökdoğan, 2004, s. 92).

1700-1900 yılları arasındaki Klasik Matematik Dönemi, büyük hipotezlerin ve teorilerin ortaya çıktığı, *matematiğin altın çağı* olarak kabul edilen bir dönemdir. Bu süreçte matematik, tüm bilim dallarında yaygın olarak kullanılmaya başlanmış ve pozitif bilimlerin temelini oluşturan bir disiplin hâline gelmiştir. Ayrıca, günümüzde üniversitelerde öğretilen matematiğin temel kavramları bu dönemde şekillenmiştir (Polat, 2019, s. 17). Bernoulli, Leibniz, Euler ve Gauss gibi matematikçilerin çalışmaları, 19. yüzyılda matematiğin yeni alanlarının keşfedilmesine önemli ölçüde katkı sağlamıştır. Özellikle Newton, Leibniz ve Euler'in araştırmaları, modern analizin temelini oluşturmuş ve matematiksel yöntemlerin gelişimini hızlandırmıştır. Ayrıca, Cantor'un küme teorisi, matematiğin temel kavramlarından biri hâline gelerek modern matematiğin ilerlemesine büyük katkı sunmuştur (Bayam, 2012, s. 13).

2. Matematik ve Sanatın Kesişimi

2.1.Geometrik Yapılar ve Kompozisyon

Matematik ve sanat, farklı uygulama biçimlerine sahip olsalar da, insanın kendini ve yaşadığı dünyayı anlama çabasının ortak ürünleridir. Her ikisinin de temelinde insanın yaratıcılığı yer alırken, bilimsel ve teknolojik gelişmeler bu iki alanı derinden etkilemiştir. Plastik sanatlarda özellikle matematik, kompozisyonun temel unsurlarının belirlenmesinde büyük rol oynar.

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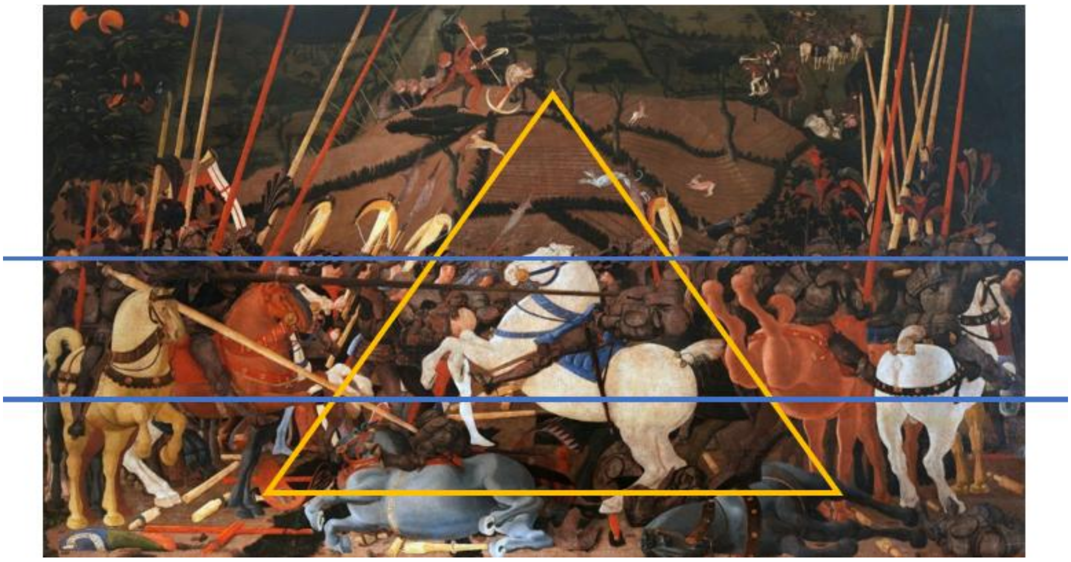
Resimde ölçü hesaplamaları, espas dengesi, nesnelerin oranı ve ölçeklendirilmesi gibi unsurlar, matematiksel hesaplamalarla düzenlenir. Geometrik şekiller ve matematik sembolleri, sanat yüzeyinde somut olarak gözlemlenebilir (Sevinç, 2018, s.2).

Geometri, insan yaşamına M.Ö. 4000'li yıllarda girmiştir. Eski Mısırlılar ve Mezopotamya uygarlıkları, ihtiyaçlarından doğan geometri bilgisini geliştirmiştir. Herodot (M.Ö. 485-425), geometrinin Eski Mısır'da başladığını ve arazi ölçümlerinden kaynaklandığını belirtir. Mısırlılar, iki ve üç boyutlu şekillerin alan ve hacim hesaplamalarını yapabilmekteydi (Tecer, 2014, s.6). Yunanistan'da da geometri önemli bir yer tutmuş, M.Ö. 700'lü yıllarda seramik sanatında yoğun olarak kullanılmıştır. Çanak ve çömleklerdeki geometrik desenler, bu dönemin "geometrik dönem" olarak adlandırılmasına neden olmuştur. Bu eserler, geometrik formların yanı sıra toplumsal olayları da yansıtmaktadır (Danış, 2019, s.8).

Platon, güzelliğin salt geometrik formlarda bulunduğunu savunarak, sanat ve doğadaki güzelliğin matematiksel düzen ile açıklanabileceğini belirtir. Matematik ve sanat arasındaki bu ilişki, sanatçıları ve düşünürleri doğa ve sanatta tüm güzellikleri açıklayacak bir matematiksel formül arayışına yöneltmiştir. Bu formül, altın oran olarak ortaya çıkmış, sanatta ve doğada gözlemlenen bir estetik anlayışı doğurmuştur. Orantıya dayalı bir diğer ilke olan simetri, doğada olduğu kadar sanatta da önemlidir. Dikey eksene göre sağ ve solun dengeli olması, sanat eserlerine estetik bir bütünlük kazandırır (Tecer, 2014, s.6-8).



Görsel 1. Paolo Uccello'nun The Battle of San Romano [San Romano Bozgunu], 1435-1460

Antik sanat ve İtalyan Rönesans sanatı, simetri ve matematiksel kurallara dayanmaktadır. Özellikle üçgen kompozisyon kuralı Rönesans'ta yaygın olarak uygulanmıştır. Sanatçılar, geometri ve matematiği resimlerine entegre ederek kompozisyonlarını titizlikle matematiksel hesaplarla düzenlemiştir. Rönesans dönemi, sanat ile bilimin iç içe geçtiği, özellikle matematiksel perspektifin resim sanatında yoğun bir şekilde kullanılmaya başlandığı bir dönemdir. İtalya'da doğan doğrusal perspektif, tek bir bakış noktasına dayalı geometrik bir konstrüksiyon oluşturmuş ve resim sanatına yeni bir boyut kazandırmıştır (Maltaş, 2019, s.223). Bu teknik, sanatçıların mekânı rasyonel bir temelde kavrayıp yansıtmalarına imkân sağlayarak sanat anlayışında köklü bir dönüşüm yaratmıştır. Paolo Uccello, doğrusal perspektifin

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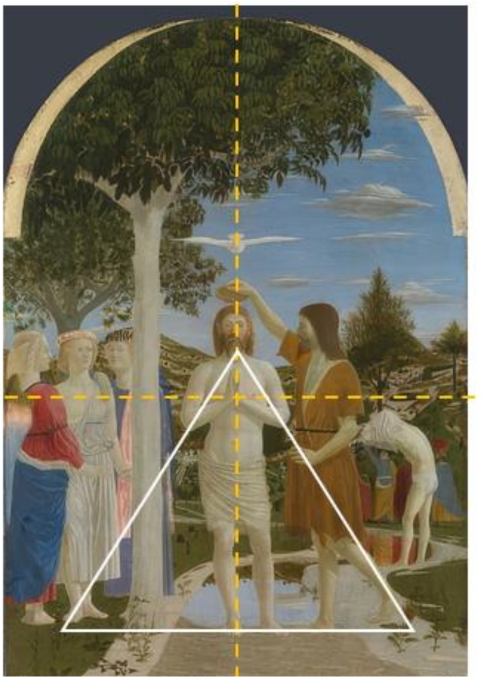
imkânlarını araştıran öncü ressamlardan biri olmuştur. Uccello'nun *The Battle of San Romano [San Romano Bozgunu]* (1435-1460) adlı eseri, bu anlayışın önemli örneklerindendir. 1432'de Floransa ve Siena arasında yaşanan San Romano Muharebesi'ni anlatan üç resimden oluşan seride yatay ve dikey formlar ile simetrik dengenin resim sanatında en güçlü örneklerinden birini aktaran sanatçı aynı zamanda her üç resimde de merkezi kompozisyon yapısına sahip bir kurgu yaratmıştır. Eserde, zemine yerleştirilen kırık mızraklar, silahlar ve savaşın izleri, belirli bir kaçış noktasına göre düzenlenmiştir. Bu düzen, izleyicinin dikkatini sahnenin merkezine yönlendirerek derinlik algısını güçlendirmektedir (Alper, 2008, s.10).

Savaş sahnesindeki figürlerin geometrik düzeni matematiksel ilkeler doğrultusunda oluşturulmuştur. Atların anatomik yapıları ve savaşçı figürleri, simetri ve oran dikkate alınarak tasarlanmıştır. Zemindeki perspektif ızgarası ise eserin matematiksel yapısını pekiştirerek mekânın üç boyutlu bir gerçeklik hissi vermesini sağlamıştır. Doğrusal perspektifi ustalıkla kullanarak derinlik algısını güçlendiren sanatçının eseri, matematik ve sanatın nasıl iç içe geçerek estetik ve bilimsel bir bütünlük sağladığını açıkça ortaya koymaktadır.

Rönesans döneminde perspektif ve kompozisyon kaygılarını ele alan önemli sanatçılardan bir diğeri Piero Della Francesca'dır. Sanatçının 1442 yılında tempera tekniği ile yaptığı *The Baptism of Christ [İsa'nın Vaftizi]* (1448-1450) adlı eserinde biçim, renk dengesi ve oranlama matematiksel bir düzen içerisinde ele alınmıştır (Alper, 2008, s.11-13). Sanatçı, dönemin ruhuna uygun olarak dinsel bir töreni betimlemiş ve kompozisyonunda matematiksel ilkeleri ustalıkla kullanmıştır (Atasoy ve Tükel, 2013).



Görsel 2. Piero Della Francesca, The Baptism of Christ [İsa'nın Vaftizi], 1448-1450

Eserin kompozisyonu, simetri, perspektif ve geometrik düzenlemeler açısından dikkat çekicidir. Merkezde yer alan İsa figürü, gökyüzünden yere kadar uzanan hayali bir dikey eksen üzerinde konumlandırılmıştır. Bu eksen, güvercin figürü ile suyun kesiştiği noktada belirginleşerek eserde ruhani bir denge oluşturur. Arka planda kullanılan doğrusal perspektif,

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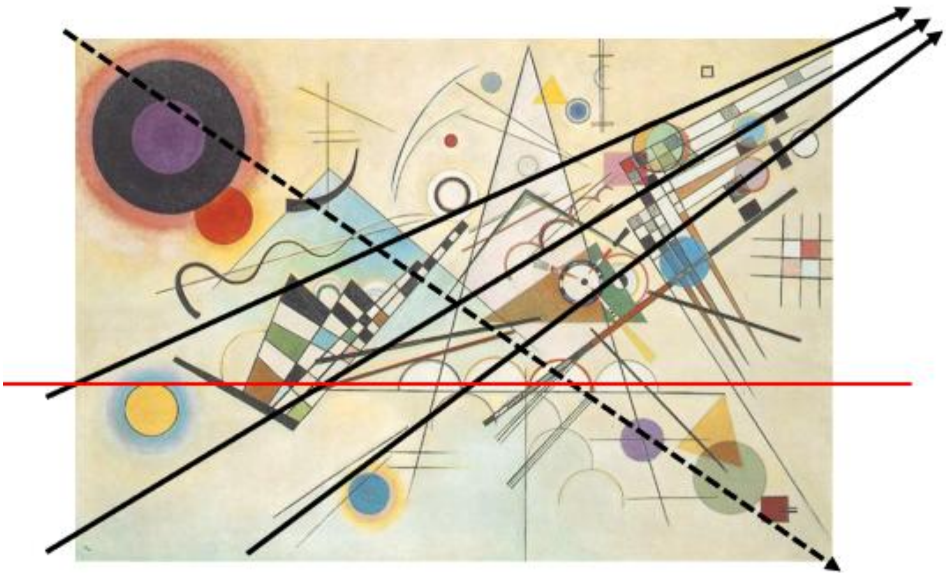
mekân algısını güçlendirir. Mimari unsurlar ufuk çizgisine doğru küçülerek sahneye üç boyutlu bir derinlik kazandırır (Düz ve Boztaş, 2013, s.10). Geometrik formlar, eserin matematiksel yapısını destekleyen diğer unsurdur. Figürlerin üçlü gruplar halinde düzenlenmesi, dengeyi güçlendirir. Bu yönüyle *The Baptism of Christ [İsa'nın Vaftizi],* Rönesans sanatında matematik ve sanatın nasıl bir arada kullanılabileceğini gösteren önemli örnekler arasında yer alır.

Modern sanatta ise geometrik form anlayışının doğrudan onu simgeleyen nesne ya da formun yerini aldığı görülür. Ancak yine de kompozisyonlarda simetri-asimetri ilkeleri, denge ve uyum gibi temel unsurların kurallı bir yapıda kullanımına özen gösterilmiştir. Örneğin 1920'lardan itibaren nesnel gerçekliğin basit geometrik formlara indirgendiği bir ifade biçimi olan soyut sanat kapsamında Wassily Kandinsky'nin *Composition VIII [Kompozisyon VIII]* (1923) isimli çalışması ya da Paul Klee'nin *Castle and Sun [Kale ve Güneş]* (1928) eseri bu örnekler arasında tanımlanabilir.



Görsel 3. Wassily Kandinsky, Composition VIII [Kompozisyon VIII], 1923

Geometrik form anlayışı, mağara resimlerinden günümüze kadar uzanan geniş bir geçmişe sahiptir. Mısır, Sümer, Asur, İnka gibi birçok medeniyet, sanatsal ve mimari tasarımlarında geometriyi kullanmıştır. Günümüzde de soyut sanat ve geometri arasındaki ilişki, sanatın matematikle olan bağının önemli örneklerini sunmaktadır. Simetri ve asimetri kavramları, sanatın temel estetik unsurlarını belirlemede önemli bir yere sahiptir. Bu unsurlar, sanatın biçimsel yapısını oluştururken, aynı zamanda matematik ile olan kopmaz bağını da kanıtlamaktadır (Angay, 2023, s.29).

2.2.Fraktallar, Çokyüzlüler ve Sayı Dizilerinin Görsel Temsili

Matematiğe özgü terim ve tanımlamalar olan geometrik şekiller, simetri, orantı ve fraktal yapılar, sanat eserlerinin de temelini oluşturan unsurlardır. Araştırma kapsamında örnekleme alınan altın oran, Fibonacci dizisi, fraktal geometri, helis eğrisi, Möbius şeridi ve çokyüzlüler gibi matematiksel kavramların, doğada olduğu kadar sanatta da hemen her dönemde önemli örneklerine rastlamak mümkündür.

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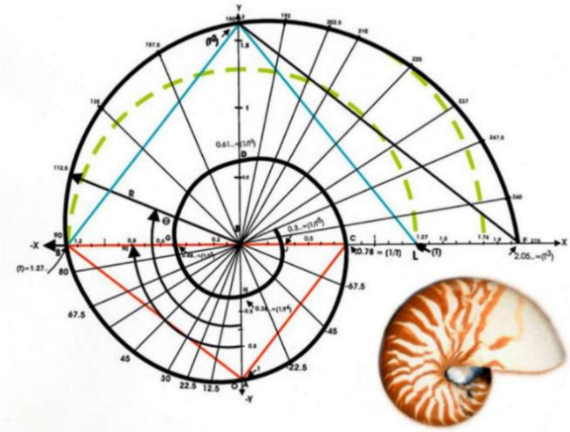
Matematik dünyasında özellikle *Liber Abaci (The Book of Calculation) [Hesaplama Kitabı]* (1202) adlı eseriyle tanınan ve Rönesans öncesi Avrupa'nın önemli matematikçilerinden biri olan Pisalı Leonardo Fibonacci, Batı dünyasına Arap matematiğinin kullanışlı Hindu-Arap sayı sistemini tanıtmış, söz konusu kitapta günümüzde Fibonacci dizisi olarak bilinen sayı dizisini tanımlayarak bu dizinin matematiksel önemini ortaya koymuştur (Ayran ve Aydın, 2017, s.510). Fibonacci dizisi, yalnızca matematiksel bir yapı olarak kalmamış, doğada ve sanatta da kendine geniş bir yer bulmuştur.

"Fibonacci sayıları, iki tane 1 sayısıyla başlayıp, her seferinde bir önceki iki sayının toplamını alarak oluşturulan diziye denir ve bu dizideki sayılar da Fibonacci sayıları olarak anılır; F 1 =1, F 2 =1 ve Fn =Fn-1 +Fn-2. Buna göre dizi şöyle başlar: 1, 1, 2, 3, 5, 8, 13, 21, 34, 55, 89, 144, 233, 377, ..." (Sertöz, 2020, s.66).



Görsel 4. Fibonacci sarmalı ve altın oran

Özellikle Fibonacci spirali, doğada sıklıkla karşılaşılan bir yapıdır. Gökadaların sarmallarından deniz kabuklarına, ayçiçeği ve papatya gibi bitkilerin yaprak düzenlerinden kasırga bulutlarına kadar birçok doğal oluşum, bu spiral ile ilişkilendirilmiştir. Her ne kadar birebir Fibonacci dizisine uymasa da, bu yapılar genellikle logaritmik spirallerle bağlantılıdır (Ankaralıgil, 2013, s.83). Bu doğal formlar, sanatçılara ilham kaynağı olmuş ve estetik kompozisyonların oluşturulmasında önemli bir unsur haline gelmiştir.

Sanatta denge ve uyumu sağlayan en önemli matematiksel oranlardan biri de altın orandır. Fibonacci dizisinin ardışık iki sayısının oranı büyüdükçe, altın orana (1.618) yaklaşmaktadır. Altın oran, doğada sıkça gözlemlenen bir oran olup, bitkilerin dallanma yapılarından hayvan anatomisine kadar geniş bir alanda görülebilmektedir (Değer, 2017, s.169). Örneğin, penguenlerin vücut yapılarında, kelebek kanatlarının simetrisinde ve bal arılarının peteklerinin düzeninde bu oran belirgin bir şekilde ortaya çıkmaktadır (Aydın, 2015, s.5). Sanatta ve mimaride ise, altın oran, birçok yapının estetik bütünlüğünü oluşturmak için kullanılmıştır.

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Görsel 5. Leonardo Da Vinci, Annunciation [Müjde], 1472

Sanat tarihinin en erken örneklerinden itibaren kompozisyonların bilinçli ya da bilinçsiz altın orana uygun olarak düzenlendiği ve figür ya da nesnelerin belirli ilkeler doğrultusunda sistematik bir yapıda resmedildiği görülür. Leonardo Da Vinci'nin 1472 tarihli *Annunciation [Müjde]* isimli eseri Rönesans sanatı kapsamında matematik ve sanat ilişkisinin tanımlanabileceği en belirgin örneklerden biridir. Benzer biçimde Sandro Botticelli'nin *The Birth of Venus [Venüs'ün Doğuşu]* (1482-1486) adlı eseri, sanat ile matematiğin estetik düzlemde birleştiği dikkat çekici örneklerden biridir. 1480'lerin ortalarında tamamlanan eser, mitolojik bir anlatı sunarken altın oranın estetik etkisini gözler önüne sermektedir (Tosun, 2021, s.24). Eserde, denizden doğan Venüs figürü merkezi bir konumda yer alır. Venüs'ün beden oranları, altın orana uygun olarak düzenlenmiş; baş, gövde ve bacak uzunlukları matematiksel bir simetri içinde tasarlanmıştır. Figürün yüzü, altın dikdörtgen içine yerleştirilerek orantılı bir görünüm sağlanmıştır. Venüs'ün doğduğu deniz kabuğu, altın spiral formunda tasarlanmış ve hareketin doğallığı bu matematiksel düzenle pekiştirilmiştir. Renk kullanımı ve ışık-gölge oyunları da bu matematiksel yapıyı destekler niteliktedir. Venüs'ün açık ten rengi, arka planın mavi-yeşil tonları ile kontrast oluşturarak kompozisyonun estetik dengesini artırmıştır. Japon sanatının önemli baskı resimlerinden olan Katsushika Hokusai'nin *The Great Wave off Kanagawa [Kanagawa Açıklarında Büyük Dalga]* (1831) isimli eseri de yine fibonacci dizilimine dayanan altın orana uygun olarak yapılandırılmış bir kompozisyon düzenine sahiptir.

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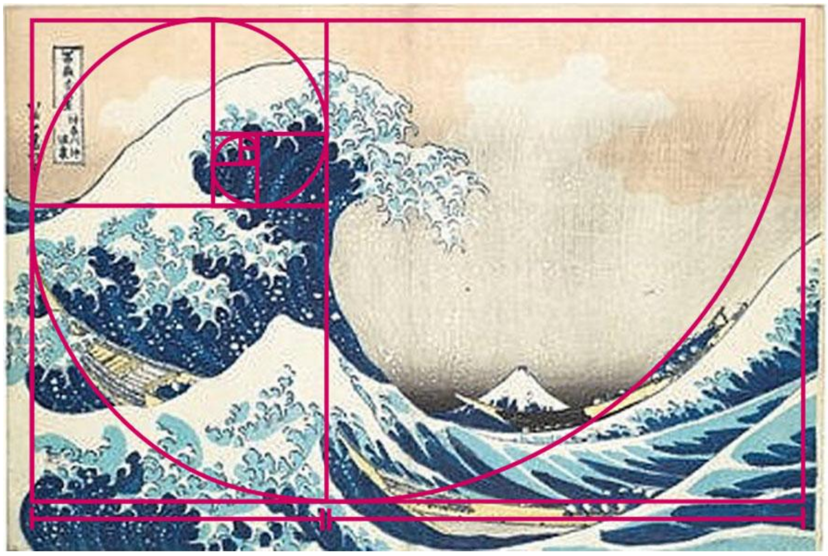
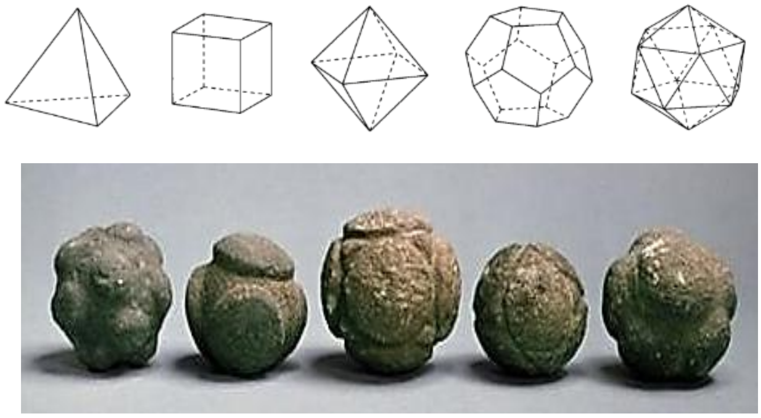


Görsel 6. Katsushika Hokusai, The Great Wave off Kanagawa [Kanagawa Açıklarında Büyük Dalga], 1831

Geometri, sanat ve doğa arasındaki ilişkiyi en iyi gösteren yapılardan biri de çokyüzlülerdir. Matematiksel olarak, her bir yüzü düzlemsel çokgenlerden oluşan bu yapılar, doğada ve sanatta estetik bir düzenin temel unsuru olmuştur. İskoçya’da yapılan arkeolojik kazılarda, cilalı taş devri insanları tarafından oyulmuş düzgün çokyüzlülerin bulunması, bu yapıların tarih boyunca ilgi gördüğünü kanıtlamaktadır. Ancak, yalnızca beş adet düzgün çokyüzlü bulunabilmiş ve Euclid, *Elements [Elementler]* adlı eserinde, yeni düzgün çokyüzlülerin elde edilemeyeceğini ispatlamıştır (Ermiş, 2014, s.1). Sanatta ise, çokyüzlüler simetri ve dengenin vurgulanmasında önemli bir yer tutmaktadır.



Görsel 7. (Üst) Platonik cisimler (çokyüzlüler) / (Alt) Çokyüzlülerin bulunan ilk örnekleri

Diğer matematiksel tanımlamalar ve sembollerde olduğu gibi platonik cisimler olan çokyüzlüler de sanat tarihinin farklı dönemlerinde üretilen eserlerde hem nitelik hem de içerik olarak yer almaktadır. Örneğin Hollandalı mimar Piet Blom’un Rotterdam’da yer alan *Kubuswoningen [Küp Evler]* tasarımı geometrik şekillerin sanatsal ifadeyle bütünleştiği dikkat çekici bir mimari yapıttır (Görsel 14). Bu yapı, küp formlarının 45 derece döndürülerek yerleştirilmesiyle oluşturulmuş ve matematiksel simetri, estetikle harmanlanmıştır (Bebek ve Coşar, 2021: 402). Bu yapı, izleyicinin mekânsal algısını değiştirerek perspektif yanılsamaları yaratmaktadır. Matematikteki simetri kavramı, bu yapıların estetik düzenini sağlamıştır. Blom,

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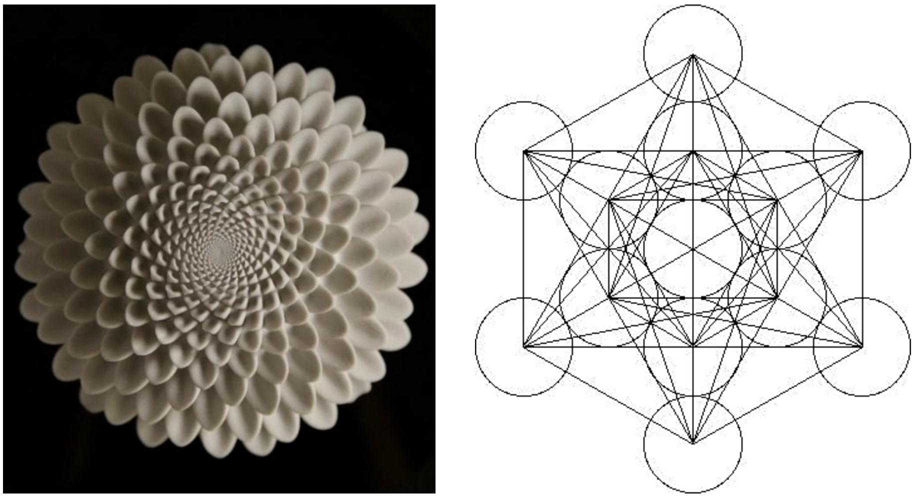
projede altı yüzlü düzgün küp formunun simetrisini korurken, geleneksel mimari anlayıştan saparak yeni bir bakış açısı kazandırmıştır. Küplerin konumlandırılması sırasında ortaya çıkan üçgen biçimli boşluklar, mimaride matematiksel prensiplerin işlevselliği artırmak için nasıl kullanılabileceğini göstermektedir.

Görsel 8. (Sol) Altıyüzlü (Küp) / (Sağ) Piet Blom, Kubuswoningen [Küp Evler], Rotterdam

Fraktal geometri, sanat ve matematik arasındaki etkileşimi en iyi gösteren kavramlardan bir diğeridir. Fraktallar, kendini tekrar eden ve sonsuz detay içeren geometrik yapılardır. İlk fraktal yapılar, 1870'li yıllarda diferansiyellenmeyen ancak sürekli eğriler üzerine yapılan çalışmalarla keşfedilmiştir. Weierstrass fonksiyonu, Cantor kümesi, Peano eğrisi, Koch eğrisi ve Sierpinski üçgeni gibi fraktal yapılar, matematik dünyasında önemli bir yer edinmiştir (Karakuş ve Baki, 2011, s.1082). Günümüzde ise, fraktal sanat, dijital sanat alanında büyük bir ilgi görmekte ve sanatta soyut matematiksel yapılarla estetik bütünlük sağlanmaktadır (Genç, 2019, s.2). Doğada sıkça karşımıza çıkan birçok biçim fraktal geometriye dayanır. Fraktaller, karmaşık matematiksel formüllerle tanımlanan olağanüstü geometrik yapılar olarak bilinirler. Ağaç dallarından, akciğer hava yollarının dallanmalarına, karnabahar bitkisinin yapısından gökyüzündeki bulutların şekillerine kadar, doğanın pek çok doğal oluşumu, fraktal kurallara uygun olarak şekillenir (Canan, 2015, s. 228).



Görsel 9. John Edmark, *Creating Never-Ending Bloom [Hiç Bitmeyen Çiçekler Yaratmak], 2017*

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Fibonacci sayı dizisinin spiral formlarından ve fraktallardan yararlanılan güncel çalışmalara John Edmark'ın *Creating Never-Ending Bloom [Hiç Bitmeyen Çiçekler Yaratmak] (2017) isimli eseri örnek gösterilebilir. Aynı zamanda Stanford Üniversitesi'nde tasarım eğitimi de veren Edmark'ın* Fibonacci dizisini temel alarak ürettiği etkileyici eserler arasından örnekleme alınan çalışması matematik ve sanat arasındaki etkileşimin yeni olasılıklarına dair deneysel bir yansımasıdır (Atabey, 2022, s.65). Eser, Fibonacci dizisinin spiral formlarını kullanarak zaman ve hareket algısını manipüle ederken, sanatçı sürekli genişleyen bir çiçek açma illüzyonu yaratmıştır. İzleyici, hareket eden formlar aracılığıyla zamanın durmaksızın ilerlediği hissine ve hareketin hipnotik etkisine kapılırken, hareketle birlikte gölge oyunları ve ışık kırılımları, eserin dinamik yapısını destekleyerek izleyiciyi etkileyici bir görsel deneyime davet eder.

Kavramsal sanat ve minimalizm akımlarıyla özdeşleşmiş önemli sanatçılardan biri olan Sol LeWitt'in de geometrik formları parçalayarak veya çizgisel müdahalelerle mekânı bölerek ürettiği pek çok eserinde fraktal özellikler belirgin şekilde görülmektedir. Özellikle yıldız motiflerine dayalı kompozisyonlarında, kendine benzerlik ilkesiyle oluşturulmuş örüntüler dikkat çekmektedir. *Star Light Center [Yıldız Işığı Merkezi]* (1983) isimli çalışması da yine çokyüzlülerin sanatın konusu olduğu diğer örnekler arasında yer almaktadır (Gülderen, 2017, s.51). Söz konusu eser sistematik sanat anlayışı ile fraktal geometri arasındaki ilişkiyi görselleştiren önemli bir çalışmadır. İlk bakışta, eser matematiksel bir düzenin hâkim olduğu simetrik bir yapı gibi görünse de, detaylara inildikçe fraktal özellikler taşıdığı fark edilmektedir. Küçük ölçeklerde tekrar eden benzer formlar, eserin yalnızca geometrik bir kompozisyon değil, aynı zamanda dinamik bir yapı sunduğunu gösterir. LeWitt'in sanatsal yaklaşımı, belirli kurallar çerçevesinde üretime dayanmasına rağmen, eserin durağan olmaktan çok genişleyebilir ve değişken bir yapıya sahip olduğu görülür. Bu noktada, doğadaki fraktal formlara yakın bir sistem yaratılmış olması dikkat çekicidir. Kar taneleri, ağaç dalları veya galaksi dağılımlarında görülen fraktal yapılar, LeWitt'in tasarladığı yapay düzen içinde doğal bir matematiksel estetik hissi uyandırmaktadır. Bu kapsamda eser, hem katı kurallarla inşa edilmiş sistematik bir kompozisyon hem de kendi içinde çoğalan, izleyiciye farklı perspektifler sunan bir sanatsal form olarak değerlendirilebilir.

2.3.Geometrisinden Eliptik ve Hiperbolik Geometriye Sanatın Yeni Gerçekliği

Matematiksel eğrilerden biri olan helisoid eğrisinin de doğada olduğu kadar sanatta da pek çok sanatçının ilham aldığı bir yapı olduğu görülür. Helisodi eğrisi "merkezinden uzaklaşarak ve merkezi etrafında dönmesi ile oluşan" bir spiraldir ve birbirinden eşit uzaklıkta sarımlardan oluşan spirali ilk tanımlayan Yunan matematikçi Arşimet olmuştur. "Logaritmik ya da eşit açılı spiral" olarak adlandırılan ikinci tip spiral ise 1638'te Descartes tarafından bulunmuştur (Deligeorge, 1998, s.47; Atabey, 2022, s.71). DNA molekülü, spiral galaksiler, deniz kabukları ve sarmaşık bitkilerinin büyüme şekli, helisoid eğrisine örnek olarak verilebilir. Bu eğri, sanat eserlerinde genellikle hareket ve akıcılığı vurgulamak amacıyla ve yoğun olarak konstrüktivist sanatçıların kinetik heykellerinde kullanılmıştır. Helisoid eğrisi, mimari tasarımlarda dinamik bir görünüm sağlarken, resim ve heykel sanatında derinlik hissi yaratmaktadır (İrhan, 2013, s.44). Örneğin Gorproekt şirketi tarafından 2011-2014 yılları arasında Moskova'da tasarlanan ve baş mimarı Philipp Nikandrov tarafından hayata geçirilen *Evolution Tower [Evrim Kulesi],* helisoid eğrisi temel alınarak oluşturulan bir yapıdır ve modern mimaride matematiksel

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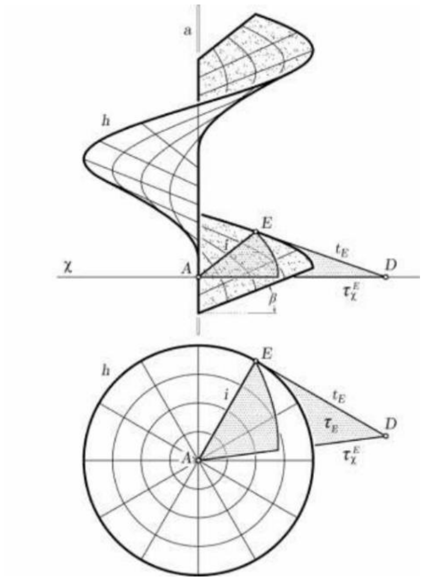
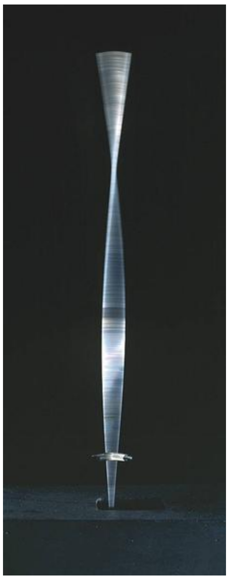
formların estetikle nasıl birleşebileceğini gösteren dikkat çekici örneklerden biridir. Kule, 2016 yılında Yüksek Binalar ve Kentsel Çevre Konseyi tarafından dünyanın en yüksek 30 spiral gökdeleni arasında gösterilmiştir (Atabey, 2022, s.71). Evrim Kulesi'nin tasarımında helisoid eğrisi kullanılmıştır. Bu eğri, silindirik bir yüzey etrafında dönerken yükselen ve dinamik bir form oluşturan matematiksel bir yapıdır. DNA sarmalına benzerliğiyle evrim ve gelişim kavramlarına atıfta bulunmaktadır. Matematiksel açıdan bakıldığında, helisoid eğrisi simetri, açı hesaplamaları ve mekânsal düzenlemeler gerektirir. Bu geometrik yapı, estetik güzellik sağlarken mühendislik açısından da önemli işlevler üstlenmiştir.



Görsel 10. Helisoid eğrisi matematiksel formül / Görsel 11. Philipp Nikandrov (mimar), Evolution Tower [Evrim Kulesi], 2011-2014 / Görsel 12. Naum Gabo, Standing Wave [Duran Dalga], 1920

Naum Gabo'nun diğer pek çok eserinde olduğu gibi *Standing Wave [Duran Dalga]* (1920) isimli eserinde de geometrik yapılara yoğun bir gönderme vardır ve söz konusu kinetik heykel özellikle belirli bir tetikleyiciyle etkileşime girdiği anda helisoid eğrisine benzer bir sarmal/spiral form yaratacak şekilde merkez etrafında titreşen dinamik bir forma dönüşür. Yine Bertil Herlow Svensson'ın -diğer çalışmalarında sıklıkla gözlemlenen geometrik yapılar ve matematiksel eğrilere olan göndermeler gibi- *Konstruktion-Spiral [Konstrüksiyon-Sarmal]* isimli alüminyum malzemeden üretilen heykeli de doğrudan helisoid eğrisine gönderme yapan spiral bir forma sahiptir.

Helisoid eğrisinin yanı sıra Möbius şeridi ve Klein şişesi gibi matematiksel yüzeylerin de sanat ve mimaride önemli ilham kayaklarından olduğu görülmektedir. 1858'de Alman matematikçiler August Ferdinand Möbius ve Johann Benedict Listing tarafından bağımsız olarak keşfedilen Möbius şeridi, yalnızca bir kenarı ve yalnızca bir sınır bileşeni olan bir yüzeydir. "Normal bir şeridin iki yüzü olmasına karşın Möbius şeridinin bir yüzü vardır. Diğer bir ifadeyle, Möbius şeridinin üzerindeki bir noktadan hareket edildiğinde yine aynı noktaya geri dönülür" (Baytaroğlu ve Bayhan, 2019, s.20). Tek bir yüzeye sahip olmasıyla ilginç bir matematiksel yapı olan bu şerit, sanatçılar tarafından sıklıkla sonsuzluk ve döngüsellik kavramlarını yansıtmak için kullanılmaktadır (Öner, 2016, s.607). Ayrıca, Möbius şeridinin

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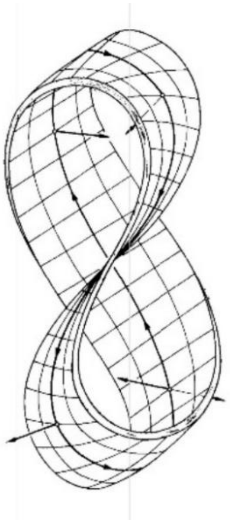
fiziksel formlara dönüşümü, sanat eserlerinde soyut matematiğin somut bir yansıması olarak karşımıza çıkmaktadır.



Görsel 13. Mobius Şeridi matematiksel formül / Görsel 14. Plamen Yordanov, Double Mobius Strip [Çift Mobius Şeridi], 2011 / / Görsel 15. Fenella Elms, Moody Mobius

Mobius şeridinden ilhamla yaratılan sanat eserleri arasında Escher'ın 1964 tarihli *Mobius Strip II [Mobius Şeridi]* isimli çalışması şüphesiz formun görsel illüzyon yaratmak için doğrudan kullanıldığı en bilinen örnekler arasında yer almaktadır. Söz konusu matematiksel yapı yine pek çok heykel sanatçısının da farklı dönemlerde esinlendiği ve kullandığı bir form olmuş, 2011 yılında Plamen Yordanov'un kamusal alanda yer sergilenen heykelleri arasından *Double Mobius Strip [Çift Mobius Şeridi]* bu örnekler arasında yer almıştır. Benzer biçimde Fenella Elms'in *Moody Mobius [Huysuz Mobius]* eseri de, Möbius şeridinin matematiksel yapısını sanatsal bir formda yeniden yorumlayan dikkat çekici bir çalışmadır. Tek yüzeyli ve tek kenarlı bu yapı, geleneksel iç-dış, başlangıç-bitiş kavramlarını ortadan kaldırarak izleyicide yönsüz bir akış hissi uyandırır. Form, sürekli kendini tekrar eden döngüsel bir hareketle mekân algısını kırar ve izleyicinin bakış açısına göre değişen bir perspektif sunar. Sanatçının ifadesiyle, üretim süreci psikanalitik çalışmalarından aktarılan bir uygulamaya dayanır ve "birçok bileşeni bir araya getirmenin tekrarlayan doğası bir ritim yaratır" (Milena, 2013). Elms'in eseri, yalnızca biçimsel bir Möbius referansı sunmakla kalmaz, aynı zamanda kavramsal düzeyde de bu matematiksel yapıyı hissettiren bir yapıdadır. İlk bakışta düzenli bir form gibi görünse de farklı açılardan incelendiğinde yönlerin ve sınırların akışkan olduğu anlaşılır. Sanatçının seramik parçaları titizlikle birbirine bağlaması, eserin hem matematiksel kesinliğini hem de el işçiliği ile kazandırılan organik dinamizmini vurgular.

Diğer bir matematiksel yapı olan Klein şişesi de Möbius şeridi ile benzer özelliklere sahip olup, iç ve dış yüzeyin birleştiği tek bir yüzey oluşturur. Bu yapı, sanatçılara ve tasarımcılara yeni perspektifler sunarak, görsel sanatlarda derinlikli ve çarpıcı eserler ortaya çıkarmalarına olanak tanımıştır (Miraboğlu, 2019, s.8).

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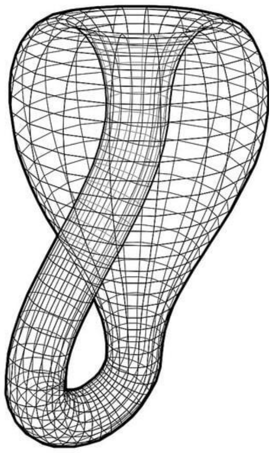
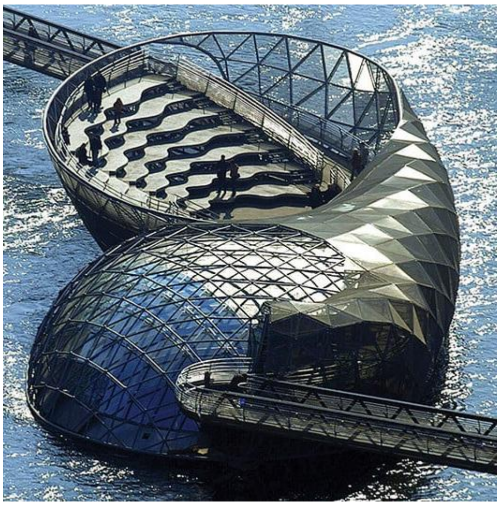


Görsel 16. Klein Şişesi Modeli / Görsel 17. Vito Acconci, Mur Island [Mur Adası], 2004 / Görsel 18. Alan Bennett, Klein Bottle [Klein Şişesi], 1995

Alan Bennett, Klein şişesi ile Möbius şeridi arasındaki ilişkiden yola çıkarak, matematiksel hesaplamalardan çok bu yapıların fiziksel olarak üretilmesine odaklanan sanatçılardan biridir. İlk Klein şişesi deneyimi sonrası, "İki parçaya bölündüğünde üç burmalı iki Möbius şeridi oluşturacak bir form nasıl tasarlanabilir?" sorusunu merkeze alarak farklı şişe formları geliştirdiği bilinmektedir (Daşkesen, 2015, s.37). Bennett'in Klein şişeleri, matematiği sanat yoluyla somutlaştıran örnekler arasında önemli bir yer tutmaktadır. Sanatçı, matematiksel kavramları cam üfleme tekniğiyle fiziksel bir gerçekliğe dönüştürerek, bu alanda çarpıcı sonuçlar elde etmiştir (İrhan, 2013, s.31). Sanatçının 1995 tarihli iç içe geçmiş üç Klein şişesinden oluşan eseri *Klein Bottle [Klein Şişesi]* -kullandığı malzemenin yapısal özellikleri nedeniyle de- herhangi bir başlangıç veya bitiş noktasına sahip olmayan bir formda tasarlanmıştır. Sanatçının matematiksel bir nesneyi fiziksel dünyaya taşıma biçimi, eserin en dikkat çekici yanıdır. Matematiksel olarak dört boyutlu uzayda var olması gereken Klein şişesi, üç boyutlu dünyada kaçınılmaz bir indirgemeye maruz kalmaktadır. Bu noktada Bennett'in sanatsal yorumu devreye girer; camın akışkanlığı ve formun organik yapısı, esere yalnızca matematiksel değil, aynı zamanda estetik bir boyut kazandırır. Eserin yüzeylerinin kıvrılması ve kendi içine kapanması, tek bir yüzeyden oluşmasına rağmen çok katmanlı bir yapı hissi yaratır. Möbius şeridinde olduğu gibi, izleyici yönelim duygusunu kaybetmeye başlar; formu anlamaya çalıştıkça mekânsal algı kırılmaya uğrar. Bennett, Klein şişesi ile yalnızca matematiksel bir modeli fiziksel dünyaya taşımakla kalmaz, aynı zamanda izleyiciyi mekân ve boyut algısının sınırlarıyla yüzleşmeye davet eder.

Benzer biçimde New York merkezli sanatçı Vito Acconci tarafından 2004 yılında Avusturya'nın Graz şehri için tasarlanan *Mur Island [Mur Adası]* isimli proje de doğrudan olmasa da Klein şişesi modelinden ilhamla tasarlanan önemli mimari yapılar arasındadır. Yapısal olarak Klein şişesine olan benzerliği ile dikkat çeken proje "camdan yapılmış çelik bir kafes yapıdan yapılmış yüzen bir platform üzerine" yerleştirilmiştir (Lord, 2005).

Görüldüğü gibi matematik ve sanat, doğanın temel yapı taşlarını anlamak ve ifade etmek için birbirini tamamlayan iki önemli alan olmuştur. Fibonacci dizisi, altın oran, fraktal geometri, Helisoid eğrisi ve Möbius şeridi gibi matematiksel yapılar, hem doğanın düzenini anlamamıza

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yardımcı olmuş hem de sanatçılar için estetik ve denge unsuru olarak önemli bir yer tutmuştur. Tarih boyunca, matematiksel prensipler sanat eserlerinde kendini göstermiş, sanatçılar da bu prensipleri kullanarak evrensel güzellik anlayışını eserlerine yansıtmıştır.

SONUÇ

Matematik ve sanat arasındaki ilişki, estetik ve yapısal düzenin buluştuğu noktada şekillenmektedir. Matematik, sanatta kompozisyon, oran ve perspektifin belirlenmesinde sistematik bir yaklaşım sunarken, sanat da matematiksel yapıların görsel bir dil ile ifadesine aracı olmaktadır. Geometri, simetri, fraktal yapılar, altın oran ve perspektif gibi matematiksel kavramlar, sanatçılara estetik çözümler sunmuş, eserlerin düzen ve uyum içerisinde tasarlanmasını sağlamıştır. Tarihsel süreçte Pisagor, Platon ve Euclid gibi matematikçilerin düşünceleri, sanatçıların estetik anlayışlarını şekillendirirken; Rönesans döneminde Leonardo da Vinci, Paolo Uccello ve Piero della Francesca gibi sanatçılar matematikle sanatsal düzeni birleştirerek eserlerine bilimsel bir bakış kazandırmıştır. Modern dönemde ise Fibonacci dizisi ve fraktal geometri gibi matematiksel kavramlar, sanat ve mimarlıkta yeni perspektifler sunarak çağdaş sanatçılar ve tasarımcılar için ilham kaynağı olmuştur.

Matematiksel kavramların sanatta bilinçli olarak uygulanması, sanat eserlerinin daha düzenli ve estetik olmasını sağlarken, aynı zamanda izleyicinin görsel algısını da etkileyerek daha derin bir sanat deneyimi oluşturmaktadır. Özellikle perspektifin resim sanatında devrim yaratması, sanatçıların mekânı daha gerçekçi bir biçimde betimlemelerine olanak tanımış ve bu sayede sanat eserlerinin güzellik algısı çok daha bilimsel bir yaklaşımla şekillendirilmiştir. Ayrıca, modern ve dijital sanat uygulamalarında matematiksel ilkeler, yeni teknolojilerle birlikte sanatçılara yaratıcı ve yenilikçi yöntemler sunarak sanat ve bilimin keskin sınırlarını ortadan kaldırmaktadır. Sanat ve matematik arasındaki bağ, insanlığın doğayı ve evreni anlama çabasının bir sonucu olarak ortaya çıkmış ve gelişmiştir.

Sonuç olarak, matematik ve sanat birbirini tamamlayan iki düşünsel alan olarak kabul edilmelidir. Matematik, sanatta estetik ve düzeni sağlarken, sanat da matematiksel yapıların duygusal ve görsel anlatımını güçlendirmektedir. Gerek geleneksel sanat anlayışında, gerekse modern ve çağdaş sanat uygulamalarında matematiksel kavramlar, sanat eserlerinin derinlik ve anlam kazanmasını sağlayan temel bileşenlerden biri olmaya devam etmektedir. Matematik ve sanatın keskin çizgilerle ayrılması yerine, bu iki alanın birbirini tamamlayan disiplinler olarak görülmesi, hem sanatsal yaratıcılığın gelişmesine hem de matematiksel kavrayışın genişlemesine katkı sağlayacaktır.

KAYNAKÇA

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GRAY MAP IN THE RING $\mathbb{Z}_2+u_2\mathbb{Z}_2+u_1\mathbb{Z}_2+u_2^2\mathbb{Z}_2+u_1^2\mathbb{Z}_2$

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ABSTRACT

On the ring $\mathbb{Z}_2+u_2\mathbb{Z}_2+u_1\mathbb{Z}_2+u_2^2\mathbb{Z}_2+u_1^2\mathbb{Z}_2$defined by conditions $u_1^3=0$, $u_2^3=0$ and $u_1.u_2=u_2.u_1=0$ the elements $\mathbb{Z}_2$to a function covering 1-1 is defined. This ring is created to define certain codes in coding theory. In order to determine the application areas of the codes defined on the ring, the equivalents of these codes on the object and the code features they provide are studied. For this, it is necessary to define an isomorphism between the ring and the object. In addition, this defined function must maintain the minimum distance between both codes. In this study, $\mathbb{Z}_2+u_1\mathbb{Z}_2+u_2\mathbb{Z}_2+u_1^2\mathbb{Z}_2+u_2^2\mathbb{Z}_2$the Gray transform defined in the given ring is first $\mathbb{Z}_2+u_1\mathbb{Z}_2+u_1^2\mathbb{Z}_2$taken to the ring. Then, a transition is provided by defining it on the field from here $\mathbb{Z}_2$. The Gray map on $\mathbb{Z}_2+u_1\mathbb{Z}_2+u_2\mathbb{Z}_2+u_1^2\mathbb{Z}_2+u_2^2\mathbb{Z}_2$ the ring and field $\mathbb{Z}_2$of 32 elements in the ring $\mathbb{Z}_2+u_1\mathbb{Z}_2+u_1^2\mathbb{Z}_2$are presented.

Keywords: Finite Ring, Gray Map, Codes.

1. $\mathbb{Z}_2+u_2\mathbb{Z}_2+u_1\mathbb{Z}_2+u_2^2\mathbb{Z}_2+u_1^2\mathbb{Z}_2$ the Ring

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Firstly $\mathbb{Z}_2[u_1, u_2] / \langle u_1{}^3, u_2{}^3, u_1 . u_2 \rangle$ ring is defined and its structure is investigated. A new Gray transformation from this ring $\mathbb{Z}_2 + u_1\mathbb{Z}_2 + u_1{}^2\mathbb{Z}_2$ to the finite chain ring is created in this ring. weight function by us prepared . These rings with objects on Relationships will be established. More This in the rings different linear code structures is defined and Results periodic in the lists place is taking.

$\mathbb{Z}_2 + u_2\mathbb{Z}_2 + u_2\mathbb{Z}_2$ that is a ring with addition and multiplication operations and $u_1{}^3 = 0$ is isomorphic to the ring of . Here, $\mathbb{Z}_2$ when the ring of is taken $\mathbb{Z}_2[u] / \langle u^3 \rangle$ instead of $R' = \mathbb{Z}_2 + u_2\mathbb{Z}_2 + u_2{}^2\mathbb{Z}_2$ the field of $u_2{}^3 = 0$, the set $u_1{}^3 = 0$ of $R' + u_1R' + u_1{}^2R'$ is obtained. To write it more clearly, This of the cluster elements

$$
\begin{aligned}
R = \mathbb{Z}_2 + u_2\mathbb{Z}_2 + u_1\mathbb{Z}_2 + u_2{}^2\mathbb{Z}_2 + u_1{}^2\mathbb{Z}_2
&= \{0,1, u_2, u_1, u_2{}^2, u_1{}^2, 1 + u_2, 1 + u_1, 1 + u_2{}^2, 1 + u_1{}^2, u_2 + u_1, u_2 + u_2{}^2, u_2 \\
&+ u_1{}^2, u_1 + u_2{}^2, u_1 + u_1{}^2, u_2{}^2 + u_1{}^2, 1 + u_2 + u_1, 1 + u_2 + u_2{}^2, 1 + u_2 + u_1{}^2, 1 \\
&+ u_1 + u_2{}^2, 1 + u_1 + u_1{}^2, 1 + u_2{}^2 + u_1{}^2, u_2 + u_1 + u_1{}^2, u_2 + u_2{}^2 + u_1{}^2, u_2 + u_1 \\
&+ u_2{}^2, u_1 + u_2{}^2 + u_1{}^2, 1 + u_2 + u_1 + u_1{}^2, 1 + u_2 + u_2{}^2 + u_1{}^2, 1 + u_1 + u_2{}^2 \\
&+ u_1{}^2, u_2 + u_1 + u_2{}^2 + u_1{}^2, 1 + u_2 + u_1 + u_2{}^2 + u_1{}^2\}
\end{aligned}
$$

is in the form.

2. Gray Map in Ring $\mathbb{Z}_2 + \mathbf{u_2}\mathbb{Z}_2 + \mathbf{u_1}\mathbb{Z}_2 + \mathbf{u_2^2}\mathbb{Z}_2 + \mathbf{u_1^2}\mathbb{Z}_2$

This section $\mathbb{Z}_2 + u_2\mathbb{Z}_2 + u_1\mathbb{Z}_2 + u_2^2\mathbb{Z}_2 + u_1^2\mathbb{Z}_2$ A new Gray map is defined in the ring. With this Gray map, the Gray $\mathbb{Z}_2 + u_2\mathbb{Z}_2 + u_1\mathbb{Z}_2 + u_2^2\mathbb{Z}_2 + u_1^2\mathbb{Z}_2$ transform of the complete elements in the ring is under images calculated .

DEFINITION: $R = \mathbb{Z}_2 + u_2\mathbb{Z}_2 + u_1\mathbb{Z}_2 + u_2{}^2\mathbb{Z}_2 + u_1{}^2\mathbb{Z}_2$ and $R_1 = \mathbb{Z}_2 + u_1\mathbb{Z}_2 + u_1{}^2\mathbb{Z}_2$ to be as follows ;

$$\Phi: R \rightarrow R_1^4$$

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$a + b\mathrm{u}_2 + cu_1 + d\mathrm{u}_2{}^2 + eu_1{}^2 \mapsto \Phi(a + bv + cu_1 + dv^2 + eu_1{}^2)$

It happens . From here

$\Phi(a + bv + cu_1 + dv^2 + eu_1{}^2) = (x + y\mathrm{u}_2 + z\mathrm{u}_2{}^2) = (z, x + z, y + z, x + y + z)$

form defined to transformation $R = \mathbb{Z}_2 + \mathrm{u}_2\mathbb{Z}_2 + u_1\mathbb{Z}_2 + \mathrm{u}_2{}^2\mathbb{Z}_2 + u_1{}^2\mathbb{Z}_2$ ring is called the Gray map. Here

$x = a + cu_1 + eu_1{}^2$

$y = b + au_1 + (a + c)u_1{}^2$

$z = d + (a + b)u_1 + (b + c)u_1{}^2$

$a, b, c, d, e \in \mathbb{F}_2$ aspect has been taken .

DEFINITION: $R_1 = \mathbb{Z}_2 + u_1\mathbb{Z}_2 + u_1{}^2\mathbb{Z}_2, x', y', z' \in \mathbb{Z}_2$ including

$\Phi_1 : R_1 \rightarrow \mathbb{Z}_2^4$

$x' + y'u_1 + z'u_1{}^2 \longmapsto \Phi_1(x' + y'u_1 + z'u_1{}^2) = (z', x' + z', y' + z', x' + y' + z')$

form defined R_1Gray transform on the ring It is called .

3. Gray Map Application

This section we will look at the Gray map. according to elements images is stated . Before $R = \mathbb{Z}_2 + \mathrm{u}_2\mathbb{Z}_2 + u_1\mathbb{Z}_2 + \mathrm{u}_2{}^2\mathbb{Z}_2 + u_1{}^2\mathbb{Z}_2$ ring Gray map on images of When we examine

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$\Phi: R \to R_1^4$

$(0) \to \Phi(0) = (0,0,0,0)$

$(1) \to \Phi(1) = (u_1, 1 + u_1, u_1{}^2, 1 + u_1{}^2)$

$(\mathrm{u}_2) \to \Phi(\mathrm{u}_2) = (u_1 + u_1{}^2, u_1 + u_1{}^2, 1 + u_1 + u_1{}^2, 1 + u_1 + u_1{}^2)$

$(u_1) \to \Phi(u_1) = (u_1{}^2, u_1 + u_1{}^2, 0, u_1)$

$(\mathrm{u}_2{}^2) \to \Phi(\mathrm{u}_2{}^2) = (1,1,1,1)$

$(u_1{}^2) \to \Phi(u_1{}^2) = (0, u_1{}^2, 0, u_1{}^2)$

$(1 + \mathrm{u}_2) \to \Phi(1 + \mathrm{u}_2) = (u_1{}^2, 1 + u_1{}^2, 1 + u_1, u_1)$

$(1 + u_1) \to \Phi(1 + u_1) = (u_1 + u_1{}^2, 1 + u_1{}^2, u_1{}^2, 1 + u_1 + u_1{}^2)$

$(1 + \mathrm{u}_2{}^2) \to \Phi(1 + \mathrm{u}_2{}^2) = (1 + u_1, u_1, 1 + u_1{}^2, u_1{}^2)$

$(1 + u_1{}^2) \to \Phi(1 + u_1{}^2) = (u_1, 1 + u_1 + u_1{}^2, u_1{}^2, 1)$

$(\mathrm{u}_2 + u_1) \to \Phi(\mathrm{u}_2 + u_1) = (u_1, 0, 1 + u_1 + u_1{}^2, 1 + u_1{}^2)$

$(\mathrm{u}_2 + \mathrm{u}_2{}^2) \to \Phi(\mathrm{u}_2 + \mathrm{u}_2{}^2) = (1 + u_1 + u_1{}^2, 1 + u_1 + u_1{}^2, u_1 + u_1{}^2, u_1 + u_1{}^2)$

$(\mathrm{u}_2 + u_1{}^2) \to \Phi(\mathrm{u}_2 + u_1{}^2) = (u_1 + u_1{}^2, u_1, 1 + u_1 + u_1{}^2, 1 + u_1)$

$(u_1 + \mathrm{u}_2{}^2) \to \Phi(u_1 + \mathrm{u}_2{}^2) = (1 + u_1{}^2, 1 + u_1 + u_1{}^2, 1, 1 + u_1)$

$(u_1 + u_1{}^2) \to \Phi(u_1 + u_1{}^2) = (u_1{}^2, u_1, 0, u_1 + u_1{}^2)$

$(\mathrm{u}_2{}^2 + u_1{}^2) \to \Phi(\mathrm{u}_2{}^2 + u_1{}^2) = (1, 1 + u_1{}^2, 1, 1 + u_1{}^2)$

$(1 + \mathrm{u}_2 + u_1) \to \Phi(1 + \mathrm{u}_2 + u_1) = (0, 1 + u_1, 1 + u_1, 0)$

$(1 + \mathrm{u}_2 + v^2) \to \Phi(1 + \mathrm{u}_2 + \mathrm{u}_2{}^2) = (1 + u_1{}^2, u_1{}^2, u_1, 1 + u_1)$

$(1 + \mathrm{u}_2 + u_1{}^2) \to \Phi(1 + \mathrm{u}_2 + u_1{}^2) = (u_1{}^2, 1, 1 + u_1, u_1 + u_1{}^2)$

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$(1+u_1+\mathrm{u}_2{}^2) \rightarrow \Phi(1+u_1+\mathrm{u}_2{}^2) = (1+u_1+u_1{}^2, u^2, 1+u_1{}^2, u_1+u_1{}^2)$

$(1+u_1+u_1{}^2) \rightarrow \Phi(1+u_1+u_1{}^2) = (u_1+u_1{}^2, 1, u_1{}^2, 1+u_1)$

$(1+\mathrm{u}_2{}^2+u_1{}^2) \rightarrow \Phi(1+\mathrm{u}_2{}^2+u_1{}^2) = (1+u_1, u_1+u_1{}^2, 1+u_1{}^2, 0)$

$(\mathrm{u}_2+u_1+u_1{}^2) \rightarrow \Phi(\mathrm{u}_2+u_1+u_1{}^2) = (u_1, u_1{}^2, 1+u_1+u_1{}^2, 1)$

$(\mathrm{u}_2+\mathrm{u}_2{}^2+u_1{}^2) \rightarrow \Phi(\mathrm{u}_2+\mathrm{u}_2{}^2+u_1{}^2) = (1+u_1+u_1{}^2, 1+u_1, u_1+u_1{}^2, u_1)$

$(\mathrm{u}_2+u_1+\mathrm{u}_2{}^2) \rightarrow \Phi(\mathrm{u}_2+u_1+\mathrm{u}_2{}^2) = (1+u_1, 1, u_1+u_1{}^2, u_1{}^2)$

$(u_1+\mathrm{u}_2{}^2+u_1{}^2) \rightarrow \Phi(u_1+\mathrm{u}_2{}^2+u_1{}^2) = (1+u_1{}^2, 1+u_1, 1, 1+u_1+u_1{}^2)$

$(1+\mathrm{u}_2+u_1+\mathrm{u}_2{}^2) \rightarrow \Phi(1+\mathrm{u}_2+u_1+\mathrm{u}_2{}^2) = (1, u_1, u_1, 1)$

$(1+\mathrm{u}_2+u_1+u_1{}^2) \rightarrow \Phi(1+\mathrm{u}_2+u_1+u_1{}^2) = (0, 1+u_1+u_1{}^2, 1+u_1, u_1{}^2)$

$(1+\mathrm{u}_2+\mathrm{u}_2{}^2+u_1{}^2) \rightarrow \Phi(1+\mathrm{u}_2+\mathrm{u}_2{}^2+u_1{}^2) = (1+u_1{}^2, 0, u_1, 1+u_1+u_1{}^2)$

$(1+u_1+\mathrm{u}_2{}^2+u_1{}^2) \rightarrow \Phi(1+u_1+\mathrm{u}_2{}^2+u_1{}^2) = (1+u_1+u_1{}^2, 0, 1+u_1{}^2, u_1)$

$(\mathrm{u}_2+u_1+\mathrm{u}_2{}^2+u_1{}^2) \rightarrow \Phi(\mathrm{u}_2+u_1+\mathrm{u}_2{}^2+u_1{}^2) = (1+u_1, 1+u_1{}^2, u_1+u_1{}^2, 0)$

$(1+\mathrm{u}_2+u_1+\mathrm{u}_2{}^2+u_1{}^2) \rightarrow \Phi(1+\mathrm{u}_2+u_1+\mathrm{u}_2{}^2+u_1{}^2) = (1, u_1+u_1{}^2, u_1, 1+u_1{}^2)$

aspect is found . Then $R_1 = \mathbb{Z}_2 + u_1\mathbb{Z}_2 + u_1{}^2\mathbb{Z}_2$ ring Gray transformation on images of When we examine

$\Phi_1 : R_1^4 \rightarrow \mathbb{F}_2^{16}$

$(0,0,0,0) \rightarrow \Phi_1(0,0,0,0) = (0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0)$

$(u_1, 1+u_1, u_1{}^2, 1+u_1{}^2) \rightarrow \Phi_1(u_1, 1+u_1, u_1{}^2, 1+u_1{}^2) = (0,0,1,1,0,1,1,0,1,1,1,1,1,0,1,0)$

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$$(u_1+u_1^2,u_1+u_1^2,1+u_1+u_1^2,1+u_1+u_1^2) \rightarrow \Phi_1(u_1+u_1^2,u_1+u_1^2,1+u_1+u_1^2,1+u_1+u_1^2) = (1,1,1,1,1,1,0,0,0,0,0,0,0,0,1,1)$$

$$(u_1^2,u_1+u_1^2,0,u_1) \rightarrow \Phi_1(u_1^2,u_1+u_1^2,0,u_1) = (1,1,0,0,1,1,0,0,1,0,0,1,1,0,0,1)$$

$$(1,1,1,1) \rightarrow \Phi_1(1,1,1,1) = (0,0,0,0,1,1,1,1,0,0,0,0,1,1,1,1)$$

$$(0,u_1^2,0,u_1^2) \rightarrow \Phi_1(0,u_1^2,0,u_1^2) = (0,1,0,1,0,1,0,1,0,1,0,1,0,1,0,1)$$

$$(u_1^2,1+u_1^2,1+u_1,u_1) \rightarrow \Phi_1(u_1^2,1+u_1^2,1+u_1,u_1) = (1,1,0,0,1,0,1,0,1,1,1,1,1,0,0,1)$$

$$(u_1+u_1^2,1+u_1^2,u_1^2,1+u_1+u_1^2) \rightarrow \Phi_1(u_1+u_1^2,1+u_1^2,u_1^2,1+u_1+u_1^2) = (1,1,1,1,1,0,1,0,0,1,1,0,0,0,1,1)$$

$$(1+u_1,u_1,1+u_1^2,u_1^2) \rightarrow \Phi_1(1+u_1,u_1,1+u_1^2,u_1^2) = (0,0,1,1,1,0,0,1,1,1,1,1,0,1,0,1)$$

$$(u_1,1+u_1+u_1^2,u_1^2,1) \rightarrow \Phi_1(u_1,1+u_1+u_1^2,u_1^2,1) = (0,1,1,0,0,0,1,1,1,0,1,0,1,1,1,1)$$

$$(u_1,0,1+u_1+u_1^2,1+u_1^2) \rightarrow \Phi_1(u_1,0,1+u_1+u_1^2,1+u_1^2) = (0,0,1,1,0,0,0,0,1,0,0,1,1,0,1,0)$$

$$(1+u_1+u_1^2,1+u_1+u_1^2,u_1+u_1^2,u_1+u_1^2) \rightarrow \Phi_1(1+u_1+u_1^2,1+u_1+u_1^2,u_1+u_1^2,u_1+u_1^2) = (1,1,1,1,0,0,1,1,0,0,0,0,1,1,0,0)$$

$$(u_1 + {u_1}^2, u_1, 1 + u_1 + {u_1}^2, 1 + u_1) \to \Phi_1(u_1 + {u_1}^2, u_1, 1 + u_1 + {u_1}^2, 1 + u_1)$$
$$= (1,0,1,0,1,0,0,1,0,1,0,1,0,1,1,0)$$

$$(1 + {u_1}^2, 1 + u_1 + {u_1}^2, 1,1 + u_1) \to \Phi_1(1 + {u_1}^2, 1 + u_1 + {u_1}^2, 1,1 + u_1)$$
$$= (1,1,0,0,0,0,1,1,1,0,0,1,0,1,1,0)$$

aspect is found.

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FORMATION OF A 32-ELEMENT RING WITH COEFFICIENTS IN $\mathbb{Z}_2$ AND CYCLIC CODES OVER THE RING

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ABSTRACT

The formation of a 32-element ring with two variables and certain conditions are explained. The addition and multiplication operations of the elements on the ring and their results are presented. The main ideals of the ring are classified and the unitary elements are classified. In addition, the existence of cyclic codes on this ring is revealed. Certain properties of cyclic codes are explained.

Key Words: Finite Ring, Finite Field, Cyclic Codes.

1. 32 Element Ring with Binary Coefficients

This section , p *is* a prime number $u^3 = 0,\ v^3 = 0$and $u.v = v.u = 0$ while $\mathbb{F}_p[u,v]/\langle u^3, v^3, u.v\rangle$ and $\mathbb{F}_p + v\mathbb{F}_p + u\mathbb{F}_p + v^2\mathbb{F}_p + u^2\mathbb{F}_p$ rings are studied. New defined we are This two ring each other isomorphic . p^5 The relationships between the elements of the ring have been examined.

First $p = 2$, the elements $\mathbb{F}_2[u,v]/\langle u^3, v^3, u.v\rangle$on the ring $(1 + v^2)$ and cyclic codes were examined. The results of the multiplication of the elements of this ring with each other are given below.

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$\otimes$	0	1	v	u	v^2	u^2	$1+v$	$1+u$
0	0	0	0	0	0	0	0	0
1	0	1	v	u	v^2	u^2	$1+v$	$1+u$
v	0	v	v^2	0	0	0	$v+v^2$	v
u	0	u	0	u^2	0	0	u	$u+u^2$
v^2	0	v^2	0	0	0	0	v^2	v^2
u^2	0	u^2	0	0	0	0	u^2	u^2
$1+v$	0	$1+v$	$v+v^2$	u	v^2	u^2	$1+v^2$	$1+v+u$
$1+u$	0	$1+u$	v	$u+u^2$	v^2	u^2	$1+v+u$	$1+u^2$
$1+v^2$	0	$1+v^2$	v	u	v^2	u^2	$1+v+v^2$	$1+u+v^2$
$1+u^2$	0	$1+u^2$	v	u	v^2	u^2	$1+v+u^2$	$1+u+v^2$
$v+u$	0	$v+u$	v^2	u^2	0	0	$v+u+v^2$	$v+u+u^2$
$v+v^2$	0	$v+v^2$	v^2	0	0	0	v	$v+v^2$
$v+u^2$	0	$v+u^2$	v^2	0	0	0	$v+v^2+u^2$	$v+u^2$
$u+v^2$	0	$u+v^2$	0	u^2	0	0	$u+v^2$	$u+u^2+v^2$
$u+u^2$	0	$u+u^2$	0	u^2	0	0	$u+u^2$	u
v^2+u^2	0	v^2+u^2	0	0	0	0	v^2+u^2	v^2+u^2
$1+v+u$	0	$1+v+u$	$v+v^2$	$u+u^2$	v^2	u^2	$1+v+u+v^2$	$1+v+u^2$
$1+v+v^2$	0	$1+v+v^2$	$v+v^2$	u	v^2	u^2	1	$1+v+u^2$
$1+v+u^2$	0	$1+v+u^2$	$v+v^2$	u	v^2	u^2	$1+v^2+u^2$	$1+u+v+u^2$
$1+u+v^2$	0	$1+u+v^2$	v	$u+u^2$	v^2	u^2	$1+v+u+v^2$	$1+u^2+v^2$
$1+u+u^2$	0	$1+u+u^2$	v	$u+u^2$	v^2	u^2	$1+v+u+u^2$	1
$1+v^2+u^2$	0	$1+v^2+u^2$	v	u	v^2	u^2	$1+v+v^2+u^2$	$u+v^2+u^2$
$v+u+u^2$	0	$v+u+u^2$	v^2	u^2	0	0	$v+u+v^2+u^2$	$v+u$
$v+v^2+u^2$	0	$v+v^2+u^2$	v^2	0	0	0	$v+u^2$	$v+v^2+u^2$
$v+u+v^2$	0	$v+u+v^2$	v^2	u^2	0	0	$v+u$	$v+u+v^2+u^2$
$u+v^2+u^2$	0	$u+v^2+u^2$	0	u^2	0	0	$u+v^2+u^2$	$u+v^2$
$1+v+u+v^2$	0	$1+v+u+v^2$	$v+v^2$	$u+u^2$	v^2	u^2	$1+u$	$1+v+v^2+u^2$
$1+v+u+u^2$	0	$1+v+u+u^2$	$v+v^2$	$u+u^2$	v^2	u^2	$1+u+v^2+u^2$	$1+v$
$1+v+v^2+u^2$	0	$1+v+v^2+u^2$	$v+v^2$	u	v^2	u^2	$1+u^2$	$1+u+v+v^2+u^2$
$1+u+v^2+u^2$	0	$1+u+v^2+u^2$	v	$u+u^2$	v^2	u^2	$1+v+u+v^2+u^2$	$1+v^2$
$v+u+v^2+u^2$	0	$v+u+v^2+u^2$	v^2	u^2	0	0	$v+u+u^2$	$v+u+v^2$
$1+v+u+v^2+u^2$	0	$1+v+u+v^2+u^2$	$v+v^2$	$u+u^2$	v^2	u^2	$1+u+u^2$	$1+v+v^2$

$\otimes$	$1+v^2$	$1+u^2$	$v+u$	$v+v^2$	$v+u^2$	$u+v^2$	$u+u^2$	v^2+u^2
0	0	0	0	0	0	0	0	0
1	$1+v^2$	$1+u^2$	$v+u$	$v+v^2$	$v+u^2$	$u+v^2$	$u+u^2$	v^2+u^2
v	v	v	v^2	v^2	v^2	0	0	0
u	u	u	u^2	0	0	u^2	u^2	0
v^2	v^2	v^2	0	0	0	0	0	0
u^2	u^2	u^2	0	0	0	0	0	0
$1+v$	$1+v+v^2$	$1+v+u^2$	$v+u+v^2$	v	$v+v^2+u^2$	$u+v^2$	$u+u^2$	v^2+u^2
$1+u$	$1+u+v^2$	$1+u+v^2$	$v+u+u^2$	$v+v^2$	$v+u^2$	$u+u^2+v^2$	u	v^2+u^2
$1+v^2$	1	$1+u^2+v^2$	$v+u$	$v+v^2$	$v+u^2$	$u+v^2$	$u+u^2$	v^2+u^2
$1+u^2$	$1+v^2+u^2$	1	$v+u$	$v+v^2$	$v+u^2$	$u+v^2$	$u+u^2$	v^2+u^2
$v+u$	$v+u$	$v+u$	v^2+u^2	v^2	v^2	u^2	u^2	0
$v+v^2$	$v+v^2$	$v+v^2$	v^2	v^2	v^2	u^2	0	0
$v+u^2$	$v+u^2$	$v+u^2$	v^2	v^2	v^2	u^2	0	0
$u+v^2$	$u+v^2$	$u+v^2$	u^2	0	0	0	u^2	0
$u+u^2$	$u+u^2$	$u+u^2$	u^2	0	0	0	u^2	0
v^2+u^2	v^2+u^2	v^2+u^2	0	0	0	0	0	0
$1+v+u$	$1+v+u+v^2$	$1+v+u+u^2$	$v+u+v^2+u^2$	v	$v+v^2+u^2$	$u+u^2+v^2$	u	v^2+u^2
$1+v+v^2$	$1+v$	$1+v+v^2+u^2$	$v+u+v^2$	v	$v+v^2+u^2$	$u+u^2+v^2$	$u+u^2$	v^2+u^2
$1+v+u^2$	$1+v+u^2+v^2$	$1+v$	$v+u+v^2$	$v+v^2$	$v+v^2+u^2$	$u+u^2+v^2$	$u+u^2$	v^2+u^2
$1+u+v^2$	$1+u$	$u+v^2+u^2$	$v+u+u^2$	$v+v^2$	$v+u^2$	$u+v^2$	u	v^2+u^2
$1+u+u^2$	$1+u+u^2+v^2$	$1+u$	$v+u+u^2$	$v+v^2$	$v+u^2$	$u+v^2$	u	v^2+u^2
$1+v^2+u^2$	$1+u^2$	$1+v^2$	$v+u$	$v+v^2$	$v+u^2$	$u+v^2$	$u+u^2$	v^2+u^2

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$v+u+u^2$	$v+u+u^2$	$v+u+u^2$	v^2+u^2	v^2	$v+u^2$	$u+v^2$	u^2	0
$v+v^2+u^2$	$v+v^2+u^2$	$v+v^2+u^2$	v^2	v^2	v^2	u^2	0	0
$v+u+v^2$	$v+u+v^2$	$v+u+v^2$	v^2+u^2	v^2	v^2	u^2	u^2	0
$u+v^2+u^2$	$u+v^2+u^2$	$u+v^2+u^2$	u^2	0	0	0	u^2	0
$1+v+u+v^2$	$1+v+u$	$1+v+u+v^2+u^2$	$v+u+v^2+u^2$	v	$v+v^2+u^2$	$u+u^2+v^2$	u	v^2+u^2
$1+v+u+u^2$	$1+v+u+v^2+u^2$	$1+v+u$	$v+u+v^2+u^2$	v	$v+v^2+u^2$	$u+u^2+v^2$	u	v^2+u^2
$1+v+v^2+u^2$	$1+v+u^2$	$1+v+v^2$	$v+u+v^2$	v	$v+v^2+u^2$	$u+u^2+v^2$	$u+u^2$	v^2+u^2
$1+u+v^2+u^2$	$1+u+u^2$	$1+u+v^2$	$v+u+u^2$	$v+v^2$	$v+u^2$	$u+v^2$	u	v^2+u^2
$v+u+v^2+u^2$	$u+u^2$	$v+u+v^2+u^2$	v^2+u^2	v^2	v^2	u^2	u^2	0
$1+v+u+v^2+u^2$	$1+u+u^2+v^2$	$1+v+u+v^2$	$v+u+v^2+u^2$	v	$v+v^2+u^2$	$u+u^2+v^2$	u	v^2+u^2

$\otimes$	$1+v+u$	$1+v+v^2$	$1+v+u^2$	$1+u+v^2$	$1+u+u^2$	$1+v^2+u^2$
0	0	0	0	0	0	0
1	$1+v+u$	$1+v+v^2$	$1+v+u^2$	$1+u+v^2$	$1+u+u^2$	$1+v^2+u^2$
v	$v+v^2$	$v+v^2$	$v+v^2$	v	v	v
u	$u+u^2$	u	u	$u+u^2$	$u+u^2$	u
v^2	v^2	v^2	v^2	v^2	v^2	v^2
u^2	u^2	u^2	u^2	u^2	u^2	u^2
$1+v$	$1+u+v^2$	1	$1+v^2+u^2$	$1+v+u+v^2$	$1+v+u+u^2$	$1+v+v^2+u^2$
$1+u$	$1+v+u^2$	$1+v+u+v^2$	$1+v+u+u^2$	$1+v^2+u^2$	1	$1+u+v^2+u^2$
$1+v^2$	$1+v+u+v^2$	$1+v$	$1+v+v^2+u^2$	$1+u$	$1+u+u^2+v^2$	$1+u^2$
$1+u^2$	$1+v+u+u^2$	$1+v+v^2+u^2$	$1+v$	$1+u+v^2+u^2$	$1+u$	$1+v^2$
$v+u$	$v+u+v^2+u^2$	$v+u+v^2$	$v+u+v^2$	$v+u+u^2$	$v+u+u^2$	$v+u$
$v+v^2$	v	v	v	$v+v^2$	$v+v^2$	$u+v^2$
$v+u^2$	$v+v^2+u^2$	$v+v^2+u^2$	$v+v^2+u^2$	$v+u^2$	$v+u^2$	$v+u^2$
$u+v^2$	$u+v^2+u^2$	$u+v^2$	$u+v^2$	$u+v^2+u^2$	$u+u^2+v^2$	$u+v^2$
$u+u^2$	u	$u+u^2$	$u+u^2$	u	u	$u+u^2$
v^2+u^2	v^2+u^2	v^2+u^2	v^2+u^2	v^2+u^2	v^2+u^2	v^2+u^2
$1+v+u$	$1+v^2+u^2$	$1+u$	$1+u+v^2+u^2$	$1+v+v^2+u^2$	$1+v$	$1+v+u+v^2+u^2$
$1+v+v^2$	$1+u$	$1+v^2$	$1+u^2$	$1+v+u$	$1+u+u^2+v+v^2$	$1+u+u^2$
$1+v+u^2$	$1+u+v^2+u^2$	$1+u^2$	$1+v^2$	$1+v+u+v^2+u^2$	$1+v+u$	$1+v+v^2$
$1+u+v^2$	$1+v+v^2+u^2$	$1+v+u$	$1+v+u+v^2+u^2$	$1+u^2$	$1+v^2$	$1+u+u^2$
$1+u+u^2$	$1+v$	$1+v+u+v^2+u^2$	$1+v+u$	$1+v^2$	$1+u^2$	$1+u+v^2$
$1+v^2+u^2$	$1+v+u+v^2+u^2$	$1+v+u^2$	$1+v+v^2$	$1+u+u^2$	$1+u+v^2$	1
$v+u+u^2$	$v+u+v^2$	$v+u+v^2+u^2$	$v+u+v^2+u^2$	$v+u$	$v+u$	$v+u+u^2$
$v+v^2+u^2$	$v+u^2$	$v+u^2$	$v+u^2$	$v+v^2+u^2$	$v+v^2+u^2$	$v+v^2+u^2$
$v+u+v^2$	$v+u+u^2$	$v+u$	$v+u$	$v+u+v^2+u^2$	$v+u+v^2+u^2$	$v+u+v^2$
$u+v^2+u^2$	$u+v^2$	$u+v^2+u^2$	$u+v^2+u^2$	$u+v^2$	$u+v^2$	$u+v^2+u^2$
$1+v+u+v^2$	u^2	$1+u+v^2$	$1+u+u^2$	$1+v+u^2$	$1+v+v^2$	$1+v+u+u^2$
$1+v+u+u^2$	v^2	$1+u+u^2$	$1+u+v^2$	$1+v+v^2$	$1+v+u^2$	$1+v+u+v^2$
$1+v+v^2+u^2$	$1+u+u^2$	$1+u^2+v^2$	1	$v+u+u^2$	$1+v+u+v^2$	$1+v$
$1+u+v^2+u^2$	$1+v+v^2$	$1+v+u+u^2$	$1+v+u+v^2$	1	$1+v^2+u^2$	$1+u$
$v+u+v^2+u^2$	$v+u$	$v+u+u^2$	$v+u+u^2$	$v+u+v^2$	$v+u+v^2$	$v+u+v^2+u^2$
$1+v+u+v^2+u^2$	1	$1+u+u^2+v^2$	$1+u$	$1+v$	$1+v+v^2+u^2$	$1+v+u$

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$\otimes$	$v+u+u^2$	$v+v^2+u^2$	$v+u+v^2$	$u+v^2+u^2$	$1+v+u+v^2$
0	0	0	0	0	0
1	$v+u+u^2$	$v+v^2+u^2$	$v+u+v^2$	$u+v^2+u^2$	$1+v+u+v^2$
v	v^2	v^2	v^2	0	$v+v^2$
u	u^2	0	u^2	u^2	$u+u^2$
v^2	0	0	0	0	v^2
u^2	0	0	0	0	u^2
$1+v$	$v+u+v^2+u^2$	$v+u^2$	$v+u$	$u+v^2+u^2$	$1+u$
$1+u$	$v+u$	$v+v^2+u^2$	$v+u+v^2+u^2$	$u+v^2$	$1+v+v^2+u^2$
$1+v^2$	$v+u+u^2$	$v+v^2+u^2$	$v+u+v^2$	$u+v^2+u^2$	$1+v+u$
$1+u^2$	$v+u+u^2$	$v+v^2+u^2$	$v+u+v^2$	$u+v^2+u^2$	$1+v+u+v^2+u^2$
$v+u$	v^2+u^2	v^2	v^2+u^2	u^2	$v+u+v^2+u^2$
$v+v^2$	v^2	v^2	v^2	0	v
$v+u^2$	v^2	v^2	v^2	0	$v+v^2+u^2$
$u+v^2$	u^2	0	u^2	u^2	$u+v^2+u^2$
$u+u^2$	u^2	0	u^2	u^2	u
v^2+u^2	0	0	0	0	v^2+u^2
$1+v+u$	$v+u+v^2$	$v+u^2$	$v+u+u^2$	$u+v^2$	$1+u^2$
$1+v+v^2$	$v+u+v^2+u^2$	$v+u^2$	$v+u$	$u+v^2+u^2$	$1+u+v^2$
$1+v+u^2$	$v+u+v^2+u^2$	$v+u^2$	$v+u$	$u+v^2+u^2$	$1+u+u^2$
$1+u+v^2$	$v+u$	$v+v^2+u^2$	$v+u+v^2+u^2$	$u+v^2$	$1+v+u^2$
$1+u+u^2$	$v+u$	$v+v^2+u^2$	$v+u+v^2+u^2$	$u+v^2$	$1+v+v^2$
$1+v^2+u^2$	$v+u+u^2$	$v+v^2+u^2$	$v+u+v^2$	$u+v^2+u^2$	$1+v+u+u^2$
$v+u+u^2$	v^2+u^2	v^2	v^2+u^2	u^2	$v+u+v^2$
$v+v^2+u^2$	v^2	v^2	v^2	0	$v+u^2$
$v+u+v^2$	v^2+u^2	v^2	v^2+u^2	u^2	$v+u+u^2$
$u+v^2+u^2$	u^2	0	u^2	u^2	$u+v^2$
$1+v+u+v^2$	$v+u+v^2$	$v+u^2$	$v+u+u^2$	$u+v^2$	$1+v^2+u^2$
$1+v+u+u^2$	$v+u+v^2$	$v+u^2$	$v+u+u^2$	$u+v^2$	1
$1+v+v^2+u^2$	$v+u+v^2+u^2$	$v+u^2$	$v+u$	$u+v^2+u^2$	$1+u+v^2+u^2$
$1+u+v^2+u^2$	$v+u$	$v+v^2+u^2$	$v+u+v^2+u^2$	$u+v^2$	$1+v$
$v+u+v^2+u^2$	v^2+u^2	v^2	v^2+u^2	u^2	$v+u$
$1+v+u+v^2+u^2$	$v+u+v^2$	$v+u^2$	$v+u+u^2$	$u+v^2$	$1+v^2$

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$\otimes$	$1+v+u+u^2$	$1+v+v^2+u^2$	$1+u+v^2+u^2$	$v+u+v^2+u^2$	$1+v+u+v^2+u^2$
0	0	0	0	0	0
1	$1+v+u+u^2$	$1+v+v^2+u^2$	$1+u+v^2+u^2$	$v+u+v^2+u^2$	$1+v+u+v^2+u^2$
v	$v+v^2$	$v+v^2$	v	v^2	$v+v^2$
u	$u+u^2$	u	$u+u^2$	u^2	$u+u^2$
v^2	v^2	v^2	v^2	0	v^2
u^2	u^2	u^2	u^2	0	u^2
$1+v$	$1+u+v^2+u^2$	$1+u^2$	$1+v+u+v^2+u^2$	$v+u+u^2$	$1+u+u^2$
$1+u$	$1+v$	$1+v+u+v^2+u^2$	$1+v^2$	$v+u+v^2$	$1+v+v^2$
$1+v^2$	$1+v+u+v^2+u^2$	$1+v+u^2$	$1+u+u^2$	$v+u+v^2+u^2$	$1+v+u+u^2$
$1+u^2$	$1+v+u$	$1+v+v^2$	$1+u+v^2$	$v+u+v^2+u^2$	$1+v+u+v^2$
$v+u$	$v+u+v^2+u^2$	$v+u+v^2$	$v+u+u^2$	v^2+u^2	$v+u+v^2+u^2$
$v+v^2$	v	v	$v+v^2$	v^2	v
$v+u^2$	$v+v^2+u^2$	$v+v^2+u^2$	$v+u^2$	v^2	$v+v^2+u^2$
$u+v^2$	$u+v^2+u^2$	$u+v^2$	$u+v^2+u^2$	u^2	$u+v^2+u^2$
$u+u^2$	u	$u+u^2$	u	u^2	u
v^2+u^2	v^2+u^2	v^2+u^2	v^2+u^2	0	v^2+u^2
$1+v+u$	$1+v^2$	$1+u+u^2$	$1+v+v^2$	$v+u$	1
$1+v+v^2$	$1+u+u^2$	$1+v^2+u^2$	$1+v+u+u^2$	$v+u+u^2$	$1+u+v^2+u^2$
$1+v+u^2$	$1+u+v^2$	1	$1+v+u+v^2$	$v+u+u^2$	$v+v^2+u^2$
$1+u+v^2$	$1+v+v^2$	$1+v+u+u^2$	1	$v+u+v^2$	$1+v$
$1+u+u^2$	$1+v+u^2$	$1+v+u+v^2$	$1+v^2+u^2$	$v+u+v^2$	$1+v+v^2+u^2$
$1+v^2+u^2$	$1+v+u+v^2$	$1+v$	$1+u$	$v+u+v^2+u^2$	$1+v+u$
$v+u+u^2$	$v+u+v^2$	$v+u+v^2+u^2$	$v+u$	v^2+u^2	$v+u+v^2$
$v+v^2+u^2$	$v+u^2$	u^2	$v+v^2+u^2$	v^2	$v+u^2$
$v+u+v^2$	$v+u+u^2$	$v+u$	$v+u+v^2+u^2$	v^2+u^2	$v+u+u^2$
$u+v^2+u^2$	$u+v^2$	$u+v^2+u^2$	$u+v^2$	u^2	$u+v^2$
$1+v+u+v^2$	1	$1+u+v^2+u^2$	$1+v$	$v+u$	$1+v^2$
$1+v+u+u^2$	$1+v^2+u^2$	$1+u$	$1+v+v^2+u^2$	$v+u$	$1+u^2$
$1+v+v^2+u^2$	$1+u$	$1+v+v^2$	$1+v+u$	$v+u+u^2$	$1+u+v^2$
$1+u+v^2+u^2$	$1+v+v^2+u^2$	$1+v+u$	$1+u^2$	$v+u+v^2$	$1+v+u^2$
$v+u+v^2+u^2$	$v+u$	$v+u+u^2$	$v+u+v^2$	v^2+u^2	$v+u$
$1+v+u+v^2+u^2$	$1+u^2$	$1+v+u+v^2$	$1+v+u^2$	$v+u$	$1+v^2+u^2$

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2. Cyclic Code on This Ring

In this section When we work on the ring $\mathbb{F}_2 + v\mathbb{F}_2 + u\mathbb{F}_2 + v^2\mathbb{F}_2 + u^2\mathbb{F}_2$ in the cases of $u^3 = 0$, $v^3 = 0$, and $u.v = v.u = 0$, let's call this ring R for convenience. Cyclic codes with this R ring are explained below.

DEFINITION : Let C be linear code (length n) on the ring $R = \mathbb{F}_2 + v\mathbb{F}_2 + u\mathbb{F}_2 + v^2\mathbb{F}_2 + u^2\mathbb{F}_2$.

$$\sigma: R^n \to R^n$$

$$(c_0, c_1, \dots, c_{n-1}) \longmapsto \sigma(c_0, c_1, \dots, c_{n-1}) = (c_{n-1}, c_0, \dots, c_{n-2})$$

If permutation $\sigma(C) = C$ is satisfied, then the C code is called a cyclic code in R.

DEFINITION : Let C be linear code (length n) on the ring $R = \mathbb{F}_2 + v\mathbb{F}_2 + u\mathbb{F}_2 + v^2\mathbb{F}_2 + u^2\mathbb{F}_2$.

$$\gamma: R^n \to R^n$$

$$(c_0, c_1, \dots, c_{n-1}) \longmapsto \gamma(c_0, c_1, \dots, c_{n-1}) = \left((1 + v^2).c_{n-1}, c_0, \dots, c_{n-2}\right)$$

If permutation $\gamma(C) = C$ is satisfied, then C code is called a $(1 + v^2)$ $-$constacyclic code in R.

$c = (c_0, c_1, \dots, c_{n-1})$ code word of length n is represented on a ring in the form $R[x]$, where the ring R , a code is $c(x) = \sum_{i=0}^{n-1} c_i \,.\, x^i$. This notation on the ring R_1 can be used similarly and the Field $\mathbb{F}_2$

PROPOSITION: $C$is a linear code of length n on the ring R and the polynomial representation of this code is in the form $P(C) = \left\{\sum_{i=0}^{n-1} r_i x^i \,\middle|\, (r_0, r_1, \dots, r_{n-1}) \in C\right\}$. From here;

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i. C be a cyclic code on R necessary and sufficient condition $P(C)$ is that it is an ideal on the ring $R[x]/\langle x^n - 1\rangle$.

ii. C be a $(1+v^2)-consta$cyclic code on R necessary and sufficient condition $P(C)$ is that it is an ideal on the ring $R[x]/\langle x^n - (1+v^2)\rangle$.

DEFINITION : Let D be linear code (length 4n) on the ring R_1.

$$\tau: R_1^{4n} \to R_1^{4n}$$

$$(d_0, d_1, \dots, d_{4n-1}) \mapsto \tau(d_0, d_1, \dots, d_{4n-1}) = (d_{4n-1}, d_0, \dots, d_{4n-2})$$

If permutation $\tau(D) = D$ is satisfied, then C code is called a cyclic code in R_1.

$c = (c_0, c_1, \dots, c_{n-1})$ code word of length n is represented on a ring in the form $R[x]$, where the ring R , a code is $c(x) = \sum_{i=0}^{n-1} c_i . x^i$. This notation on the ring R_1 can be used similarly and the Field $\mathbb{F}_2$

PROPOSITION: D is a linear code of length n on the ring R_1 and the polynomial representation of this code is in the form $P_1(D) = \left\{\sum_{i=0}^{4n-1} s_i x^i \,\middle|\, (s_0, s_1, \dots, s_{4n-1}) \epsilon D\right\}$. From here;

i. D be a cyclic code on R_1 necessary and sufficient condition $P(D)$ is that it is an ideal on the ring $R_1[x]/\langle x^n - 1\rangle$.

ii. D be a $(1+u^2)-consta$cyclic code on R necessary and sufficient condition $P(D)$ is that it is an ideal on the ring $R_1[x]/\langle x^n - (1+u^2)\rangle$.

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MATEMATİK ÖĞRETİMİ: GELENEKSEL VE MODERN YAKLAŞIMLARIN BİRLEŞTİRİLMESİ

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ÖZET

Matematik öğretimi zamanla çeşitli yöntem ve yaklaşımlarla gelişmiştir. Aktif öğrenme yöntemleri öğrencileri derse daha fazla dahil eder ve bağımsız düşünme becerilerini geliştirir. İşbirlikli öğrenme, öğrencilerin birbirlerine yardım ederek kolektif olarak öğrenmelerini sağlar. Çağdaş yaklaşımlar, öğretimde teknoloji ve yeni yöntemlerin kullanımını içerir. Teknoloji, programlar ve simülasyonlar, derslerin daha etkileşimli ve görsel bir şekilde işlenmesini mümkün kılar. Matematik öğretim metodolojisinde geleneksel ve modern yaklaşımların birleştirilmesi, öğrencilerin derse olan ilgisini artırır ve daha yaratıcı ve analitik düşünmelerini teşvik eder. Modern yaklaşımlar aynı zamanda öğrencilerin bireysel ihtiyaçlarına göre hazırlanmış müfredatların tasarlanmasına ve bağımsız düşünme becerilerinin geliştirilmesine de yardımcı olmaktadır.

Anahtar kelimeler: Matematik öğretimi, Geleneksel öğretim yöntemi, Modern öğretim yaklaşımları, Öğrenci merkezli öğretim, Matematik programları.

TEACHING MATHEMATICS: COMBINING TRADITIONAL AND MODERN APPROACHES

Nuride ORUCOVA
Elgayid ALİZADE

SUMMARY

Mathematics education has been developed over time based on different methods and approaches. Active learning methods make the lesson a lesson and develop the ability to think independently. Cooperative learning enables them to learn collectively to help each other to learn. Uses modern approaches, technology and new methods in teaching. It is possible to teach lessons in technology, programs and simulations in a more interactive and visual way. Increases interest in the lessons of combining modern approaches in mathematics teaching methodology

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and encourages them to think more creatively and analytically. Modern approaches also help them to develop curricula tailored to their individual needs and develop independent skills.

Keyword: Mathematics teaching, Traditional teaching methods, Modern teaching approaches, Student-centered teaching, Mathematics programs.

1. MATEMATİK ÖĞRETİM METODOLOJİSİNİN ÖNEMİ VE AMACI

1.1. Matematik Öğretim Metodolojisinin Önemi:

Matematik öğretim metodolojisi, matematiğin öğrencilere nasıl öğretileceğine ilişkin bilimsel ve pratik ilkeler ile bunu sunmada kullanılan yöntem ve yaklaşımların bütünüdür. Matematik öğretiminde doğru metodoloji ve yaklaşımın seçilmesi, öğrencilerin bu konuya olan ilgi ve becerilerini doğrudan etkiler. Önemi birkaç temel noktada ortaya çıkmaktadır:

1. Temel Matematik Becerilerinin Kazanılması: Doğru matematik öğretim metodolojisini seçmek, öğrencilerin temel matematik bilgi ve becerilerine hakim olmalarına yardımcı olur. Matematiğin temel kavram ve prensiplerini öğrenmek, öğrencilerin daha karmaşık konuları anlamaları ve uygulamaları için temel oluşturur.
2. Öğrencilerin Analitik Düşünme Becerilerinin Geliştirilmesi: Matematik sadece bilginin ezberlenmesini değil, aynı zamanda problem çözmeyi, analitik düşünmeyi ve eleştirel düşünmeyi de gerektirir. Bu beceriler öğrencilerin diğer alanlardaki (örneğin fen bilimleri, mühendislik, ekonomi) başarısını da artırmaktadır.
3. Modern Eğitim Taleplerine Cevap Vermek: Modern eğitim sistemi daha öğrenci merkezli yaklaşımları ve etkileşimli öğrenme yöntemlerini desteklemektedir. Matematik öğretim metodolojilerinin modern yaklaşımlara uyarlanması, öğrencilerin çeşitli öğretim araç ve teknolojilerini kullanmalarına olanak tanır. Bu, onların öğrenme sürecini daha ilgi çekici ve etkili hale getirir.
4. Öğretim Sürecini Etkinleştirme: Matematik öğretiminde çeşitli yöntemlerin uygulanması, öğrencilerin daha aktif öğrenmesini sağlar. Örneğin, grup çalışmaları, projeler, oyunlar ve diğer etkileşimli yöntemler öğrencilerin derse olan ilgisini artırır. Bu yaklaşımlar, öğretim sürecini monotonluktan kurtarır ve öğrencilerin öğrenmeye daha fazla motive olmasını sağlar.
5. Ek Becerilerin Geliştirilmesi: Matematik öğretmek sadece mantıksal ve matematiksel becerileri değil, aynı zamanda takım çalışması, iletişim ve kendini ifade etme becerilerini de geliştirir. Modern öğretim yöntemleriyle öğrencilere bu tür ek beceriler kazandırılabilir.

1.2. Matematik Öğretim Metodolojisinin Amacı

Matematik öğretim metodolojisinin amacı, öğrencilere matematiğin temel kavramlarını, teorilerini ve pratik uygulamalarını öğretmekten daha fazlasıdır. Amacı, matematiğin çekici ve yararlı bir şekilde öğrenilmesini sağlayarak öğrencilerin genel entelektüel gelişimini desteklemektir.

1. Öğrencilerin Matematiksel Becerilerinin Geliştirilmesi: Matematik öğretiminin temel amacı öğrencilere matematiksel beceriler öğretmek ve bu becerileri gerçek hayatta uygulayabilmelerini sağlamaktır. Öğrencilerin problem çözme yetenekleri artar.

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2. Özgüven ve Bağımsız Düşünme Becerileri: Matematik öğretim metodolojisi, öğrencilerin özgüven ve bağımsız düşünme becerilerini geliştirmelerine yardımcı olmalıdır. Öğretim yöntemleri öğrencilerin bağımsız olarak problem çözmeyi, karar almayı ve sonuç çıkarmayı öğrenmelerini desteklemelidir.
3. Yaratıcılığın ve Entelektüel Gelişimin Geliştirilmesi: Matematik öğretiminin temel amacı sadece tekrar ve formül ezberlemek değil, aynı zamanda öğrencilerin analitik ve yaratıcı düşünme yeteneklerini geliştirmektir. Öğrencilere doğru düşünme ve farklı yaklaşımlarla sorun çözme becerileri öğretilmelidir.
4. Çağdaş Eğitim Teknolojilerinin Kullanımı: Öğrencileri çağdaş eğitim teknolojileriyle tanıştırmak ve bu teknolojileri etkili bir şekilde nasıl kullanacaklarını öğretmek amaçlanmaktadır. Yeni teknolojilerin kullanımıyla matematik öğretimi daha etkileşimli, ilgi çekici ve faydalı hale getirilebilir.
5. Matematiğe İlgiyi Artırmak: Matematik öğretiminin amacı öğrencilerin matematiğe olan ilgisini artırmaktır. Eğer öğretim yöntemleri çekici ve öğrencilerin günlük yaşamlarına uygulanabilir ise,
Öğretim sürecinin doğru bir şekilde düzenlenmesinin öğrencilerin matematiksel becerilerinin gelişmesine nasıl yardımcı olduğunu vurgulamak.
Matematiksel analiz ve cebirin geliştirilmesinde gerekli beceriler: kavram oluşturma, soyut düşünme, analitik beceriler.
Öğrenci başarısını değerlendirme yolları: testler, projeler, uygulamalı ödevler.
Matematik Öğretim Yöntemleri ve Modern Yaklaşımlar hakkında daha detaylı konuşalım. Bu iki konu oldukça önemlidir çünkü öğretim yöntemleri ve yaklaşımları zamanla gelişir ve yeni teknolojiler ve metodolojiler derslerin daha ilgi çekici ve etkili olmasını sağlar.

2. MATEMATİK ÖĞRETİM YÖNTEMLERİ

Matematik öğretimi zaman içinde çeşitli yöntemlerle gelişmiştir. Her yöntemin kendine göre güçlü ve zayıf yönleri vardır. Bu yöntemlerin seçimi dersin amacına ve öğrencilerin ihtiyaçlarına uygun olmalıdır.

2.1. Geleneksel Yöntemler

2.1.1. Geleneksel Öğretim Yöntemi

Geleneksel öğretim yöntemi, matematik öğretiminde en uzun süredir kullanılan yaklaşımdır. Bu yöntemde öğretmen dersi anlatır, konuları örneklerle açıklar ve öğrencilere belirli görevler verir.
Öğretmen merkezli yaklaşım: Bu yaklaşımda öğretmen dersin merkezindedir. Öğretmen öğrencilere matematiğin teorik yönlerini anlatır ve görevleri tek tek açıklar.
Faydası: Geleneksel yöntem, öğrencilere formül içeren matematiksel teori ve kavramların doğru bir şekilde aktarılmasında etkili olabilir. Öğretmen açıklamaları, öğrencilere temel prensipleri açıklamak açısından çok önemlidir.
Zayıf yönleri: Bu yöntemde öğrencilerin aktif katılımı azdır ve öğrenme bağımsız olmaktan ziyade öğretmen tarafından yönlendirilir. Öğrenciler derslere karşı pasif bir yaklaşım sergilemektedirler ve ders anlatımı monoton ve sıkıcı hale gelebilmektedir.

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2.1.2. Aktif Öğrenme Yaklaşımları

Aktif öğrenme yöntemleri öğrencilerin kendilerini öğrenme sürecine dahil etmeye çalışır. Bu yaklaşım öğrencilerin öğrenme sürecine daha fazla katılımını sağlar.

Görev ve problemlerin tartışılması: Öğrenciler belirli konuları birlikte çözer ve birbirlerine yardım ederler. Bu hem analitik düşünme becerilerini geliştirir hem de sosyal becerilerini artırır.

Faydası: Aktif öğrenme yöntemleri öğrencilerin derse olan ilgisini artırır, bağımsız düşünmelerini ve yaratıcı yaklaşımlar uygulamalarını teşvik eder.

Dezavantajları: Bu yöntemin uygulanması zaman alıcı olabilir ve öğretmen için daha fazla hazırlık gerektirir. Aynı zamanda her öğrencinin öğrenme hızı farklı olduğu için her öğrenciye eşit şekilde yardımcı olmak zorlaşır.

2.1.3. Kooperatif Öğrenme Yaklaşımı

İşbirlikli öğrenme, öğrencilerin konuları öğrenmek ve birbirlerine destek olmak için küçük gruplar halinde çalışmalarına olanak tanır.

Grup ödevleri ve tartışmalar: Bu yaklaşımda öğrenciler birbirlerine sorunları çözmek ve yeni bakış açıları kazanmak için yardım ederler. Öğretmen grup çalışmalarının sonuçlarını izler ve öğrencilere rehberlik eder.

Faydası: Öğrenciler arasında işbirliği ve deneyim alışverişi gerçekleşir. İşbirlikli öğrenme sosyal becerileri geliştirir ve kolektif öğrenmeyi teşvik eder.

Zayıflıklar: Bazı öğrenciler grup çalışmalarında aktif olmayabilir ve öğrenmelerini diğer öğrencilere bağımlı hale getirebilirler.

2.2. Modern Yaklaşımlar

Çağdaş öğretim yaklaşımları, modern teknolojinin kullanımına ve öğrencilerin öğrenme ihtiyaçlarına uygun değişikliklere odaklanır. Bu yaklaşımlar dersin daha etkileşimli, dinamik ve öğrenci merkezli olmasını amaçlamaktadır.

2.2.1. Teknolojinin Kullanımı

Teknolojinin öğretimdeki rolü vazgeçilmezdir. Günümüzde matematik öğrenimi çeşitli programlar ve araçlar sayesinde çok daha kolay ve etkili hale gelmiştir.

Programlar ve eğitim uygulamaları: GeoGebra, Mathematica, MATLAB, Desmos gibi programlar ve uygulamalar matematiksel kavramları görsel olarak sunar ve öğrencilere daha etkileşimli bir öğrenme deneyimi sağlar. Video dersler, öğretim uygulamaları ve çevrimiçi platformlar sayesinde öğrenciler daha fazla kaynağa kolayca erişebilmektedir.

Matematiksel benzetimler ve görselleştirmeler: Matematiksel kavramlar bilgisayarlar ve programlar aracılığıyla görselleştirilir, örneğin grafikler ve üç boyutlu modeller oluşturulur. Bu, öğrencilerin matematiksel kavramları daha iyi anlamalarına yardımcı olur.

Avantajı: Teknoloji dersleri daha etkileşimli ve eğlenceli hale getirerek öğrencilerin dersleri kendi hızlarında öğrenmelerine olanak tanır.

Zayıflıklar: Teknoloji tabanlı dersler, öğrencilerin çoğunlukla görsel ve teknik araçlara odaklanması nedeniyle bazen temel kavramları anlamalarını zorlaştırabilir.

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Modern yaklaşımlar her öğrencinin kendi hızında öğrenmesine olanak tanır. Çevrimiçi platformlar ve uyarlanabilir öğrenme araçları öğrencilerin gelişimini takip eder ve onlara kişiselleştirilmiş ödevler sunar.

Öğrencilerin yeteneklerine göre uygun bir müfredat hazırlanır. Öğrencinin zayıf veya güçlü yönleri dikkate alınarak ders daha etkili hale getirilir.

Dünya genelinde kullanılan yeni matematik öğretim yöntemleri:

2.2.2. Tersine Çevrilmiş Sınıf

Tersine Sınıf yaklaşımında dersin geleneksel yapısı değiştirilir. Öğrenciler dersin teorik kısmını evde video dersleri aracılığıyla öğrenirler ve pratik konuları sınıfta tartışıp uygularlar.

Öğretmen merkezli değil, öğrenci merkezli öğretim: Bu yaklaşımda öğrenciler dersi evde takip ederler ve sınıfta aktif olarak alıştırmaları tamamlarlar ve öğretmenle tartışmalara katılırlar.

Faydası: Bu yaklaşım, öğrencilerin derse önceden hazırlıklı gelmesini ve sınıfta daha pratik uygulamaların yapılmasını sağlar. Öğrenciler dersleri kendi hızlarında takip edebilirler.

Zayıflıkları: Bu yöntem, teknolojiye ve internete erişimi olmayan öğrenciler için zorlayıcı olabilir. Aynı zamanda öğrenciler bazen evde dersi izlemekle ilgilenmeyebilirler.

2.2.3. Problem Tabanlı Öğrenme (PBL)

Problem Tabanlı Öğrenme, öğrencilerin gerçek yaşam problemlerini çözerek öğrenmelerini sağlar. Burada öğrenciler konuları uygulamalı olarak öğreniyor.

Gerçek yaşam problemleri: Öğrencilere gerçek yaşamda karşılaşacakları matematik problemleri sunulur ve bu problemleri çözerek konulara hakim olmaları sağlanır.

Faydası: Bu yaklaşım, öğrencilerin matematiksel kavramları günlük yaşama uygulamalarını sağlayarak anlayışlarını derinleştirir.

Zayıf yönleri: Öğretmenlerden ve sınıftan daha fazla zaman ve hazırlık gerektirir, çünkü konuların gerçek hayattan alınması ve tartışmaların geniş kapsamlı olması gerekir.

Sorgulamaya Dayalı Öğrenme: Öğrenciler, ilgi alanlarıyla ilgili sorular sorarak ve sorunları araştırarak öğrenirler. Öğretmen burada kolaylaştırıcı rolü üstlenir, ancak öğrencilerin kendi öğrenme süreçlerini kontrol etmelerine olanak tanır.

3. SONUÇ

Sonuç olarak, matematik öğretiminde geleneksel yöntemler hâlâ önemli olmakla birlikte, modern yaklaşımların devreye girmesiyle öğrencilerin derslere olan ilgisi artmakta ve öğrenme süreci daha dinamik ve etkileşimli hale gelmektedir. Teknolojinin kullanımı, kişiselleştirilmiş yaklaşımlar ve aktif öğrenme yöntemleri öğrencilerin öğrenmeye yönelik yaklaşımlarını dönüştürüyor ve onları daha yaratıcı, analitik ve bağımsız düşünen bireylere çeviriyor.

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SOME PROPERTIES OF GENERALIZED *B*-KANNAN TYPE MAPPINGS

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ABSTRACT

Fixed-point theory is a fundamental area of mathematics with significant applications in various fields, including analysis, topology, and computational mathematics. It provides crucial insights into the existence and behavior of solutions to equations and systems, where a point remains unchanged under a given transformation. This theory is essential for understanding stability, convergence, and optimization problems, and it plays a vital role in areas such as differential equations, game theory, and economic modeling. Through its many generalizations, fixed-point theory continues to be a powerful tool for solving real-world problems across diverse disciplines. Fixed-point theory has been thoroughly explored from various perspectives. One such approach involves generalizing the contractive conditions traditionally used, such as the introduction of Kannan-type contractive conditions. Another line of exploration focuses on expanding the scope of metric spaces, exemplified by the concept of b-metric spaces. Motivated by these two directions, this study introduces the concept of a generalized b-Kannan type mapping on b-metric spaces and investigates several properties of this novel concept.

Keywords : b-metric space, Kannan type mapping, generalized b-Kannan type mapping.

1. INTRODUCTION

The concept of a fixed point in mathematics refers to a point that remains unchanged under a given function. That is, for a function T, a point u is called a fixed point if

$$Tu = u.$$

The history of fixed point theory can be traced back to several foundational developments in mathematics. The concept of fixed points dates back to ancient mathematics, but the formal development started in the 19th century. Early applications of fixed points appeared in geometry and algebra.

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Some basic fixed-point theorems are follows:

- Brouwer's Fixed-Point Theorem (1912),
- Schauder Fixed-Point Theorem (1930s),
- Kakutani's Fixed-Point Theorem (1941),
- Tarski's Fixed-Point Theorem (1955).

Several generalizations and extensions of the classical fixed-point theorems have been developed to address more complex situations. These include

- Nonlinear Fixed-Point Theorems,
- Fixed Points in Metric Spaces,
- Set-Valued Fixed-Point Theorems,
- Topological and Algebraic Generalizations,
- Generalized Brouwer Fixed-Point Theorem.

The generalization and extension of fixed-point theorems have had a profound impact on several fields:

- Economics and Game Theory,
- Dynamical Systems,
- Computer Science,
- Topology and Analysis.

In summary, the fixed-point theory has evolved significantly from early developments in geometry and algebra to a more abstract and generalized framework that has broad applications in mathematics, economics, and computer science.

In the context of fixed-point theory, the contraction condition plays a fundamental role in ensuring the existence and uniqueness of fixed points for certain types of functions. Typically, in metric spaces, a contraction mapping $T: X \to X$ is a function for which there exists a constant $c \in [0,1)$ such that for all $u, v \in X$

$$d(Tu, Tv) \leq c d(u, v),$$

where d is a metric on X. The classical Banach Fixed-Point Theorem (or Contraction Mapping Theorem) states that any contraction mapping on a complete metric space has exactly one fixed point, and this fixed point can be found through successive approximations. The contraction condition is quite powerful and essential in proving the existence and uniqueness of fixed points in many applications. However, in more complex spaces or more general settings, the contraction condition might not always apply directly. Therefore, generalizing this condition becomes important for several reasons. The generalization of the contraction condition in metric spaces is crucial because it broadens the applicability of fixed-point theorems to a wider range of mathematical spaces, systems, and functions. By relaxing or extending the condition, we can apply these powerful tools to more complex problems in dynamical systems, optimization, game theory, and numerical analysis, making them more versatile and useful in practical scenarios. This generalization allows for deeper insights and more robust solutions in both theoretical and applied mathematics.

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From the above motivations, we introduce the concept of a generalized *b*-Kannan type mapping on *b*-metric spaces and investigates several properties of this novel concept.

2. PRELIMINARIES

In this section, we recall some necessary notions.

Definition 2.1. [1, 2] Let X be a nonempty set and $s \geq 1$ be a given real number. A mapping $d_s : X \times X \to [0,\infty)$ is called a *b*-metric on X, if the following conditions are satisfied for all $u,v,w \in X$:

(1) $d_s(u,v) = 0 \Leftrightarrow u = v,$

(2) $d_s(u,v) = d_s(v,u),$

(3) $d_s(u,v) \leq s\left[d_s(u,w) + d_s(w,v)\right].$

Then the pair (X,d_s) is called a *b*-metric space.

Remark 2.1. Every metric space is a b-metric space with $s = 1$, but the converse statement is not always true as seen in the following example.

Example 2.1. [3] Let R be the set of all real numbers and

$$X = l^{1/2}(R) := \left\{ u = \{u_n\} \subset R : \sum_{n=1}^{\infty} |u_n|^{1/2} < \infty \right\}.$$

Let us define the mapping $d_s : X \times X \to [0,\infty)$ as

$$d_s(u,v) = \left[\sum_{n=1}^{\infty} |u_n - v_n|^{1/2} \right]^2 .$$

Then (X,d_s) be a *b*-metric space with $s = 2$, but it is not a metric space.

Definition 2.2. [2] Let (X,d_s) be a *b*-metric space. Then the sequence $\{u_n\}$ is called convergent if and only if there exist $u \in X$ such that for all $\varepsilon > 0$ there exists $n(\varepsilon) \in N$, where N is the set of all natural numbers, such that for all $n \geq n(\varepsilon)$ we have

$$d_s(u_n,u) < \varepsilon.$$

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Proposition 2.1. [4] Let (X,d_s) be a b-metric space. A sequence $\{u_n\}$ is convergent to a limit $u\in X$ if and only if

$$\lim_{n\to\infty} d_s(u_n,u)=0.$$

Proposition 2.2. [4] A map $T:X\to Y$, where X,Y are two b-metric spaces, is continuous at $u\in X$ if and only if T is sequentially continuous at u, that is, if $\lim_{n\to\infty} u_n=u$ then $\lim_{n\to\infty} Tu_n=Tu.$

Definition 2.3. [3] Let $s\geq 1$ be a given real number. A nonempty subset I_s of $[0,\infty)$ is called the best area for Kannan system with degree s, if the following two conditions are satisfied:

(L3) If $\lambda\in I_s$ then for any b-metric space (X,d_s) with constant s and any self-mapping $T:X\to X$ satisfying

$$d_s(Tu,Tv)\leq\lambda\left[d_s(u,Tu)+d_s(v,Tv)\right],$$

for all $u,v\in X$, we have $F(T)\neq\varnothing$, where $F(T)$ is the set of all fixed points of T.

(L4) For any $\lambda\geq 0$ with $\lambda\notin I_s$, there exists a b-metric space (X,d_s) with constant s and a self-mapping $T:X\to X$ satisfying the above inequality such that $F(T)=\varnothing$.

3. MAIN RESULTS

In this section, we define a new contractive notion on b-metric spaces and investigate some properties of this new notion.

Definition 3.1. Let (X,d_s) be a b-metric space with $s\geq 1$ and $|X|\geq 3$. The self-mapping $T:X\to X$ is said to be generalized b-Kannan type mapping if there is $h\in\left[0,\frac{2}{3}\right)$ such that

$$d_s(Tu,Tv)+d_s(Tv,Tw)+d_s(Tu,Tw)\leq h\left[d_s(u,Tu)+d_s(v,Tv)+d_s(w,Tw)\right],$$

for all three pairwise distinct points $u,v,w\in X$.

Proposition 3.1. Let (X,d_s) be a b-metric space with $s\geq 1$ and $T:X\to X$ be a self-mapping satisfying the inequality

$$d_s(Tu,Tv)\leq\frac{1}{\alpha+\beta}\left[d_s(u,Tu)+d_s(v,Tv)\right],$$

for all $u,v\in X$ with $\alpha+\beta>3$, $\beta>0$. Then T is a generalized b-Kannan type mapping.

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Proof. Let (X, d_s) be a *b*-metric space with $s \geq 1$, $|X| \geq 3$ and u, v, w be three pairwise distinct point. Using hypothesis, we get

$$d_s(Tu, Tw) \leq \frac{1}{\alpha+\beta}\left[d_s(u, Tu) + d_s(w, Tw)\right]$$

and

$$d_s(Tv, Tw) \leq \frac{1}{\alpha+\beta}\left[d_s(v, Tv) + d_s(w, Tw)\right].$$

Then we have

$$d_s(Tu, Tv) + d_s(Tv, Tw) + d_s(Tu, Tw) \leq \frac{2}{\alpha+\beta}\left[d_s(u, Tu) + d_s(v, Tv) + d_s(w, Tw)\right].$$

Consequently, T is a generalized *b*-Kannan type mapping. □

Proposition 3.2. Let (X, d_s) be a *b*-metric space with $s \geq 1$ and the self-mapping $T : X \to X$ be a generalized *b*-Kannan type mapping with some $h \in \left[0, \frac{2}{3}\right)$. If u is a limit point of X and T is continuous at u, then the inequality

$$d_s(Tu, Tv) \leq h\left[d_s(u, Tu) + \frac{d_s(v, Tv)}{2}\right]$$

holds for all $v \in X$.

Proof. Let $u \in X$ be a limit point and $v \in X$. If $u = v$ then the proof is clear. Assume $u \neq v$. Since u is a limit point, there exists a sequence x_n such that

$$x_n \to u, \quad x_n \neq u, \quad x_n \neq v$$

and all x_n are different. Using the hypothesis, we get

$$d_s(Tu, Tv) + d_s(Tv, Tx_n) + d_s(Tu, Tx_n) \leq h\left[d_s(u, Tu) + d_s(v, Tv) + d_s(x_n, Tx_n)\right],$$

for all n where n is a natural number. Since $x_n \to u$ and T is continuous, we have $Tx_n \to Tu$. As $n \to \infty$, we obtain

$$d_s(Tu, Tv) + d_s(Tv, Tu) + d_s(Tu, Tu) \leq h\left[d_s(u, Tu) + d_s(v, Tv) + d_s(u, Tu)\right]$$

$$\Rightarrow 2d_s(Tu, Tv) \leq h\left[2d_s(u, Tu) + d_s(v, Tv)\right]$$

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$$\Rightarrow d_s(Tu,Tv) \le h\left[d_s(u,Tu) + \frac{d_s(v,Tv)}{2}\right]. \square$$

Proposition 3.3. Let (X, d_s) be a b-metric space with $s \ge 1$ and $T: X \to X$ be a Kannan type mapping with $\lambda \in \left[0, \frac{1}{3}\right)$. Then T is a generalized b-Kannan type mapping on X.

Proof. Let $u, v, w \in X$ be three pairwise distance point. By the hypothesis, we have

$$d_s(Tu,Tw) \le \lambda\left[d_s(u,Tu) + d_s(w,Tw)\right]$$

and

$$d_s(Tv,Tw) \le \lambda\left[d_s(v,Tv) + d_s(w,Tw)\right].$$

Then we get

$$d_s(Tu,Tv) + d_s(Tv,Tw) + d_s(Tu,Tw) \le 2\lambda\left[d_s(u,Tu) + d_s(v,Tv) + d_s(w,Tw)\right]$$

and so T is a generalized b-Kannan type mapping with $h = 2\lambda \in \left[0, \frac{2}{3}\right)$ on X. $\square$

Proposition 3.4. Let (X, d_s) be a b-metric space, $T: X \to X$ be a continuous generalized b-Kannan type mapping and all points of X be limit points. Then T is a Kannan type mapping with $\lambda \in \left[0, \frac{1}{2}\right)$.

Proof. From the hypothesis and Proposition 3.2, we have

$$d_s(Tu,Tv) \le h\left[d_s(v,Tv) + \frac{d_s(u,Tu)}{2}\right]$$

and

$$d_s(Tu,Tv) \le h\left[d_s(u,Tu) + \frac{d_s(v,Tv)}{2}\right].$$

Using the above two inequalities, we get

$$d_s(Tu,Tv) \le \frac{3h}{4}\left[d_s(u,Tu) + d_s(v,Tv)\right].$$

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Consequently, T is a Kannan type mapping with $\lambda = \frac{3h}{4} \in \left[0, \frac{1}{2}\right)$ on X. □

Example 3.1. Let $X = [0,1]$ be the usual metric space with the usual metric

$$d(u,v) = |u - v|,$$

for all $u, v \in X$. Then (X, d) is also *b*-metric space wih $s = 1$. Let us consider the mapping $T : X \to X$ defined as

$$Tu = \frac{u}{a}, \quad a > 1$$

for all $u \in X$ [5]. Then T is a generalized *b*-Kannan type mapping but T is not a Kannan type mapping on X.

Remark 3.1.

1) If we take $s = 1$, then the notion of a generalized Kannan type mapping and the notion of a generalized *b*-Kannan type mapping are coincide.

2) Proposition 3.2 is a generalization of Proposition 2.2 proved in [5].

3) Proposition 3.3 is a generalization of Proposition 2.1 given in [5].

4) Proposition 3.4 is a generalization of Corollary 2.3 given in [5].

5) Every Kannan type mapping is a generalized *b*-Kannan type mapping, but the converse statement is not always true (see, Example 3.1).

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SOME INTEGRAL TYPE FIXED-CIRCLE RESULTS ON G-METRIC SPACES

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ABSTRACT

Fixed-point theory is a core area of mathematics that has widespread significance across many disciplines. It helps in identifying and analyzing points that remain invariant under specific operations or transformations. The theory is critical in studying the existence of solutions to various equations, as well as understanding key concepts like stability and convergence. Its applications span across fields such as dynamical systems, optimization, and economics, providing valuable insights into real-world phenomena. With its numerous extensions and generalizations, fixed-point theory remains a powerful and versatile tool in both theoretical and applied mathematics. In fixed-point theory, studies continue to be pursued through three main approaches. The first approach focuses on generalizing the contraction conditions used. Within this generalization, various techniques have been and continue to be employed. For example, integral-type contraction conditions are just one of the techniques used. The second approach involves the generalization of the structure of the metric space under new conditions. An example of this approach is the concept of a G-metric space. The concept of a G-metric space, which involves working with three variables, stands as an example of a different type of generalization. Another recent generalization being studied is the fixed-circle problem. The goal of this problem is to investigate whether, in the case where a given function has multiple fixed points, the set of these fixed points can be expressed as a geometric figure, or if a subset of this set corresponds to a geometric figure, while also examining the invariance of each element in the set. With these three approaches, in this study, we derive existence and uniqueness theorems for fixed circles by utilizing the concept of integral-type contraction conditions on G-metric spaces. The results are supported by some remarks and examples.

Keywords : G-metric space, fixed circle, integral type contraction.

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1. INTRODUCTION

Fixed-point theory has been studied from various perspectives in many areas of mathematics for many years and continues to be explored. Moreover, the applications of this field make fixed-point theory even more attractive. Metric fixed-point theory began with Banach's fixed-point theorem [1] and has continued through generalizations developed in cases where this theorem is insufficient. This theory provides an important method for determining the existence and uniqueness of a fixed point for a given function. However, there are examples of functions in the literature that, despite having a fixed point that is both existent and unique, do not satisfy the conditions of Banach's fixed-point theorem. This is where the investigation of new theories becomes of great importance.

While researching new theories, different generalization techniques have been applied. The first of these is the generalization of the contraction condition used. Various approaches have been employed in the logic of generalizing this contraction condition. One of these approaches is of the integral type [2]. This integral-type approach has introduced more general and different contraction conditions in the literature. As a result, fixed-point theory has gained integral-type fixed-point results. Another generalization approach is the generalization of the metric space structure being studied. While generalizing this structure, both the conditions provided by the metric function have been altered, and changes have been made not only to these conditions but also to the domain of the definition. An example of this is the concept of G-metric spaces, which has been defined specifically for this purpose [3]. Another type of generalization studied recently is a geometric generalization. This geometric generalization approach is based on the fixed circle problem [4]. The aim of this problem is to investigate whether, when the number of fixed points of a given function is more than one, there is a geometric counterpart to the fixed point set of this function, and whether each element of this geometric figure remains fixed or not.

After all these motivations, in this study, we plan to obtain integral-type fixed circle results on G-metric spaces by using all the generalizations together. For this purpose, the main objectives of the work are to present two theorems that establish the existence and uniqueness of the fixed circle, and to support the obtained results with examples.

2. PRELIMINARIES

In this section, we recall some basic notions related to the this study.

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Definition 2.1. [3] Let X be a nonempty set. A function $G: X \times X \times X \to [0,\infty)$ is called a G-metric if the following conditions are satisfied:

(G1) $G(x,y,z)=0$ if and only if $x=y=z$,

(G2) $0<G(x,x,y)$ for all $x,y\in X$ with $x\neq y$,

(G3) $G(x,x,y)\leq G(x,y,z)$ for all $x,y,z\in X$ with $y\neq z$,

(G4) $G(x,y,z)=G(x,z,y)=G(z,y,x)=\cdots$ (symmetry in all three variables),

(G5) $G(x,y,z)\leq G(x,y,w)+G(w,y,z)$ for all $x,y,z,w\in X$ (rectangle inequality).

Then the pair (X,G) is called a G-metric space.

Example 2.1. [5] Let X be nonempty subset of the set of real numbers. Then the function $G: X\times X\times X\to[0,\infty)$ defined as

$$G(x,y,z)=|x-y|+|x-z|+|y-z|,$$

for all $x,y,z\in X$. Then (X,G) is a G-metric space.

Definition 2.2. [6] Let (X,G) be a G-metric space. A circle of center $x_0\in X$ and radius $r\in(0,\infty)$ is defined as

$$C_G(x_0,r)=\{x\in X: G(x,x,x_0)=r\}.$$

Example 2.2. [6] Let us take the G-metric space given in Example 2.1. Then we have

$$C_G(5,10)=\{0,10\}.$$

Definition 2.3. [6] Let (X,G) be a G-metric space and $C_G(x_0,r)$ be any circle on X. For a self-mapping $T: X\to X$, if $Tx=x$ for each $x\in C_G(x_0,r)$, then $C_G(x_0,r)$ is called a fixed circle of T.

In this paper, assume that $\varphi:[0,\infty)\to[0,\infty)$ is a Lebesgue-integrable mapping which is summable, that is, with finite integral on each compact subset of $[0,\infty)$, nonnegative and such that

$$\int_0^{\varepsilon}\varphi(s)ds>0$$

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for each $\varepsilon > 0$ [2].

3. MAIN RESULTS

In this section, we introduce some new integral type fixed-circle results on G-metric spaces.

Theorem 3.1. Let (X,G) be a G-metric space and $C_G(x_0,r)$ be any circle on X. Let us define the mapping $\alpha : X \to [0,\infty)$ as

$$\alpha(x) = G(x,x,x_0),$$

for all $x \in X$. If there exists a self-mapping $T : X \to X$ satisfying

(i) $\int_0^{G(x,x,Tx)} \varphi(t)dt \leq \int_0^{\alpha(x)} \varphi(t)dt - \int_0^{\alpha(Tx)} \varphi(t)dt$ for all $x \in C_G(x_0,r)$,

(ii) $G(Tx,Tx,x_0) \geq r$ for all $x \in C_G(x_0,r)$,

(iii) $\int_0^{G(Tx,Tx,Ty)} \varphi(t)dt \leq h \int_0^{G(x,x,y)} \varphi(t)dt$ for all $x \in C_G(x_0,r)$, $y \in X - C_G(x_0,r)$ and some $h \in [0,1)$

,

then the circle $C_G(x_0,r)$ is a unique fixed circle of T.

Proof. Let $x \in C_G(x_0,r)$ be any point. Using (i) and (ii), we get

$$\int_0^{G(x,x,Tx)} \varphi(t)dt \leq \int_0^{\alpha(x)} \varphi(t)dt - \int_0^{\alpha(Tx)} \varphi(t)dt = \int_0^{G(x,x,x_0)} \varphi(t)dt - \int_0^{G(Tx,Tx,x_0)} \varphi(t)dt$$
$$= \int_0^{r} \varphi(t)dt - \int_0^{G(Tx,Tx,x_0)} \varphi(t)dt \leq \int_0^{r} \varphi(t)dt - \int_0^{r} \varphi(t)dt = 0$$

and so

$$G(x,x,Tx) = 0 \Rightarrow Tx = x.$$

Hence $C_G(x_0,r)$ is a fixed circle of T. Now, we show that the uniqueness of a fixed circle $C_G(x_0,r)$. To do this, suppose that there are two different fixed circles $C_G(x_0,r)$ and

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$C_G(x_1,\rho)$ of the self-mapping T. Let $x \in C_G(x_0,r)$ and $y \in C_G(x_1,\rho)$ with $x \neq y$. By (*iii*), we obtain

$$\int_0^{G(Tx,Tx,Ty)} \varphi(t)dt = \int_0^{G(x,x,y)} \varphi(t)dt \leq h \int_0^{G(x,x,y)} \varphi(t)dt,$$

a contradiction since $h \in [0,1)$. It should be $x = y$. Consequently, $C_G(x_0,r)$ is a unique fixed circle of T. □

Theorem 3.2. Let (X,G) be a G-metric space, $C_G(x_0,r)$ be any circle on X and the mapping $\alpha : X \to [0,\infty)$ be defined as in Theorem 3.1. If there exists a self-mapping $T : X \to X$ satisfying

(*i*) $\int_0^{G(x,x,Tx)} \varphi(t)dt \leq \int_0^{\alpha(x)} \varphi(t)dt + \int_0^{\alpha(Tx)} \varphi(t)dt - 2\int_0^{r} \varphi(t)dt$ for all $x \in C_G(x_0,r)$,

(*ii*) $G(Tx,Tx,x_0) \leq r$ for all $x \in C_G(x_0,r)$,

(*iii*) $\int_0^{G(Tx,Tx,Ty)} \varphi(t)dt \leq h\left[\int_0^{G(x,x,Tx)} \varphi(t)dt + \int_0^{G(y,y,Ty)} \varphi(t)dt\right]$ for all $x \in C_G(x_0,r)$, $y \in X - C_G(x_0,r)$ and some $h \in [0,1)$,

then the circle $C_G(x_0,r)$ is a unique fixed circle of T.

Proof. Let $x \in C_G(x_0,r)$ be any point. Using (*i*) and (*ii*), we obtain

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$$\int_0^{G(x,x,Tx)} \varphi(t)\,dt \le \int_0^{\alpha(x)} \varphi(t)dt + \int_0^{\alpha(Tx)} \varphi(t)dt - 2\int_0^{r} \varphi(t)dt$$
$$= \int_0^{G(x,x,x_0)} \varphi(t)dt + \int_0^{G(Tx,Tx,x_0)} \varphi(t)dt - 2\int_0^{r} \varphi(t)dt$$
$$= \int_0^{r} \varphi(t)dt + \int_0^{G(Tx,Tx,x_0)} \varphi(t)dt - 2\int_0^{r} \varphi(t)dt$$
$$\le \int_0^{r} \varphi(t)dt + \int_0^{r} \varphi(t)dt - 2\int_0^{r} \varphi(t)dt = 0$$

and so

$$G(x,x,Tx) = 0 \Rightarrow Tx = x.$$

Hence $C_G(x_0,r)$ is a fixed circle of T. Now, we show that the uniqueness of a fixed circle $C_G(x_0,r)$. To do this, suppose that there are two different fixed circles $C_G(x_0,r)$ and $C_G(x_1,\rho)$ of the self-mapping T. Let $x \in C_G(x_0,r)$ and $y \in C_G(x_1,\rho)$ with $x \neq y$. By (*iii*), we obtain

$$\int_0^{G(Tx,Tx,Ty)} \varphi(t)dt = \int_0^{G(x,x,y)} \varphi(t)dt \le h\left[\int_0^{G(x,x,Tx)} \varphi(t)dt + \int_0^{G(y,y,Ty)} \varphi(t)dt\right] = 0,$$

a contradiction. It should be $x = y$. Consequently, $C_G(x_0,r)$ is a unique fixed circle of T. □

Example 3.1. Let (X,G) be a G-metric space and $C_G(x_0,r)$ be any circle on X with $r > 0$. Let us define the self-mapping $T : X \to X$ as

$$Tx = \begin{cases} x & , \quad x \in C_G(x_0,r) \\ x_0 & , \quad x \in X - C_G(x_0,r) \end{cases},$$

for all $x \in X$. Then T satisfies the conditions of Theorem 3.1 and Theorem 3.2. Hence, $C_G(x_0,r)$ is a unique fixed circle of T.

Example 3.2. Let (X,G) be a G-metric space and $C_G(x_0,r)$, $C_G(x_1,\rho)$ be any two circles on X with $r>0$, $\rho>0$. Let us define the self-mapping $S:X\to X$ as

$$Sx=\begin{cases} x & , \quad x\in C_G(x_0,r)\cup C_G(x_1,\rho) \\ x_1 & , \quad \text{otherwise} \end{cases},$$

for all $x\in X$. Then S fixes the circles $C_G(x_0,r)$ and $C_G(x_1,\rho)$. Also, S satisfies the conditions (*i*) and (*ii*) of Theorem 3.1 and Theorem 3.2. But the fixed circles are not unique.

Remark 3.1.

1) The condition (*ii*) of Theorem 3.1 guarantees that Tx is not interior of the circle $C_G(x_0,r)$ for $x\in C_G(x_0,r)$.

2) Theorem 3.1 is a generalization of Theorem 1 proved in [6].

3) The condition (*ii*) of Theorem 3.2 guarantees that Tx is not exterior of the circle $C_G(x_0,r)$ for $x\in C_G(x_0,r)$.

4) Theorem 3.2 is a generalization of Theorem 2.2 proved in [7].

5) The condition (*iii*) of Theorem 3.1 is an integral Banach type contraction (see [1] for Banach type contraction).

6) The condition (*iii*) of Theorem 3.2 is an integral Kannan type contraction (see [8] for Kannan type contraction).

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BANACH CONTRACTION THEOREM IN TRIPLE CONTROLLED S-METRIC TYPE SPACES

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ABSTRACT

A triple controlled S-metric type space is one of the most recent definitions obtained by combining the notions of S-metric space and controlled metric type space. This structure extends the applicability of classical results in analysis and topology, providing a more flexible framework for studying distance-related properties and fixed point theorems.

In this paper, we prove the Banach fixed point theorem which guarantees the existence and uniqueness of a fixed point for contractive maps. The extension of this theorem to triple controlled S-metric type space provides powerful tools for solving nonlinear problems in differential equations, optimisation and applied mathematics.

Key Words: Controlled metric type space, S-metric space, Banach contraction theorem

1. INTRODUCTION

Stefan Banach started the research of metric fixed point theory in 1922 and presented the Banach contraction principle. It states that if a function T defined on a complete metric space (X,d) is a contraction (i.e., there exists a constant $k\in[0,1)$ such that for all), then T has a unique fixed point in X [1]. Its many uses vary mathematics and several scientific fields, including computer science, engineering, physics, and economics. Combining ideas from topology, analysis, and geometry, the theory of fixed points investigates both the existence and uniqueness of fixed points of functions. Particularly in the development of several types of

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metric spaces, the Banach Fixed Point Theorem has been enlarged in several ways throughout time. Bakhtin [2] first proposed b-metric spaces, for example, which later evolved into expanded forms often known as extended b-metric spaces [3]. Researchers have also introduced double and triple controlled metric-like spaces [4], [5], [6], [7], [8] as well as controlled metric-type spaces [9]. As an extension of metric spaces, Sedghi et al. proposed the S-metric spaces [10]. S_b-metric spaces [11], extended S_b-metric spaces of type [12], controlled S-metric-like spaces [13] and triple controlled S-metric type spaces [14] were further developed from this notion.

Motivated by the Azmi's article [14], we examined the existence and uniqueness conditions of the Banach fixed point theorem in this new space.

2. PRELIMINARIES

The primary results and definitions of S-metric spaces that were proposed by Sedghi et al. [10] are also recalled.

Definition 2.1 [10] Let $X \neq \emptyset$, and let $S : X \times X \times X \to [0,\infty)$ be a mapping such that for all $x, y, z, a \in X$, it satisfies the following:

$(S1)$ $S(x, y, z) = 0$ if and only if $x = y = z$;
$(S2)$ $S(x, y, z) \leq S(x, x, a) + S(y, y, a) + S(z, z, a)$.

The pair (X, S) is called an S-metric space.

Definition 2.2 [13] Let $S : X \times X \times X \to [0,\infty)$ be a mapping, where X be a nonempty set and assume that $\alpha : X^2 \to [1,\infty)$ is a function so that for all $x, y, z, a \in X$, it satisfies the followings:

$(CS1)$ $S(x, y, z) = 0$ if and only if $x = y = z$;
$(CS2)$ $S(x, y, z) \leq \alpha(x, a) S(x, x, a) + \alpha(y, a) S(y, y, a) + \alpha(z, a) S(z, z, a)$.

The pair (X, S) is called a controlled S-metric type space.

On the other hand, in 2024, Fatima Azmi [14] introduced the Notion of triple controlled S-metric type spaces.

Definition 2.2 [14] Let $S : X \times X \times X \to [0,\infty)$ be a mapping, where X be a nonempty set and assume that $\alpha, \beta, \gamma : X^2 \to [1,\infty)$ are functions so that for all $x, y, z, a \in X$, it satisfies the followings:

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$(TCS1)\ S(x,y,z)=0$ if and only if $x=y=z$;
$(TCS2)\ S(x,x,y)=S(y,y,x)$;
$(TCS2)\ S(x,y,z)\leq\alpha(x,a)S(x,x,a)+\beta(y,a)S(y,y,a)+\gamma(z,a)S(z,z,a)$.

The pair (X,S) is called a triple controlled S-metric type space.

Remark 2.3 By setting the control functions α,β and γ to be equal in Definition 2.2, we obtain a controlled S-metric type space as described in Definition 2.1. Therefore, the definition of a triple controlled S-metric type space generalizes the concept of a controlled S-metric type space. Furthermore, by assigning $\alpha=\beta=\gamma=1$, the definition of a triple controlled S-metric type space reduces to an S-metric space as outlined in Definition 2.1.

Definition 2.4 [14] Let (X,S) be a triple controlled S-metric type space, and consider a sequence $\{x_n\}\in X$.

1. The sequence $\{x_n\}$ converges to a point x in X if, for every $\varepsilon>0$, there exists a $n_0\in\mathbb{N}$ such that $S(x_n,x_n,x)<\varepsilon$ for all $n\geq n_0$.
2. The sequence $\{x_n\}$ is called a Cauchy sequence if, for every $\varepsilon>0$, there exists a $n_0\in\mathbb{N}$ such that $S(x_n,x_n,x_m)<\varepsilon$ for all $m,n\geq n_0$.
3. The space (X,S) is said to be complete if every Cauchy sequence in X converges to a point in X.

Lemma 2.5 [14] Let (X,S) be a triple controlled S-metric type space, and let $\alpha,\beta,\gamma:X^2\to[1,\infty)$ be mappings. If the sequence $\{x_n\}$ in X is convergent, then the limit is unique.

3. MAIN RESULTS

In this section, we establish the existence and uniqueness of fixed point for contraction theorem in a complete triple controlled S-metric type space (X,S).

Theorem 3.1 Let (X,S) be a complete triple controlled S-metric type space and $T:X\to X$ be a mapping such that

$$S(Tx,Tx,Ty)\leq kS(x,x,y)$$

for all $x,y\in X$ where $k\in(0,1)$. For $x_0\in X$, take $x_n=T^n x_0$. Suppose that

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$$\sup_{m\geq 1}\lim_{n\to\infty}\frac{\gamma(x_{n+1},x_m)\left[\alpha(x_{n+1},x_{n+2})+\beta(x_{n+1},x_{n+2})\right]}{\alpha(x_n,x_{n+1})+\beta(x_n,x_{n+1})}<\frac{1}{k}.$$

In addition, assume that for every $x\in X$, the limits

$$\lim_{n\to\infty}\alpha(x,x_n),\ \lim_{n\to\infty}\beta(x,x_n)\quad\text{and}\quad\lim_{n\to\infty}\gamma(x,x_n)$$

exists and are finite.

Then, T has a unique fixed point.

Proof: Consider the sequence $x_n=T^n x_0$. By using (1.1), we have

$$\begin{aligned}
S(x_n,x_n,x_{n+1}) &= S\left(T^n x_0,T^n x_0,T^n x_1\right)\\
&< kS\left(T^{n-1}x_1,T^{n-1}x_1,T^{n-1}x_2\right)\\
&\ \vdots\\
&< k^n S(x_0,x_0,x_1)
\end{aligned}$$

for all $n\geq 0$. For all natural numbers $n<m$, we have

$$\begin{aligned}
S(x_n,x_n,x_m) &\leq \alpha(x_n,x_{n+1})S(x_n,x_n,x_{n+1})+\beta(x_n,x_{n+1})S(x_n,x_n,x_{n+1})+\gamma(x_m,x_{n+1})S(x_m,x_m,x_{n+1})\\
&=\left[\alpha(x_n,x_{n+1})+\beta(x_n,x_{n+1})\right]S(x_n,x_n,x_{n+1})+\gamma(x_m,x_{n+1})S(x_{n+1},x_{n+1},x_m)\\
&\leq\left[\alpha(x_n,x_{n+1})+\beta(x_n,x_{n+1})\right]S(x_n,x_n,x_{n+1})\\
&\quad+\gamma(x_m,x_{n+1})\begin{bmatrix}\alpha(x_{n+1},x_{n+2})S(x_{n+1},x_{n+1},x_{n+2})+\beta(x_{n+1},x_{n+2})S(x_{n+1},x_{n+1},x_{n+2})\\ +\gamma(x_{n+2},x_m)S(x_{n+2},x_{n+2},x_m)\end{bmatrix}\\
&=\left[\alpha(x_n,x_{n+1})+\beta(x_n,x_{n+1})\right]S(x_n,x_n,x_{n+1})+\gamma(x_m,x_{n+1})S(x_{n+1},x_{n+1},x_{n+2})\\
&\quad\left[\alpha(x_{n+1},x_{n+2})+\beta(x_{n+1},x_{n+2})\right]+\gamma(x_{n+1},x_m)\gamma(x_{n+2},x_m)S(x_{n+2},x_{n+2},x_m)\\
&\leq\left[\alpha(x_n,x_{n+1})+\beta(x_n,x_{n+1})\right]S(x_n,x_n,x_{n+1})+\gamma(x_m,x_{n+1})\left[\alpha(x_{n+1},x_{n+2})+\beta(x_{n+1},x_{n+2})\right]\\
&\quad S(x_{n+1},x_{n+1},x_{n+2})+\gamma(x_{n+1},x_m)\gamma(x_{n+2},x_m)\begin{bmatrix}\alpha(x_{n+2},x_{n+3})S(x_{n+2},x_{n+2},x_{n+3})\\ +\beta(x_{n+2},x_{n+3})Sx_{n+2},x_{n+2},x_{n+3}\\ +\gamma(x_{n+3},x_m)S(x_{n+3},x_{n+3},x_m)\end{bmatrix}\\
&\leq\left[\alpha(x_n,x_{n+1})+\beta(x_n,x_{n+1})\right]S(x_n,x_n,x_{n+1})\\
&\quad+\gamma(x_m,x_{n+1})\left[\alpha(x_{n+1},x_{n+2})+\beta(x_{n+1},x_{n+2})\right]S(x_{n+1},x_{n+1},x_{n+2})\\
&\quad+\gamma(x_{n+1},x_m)\gamma(x_{n+2},x_m)\left[\alpha(x_{n+2},x_{n+3})+\beta(x_{n+2},x_{n+3})\right]S(x_{n+2},x_{n+2},x_{n+3})\\
&\quad+\gamma(x_{n+1},x_m)\gamma(x_{n+2},x_m)\gamma(x_{n+3},x_m)S(x_{n+3},x_{n+3},x_m)
\end{aligned}$$

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$$\leq\left[\alpha\left(x_n,x_{n+1}\right)+\beta\left(x_n,x_{n+1}\right)\right]S\left(x_n,x_n,x_{n+1}\right)$$
$$+\sum_{i=n+1}^{m-2}\left[\prod_{j=n+1}^{i}\gamma\left(x_j,x_m\right)\right]\left[\alpha\left(x_i,x_{i+1}\right)+\beta\left(x_i,x_{i+1}\right)\right]S\left(x_i,x_i,x_{i+1}\right)$$
$$+\left[\prod_{i=n+1}^{m-1}\gamma\left(x_i,x_m\right)\right]S\left(x_{m-1},x_{m-1},x_m\right)$$

$$\leq\left[\alpha\left(x_n,x_{n+1}\right)+\beta\left(x_n,x_{n+1}\right)\right]k^nS\left(x_0,x_0,x_1\right)$$
$$+\sum_{i=n+1}^{m-2}\left[\prod_{j=n+1}^{i}\gamma\left(x_j,x_m\right)\right]\left[\alpha\left(x_i,x_{i+1}\right)+\beta\left(x_i,x_{i+1}\right)\right]k^iS\left(x_0,x_0,x_1\right)$$
$$+\left[\prod_{i=n+1}^{m-1}\gamma\left(x_i,x_m\right)\right]k^{m-1}S\left(x_0,x_0,x_1\right)$$

$$\leq\left[\alpha\left(x_n,x_{n+1}\right)+\beta\left(x_n,x_{n+1}\right)\right]k^nS\left(x_0,x_0,x_1\right)$$
$$+\sum_{i=n+1}^{m-2}\left[\prod_{j=n+1}^{i}\gamma\left(x_j,x_m\right)\right]\left[\alpha\left(x_i,x_{i+1}\right)+\beta\left(x_i,x_{i+1}\right)\right]k^iS\left(x_0,x_0,x_1\right)$$
$$+\left[\prod_{i=n+1}^{m-1}\gamma\left(x_i,x_m\right)\right]\left[\alpha\left(x_{m-1},x_m\right)+\beta\left(x_{m-1},x_m\right)\right]k^iS\left(x_0,x_0,x_1\right)$$

$$\leq\left[\alpha\left(x_n,x_{n+1}\right)+\beta\left(x_n,x_{n+1}\right)\right]k^nS\left(x_0,x_0,x_1\right)$$
$$+\sum_{i=n+1}^{m-1}\left[\prod_{j=n+1}^{i}\gamma\left(x_j,x_m\right)\right]\left[\alpha\left(x_i,x_{i+1}\right)+\beta\left(x_i,x_{i+1}\right)\right]k^iS\left(x_0,x_0,x_1\right)$$

Let

$$A_p=\sum_{i=0}^{p}\left(\prod_{j=0}^{i}\gamma\left(x_j,x_m\right)\right)\left[\alpha\left(x_i,x_{i+1}\right)+\beta\left(x_i,x_{i+1}\right)\right]k^i.$$

Hence, we get

$$S\left(x_n,x_n,x_m\right)\leq\left[\left[\alpha\left(x_n,x_{n+1}\right)+\beta\left(x_n,x_n\right)\right]k^n+\left(A_{m-1}-A_n\right)\right]S\left(x_0,x_0,x_1\right).$$

From condition (1.2) and using the ratio test, we see that $\lim_{n\to\infty}A_n$ exists and the sequence $\{A_n\}$ is Cauchy. If we take limit for $n,m\to\infty$, we deduce that

$$\lim_{n\to\infty}S\left(x_n,x_n,x_m\right)=0.$$

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Then, $\{x_n\}$ is a Cauchy sequence. Since (X,S) is a triple controlled S-metric space there exists $u \in X$ such that $\{x_n\} \to u$. We next prove that u is a fixed point of T. By the definition of a triple controlled S-metric type, we have

$$S(x_{n+1},x_{n+1},u) \leq [\alpha(x_{n+1},x_n)+\beta(x_{n+1},x_n)]S(x_{n+1},x_{n+1},x_n)+\gamma(x_n,u)S(x_n,x_n,u) \ .$$

If we take the limit for $n \to \infty$, using $(1.2),(1.3)$ and (1.4), we obtain

$$\lim_{n\to\infty} S(x_{n+1},x_{n+1},u)=0.$$

Using the same conditions again, we have

$$\begin{aligned} S(Tu,Tu,u) &= S(u,u,Tu) \\ &\leq [\alpha(u,x_{n+1})+\beta(u,x_{n+1})]S(u,u,x_{n+1})+\gamma(x_{n+1},Tu)S(x_{n+1},x_{n+1},Tu) \\ &\leq [\alpha(u,x_{n+1})+\beta(u,x_{n+1})]S(u,u,x_{n+1})+\gamma(x_{n+1},Tu)kS(x_n,x_n,u) \end{aligned}$$

As n tends to ∞ in the preceding inequality, we conclude that $S(Tu,Tu,u)=0,$ impliying $Tu=u.$ Now, we proceed to establish the uniqueness of the fixed point. Suppose there exists two fixed points, u and $v,$ with $u \neq v.$ Since $Tu=u\neq v=Tv,$ it implies that $S(Tu,Tu,Tv)>0.$ Then we obtain

$$S(u,u,v)=S(Tu,Tu,Tv)<kS(u,u,v).$$

Since it is a contradiction, it must be $S(u,u,v)=0,$ i.e., $u=v.$ Therefore, T has a unique fixed point.

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A NEW PRECONDITIONING REFLECTED FORWARD-BACKWARD-FORWARD ALGORITHM FOR MONOTONE INCLUSION PROBLEM AND ITS APPLICATION

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ABSTRACT

The problem of finding a zero of the sum of two monotone operators is a fundamental challenge in monotone operator theory, with applications in optimization, variational inequalities, and signal processing. The reflected forward-backward-forward algorithm is one of the most prominent iterative methods for tackling this problem, particularly when one of the operators is maximally monotone and the other is cocoercive. In this paper, we introduce a novel preconditioning reflected forward-backward-forward algorithm that effectively computes a zero of the sum of two operators, where one operator is maximal monotone, and the other is $\boldsymbol{M}$ −cocoercive, with M being a linear bounded operator. Our proposed approach generalizes existing methods by incorporating a preconditioning strategy, which enhances convergence properties and broadens its applicability. Our proposed approach generalizes existing methods by incorporating a preconditioning strategy, which enhances convergence properties and broadens its applicability. We establish the weak convergence of our algorithm in Hilbert spaces, thereby providing a solid theoretical foundation. Furthermore, we demonstrate the practical applicability of the algorithm by employing it to solve convex minimization problems, thereby highlighting its effectiveness in optimization contexts.

Anahtar Kelimeler: Monotone Inclusion Problem, Convex Minimization Problem, Reflected Effects, Forward-Backward-Forward Algorithm.

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1. INTRODUCTION

Let H be a real Hilbert space with inner product $\langle .,. \rangle$ and the induced norm $\|.\|$. One of the most important problems in monotone operator theory is the problem of finding a zero of the sum of two monotone operators known as the monotone inclusion problem, which is formulated as finding $x \in H$ such that

$$0 \in (A+B)(x) \tag{1.1}$$

where $A: H \to 2^H$ is a set-valued operator and $B: H \to H$ is an operator. This problem encompasses various mathematical problems, including variational inequality problems, convex minimization problems, equilibrium problems, and convex-concave saddle point problems see e.g. : [1, 2, 3, 5, 6, 12, 13].

The most widely used technique for solving the monotone inclusion problem is the forward-backward splitting algorithm, introduced by Lions and Mercier [7]:

$$x_{n+1} = (I + \lambda_n A)^{-1}(I - \lambda_n B)x_n, \text{for all } n \in \mathbb{N} \tag{1.2}$$

where λ_n is a step size term and A and B are monotone operators. If $B: H \to H$ is $1/L-$ cocoercive operator and $\lambda_n \in (0,2/L)$, (L is the Lipschitz constant of A) the forward-backward splitting algorithm converges weakly to a solution of the monotone inclusion problem.

Later, Tseng [9] is defined the following algorithm:

$$\begin{cases} y_n = x_n + \theta_n(x_n - x_{n-1}) \\ x_{n+1} = y_n + \lambda_n(Ax_n - Ay_n), \text{forall } n \in \mathbb{N} \end{cases} \tag{1.3}$$

where $\lambda_n \in (0,2/L)$, is determined using an Armijo line search rule, as described in ([9] (2.4)). The forward–backward–forward algorithm (3) has been studied extensively in the literatüre—e.g., in [4, 11, 14-16].

In recent years, Lorenz and Pock [10] proposed the following preconditioning algorithm to solve the monotone inclusion problem:

$$\begin{cases} y_n = x_n + \theta_n(x_n - x_{n-1}) \\ x_{n+1} = (I + \lambda_n M^{-1}A)^{-1}(I - \lambda_n M^{-1}B)(y_n), \text{for all } n \in \mathbb{N}' \end{cases} \tag{1.4}$$

where θ_n is an accelareted term on $[0,1)$ and λ_n is a step size term. They proved the weak convergence of the algorithm. It is clear that the Algorithm (1.4) is reduced to the classical forward-backward splitting algorithm (1.2) for $\theta_n = 0$ and $M = I$.

Subsequently, in 2021, Dixit et al. [5] introduced the following algorithm, known as the accelerated preconditioning forward-backward normal $S-$iteration (APFBNSM), for all $n \in \mathbb{N}$:

$$\begin{cases} y_n = x_n + \theta_n(x_n - x_{n-1}) \\ x_{n+1} = (I + \lambda M^{-1}A)^{-1}(I - \lambda M^{-1}B)\big((1-\alpha_n)y_n + \alpha_n(I + \lambda M^{-1}A)^{-1}(I - \lambda M^{-1}B)(y_n)\big), \end{cases}$$
(1.5)

where $\alpha_n \in (0,1)$, $\lambda \in [0,1)$ and $\theta_n \in [0,1)$. They also proved weak convergence of the proposed algorithm under some assumptions in a real Hilbert space H. For $\theta_n = 0$ and $M = I$, the accelerated preconditioning forward-backward normal $S-$iteration (APFBNSM) is reduced to the normal $S-$iteration forward-backward splitting algorithm [11] $(nS - FBSA)$:

$$x_{n+1} = (I + \lambda A)^{-1}(I - \lambda B)\big((1-\alpha_n)y_n + \alpha_n(I + \lambda A)^{-1}(I - \lambda B)(y_n)\big), \text{for all } n \in \mathbb{N} .$$

In 2022, Altiparmak and Karahan [2] introduced a new preconditioning forward-backward-splitting algorithm in the following manner:

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$$\begin{cases} y_n = & x_n + \theta_n(x_n - x_{n-1}) \\ z_n = & (I + \lambda M^{-1}A)^{-1}(I - \lambda M^{-1}B)\big((1-\beta_n)y_n + \beta_n(I + \lambda M^{-1}A)^{-1}(I - \lambda M^{-1}B)(y_n)\big) \\ x_{n+1} = & (1-\gamma_n)(I + \lambda M^{-1}A)^{-1}(I - \lambda M^{-1}B)(z_n) + \gamma_n f(z_n) \end{cases} \quad (1.6)$$

where $\{\theta_n\} \subset [0, \theta]$ is a sequence with $\theta \in [0, 1)$ and $\{\alpha_n\}, \{\beta_n\}$, $\{\gamma_n\} \in (0, 1)$ and f is a k-contraction mapping on H with respect to M -norm. They also established the strong convergence theorem in a real Hilbert space.

In this paper, we propose a new preconditioning reflected forward-backward-forward splitting algorithm which generalizes many existed algorithms including the algorithms (1.3), (1.4), (1.5) and (1.6). Additionally, we demonstrate that the sequence produced by the proposed algorithm weakly converges to a solution of the monotone inclusion problem.

2. PRELIMINARIES

In this section, we present key definitions and lemmas that play a crucial role in proving our main theorem.

Let $A: H \to 2^H$ be a set-valued operator. If $\langle u - v, x - y\rangle \geq 0$ for all $u \in Ax$ and $v \in Ay$, then A is said to be a monotone operator. If the graph of a monotone operator is not properly contained in the graph of any other monotone operators, then A is said to be a maximal monotone operator.

Let $f: H \to (-\infty, +\infty]$ be a function. Then, f is said to be proper if there exists at least one $x \in H$ such that $f(x) < +\infty$. Also, the subdifferential of a proper function f is defined by

$$\partial f(x) = \{u \in H: \langle y - x, u\rangle \leq f(y) - f(x) \text{forally} \in H\}.$$

and f is subdifferentiable at $x \in H$, if $\partial f(x) \neq \emptyset$. The elements of $\partial f(x)$ are called the subgradients of f at x.

Let $M: H \to H$ be a bounded linear operator. M is said to be self-adjoint if $M^* = M$ where M^* is the adjoint of operator M. A self-adjoint operator is said to be positive definite if $\langle M(x), x\rangle > 0$ for every $0 \neq x \in H$ [8]. By using the self adjoint, positive and bounded linear operator M, the M-inner product is defined by

$$\langle x, y\rangle_M = \langle x, M(y)\rangle, \forall x, y \in H.$$

Additionally, the corresponding M-norm induced from the M-inner product is defined by

$$\|x\|_M^2 = \langle x, M(x)\rangle \text{ for all } x \in H.$$

Definition 2.1 [5] Let C be a nonempty subset of H, $T: C \to H$ be an operator and $M: H \to H$ be a positive definite operator. Then T is said to be:

1. nonexpansive operator with respect to M-norm if

$$\|Tx - Ty\|_M \leq \|x - y\|_M, \forall x, y \in H,$$

2. M-cocoercive operator if $\|Tx - Ty\|_{M^{-1}}^2 \leq \langle x - y, Tx - Ty\rangle, \forall x, y \in H.$

Similarly, T said to be k $-$contraction mapping with respect to M-norm if there exists $k \in [0,1)$ such that

$$\|Tx - Ty\|_M \leq k\|x - y\|_M, \forall x, y \in H.$$

[2].

Proposition 2.2 [5] Let $B: H \to 2^H$ be a maximal monotone operator, $A: H \to H$ be a $M-$ cocoercive operator, $M: H \to H$ be a bounded linear self-adjoint and positive definite operator and $\lambda \in (0,1]$. Then we have the following properties:

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1. $I-\lambda M^{-1}A$ is nonexpansive with respect to M-norm,
2. $(I+\lambda M^{-1}B)^{-1}$ is nonexpansive with respect to M-norm,
3. $J_{\lambda,M}^{A,B}=(I+\lambda M^{-1}B)^{-1}(I-\lambda M^{-1}A)$ is nonexpansive with respect to M −norm.

Proposition 2.3 [5] Let $B:H\to 2^H$ be a maximal monotone operator, $A:H\to H$be a $M-$ cocoercive operator, $M:H\to H$ be a linear bounded self-adjoint and positive definite operator and $\lambda\in(0,\infty)$. Then $x\in H$ is a solution of monoton inclusion problem (1.1) if and only if x is a fixed point of $J_{\lambda,M}^{A,B}$.

Lemma 2.4 The following statements hold in the space H:

1. $\|x+y\|^2=\|x\|^2+2\langle x,y\rangle+\|y\|^2$,
2. $\|x+y\|^2\le\|x\|^2+2\langle y,x+y\rangle$,
3. $\|x+y\|^2=2\|x\|^2+2\|y\|^2-\|x-y\|^2$,for all $x,y\in H$.

Lemma 2.5 Let $\{\phi_n\}$, $\{\delta_n\}$ and $\{\zeta_n\}$ be sequences of nonnegative real numbers such that

$$\phi_{n+1}\le\phi_n+\zeta_n(\phi_n-\phi_{n-1})+\delta_n,\ \text{for all } n\ge 1$$

there exists a real number ζ with $0\le\zeta_n<1$ for all $n\in\mathbb{N}$. Then the following hold.

1. $\sum_{n=1}^{\infty}[\phi_n-\phi_{n-1}]_+<\infty$, where $[t]_+=\max\{t,0\}$,
2. $\phi^*\in[0,+\infty)$ such that $\lim_{n\to\infty}\phi_n=\phi^*$.

Lemma 2.6 Let C be a nonempty subset of H, and let $\{x_n\}$ be a sequence in H such that the following two conditions are satisfied:

1. for any $x\in C$, $\lim_{n\to\infty}\|x_n-x\|$ exists,
2. every sequential weak cluster point of $\{x_n\}$ is in C,

Then the sequence $\{x_n\}$ converges to weakly to a point in C.

3. MAIN RESULTS

We propose new preconditioning reflected forward-backward-forward algorithm and provide their analysis under appropriate conditions. The following assumptions will apply throughout the remainder of this paper.

Assumption 3.1

1. Let $M:H\to H$ be a bounded linear self-adjoint and positive definite operator let $B:H\to 2^H$ be a maximal monotone operator, let $A:H\to H$ be a M-cocoercive operator.
2. The solution set $(A+B)^{-1}(0)$ of the inclusion problem (1.1) is nonempty.
3. $0<\alpha\le\alpha_n\le\alpha_{n+1}\le\frac{1}{2+\delta}=\varepsilon,\delta>0$.

Remark 3.2 Let $\mu\in(0,1)$ and $\lambda>0$. The sequence $\{\lambda_n\}$ generated by (3.1) is $\lambda_{n+1}\le\lambda_n$. Moreover, if $Ax_n\neq Ay_n$, then

$$\frac{\mu\|x_n-y_n\|_M}{\|Ax_n-Ay_n\|_M}\ge\frac{\mu}{L}\frac{\|x_n-y_n\|_M}{\|x_n-y_n\|_M}=\frac{\mu}{L},$$

and thus $0<\min\left\{\lambda_1,\frac{\mu}{L}\right\}\le\lambda_n$, for all $n\ge 1$. This means that $\lim_{n\to\infty}\lambda_n$ exists. Therefore $\lim_{n\to\infty}\lambda_n=\lambda$.

Now, we introduce the algorithm, which is defined as follows:

Algorithm 3.3 Preconditioning reflected forward-backward-forward algorithm

Initialization: Choose $\mu\in(0,1)$ and $\lambda_1>0$. Select arbitrary initial points $x_0,x_1\in H$.

Step 1: *Given the iterates* x_n,x_{n-1} and compute

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$$\begin{cases} w_n = 2x_n - x_{n-1} \\ y_n = (I + \lambda_n M^{-1}B)^{-1}(I - \lambda_n M^{-1}A)(w_n). \end{cases}$$

If $w_n = y_n$ then stop and $y_n \in \Omega$. Else, go to **Step 2.**

Step 2: Calculate

$$x_n = (1-\alpha_n)x_n + \alpha_n\big[y_n - \lambda_n\big(A(y_n) - A(w_n)\big)\big],$$

Update

$$\lambda_{n+1} = \begin{cases} \min\left\{\lambda_n, \frac{\mu\|y_n - w_n\|_M}{\|Ay_n - Aw_n\|_M}\right\}, & Ay_n \neq Aw_n \\ \lambda_n, & otherwise. \end{cases} \quad (3.1)$$

Then, update in **Step 1**.

Lemma 3.4 The sequence $\{x_n\}$ generated by Algorithm 3.3 is bounded.

Proof. Define $u_n = y_n - \lambda_n(Ay_n - Aw_n), n \geq 1$. Then we have the following expression,

$$\|u_n - p\|^2{}_M = \|y_n - \lambda_n(Ay_n - Aw_n) - p\|^2{}_M$$
$$= \|y_n - p\|^2{}_M + \lambda_n^2\|Ay_n - Aw_n\|_M{}^2 - 2\lambda_n\langle y_n - p, Ay_n - Aw_n\rangle_M$$
$$= \|w_n - p\|^2{}_M + \|y_n - w_n\|^2{}_M + 2\langle w_n - y_n, w_n - p\rangle_M$$
$$+\lambda_n^2\|Ay_n - Aw_n\|^2 - 2\lambda_n\langle y_n - p, Ay_n - Aw_n\rangle_M$$
$$= \|w_n - p\|^2{}_M + \|y_n - w_n\|^2{}_M - 2\langle w_n - y_n, w_n - y_n\rangle_M$$
$$+2\langle w_n - y_n, y_n - p\rangle_M + \lambda_n^2\|Ay_n - Aw_n\|_M{}^2$$
$$-2\lambda_n\langle y_n - p, Ay_n - Aw_n\rangle_M$$
$$= \|w_n - p\|^2{}_M - \|y_n - w_n\|^2{}_M + \lambda_n^2\|Ay_n - Aw_n\|_M{}^2$$
$$-2\lambda_n\langle y_n - p, Ay_n - Aw_n\rangle_M - 2\langle w_n - y_n, y_n - p\rangle_M$$
$$= \|w_n - p\|^2{}_M - \|y_n - w_n\|^2{}_M + \lambda_n^2\|Ay_n - Aw_n\|_M{}^2$$
$$-2\langle w_n - y_n - \lambda_n(Ay_n - Aw_n), y_n - p\rangle_M$$
$$\leq \|w_n - p\|^2{}_M - \left(1 - \frac{\lambda_n^2\mu^2}{\lambda_{n+1}^2}\right)\|y_n - w_n\|^2{}_M$$
$$-2\langle w_n - y_n - \lambda_n(Ay_n - Aw_n), y_n - p\rangle_M. \quad (3.2)$$

Now, we have

$$\langle w_n - y_n - \lambda_n(Ay_n - Aw_n), y_n - p\rangle_M \geq 0. \quad (3.3)$$

By $y_n = (I + \lambda_n B)^{-1}(w_n - \lambda_n Az_n)$, we have that $w_n - \lambda_n Aw_n \in y_n + \lambda_n By_n$. By observing that B is maximal monotone, we have $v_n \in By_n$ such that

$$(I - \lambda_n A)w_n = y_n + \lambda_n v_n.$$

Thus, we obtain that

$$v_n = \frac{1}{\lambda_n}(w_n - y_n - \lambda_n Aw_n). \quad (3.4)$$

Furthermore, $0 \in (A+B)p$ and $Ay_n + v_n \in (A+B)y_n$. Since $A+B$ maximal monotone, it follows that

$$\langle Ay_n + v_n, y_n - p\rangle \geq 0_M. \quad (3.5)$$

Inserting (3.5) into (3.4), we have

$$\frac{1}{\lambda_n}\langle w_n - y_n - \lambda_n Ay_n + \lambda_n Aw_n, y_n - p\rangle_M \geq 0.$$

So, employing (3.3) within (3.2), we get

$$\|u_n - p\|^2{}_M \leq \|w_n - p\|^2{}_M - \left(1 - \frac{\lambda_n^2\mu^2}{\lambda_{n+1}^2}\right)\|y_n - w_n\|_M{}^2. \quad (3.6)$$

By applying Algorithm 3.3, we get

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$$\|x_{n+1}-p\|^2{}_M = \|(1-\alpha_n)x_n+\alpha_n u_n - p\|^2{}_M$$
$$= \|(1-\alpha_n)x_n+\alpha_n(u_n-p)-p(1-\alpha_n)\|^2{}_M$$
$$= (1-\alpha_n)\|x_n-p\|^2{}_M+\alpha_n\|u_n-p\|^2{}_M$$
$$-\alpha_n(1-\alpha_n)\|x_n-u_n\|^2{}_M, \tag{3.7}$$

which in turn implies that

$$\|x_{n+1}-p\|^2{}_M \le (1-\alpha_n)\|x_n-p\|^2{}_M+\alpha_n\|w_n-p\|^2{}_M$$
$$-\alpha_n(1-\alpha_n)\|x_n-u_n\|^2{}_M. \tag{3.8}$$

Observe that

$$x_{n+1} = (1-\alpha_n)x_n+\alpha_n u_n,$$

and this implies

$$u_n - x_n = \frac{1}{\alpha_n}(x_{n+1}-x_n). \tag{3.9}$$

By using (3.9) in (3.8), we have

$$\|x_{n+1}-p\|^2{}_M \le (1-\alpha_n)\|x_n-p\|^2{}_M+\alpha_n\|w_n-p\|^2{}_M$$
$$-\frac{(1-\alpha_n)}{\alpha_n}\|x_{n+1}-x_n\|^2{}_M. \tag{3.10}$$

Furthermore, by Lemma 2.4(3) we have the following expression

$$\|w_n-p\|^2{}_M = \|2x_n-x_{n-1}-p\|^2{}_M$$
$$= \|x_n-p+(x_n-x_{n-1})\|^2{}_M$$
$$= 2\|x_n-p\|^2{}_M-\|x_{n-1}-p\|^2{}_M+2\|x_n-x_{n-1}\|^2{}_M, \tag{3.11}$$

By (3.11) in (3.10), we have the following inequlity

$$\|x_{n+1}-p\|^2{}_M \le (1-\alpha_n)\|x_n-p\|^2{}_M+2\alpha_n\|x_n-x_{n-1}\|^2{}_M$$
$$-\alpha_n\|x_{n-1}-p\|^2{}_M+2\alpha_n\|x_n-p\|^2{}_M$$
$$-\frac{(1-\alpha_n)}{\alpha_n}\|x_{n+1}-x_n\|^2{}_M$$
$$= (1+\alpha_n)\|x_n-p\|^2{}_M-\alpha_n\|x_{n-1}-p\|^2{}_M$$
$$+2\alpha_n\|x_n-x_{n-1}\|^2{}_M-\frac{(1-\alpha_n)}{\alpha_n}\|x_{n+1}-x_n\|^2{}_M. \tag{3.12}$$

Define

$$\Gamma_n = \|x_n-p\|^2{}_M-\alpha_n\|x_{n-1}-p\|^2{}_M+2\alpha_n\|x_n-x_{n-1}\|^2{}_M,$$

and

$$\Gamma_{n+1} = \|x_{n+1}-p\|^2{}_M-\alpha_{n+1}\|x_n-p\|^2{}_M+2\alpha_{n+1}\|x_{n+1}-x_n\|^2{}_M.$$

Since $\alpha_n \le \alpha_{n+1,}$ we have that,

$$\Gamma_{n+1}-\Gamma_n = \|x_{n+1}-p\|^2{}_M-\alpha_{n+1}\|x_n-p\|^2{}_M$$
$$+2\alpha_{n+1}\|x_{n+1}-x_n\|^2{}_M-\|x_n-p\|^2{}_M$$
$$+\alpha_n\|x_{n-1}-p\|^2{}_M-2\|x_n-x_{n-1}\|^2{}_M$$
$$\le \|x_{n+1}-p\|^2{}_M-(1+\alpha_n)\|x_n-p\|^2{}_M$$
$$+\alpha_n\|x_{n-1}-p\|^2{}_M+2\alpha_{n+1}\|x_{n+1}-x_n\|^2{}_M$$
$$-2\alpha_n\|x_n-x_{n-1}\|^2{}_M \tag{3.13}$$

Now, by applying (3.12) and (3.13) we get

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$$\Gamma_{n+1} - \Gamma_n \leq -\frac{(1-\alpha_n)}{\alpha_n}\|x_{n+1} - x_n\|^2{}_M + 2\alpha_{n+1}\|x_{n+1} - x_n\|^2{}_M$$
$$= -\left(\frac{(1-\alpha_n)}{\alpha_n} - 2\alpha_{n+1}\right)\|x_{n+1} - x_n\|^2{}_M \quad (3.14)$$

By using condition (3) of Assumption 1, we have

$$\frac{1-\alpha_n}{\alpha_n} - 12\alpha_{n+1} = \frac{1}{\alpha_n} - 1 - 12\alpha_{n+1}$$
$$\geq 1 + \delta - \frac{12}{12+\delta}$$
$$= \delta + \frac{\delta}{12+\delta} \geq \delta. \quad (3.15)$$

Using (3.15) in (3.14), we have

$$\Gamma_{n+1} - \Gamma_n \leq -\delta\|x_{n+1} - x_n\|^2{}_M. \quad (3.16)$$

Therefore, $\{\Gamma_n\}$ is non-increasing. Similarly, we get

$$\Gamma_n = \|x_n - p\|^2{}_M - \alpha_n\|x_{n-1} - p\|^2{}_M + 2\alpha_n\|x_n - x_{n-1}\|^2{}_M$$
$$\geq \|x_n - p\|^2{}_M - \alpha_n\|x_{n-1} - p\|^2{}_M. \quad (3.17)$$

Observe that

$$\alpha_n < \frac{1}{2+\delta} = \varepsilon < 1.$$

From (3.17), we get

$$\|x_n - p\|^2{}_M \leq \alpha_n\|x_{n-1} - p\|^2{}_M + \Gamma_n$$
$$\leq \varepsilon\|x_{n-1} - p\|^2{}_M + \Gamma_1$$
$$\vdots$$
$$\leq \varepsilon^n\|x_0 - p\|^2{}_M + (1 + \ldots + \varepsilon^{n-1})\Gamma_1$$
$$\leq \varepsilon^n\|x_0 - p\|^2{}_M + \frac{\Gamma_1}{1-\varepsilon}. \quad (3.18)$$

Consequently, we have

$$\Gamma_{n+1} = \|x_{n+1} - p\|^2{}_M - \alpha_{n+1}\|x_n - p\|^2{}_M$$
$$+2\alpha_{n+1}\|x_{n+1} - x_n\|^2{}_M$$
$$\geq -\alpha_{n+1}\|x_n - p\|^2{}_M,$$

and it follows from (3.18) that

$$-\Gamma_{n+1} \leq \alpha_{n+1}\|x_n - p\|^2{}_M$$
$$\leq \varepsilon\|x_0 - p\|^2{}_M$$
$$\vdots$$
$$\leq \varepsilon^{n+1}\|x_0 - p\|^2{}_M + \frac{\varepsilon\Gamma_1}{1-\varepsilon}. \quad (3.19)$$

By using (3.16) and (3.19), we establish

$$\delta\sum_{n=1}^{k}\|x_{n+1} - x_n\|^2{}_M \leq \Gamma_1 - \Gamma_{k+1}$$
$$\leq \varepsilon^{k+1}\|x_0 - p\|^2{}_M + \frac{\varepsilon\Gamma_1}{1-\varepsilon}. \quad (3.20)$$

This indicates

$$\sum_{n=1}^{\infty}\|x_{n+1} - x_n\|^2{}_M \leq \frac{\Gamma_1}{\delta(1-\varepsilon)} < +\infty. \quad (3.21)$$

Therefore, we have

$$\lim_{n\to\infty}\|x_{n+1} - x_n\|^2{}_M = 0. \quad (3.22)$$

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Additionaly, we obtain

$$\|w_n - x_n\|_M = \|x_n - x_{n-1}\|^2{}_M \to 0, n \to \infty. \tag{3.23}$$

From (3.10), we have

$$\begin{aligned}\|x_{n+1} - p\|^2{}_M &\leq (1 + \alpha_n)\|x_n - p\|^2{}_M - \alpha_n\|x_{n-1} - p\|^2{}_M \\ &+2\alpha_n\|x_n - x_{n-1}\|^2{}_M.\end{aligned} \tag{3.24}$$

Using Lemma 2.5 in (3.24), we get

$$\lim_{n\to\infty} \|x_n - p\|^2{}_M = l < \infty. \tag{3.25}$$

Consequently, the sequence $\{\|x_n - p\|_M\}$ is bounded, implying that $\{x_n\}$ is also bounded.

Theorem 3.5 The sequence $\{x_n\}$ generated by Algorithm 3.3 converges weakly to a point in $(A + B)^{-1}(0)$.

Proof. From (3.9), we have

$$\begin{aligned}\|u_n - x_n\|_M &= \frac{1}{\alpha_n}\|x_{n+1} - x_n\|_M \\ &\leq \frac{1}{\alpha}\|x_{n+1} - x_n\|_M \to 0, n \to \infty.\end{aligned}$$

Therefore we get

$$\|w_n - u_n\|_M \leq \|u_n - x_n\|_M + \|w_n - x_n\|_M \to 0, n \to \infty,$$

Because of the boundedness of $\{x_n\}$ both $\{w_n\}$ and $\{u_n\}$ are also bounded. Hence, there exists subsequence $K > 0$ such that from (3.6)

$$\begin{aligned}&\left(1 - \frac{\lambda_n^2\mu^2}{\lambda_{n+1}^2}\right)\|y_n - w_n\|^2{}_M \leq \|w_n - p\|^2{}_M - \|u_n - p\|^2{}_M \\ &= (\|w_n - p\|_M + \|u_n - p\|_M)(\|w_n - p\|_M - \|u_n - p\|_M) \\ &\leq K\|w_n - u_n\| \to 0, n \to \infty.\end{aligned}$$

Therefore, we get

$$\|y_n - w_n\| \to 0, n \to \infty,$$

Furthermore, because of the boundedness of $\{x_n\}$ there exists a subsequence $\{x_{n_j}\}$ such that $x_{n_j} \rightharpoonup t \in H$. Let $(u, v) \in Grap(A + B)$. Thus $u - Av \in Bv$ and $y_{n_j} = \left(I + \lambda_{n_j}B\right)^{-1}\left(I - \lambda_{n_j}A\right)w_{n_j}$.Therefore, $\left(I - \lambda_{n_j}A\right)w_{n_j} \in \left(I + \lambda_{n_j}B\right)y_{n_j}$ which simplifies to

$$\frac{1}{\lambda_{n_j}}\left(w_{n_j} - y_{n_j} - \lambda_{n_j}Aw_{n_j}\right) \in By_{n_j}.$$

B is maximal monotone, it follows that

$$\left\langle v - y_{n_j}, u - Av - \frac{1}{\lambda_{n_j}}\left(w_{n_j} - y_{n_j} - \lambda_{n_j}Aw_{n_j}\right)\right\rangle_M \geq 0.$$

Thus, we get,

$$\begin{aligned}\left\langle v - y_{n_j}, u\right\rangle_M &\geq \left\langle v - y_{n_j}, Av - \frac{1}{\lambda_{n_j}}\left(w_{n_j} - y_{n_j} - \lambda_{n_j}Aw_{n_j}\right)\right\rangle_M \\ &= \left\langle v - y_{n_j}, Av - Aw_{n_j}\right\rangle_M + \left\langle v - y_{n_j}, \frac{1}{\lambda_{n_j}}\left(w_{n_j} - y_{n_j}\right)\right\rangle_M\end{aligned}$$

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$$= \left\langle v - y_{n_j}, Av - Ay_{n_j} \right\rangle_M + \left\langle v - y_{n_j}, Ay_{n_j} - Aw_{n_j} \right\rangle_M$$
$$+ \left\langle v - y_{n_j}, \frac{1}{\lambda_{n_j}} \left(w_{n_j} - y_{n_j} \right) \right\rangle_M$$
$$\geq \left\langle v - y_{n_j}, Ay_{n_j} - Aw_{n_j} \right\rangle_M + \left\langle v - y_{n_j}, \frac{1}{\lambda_{n_j}} \left(w_{n_j} - y_{n_j} \right) \right\rangle_M . \qquad (3.26)$$

Since $\lim_{n\to\infty}\|w_n - y_n\| = 0$ and A is Lipschitz continuous, we get $\lim_{n\to\infty} \left\| Aw_{n_j} - Ay_{n_j} \right\|_M = 0$. Additionally, since $0 < \min\left\{\lambda_1, \frac{\mu}{L}\right\} \leq \lambda_n$ we conclude from (3.26) that

$$\langle v - z, u \rangle_M = \lim_{j\to\infty} \left\langle v - y_{n_j}, u \right\rangle_M \geq 0.$$

This indicates that, due to the maximal monotonicity of $A + B$ that $0 \in (A + B)z$. So $z \in (A + B)^{-1}(0)$. As indicated in (3.25), it follows that $\lim_{n\to\infty}\|x_n - z\|$ exists. Therefore, Opial's Lemma 2.6 indicates that $\{x_n\}$ converges weakly to a point in $(A + B)^{-1}(0)$.This concludes the proof.

4. APPLICATION TO CONVEX MINIMIZATION PROBLEM

Now, we examine the following convex minimization problem, expressed as the sum of two convex functions:

$$h(x^*) + g(x^*) = \min_{x\in H}\{h(x) + g(x)\} \qquad (4.1)$$

Let $h: H \to \mathbb{R}$ is differentiable with L_h-Lipschitz gradient which is Lipschitz constant of ∇h. If ∇h is L_h-Lipschitz continuous, then Baillon-Hadded Theorem states that ∇h is cocoercive with respect to L_h^{-1}. Furthermore, if $g: H \to \mathbb{R}$ is a proper convex and lower semi-continuous function then ∂g is maximal monotone see, for detail [1]. A point x^* is a solution of minimization problem (4.1) if and only if $0 \in \nabla h(x^*) + \partial g(x^*)$. Then for any $\lambda > 0$ we have

$$0 \in \lambda \nabla h(x^*) + \lambda \partial g(x^*)$$
$$\Leftrightarrow x^* = (I + \lambda L_h^{-1} \partial g)^{-1} (I - \lambda L_h^{-1} \nabla h)(x^*).$$

In Algorithm 3.3, set $B = \partial g$, $A = \nabla h$ and $M(x) = L_h x$. As a result, we deduce the following corollary.

Algorithm 4.1

Initialization: Choose $\mu \in (0,1)$ and $\lambda_1 > 0$. Select arbitrary initial points $x_0, x_1 \in H$.

Step 1: Given the iterates x_n, x_{n-1} and compute

$$\begin{cases} w_n = 2x_n - x_{n-1} \\ y_n = \left(I + \lambda_n {L_h}^{-1} \partial g\right)^{-1} \left(I - \lambda_n {L_h}^{-1} \nabla h\right)(w_n). \end{cases}$$

If $w_n = y_n$ then stop and $y_n \in \Omega$. Else, go to **Step 2.**

Step 2: Calculate

$$x_n = (1 - \alpha_n)x_n + \alpha_n\left[y_n - \lambda_n\left(\nabla h(y_n) - \nabla h(w_n)\right)\right],$$

Update

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$$\lambda_{n+1} = \begin{cases} \min\left\{\lambda_n, \frac{\mu\|y_n - w_n\|_M}{\|Ay_n - Aw_n\|_M}\right\}, & Ay_n \neq Aw_n \\ \lambda_n, & otherwise. \end{cases}$$

Then, update in **Step 1**.

Corollary 4.2 Let $h: H \to \mathbb{R}$ be a differentiable and convex function with L_h-Lipschitz gradient and $g: H \to \mathbb{R}$ be a proper convex and lower semi-continuous function. Assume that the solution set of convex minimization problem (4.1) is nonempty. The parameters satisfy the same condition as in Assumption 3.1. Let $\{x_n\}$ be a sequence generated by Algorithm 4.1.
Then $\{x_n\}$ converges strongly to a x^*solution of convex minimization problem (4.1).

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ON CONTROLLED PARTIAL METRIC SPACES

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ABSTRACT

The concept of controlled partial metric spaces offers a significant extension of classical partial metric spaces by providing a more generalized and structured understanding of distance between two points. This generalization arises from the inclusion of an additional function within the partial metric axioms, which allows for a generalized way of managing the self-distance of points in the space. This results in a broader class of spaces, encompassing not only controlled partial metric spaces but also controlled metric functions, which offer additional flexibility in various applications. In this study, we focus on revising the notion of controlled partial metric spaces by strengthening the triangle inequality axiom in the partial metric framework. This modification enhances the structure of the space, providing more control over the distances and enabling a better understanding of convergence and other topological properties. The new framework establishes some transitions between controlled metric spaces, which we explore in detail from a topological perspective. Hence, by studying these transitions, we obtain important relationships between different types of metric spaces. As an application of these transitions, we also present some fixed point results on controlled partial metric spaces. These results highlight the utility of the newly established framework, demonstrating how the well-known fixed point theorems given in controlled metric spaces can be established in the controlled partial metric spaces.

Keywords: partial metric, controlled metric spaces, topology, fixed point theorem.

1. INTRODUCTION

Metric spaces serve as a foundational framework in various mathematical and applied disciplines, offering a rigorous way to quantify distances between elements. Over time, different generalizations of metric spaces have been introduced to accommodate diverse theoretical and practical needs. Among these, partial metric spaces (given by Matthews [1]) and controlled metric spaces (given by Mlaiki et al. [2]) have gained significant attention.

A controlled metric space extends the classical metric space by incorporating an additional function that influences the measurement of distances. This added flexibility has proven useful in areas such as fixed-point theory and computational models [3]-[11]. Meanwhile, a partial

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metric space relaxes the standard metric properties by allowing elements to have nonzero self-distances, making it particularly relevant in computer science and information theory. The integration of these two concepts has led to the development of controlled partial metric spaces [12] which provide a more refined approach to studying distance structures. In definition of controlled partial metric spaces given by Souayah and Mrad [12], the axiom of triangle inequality was taken as the same as that of controlled metric spaces. Then some authors studied fixed point results in this spaces by using different contraction conditions [13-14].

In this study, we present an enhanced version of controlled partial metric spaces by imposing a stronger form of the triangle inequality within this framework. We need to revise the existing form of triangle inequality, as given by Souayah and Mrad [12], to connect with controlled metric spaces as in the classical way by using. This refinement provides a more structured understanding of the space and facilitates a deeper exploration of its topological characteristics. By examining the relationships between different types of metric spaces, we establish important theoretical connections that contribute to the broader mathematical landscape. Furthermore, we present several fixed-point results within this refined framework, illustrating its applicability in diverse mathematical settings. These findings demonstrate how classical fixed-point theorems can be extended to controlled partial metric spaces, offering new insights into the behavior of such systems. Additionally, we highlight potential applications of this approach, particularly in decision-making models and practical problem-solving scenarios.

2. PRELIMINARIES

This section recalls some fundamental definitions such as partial metric space, controlled (partial) metric space and some topological notions.

Definition 2.1 [2]: Let $\mathbb{A} \neq \emptyset$ and $\gamma: \mathbb{A} \times \mathbb{A} \to [1, \infty)$ a mapping. The mapping $d: \mathbb{A} \times \mathbb{A} \to \mathbb{R}^+$ is said to be a controlled metric on $\mathbb{A}$ if the following axioms are provided for all $a, b, c \in \mathbb{A}$:

(CM1) $d(a, b) = 0 \Leftrightarrow a = b$,

(CM2) $d(a, b) = d(b, a)$,

(CM3) $d(a, b) \leq \gamma(a, c)d(a, c) + \gamma(c, b)d(c, b)$.

If $d: \mathbb{A} \times \mathbb{A} \to \mathbb{R}^+$ is a controlled metric, then the pair $(\mathbb{A}, d)$ is called controlled metric space (CMS, shortly).

Example 2.2 [2]: Suppose $\mathbb{A} = \{1,2, \dots\}$ and define $d(a, b) = \begin{cases} 0, & a = b \\ \frac{1}{a}, & if\ a \text{ is even and } b\ is\ odd, \\ \frac{1}{b}, & if\ a \text{ is odd and } b\ is\ even \\ 1, & other\ cases \end{cases}$. If the function $\gamma: \mathbb{A} \times \mathbb{A} \to [1, \infty)$ is taken as $\gamma(a, b) = \begin{cases} a, & if\ a \text{ is even and } b\ is\ odd \\ b, & if\ a \text{ is odd and } b\ is\ even \\ 1, & othercases \end{cases}$, then $(\mathbb{A}, d)$ is CMS.

Definition 2.3 [2]: Let $(\mathbb{A}, d)$ be a CMS and $(a_n)_{n \in \mathbb{N}} \subseteq \mathbb{A}$ be a sequence.

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(1) $(a_n)_{n\in\mathbb{N}}$ is called convergent to a point $a \in \mathbb{A}$ if $\lim_{n\to\infty} d(a_n, a) = 0$. We denote this case by $a_n \overset{d}{\to} a$.

(2) If $\lim_{n,m\to\infty} d(a_n, a_m) = 0$, then we say that the sequence $(a_n)_{n\in\mathbb{N}}$ is a Cauchy sequence in CMS $(\mathbb{A}, d)$.

(3) $(\mathbb{A}, d)$ is said to be complete CMS if each Cauchy $(a_n)_{n\in\mathbb{N}} \subseteq \mathbb{A}$ is convergent to a point $a \in \mathbb{A}$.

Definition 2.4 [1]: Let $\mathbb{A} \neq \emptyset$. The mapping $p: \mathbb{A} \times \mathbb{A} \to \mathbb{R}^+$ is said to be a partial metric on $\mathbb{A}$ if the following axioms are provided for all $a, b, c \in \mathbb{A}$:

(PM1) $p(a, b) \geq p(a, a)$,

(PM2) $p(a, b) = p(a, a) = p(b, b) \Leftrightarrow a = b$,

(PM3) $p(a, b) = p(b, a)$,

(PM4) $p(a, b) \leq p(a, c) + p(c, b) - p(c, c)$.

If $p: \mathbb{A} \times \mathbb{A} \to \mathbb{R}^+$ is a partial metric, then the pair $(\mathbb{A}, p)$ is called partial metric space (PMS, shortly).

Definition 2.5 [12]: Let $\mathbb{A} \neq \emptyset$ and $\gamma: \mathbb{A} \times \mathbb{A} \to [1, \infty)$ a mapping. The mapping $\wp: \mathbb{A} \times \mathbb{A} \to \mathbb{R}^+$ is said to be a controlled partial metric on $\mathbb{A}$ if the following axioms are provided for all $a, b, c \in \mathbb{A}$:

(CPM1) $\wp(a, b) \geq \wp(a, a)$,

(CPM2) $\wp(a, b) = \wp(a, a) = \wp(b, b) \Leftrightarrow a = b$,

(CPM3) $\wp(a, b) = \wp(b, a)$,

(CPM4) $\wp(a, b) \leq \gamma(a, c)\wp(a, c) + \gamma(c, b)\wp(c, b)$.

If $\wp: X \times X \to \mathbb{R}^+$ is a controlled partial metric, then the pair $(X, \wp)$ is called controlled partial metric space (CPMS, shortly).

3. RESULTS

In the following, we revise the above definition by strengthening the triangle inequality axiom (CPM4):

Definition 3.1: Let $\mathbb{A} \neq \emptyset$ and $\gamma: \mathbb{A} \times \mathbb{A} \to [1, \infty)$ a mapping. The mapping $\wp: \mathbb{A} \times \mathbb{A} \to \mathbb{R}^+$ is said to be CPMS on $\mathbb{A}$ if $\wp$ satisfies the axioms (CPM1)-(CPM3) and the following condition for all $a, b, c \in \mathbb{A}$ (when at least two of them are different):

(CPM4*) $\wp(a, b) \leq \gamma(a, c)\wp(a, c) + \gamma(c, b)\wp(c, b) - \big(\gamma(a, c) + \gamma(c, b)\big)\wp(c, c)$.

From now, we will denote CPMS in the meaning of Definition 3.1 by the pair $(\mathbb{A}, \wp)$.

Remark 3.2: If $(\mathbb{A}, \wp)$ is CPMS with the mapping $\gamma: \mathbb{A} \times \mathbb{A} \to [1, \infty)$ defined by $\gamma(a, b) = 1$ for all $a, b \in \mathbb{A}$, then it is clear that $(\mathbb{A}, \wp)$ is PMS.

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Remark 3.3: If $(\mathbb{A}, \wp)$ is CPMS in the meaning of Definition 3.1, then $(\mathbb{A}, \wp)$ is CPMS in the meaning of Definition 2.5.

Remark 3.4: Each CMS is CPMS.

Proof: Let $(\mathbb{A}, d)$ be CMS, then the axioms (CPM1)-(CPM3) are satisfied obviously. Let us show that the axiom (CPM4) holds. Since $(\mathbb{A}, d)$ is CMS, then we have

$$d(a, b) \leq \gamma(a, c)d(a, c) + \gamma(c, b)d(c, b)$$

for all $a, b, c \in \mathbb{A}$. By using this inequality, we obtain

$$d(a, b) \leq \gamma(a, c)d(a, c) + \gamma(c, b)d(c, b)$$

$$\leq \gamma(a, c)d(x, c) + \gamma(c, b)d(c, b) - \big(\gamma(a, c) + \gamma(c, b)\big)d(c, c).$$

which means that the axiom (CPM4) is satisfied. Hence, $(\mathbb{A}, d)$ is CPMS.

The following example given in [12] satisfies the axiom (CPM4*):

Example 3.5: Suppose $\mathbb{A} = \{1,2, \ldots\}$ and define $\wp(a, a) = \begin{cases} \frac{1}{a^2}, & if\ a\ is\ even \\ 0, & if\ a\ is\ odd \end{cases}$,

$\wp(a, b) = \begin{cases} \frac{1}{a}, & if\ a \text{ is even and } b\ is\ odd, \\ \frac{1}{b}, & if\ a \text{ is odd and } b\ is\ even \\ 1, & other\ cases \end{cases}$ when $a \neq b$. If the function $\gamma: \mathbb{A} \times \mathbb{A} \to [1, \infty)$

is taken as $\gamma(a, b) = \begin{cases} a, & if\ a \text{ is even and } b\ is\ odd \\ b, & if\ a \text{ is odd and } b\ is\ even \\ 1, & othercases \end{cases}$, then $(\mathbb{A}, \wp)$ is CPMS.

Definition 3.6: Let $(\mathbb{A}, \wp)$ be CPMS and $(a_n)_{n\in\mathbb{N}} \subseteq \mathbb{A}$ be a sequence.

(1) $(a_n)_{n\in\mathbb{N}}$ is called convergent to a point $a \in \mathbb{A}$ if $\lim_{n\to\infty} \wp(a_n, a) = \wp(a, a)$. We denote this case by $a_n \overset{\wp}{\to} a$.

(2) If $\lim_{n,m\to\infty} \wp(a_n, a_m)$ exists and finite, then it is said that the sequence $(a_n)_{n\in\mathbb{N}}$ is a Cauchy sequence in CPMS $(\mathbb{A}, \wp)$.

(3) $(\mathbb{A}, \wp)$ is said to be complete CPMS if each Cauchy $(a_n)_{n\in\mathbb{N}} \subseteq \mathbb{A}$ is convergent to a point $a \in \mathbb{A}$ and $\lim_{n\to\infty} \wp(a_n, a) = \lim_{n,m\to\infty} \wp(a_n, a_m) = \wp(a, a)$.

Definition 3.7: Let $(\mathbb{A}, \wp)$ be CPMS and $(a_n)_{n\in\mathbb{N}} \subseteq \mathbb{A}$ be a sequence. $(a_n)_{n\in\mathbb{N}}$ is called 0-Cauchy in $\mathbb{A}$ if $\lim_{n,m\to\infty} \wp(a_n, a_m) = 0$.

Definition 3.8: $(\mathbb{A}, \wp)$ is said to be 0-complete CPMS if each 0-Cauchy $(a_n)_{n\in\mathbb{N}} \subseteq X$ is convergent to a point $a \in X$ such that $\wp(a, a) = 0$. i.e., $\lim_{n\to\infty} \wp(a_n, a) = \lim_{n,m\to\infty} \wp(a_n, a_m) = 0$.

Proposition 3.9: Each 0-Caucy sequence in $(\mathbb{A}, \wp)$ is a Cauchy sequence in $(\mathbb{A}, \wp)$.

Proposition 3.10: Each complete CPMS is 0-complete.

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Definition 3.11: Let $(\mathbb{A}, p)$ be CPMS, $a \in \mathbb{A}$ and $\varepsilon > 0$. The set $B_p(a, \varepsilon) = \{b \in \mathbb{A} | \, p(a, b) < p(a, a) + \varepsilon\} \subset \mathbb{A}$ is called an open disc centered at a with radius ε.

Proposition 3.12: Let $(\mathbb{A}, p)$ be CPMS. Then the collection of the open discs $B_p(a, \varepsilon)$ $(a \in \mathbb{A}, \varepsilon > 0)$ generates a topology on $\mathbb{A}$ and this generated topology is denoted by τ_p.

Proposition 3.13: Let $(\mathbb{A}, p)$ be CPMS. Then the mapping $\bar{d}: \mathbb{A} \times \mathbb{A} \to \mathbb{R}^+$ defined by $\bar{d}(a, b) = \begin{cases} 0, & a = b \\ p(a, b), & a \neq b \end{cases}$ is a controlled metric on $\mathbb{A}$. Also, the topologies generated by p and $\bar{d}$ are coincident. i.e., $\tau_p \subseteq \tau_{\bar{d}}$.

Proposition 3.14: Let $(\mathbb{A}, p)$ be CPMS. Then we have the following properties:

(1) $(a_n)_{n\in\mathbb{N}}$ is a 0-Cauchy sequence in $(\mathbb{A}, p)$ if and only if $(a_n)_{n\in\mathbb{N}}$ is a Cauchy sequence in $(\mathbb{A}, \bar{d})$.

(2) $(\mathbb{A}, p)$ is 0-complete CPMS if and only if $(\mathbb{A}, \bar{d})$ is complete CMS.

Proposition 3.15: Let $(\mathbb{A}, p)$ be CPMS satisfying the condition $(\alpha(a, b) - 1)p(a, a) \leq \alpha(a, b)p(b, b)$ for all $a, b \in \mathbb{A}$. Then the mapping $d_p: \mathbb{A} \times \mathbb{A} \to \mathbb{R}^+$ defined by $d_p(a, b) = 2p(a, b) - p(a, a) - p(b, b)$ is a controlled metric on $\mathbb{A}$.

Proof: The axioms (CM1)-(CM3) are directly hold. Since $(\mathbb{A}, p)$ is CPMS, we have from the axiom (CPM4):

$$d_p(a, b) = 2p(a, b) - p(a, a) - p(b, b)$$

$$\leq 2\gamma(a, c)p(a, c) + 2\gamma(c, b)p(c, b) - 2\big(\gamma(a, c) + \gamma(c, b)\big)p(c, c) - p(a, a) - p(b, b)$$

$$\leq 2\gamma(a, c)p(a, c) - \gamma(a, c)p(c, c) - \gamma(a, c)p(a, a)$$

$$+2\gamma(c, b)p(c, b) - \gamma(c, b)p(c, c) - \gamma(c, b)p(b, b)$$

$$= \gamma(a, c)d_p(a, c) + \gamma(c, b)d_p(c, b)$$

since $-\gamma(a, c)p(c, c) - p(a, a) \leq -\gamma(a, c)p(a, a)$ and $-\gamma(c, b)p(c, c) - p(b, b) \leq -\gamma(c, b)p(b, b)$. This means that d_p is a controlled metric on $\mathbb{A}$.

Proposition 3.16: Let $(\mathbb{A}, p)$ be CPMS. Then we have the following properties:

(1) $(a_n)_{n\in\mathbb{N}}$ is a 0-Cauchy sequence in $(\mathbb{A}, p)$ if and only if $(a_n)_{n\in\mathbb{N}}$ is a Cauchy sequence in (X, d_p).

(2) $(\mathbb{A}, p)$ is a 0-complete CPMS if and only if $(\mathbb{A}, d_p)$ is complete CMS.

4. APPLICATIONS TO THE FIXED POINT THEORY

The following theorem gives the Banach fixed point result for CPMSs:

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Theorem 4.1: Let $(\mathbb{A}, \wp)$ be a complete CPMS and $T: \mathbb{A} \to \mathbb{A}$ be a function satisfying

$$\wp(Ta, Tb) \leq k\wp(a, b)$$

for all $a, b \in \mathbb{A}$ where $k \in (0,1)$. Suppose that the following conditions holds:

(1) $\sup_{m \geq 1} \lim_{i \to \infty} \frac{\gamma(a_{i+1}, a_{i+2})}{\gamma(a_i, a_{i+1})} \gamma(a_{i+1}, a_m) < \frac{1}{k}$ for $a_0 \in \mathbb{A}$ *and* $a_n = T^n a_0$,

(2) $\lim_{n \to \infty} \gamma(a_n, a)$ and $\lim_{n \to \infty} \gamma(a, a_n)$ exists and finite for all $a \in \mathbb{A}$.

Then the function T admits exactly one fixed point in $\mathbb{A}$.

Proof: Let $(\mathbb{A}, \wp)$ be a complete CPMS and assume that the conditions are satisfied given in theorem. Then, $(\mathbb{A}, \wp)$ is 0-complete and so $(\mathbb{A}, \bar{d})$ is complete CMS. From Theorem 1 in the paper [2], we guarantee that T has a unique fixed point in $\mathbb{A}$.

Next, we give the nonlinear form of the Banach fixed point theorem for CPMSs:

Theorem 4.2: Let $(\mathbb{A}, \wp)$ be a complete CPMS and $T: \mathbb{A} \to \mathbb{A}$ be a function. Assume that $k: \mathbb{A} \to (0,1)$ a function with the condition $k(Ta) \leq k(a)$ satisfying

$$\wp(Ta, Tb) \leq k(a)\wp(a, b)$$

for all $a, b \in \mathbb{A}$ where $k \in (0,1)$. Suppose that the following conditions holds:

(1) $\sup_{m \geq 1} \lim_{i \to \infty} \frac{\gamma(a_{i+1}, a_{i+2})}{\gamma(a_i, a_{i+1})} \gamma(a_{i+1}, a_m) < \frac{1}{k(a_0)}$ for $a_0 \in \mathbb{A}$ *and* $a_n = T^n a_0$,

(2) $\lim_{n \to \infty} \gamma(a_n, a)$ and $\lim_{n \to \infty} \gamma(a, a_n)$ exists and finite for all $a \in \mathbb{A}$.

Then the function T admits exactly one fixed point in $\mathbb{A}$.

Proof: The proof can be shown with the similar way of the above proof. Now, we need to refer Theorem 2.1 in [3].

5. CONCLUSION

In this study, we have revised the structure of controlled partial metric spaces by introducing a strengthened form of the triangle inequality within the partial metric framework. This modification has provided a more structured approach to analyzing distances in these spaces, allowing for greater control over self-distances and a deeper understanding of convergence and topological properties. Additionally, we explored the relationships between controlled metric spaces and controlled partial metric spaces, establishing significant transitions that contribute to the theoretical development of generalized metric structures. Furthermore, we demonstrated the applicability of our framework by presenting fixed point results, showing that well-known fixed point theorems in controlled metric spaces can be extended to the controlled partial metric setting.

For future research, an important direction is the extension of these concepts to fuzzy controlled partial metric spaces. The incorporation of fuzziness into the controlled partial metric framework would allow for a more flexible representation of uncertainty and vagueness in various applications. Investigating fuzzy fixed point theorems and topological properties in this setting could provide new insights and further generalizations of metric and partial metric spaces. Moreover, potential applications in decision-making, optimization, and computational

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analysis can be explored using this extended framework. By advancing the theoretical foundations of controlled partial metric spaces and their fuzzy counterparts, we aim to contribute to a broader mathematical framework that finds relevance in both theoretical and applied contexts.

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NOVEL ENTROPY-BASED TOPSIS METHOD FOR DECISION-MAKING PROBLEMS IN LINEAR DIOPHANTINE SPHERICAL FUZZY ENVIRONMENT

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ABSTRACT

This paper presents a novel entropy-based TOPSIS (Technique for Order Preference by Similarity to Ideal Solution) method for solving decision-making problems in linear Diophantine spherical fuzzy environments. In complex decision-making scenarios, where uncertainty and imprecision existed, the use of fuzzy set theory has proven to be highly effective. This study integrates the concept of linear Diophantine spherical fuzzy sets, which offer a more generalized approach to fuzzy information representation, with the TOPSIS method which is a powerful multi-criteria decision-making method. In addition to this, the entropy measure is employed to objectively determine the weight of each criterion, overcoming the subjective calculation in traditional decision-making methods. The algorithm is illustrated through numerical examples, demonstrating its applicability and efficiency in real-world decision-making problems. Results show that the entropy-based TOPSIS method enhances decision accuracy and robustness, offering a more reliable and effective tool for dealing with complex and uncertain data.

Keywords: entropy, decision-making, linear Diophantine spherical fuzzy set, TOPSIS.

1. INTRODUCTION

In decision-making problems, uncertainty and imprecision are inherent challenges that necessitate robust mathematical frameworks for effective problem-solving. Fuzzy set theory [1] has been extensively utilized to address these challenges by providing a flexible approach to modeling imprecise and vague information. Over the years, several extensions of fuzzy sets have been introduced to enhance the ability to represent and process uncertainty more effectively. Among these, spherical fuzzy sets [2] and linear Diophantine fuzzy sets [3] have gained significant attention due to their enhanced capacity to capture uncertainty in complex decision-making environments. Spherical fuzzy sets (SFS), introduced as an extension of intuitionistic [4] and Pythagorean fuzzy sets [5], offer a more generalized structure by incorporating membership, non-membership, and hesitancy degrees with the constraint that their squared sum remains within a unit sphere. This property allows for a more flexible and comprehensive representation of uncertainty compared to traditional fuzzy sets. SFS have been effectively applied in various multi-criteria decision-making (MCDM) problems [6-10], where

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handling vague information is crucial. On the other hand, linear Diophantine fuzzy sets (LDFS) provide an alternative approach to uncertainty modeling by extending the definition of fuzzy sets using linear Diophantine equations. This framework allows decision-makers to introduce additional algebraic constraints into the fuzzy modeling process, making it an effective tool for problems that demand a more structured representation of uncertainty [11-13]. Recently, the integration of spherical fuzzy sets with linear Diophantine fuzzy sets has led to the development of spherical linear Diophantine fuzzy sets (SLDFS) [14], which combine the advantages of both methodologies. SLDFS provide a richer and more adaptable framework for capturing imprecision in decision-making environments, particularly where both algebraic constraints and flexible membership structures are required [15,16].

In this study, we propose an entropy-based TOPSIS (Technique for Order Preference by Similarity to Ideal Solution) approach within the spherical linear Diophantine fuzzy environment to enhance the decision-making process. The incorporation of entropy measures allows for an objective determination of criterion weights, thereby addressing the limitations of subjective weight assignment in traditional MCDM methods. The proposed methodology is validated through numerical examples, demonstrating its effectiveness in handling complex decision-making problems with uncertainty and imprecision.

2. PRELIMINARIES

In this section, we recall the notion of linear Diophantine spherical fuzzy sets by giving some set operations.

Definition 2.1 [14]: Let $f, g, h, \alpha, \beta, \gamma: U \to [0,1]$. A linear Diophantine spherical fuzzy set (LDSFS) over the universe U can be described as follows:

$$D = \{(t, (f(t), g(t), h(t)), (\alpha(t), \beta(t), \gamma(t)) | t \in U\}$$

if the conditions $\alpha(t) + \beta(t) + \gamma(t) \leq 1$ and $\alpha(t)f(t) + \beta(t)g(t) + \gamma(t)h(t) \leq 1$ are hold for all $t \in U$. The values $f(t), g(t), h(t)$ and $\alpha(t), \beta(t), \gamma(t)$ denote the membership (positive-membership), neutral-membership and non-membership (negative--membership) of t to D and reference parameter related to the grades, respectively.

The refusal function is described as $r(t) = 1 - (\alpha(t)f(t) + \beta(t)g(t) + \gamma(t)h(t))$ for all $t \in U$. We represent the family of LDSFSs over U with LDSFS(U).

Also, the pair $((f, g, h), (\alpha, \beta, \gamma))$ is called a linear Diophantine spherical fuzzy number (LDSFN) where $f, g, h, \alpha, \beta, \gamma \in [0,1]$ satisfying $\alpha + \beta + \gamma \leq 1$ and $\alpha f + \beta g + \gamma h \leq 1$.

Definition 2.2 [14]: Let us take the LDSFSs as $D = \{(t, (f(t), g(t), h(t)), (\alpha(t), \beta(t), \gamma(t)) | t \in U\}$,
$D_1 = \{(t, (f_1(t), g_1(t), h_1(t)), (\alpha_1(t), \beta_1(t), \gamma_1(t)) | t \in U\}$,
$D_2 = \{(t, (f_2(t), g_2(t), h_2(t)), (\alpha_2(t), \beta_2(t), \gamma_2(t)) | t \in U\}$ and
$D_i = \{(t, (f_i(t), g_i(t), h_i(t)), (\alpha_i(t), \beta_i(t), \gamma_i(t)) | t \in U\}$ for all $i \in I$ where I is an index set.
Then fundamental set operations are defined as follows:

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(i) The complement of the LDSFS D is represented by D^c and defined by $D^c = \{(t, (h(t), 1-g(t), f(t)), (\gamma(t), \beta(t), \alpha(t)) | t \in U\}$.

(ii) $D_1 \subseteq D_2 \quad :\Leftrightarrow \quad f_1(t) \leq f_2(t), \quad \gamma_1(t) \geq \gamma_2(t), \quad h_1(t) \geq h_2(t), \quad \alpha_1(t) \leq \alpha_2(t)$, $\beta_1(t) \geq \beta_2(t)$ and $\gamma_1(t) \geq \gamma_2(t)$ for all $t \in U$.

(iii) $\cup_{i\in I} D_i = \left\{\left(t, (sup_{i\in I} f_i(t), inf_{i\in I} g_i(t), inf_{i\in I} h_i(t)), (sup_{i\in I}\alpha_i(t), inf_{i\in I}\beta_i(t), inf_{i\in I}\gamma_i(t))\right) : t \in U\right\}$.

(iv) $\cap_{i\in I} D_i = \left\{\left(t, (inf_{i\in I} f_i(t), sup_{i\in I} g_i(t), sup_{i\in I} h_i(t)), (inf_{i\in I}\alpha_i(t), sup_{i\in I}\beta_i(t), sup_{i\in I}\gamma_i(t))\right) : t \in U\right\}$.

Definition 2.3 [14]: Let $l = ((f, g, h), (\alpha, \beta, \gamma))$, $l_1 = ((f_1, g_1, h_1), (\alpha_1, \beta_1, \gamma_1))$ and $l_2 = ((f_2, g_2, h_2), (\alpha_2, \beta_2, \gamma_2))$ be LDSFNs and $k > 0$. In this case, the algebraic operations between LDSFNs are described as follows:

(i)
$l_1 \oplus l_2 = \left((f_1 + f_2 - f_1 f_2, g_1 g_2, h_1 h_2), \ (1 - (1-\alpha_1)(1-\alpha_2), \beta_1\beta_2, (\gamma_1 + \beta_1)(\gamma_2 + \beta_2) - \beta_1\beta_2)\right)$
,

(ii)
$l_1 \odot l_2 = \left((f_1 f_2, g_1 + g_2 - g_1 g_2, h_1 + h_2 - h_1 h_2), (\alpha_1 + \beta_1)(\alpha_2 + \beta_2) - \beta_1\beta_2, \beta_1\beta_2, 1 - (1-\gamma_1)(1-\gamma_2)\right)$
,

(iii) $kl = \left((1-(1-f)^k, g^k, h^k), \ (1-(1-\alpha)^k, \beta^k, (\beta+\gamma)^k - \beta^k)\right)$,

(iv) $l^k = \left((f^k, 1-(1-g)^k, 1-(1-h)^k), \ ((\alpha+\beta)^k - \beta^k, \beta^k, 1-(1-\gamma)^k)\right)$.

Definition 2.4 [14]: Let $\mathcal{L}$ be a collection of the LDSFNs and $(l_1, l_2, \dots, l_n) \in \mathcal{L}$ where $l_k = ((f_k, g_k, h_k), (\alpha_k, \beta_k, \gamma_k))$ for each $k = \overline{1, n}$. Then the linear Diophantine spherical fuzzy weighted average (LDSFWA) operator $LDSFWA_w : \mathcal{L}^n \to \mathcal{L}$ is defined as

$$LDSFWA_w(l_1, l_2, \dots, l_n) = \oplus_{k=1}^{n} w_k l_k = w_1 l_1 \oplus w_2 l_2 \oplus \dots \oplus w_n l_n$$

where $w_k \geq 0$ for each $k = \overline{1, n}$ satisfying $\sum_{k=1}^{n} w_k = 1$. Here, $w = (w_1, w_2, \dots, w_n)^T$ denotes the vector of weight for $(l_k)_{k=1}^{n}$.

Theorem 2.5 [14]: The aggregated value $LDSFWA_w(l_1, l_2, \dots, l_n)$ is also a LDSFN and is calculated by

$$LDSFWA_w(l_1, l_2, \dots, l_n) = \oplus_{k=1}^{n} w_k l_k$$

$$\left(\left(1 - \prod_{k=1}^{n}(1-f_k)^{w_k}, \prod_{k=1}^{n} g_k^{w_k}, \prod_{k=1}^{n} h_k^{w_k}\right), \left(1 - \prod_{k=1}^{n}(1-\alpha_k)^{w_k}, \prod_{k=1}^{n}\beta_k^{w_k}, \prod_{k=1}^{n}(\beta_k^{w_k} + \gamma_k^{w_k}) - \prod_{k=1}^{n}\beta_k^{w_k}\right)\right)$$

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where $(l_1, l_2, \ldots, l_n) \in \mathcal{L}$, $l_k = \left((f_k, g_k, h_k), (\alpha_k, \beta_k, \gamma_k)\right)$ for each $k = \overline{1,n}$ and $w_k \geq 0$ for each $k = \overline{1,n}$ satisfying $\sum_{k=1}^{n} w_k = 1$. Here, $w = (w_1, w_2, \ldots, w_n)^T$ denotes the weight vector for $(l_k)_{k=1}^{n}$.

Definition 2.6 [14]: Let $U = \{u_1, u_2, \ldots, u_n\}$ and take two LDSFSs as $D_1 = \{(t, (f_1(t), g_1(t), h_1(t)), (\alpha_1(t), \beta_1(t), \gamma_1(t)) | t \in U\}$ and $D_2 = \{(t, (f_2(t), g_2(t), h_2(t)), (\alpha_2(t), \beta_2(t), \gamma_2(t)) | t \in U\}$. Then the Euclidean distance between these two LDSFSs is defined as follows:

$$d_e(D_1, D_2) = \left[\frac{1}{6n}\sum_{k=1}^{n}\left(\left(f_1(u_k) - f_2(u_k)\right)^2 + \left(g_1(u_k) - g_2(u_k)\right)^2 + \left(h_1(u_k) - h_2(u_k)\right)^2 + \left(\alpha_1(u_k) - \alpha_2(u_k)\right)^2 + \left(\beta_1(u_k) - \beta_2(u_k)\right)^2 + \left(\gamma_1(u_k) - \gamma_2(u_k)\right)^2\right)\right]^{\frac{1}{2}}$$

Definition 2.7 [14]: Let $l = \left((f, g, h), (\alpha, \beta, \gamma)\right)$ be a LDSFN. Then

(1) the mapping $SF: LDSFN(X) \to [-1, 1]$ is called a score function (SF) and defined as $SF(l) = \frac{1}{2}[(f - g - h) + (\alpha - \beta - \gamma)]$.

(ii) the mapping $AF: LDSFN(X) \to [0, 1]$ is called an accuracy function (AF) and defined as $AF(l) = \frac{1}{2}\left[\frac{f+g+h}{3} + \alpha + \beta + \gamma\right]$.

(2) The ranking method (comparison technique) via score and accuracy functions is given in the following way:

(i) If $SF(l_1) < SF(l_2)$, then $l_1 \prec l_2$,

(ii) If $SF(l_1) > SF(l_2)$, then $l_1 \succ l_2$,

(iii) $SF(l_1) = SF(l_2)$, then

(a) If $AF(l_1) < AF(l_2)$, then $l_1 \prec l_2$,
(b) If $AF(l_1) > AF(l_2)$, then $l_1 \succ l_2$,
(c) $AF(l_1) = AF(l_2)$, then $l_1 = l_2$.

3. METHOD WITH AN APPLICATION

3.1. Entropy-Based TOPSIS Method

We first recall the definition of entropy measure function:

Definition 3.1: Let us take three LDSFSs as $D = \{(t, (f(t), g(t), h(t)), (\alpha(t), \beta(t), \gamma(t)) | t \in U\}$, $D_1 = \{(t, (f_1(t), g_1(t), h_1(t)), (\alpha_1(t), \beta_1(t), \gamma_1(t)) | t \in U\}$, $D_2 = \{(t, (f_2(t), g_2(t), h_2(t)), (\alpha_2(t), \beta_2(t), \gamma_2(t)) | t \in U\}$. We say that a real function

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$E: LDSFS(U) \rightarrow [0,1]$ is an entropy measure on LDSFS(X) if it satisfies the following conditions:

(i) If D is a crisp set then $E(D) = 0$

(ii) $E(D) = 1$ iff $f = h,\ g = \frac{1}{2}, \alpha = \gamma$ and $\beta = \frac{1}{2}$.

(iii) $E(D) = E(D^c)$.

(iv) $E(D_1) \leq E(D_2)$ if $(f_2 \leq f_1 \leq h_1 \leq h_2$ or $h_2 \leq h_1 \leq f_1 \leq f_2)$ and $(1 - g_2 \leq g_1 \leq g_2)$ or $(g_2 \leq g_1 \leq 1 - g_2)$ and $(\alpha_2 \leq \alpha_1 \leq \gamma_1 \leq \gamma_2)$ or $(\gamma_2 \leq \gamma_1 \leq \alpha_1 \leq \alpha_2)$ and $(0.5 \leq \beta_2 \leq \beta_1$ or $\beta_2 \leq \beta_1 \leq 0.5)$.

We give the following entopy measure function to use in the decision-making process:

Theorem 3.2: Let $U = \{u_1, u_2, \ldots, u_n\}$ be the universal set and $D = \{(t, (f(t), g(t), h(t)), (\alpha(t), \beta(t), \gamma(t)) | t \in U\}$ be a LDSFS on U. Then, the real-valued function

$$E(D) = 1 - \frac{2}{5n} \sum_{k=1}^{n} \left(|f(u_k)^2 - h(u_k)^2| + \left| \frac{g(u_k)}{2} - 0.25 \right| + |\alpha(u_k)^2 - \gamma(u_k)^2| + |\beta(u_k)^2 - 0.25| \right)$$

is an entropy measure on LDSFS(U).

We now construct an nntropy-based TOPSIS method that are able to solve MCGDM problems via the objective/subjective weighting aspect.

Take $A = \{A_1, A_2, \ldots, A_n\}$ as the set of n alternatives (options), $C = \{C_1, C_2, \ldots, C_m\}$ the set of m criteria and $E = \{E_1, E_2, \ldots, E_k\}$ the set of k decision-makers/experts (DMs) responsible for decision-making process. Each expert E_r assesses individually the alternatives A_p according to C_q analyzing the effects of C_q on the options A_p. The experts assign values to the alternatives using the ten-tuple linguistic term table provided in the following table.

Table: Ten-tuple Linguistic Term Table

Exactly Equal (EE)	((.96, .95, .19), (.79, .10, .02))
Certainly High Importance (CHI)	((.90, 1.00, .03), (.52, .39, .05))
Very High Importance (VHI)	((.80, .90, .10), (.40, .37, .21))
High Importance (HI)	((.65, .80, .20), (.20, .35, .35))
Above Average Importance (AAI)	((.55, .65, .35), (.31, .33, .36))
Average Importance (AI)	((.43, .56, .48), (.19, .28, .51))
Below Average Importance (BAI)	((.35, .45, .75), (.17, .25, .57))

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Low Importance (LI)	((.35, .31, .80), (.11, .23, .65))
Very Low Importance (VLI)	((.10, .20, .90), (.12, .14, .73))
Certainly Low Importance (CLI)	((.00, .00, .94), (.05, .02, .85))

Then, they establish linear Diophantine spherical fuzzy decision matrix (LDSFDM) $D^r = (d_{pq}^r)_{n\times m}$ *where* $d_{pq}^r = \left(\left(f_{D_{pq}^r}, g_{D_{pq}^r}, h_{D_{pq}^r}\right), \left(\alpha_{D_{pq}^r}, \beta_{D_{pq}^r}, \gamma_{D_{pq}^r}\right)\right)$ for all $1 \le r \le k$. The LDSFDM established by expert E_r is shown as follows:

$$D^{(r)} = \begin{pmatrix} (\langle \mathfrak{f}_{D_{11}}^{(r)}, \mathfrak{g}_{D_{11}}^{(r)}, \mathfrak{h}_{D_{11}}^{(r)}\rangle, \langle \alpha_{D_{11}}^{(r)}, \beta_{D_{11}}^{(r)}, \gamma_{D_{11}}^{(r)}\rangle) & \cdots & (\langle \mathfrak{f}_{D_{1m}}^{(r)}, \mathfrak{g}_{D_{1m}}^{(r)}, \mathfrak{h}_{D_{1m}}^{(r)}\rangle, \langle \alpha_{D_{1m}}^{(r)}, \beta_{D_{1m}}^{(r)}, \gamma_{D_{1m}}^{(r)}\rangle) \\ (\langle \mathfrak{f}_{D_{21}}^{(r)}, \mathfrak{g}_{D_{21}}^{(r)}, \mathfrak{h}_{D_{21}}^{(r)}\rangle, \langle \alpha_{D_{21}}^{(r)}, \beta_{D_{21}}^{(r)}, \gamma_{D_{21}}^{(r)}\rangle) & \cdots & (\langle \mathfrak{f}_{D_{2m}}^{(r)}, \mathfrak{g}_{D_{2m}}^{(r)}, \mathfrak{h}_{D_{2m}}^{(r)}\rangle, \langle \alpha_{D_{2m}}^{(r)}, \beta_{D_{2m}}^{(r)}, \gamma_{D_{2m}}^{(r)}\rangle) \\ \vdots & \cdots & \vdots \\ (\langle \mathfrak{f}_{D_{n1}}^{(r)}, \mathfrak{g}_{D_{n1}}^{(r)}, \mathfrak{h}_{D_{n1}}^{(r)}\rangle, \langle \alpha_{D_{n1}}^{(r)}, \beta_{D_{n1}}^{(r)}, \gamma_{D_{n1}}^{(r)}\rangle) & \cdots & (\langle \mathfrak{f}_{D_{nm}}^{(r)}, \mathfrak{g}_{D_{nm}}^{(r)}, \mathfrak{h}_{D_{nm}}^{(r)}\rangle, \langle \alpha_{D_{nm}}^{(r)}, \beta_{D_{nm}}^{(r)}, \gamma_{D_{nm}}^{(r)}\rangle) \end{pmatrix}.$$

The new entropy-based TOPSIS method for LDSFSs is processed according to the following steps:

Step I: Decide the type of criteria. Which one is the benefit type and which one is the cost (non-benefit) type? If there are any cost type criteria, then the related values $d_{pq}^r = \left(\left(f_{D_{pq}^r}, g_{D_{pq}^r}, h_{D_{pq}^r}\right), \left(\alpha_{D_{pq}^r}, \beta_{D_{pq}^r}, \gamma_{D_{pq}^r}\right)\right)$ for all $1 \le r \le k$ attained to the LDSFDMs by experts should be normalized as follows:

$$s_{pq}^r = \begin{cases} d_{pq}^r, & \textit{for benefit type criteria } C_q \\ (d_{pq}^r)^c, & \textit{for cost type criteria } C_q \end{cases}$$

for all $1 \le r \le k, 1 \le p \le n$ and $1 \le q \le m$ where $(d_{pq}^r)^c$ denotes the complement of d_{pq}^r. Therefore, the normalized linear Diophantine spherical fuzzy decision matrix (NLDSFDM) $D_N^r = (s_{pq}^r)_{n\times m}$ *where* $d_{pq}^r = \left(\left(f_{pq}^{(r)}, g_{pq}^{(r)}, h_{pq}^{(r)}\right), \left(\alpha_{pq}^{(r)}, \beta_{pq}^{(r)}, \gamma_{pq}^{(r)}\right)\right)$ for all $1 \le r \le k$ are written as follows:

$$D_N^{(r)} = \begin{pmatrix} (\langle \mathfrak{f}_{11}^{(r)}, \mathfrak{g}_{11}^{(r)}, \mathfrak{h}_{11}^{(r)}\rangle, \langle \alpha_{11}^{(r)}, \beta_{11}^{(r)}, \gamma_{11}^{(r)}\rangle) & (\langle \mathfrak{f}_{12}^{(r)}, \mathfrak{g}_{12}^{(r)}, \mathfrak{h}_{12}^{(r)}\rangle, \langle \alpha_{12}^{(r)}, \beta_{12}^{(r)}, \gamma_{12}^{(r)}\rangle) & \cdots & (\langle \mathfrak{f}_{1m}^{(r)}, \mathfrak{g}_{1m}^{(r)}, \mathfrak{h}_{1m}^{(r)}\rangle, \langle \alpha_{1m}^{(r)}, \beta_{1m}^{(r)}, \gamma_{1m}^{(r)}\rangle) \\ (\langle \mathfrak{f}_{21}^{(r)}, \mathfrak{g}_{21}^{(r)}, \mathfrak{h}_{21}^{(r)}\rangle, \langle \alpha_{21}^{(r)}, \beta_{21}^{(r)}, \gamma_{21}^{(r)}\rangle) & (\langle \mathfrak{f}_{22}^{(r)}, \mathfrak{g}_{22}^{(r)}, \mathfrak{h}_{22}^{(r)}\rangle, \langle \alpha_{22}^{(r)}, \beta_{22}^{(r)}, \gamma_{22}^{(r)}\rangle) & \cdots & (\langle \mathfrak{f}_{2m}^{(r)}, \mathfrak{g}_{2m}^{(r)}, \mathfrak{h}_{2m}^{(r)}\rangle, \langle \alpha_{2m}^{(r)}, \beta_{2m}^{(r)}, \gamma_{2m}^{(r)}\rangle) \\ \vdots & \cdots & \vdots \\ (\langle \mathfrak{f}_{n1}^{(r)}, \mathfrak{g}_{n1}^{(r)}, \mathfrak{h}_{n1}^{(r)}\rangle, \langle \alpha_{n1}^{(r)}, \beta_{n1}^{(r)}, \gamma_{n1}^{(r)}\rangle) & (\langle \mathfrak{f}_{n2}^{(r)}, \mathfrak{g}_{n2}^{(r)}, \mathfrak{h}_{n2}^{(r)}\rangle, \langle \alpha_{n2}^{(r)}, \beta_{n2}^{(r)}, \gamma_{n2}^{(r)}\rangle) & \cdots & (\langle \mathfrak{f}_{nm}^{(r)}, \mathfrak{g}_{nm}^{(r)}, \mathfrak{h}_{nm}^{(r)}\rangle, \langle \alpha_{nm}^{(r)}, \beta_{nm}^{(r)}, \gamma_{nm}^{(r)}\rangle) \end{pmatrix}.$$

Step II: Calculate the weight of experts. If the weight of experts isn't taken equally, then there are two ways to calculate these values: subjective and objective weighting.

Subjective weighting: The weight of experts can be calculated subjectively by using one of the following ways:

(i) The weight of experts (denote ε_r for all $1 \le r \le k$) can be taken as real numbers such as $\varepsilon_r \ge 0$ and $\sum \varepsilon_r = 1$.

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(ii) The experts' weights can be determined using the four-tuple linguistic table (provided in the following table).

Table: Four-tuple Linguistic Term Table

Very Good (VG)	((.96, .15, .12), (.65, .10, .21))
Good (G)	((.90, .20, .30), (.62, .13, .22))
Medium Good (MG)	((.85, .33, .41), (.57, .17, .25))
Fair (F)	((.72, .45, .53), (.47, .19, .31))

Let us denote the attained term by $\left((f_r, g_r, h_r),\ (\alpha_r, \beta_r, \gamma_r)\right)$. Then these terms are converted to real numbers by using the deffuzification formula and so the weight of experts (ε_r) is obtained for all $1 \leq r \leq k$:

$$\varepsilon_r = \frac{1-\sqrt{\frac{(1-f_r)^2+g_r^2+h_r^2+(1-\alpha_r)^2+\beta_r^2+\gamma_r^2}{3}}}{\sum_{r=1}^{k}\left[1-\sqrt{\frac{(1-f_r)^2+g_r^2+h_r^2+(1-\alpha_r)^2+\beta_r^2+\gamma_r^2}{3}}\right]}$$

Objective weighting: We can calculate the weight of experts objectively by following the next ways:

(I) Initially, the group opinion matrix (GM) is constructed applying the LDSFWA operator applied to the decision values in the NLDSFDMs, and it is shown as:

$$\mathrm{GM} = \begin{pmatrix} G_{11} & G_{12} & \dots & G_{1m} \\ G_{21} & G_{22} & \dots & G_{2m} \\ \vdots & \vdots & \dots & \vdots \\ G_{n1} & G_{n2} & \dots & G_{nm} \end{pmatrix}$$

where

$$\begin{aligned} G_{pq} &= \oplus_{r=1}^{k}\left(\frac{1}{k}s_{pq}^{(r)}\right) \\ &= (\langle 1-\prod_{r=1}^{k}(1-\mathfrak{f}_{pq}^{(r)})^{\frac{1}{k}}, \prod_{r=1}^{k}(\mathfrak{g}_{pq}^{(r)})^{\frac{1}{k}}, \prod_{r=1}^{k}(\mathfrak{h}_{pq}^{(r)})^{\frac{1}{k}}\rangle, \langle 1-\prod_{r=1}^{k}(1-\alpha_{pq}^{(r)})^{\frac{1}{k}}, \prod_{r=1}^{k}(\beta_{pq}^{(r)})^{\frac{1}{k}}, \prod_{r=1}^{k}(\beta_{pq}^{(r)}+\gamma_{pq}^{(r)})^{\frac{1}{k}} - \prod_{r=1}^{k}(\beta_{pq}^{(r)})^{\frac{1}{k}}\rangle). \end{aligned}$$

for all $1 \leq p \leq n$ and $1 \leq q \leq m$. Denote $G_{pq} = \left(\left(f_{G_{pq}}, g_{G_{pq}}, h_{G_{pq}}\right), \left(\alpha_{G_{pq}}, \beta_{G_{pq}}, \gamma_{G_{pq}}\right)\right)$.

(II) The left ideal opinion matrix (LM) and the right ideal opinion matrix (RM) can be determined as follows:

$$\mathrm{RM} = \begin{pmatrix} R_{11} & R_{12} & \dots & R_{1m} \\ R_{21} & R_{22} & \dots & R_{2m} \\ \vdots & \vdots & \dots & \vdots \\ R_{n1} & R_{n2} & \dots & R_{nm} \end{pmatrix}, \mathrm{LM} = \begin{pmatrix} L_{11} & L_{12} & \dots & L_{1m} \\ L_{21} & L_{22} & \dots & L_{2m} \\ \vdots & \vdots & \dots & \vdots \\ L_{n1} & L_{n2} & \dots & L_{nm} \end{pmatrix}$$

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where $R_{pq} = \{s_{pq}^{r} : max_r(SF(s_{pq}^{r}))\}$ and $L_{pq} = \{s_{pq}^{r} : min_r(SF(s_{pq}^{r}))\}$ for all $1 \leq p \leq n$ and $1 \leq q \leq m$. Denote $R_{pq} = \left(\left(f_{R_{pq}}, g_{R_{pq}}, h_{R_{pq}}\right), \left(\alpha_{R_{pq}}, \beta_{R_{pq}}, \gamma_{R_{pq}}\right)\right)$ and $L_{pq} = \left(\left(f_{L_{pq}}, g_{L_{pq}}, h_{L_{pq}}\right), \left(\alpha_{L_{pq}}, \beta_{L_{pq}}, \gamma_{L_{pq}}\right)\right)$.

(III) We calculate the distances of each NLDSFDMs $D_N^{(r)}$ from GM, RM and LM by applying the normalized Euclidean distance. Denote this distances by $DG^{(r)}$, $DR^{(R)}$ and $DL^{(r)}$, respectively. The values $DG^{(r)}$, $DR^{(R)}$ and $DL^{(r)}$ are obtained for all $1 \leq p \leq n$ and $1 \leq r \leq k$ by using the next equations:

$$DG_p^{(r)} = \left[\frac{1}{6n}\sum_{q=1}^{m}\left[(\mathfrak{f}_{pq}^{(r)} - \mathfrak{f}_{G_{pq}})^2 + (\mathfrak{g}_{pq}^{(r)} - \mathfrak{g}_{G_{pq}})^2 + (\mathfrak{h}_{pq}^{(r)} - \mathfrak{h}_{G_{pq}})^2 + (\alpha_{pq}^{(r)} - \alpha_{G_{pq}})^2 + (\beta_{pq}^{(r)} - \beta_{G_{pq}})^2 + (\gamma_{pq}^{(r)} - \gamma_{G_{pq}})^2\right]\right]^{1/2}$$

$$DR_p^{(r)} = \left[\frac{1}{6n}\sum_{q=1}^{m}\left[(\mathfrak{f}_{pq}^{(r)} - \mathfrak{f}_{R_{pq}})^2 + (\mathfrak{g}_{pq}^{(r)} - \mathfrak{g}_{R_{pq}})^2 + (\mathfrak{h}_{pq}^{(r)} - \mathfrak{h}_{R_{pq}})^2 + (\alpha_{pq}^{(r)} - \alpha_{R_{pq}})^2 + (\beta_{pq}^{(r)} - \beta_{R_{pq}})^2 + (\gamma_{pq}^{(r)} - \gamma_{R_{pq}})^2\right]\right]^{1/2}$$

$$DL_p^{(r)} = \left[\frac{1}{6n}\sum_{q=1}^{m}\left[(\mathfrak{f}_{pq}^{(r)} - \mathfrak{f}_{L_{pq}})^2 + (\mathfrak{g}_{pq}^{(r)} - \mathfrak{g}_{L_{pq}})^2 + (\mathfrak{h}_{pq}^{(r)} - \mathfrak{h}_{L_{pq}})^2 + (\alpha_{pq}^{(r)} - \alpha_{L_{pq}})^2 + (\beta_{pq}^{(r)} - \beta_{L_{pq}})^2 + (\gamma_{pq}^{(r)} - \gamma_{L_{pq}})^2\right]\right]^{1/2}$$

(IV) The closeness indices (CI) are calculated by using the following formula:

$$CI_r = \frac{\sum_{p=1}^{n} DR_p^{(r)} + \sum_{p=1}^{n} DL_p^{(r)}}{\sum_{p=1}^{n} DG_p^{(r)} + \sum_{p=1}^{n} DR_p^{(r)} + \sum_{p=1}^{n} DL_p^{(r)}}$$

for all $1 \leq r \leq k$. Then, the weight of experts is calculated as follows:

$$\varepsilon_r = \frac{CI_r}{\sum_{r=1}^{n} CI_r}.$$

Step III: Establish the aggregated decision matrix. We merge the NLDSFDMs $D_N^{(r)}$ by considering the weight of experts (calculated in the previous step) via the LDSFWA operator and so we obtain the aggregated linear Diophantine spherical fuzzy decision matrix (ALDSFDM) $D = (s_{pq})_{n\times m}$ which is constructed as follows:

$$\begin{aligned} s_{pq} &= LDSFWA_{\varepsilon}(s_{pq}^{(1)}, s_{pq}^{(2)}, \ldots, s_{pq}^{(k)}) = \oplus_{r=1}^{k}\varepsilon_r s_{pq}^{(r)} \\ &= (\langle 1 - \prod_{r=1}^{k}(1 - \mathfrak{f}_{pq}^{(r)})^{\varepsilon_r}, \prod_{r=1}^{k}(\mathfrak{g}_{pq}^{(r)})^{\varepsilon_r}, \prod_{r=1}^{k}(\mathfrak{h}_{pq}^{(r)})^{\varepsilon_r}\rangle, \langle 1 - \prod_{r=1}^{k}(1 - \alpha_{pq}^{(r)})^{\varepsilon_r}, \prod_{r=1}^{k}(\beta_{pq}^{(r)})^{\varepsilon_r}, \prod_{r=1}^{k}(\beta_{pq}^{(r)} + \gamma_{pq}^{(r)})^{\varepsilon_r} - \prod_{r=1}^{k}(\beta_{pq}^{(r)})^{\varepsilon_r}\rangle). \end{aligned}$$

Let us denote $s_{pq} = \left(\left(f_{A_p}(C_q), g_{A_p}(C_q), h_{A_p}(C_q)\right), \left(\alpha_{A_p}(C_q), \beta_{A_p}(C_q), \gamma_{A_p}(C_q)\right)\right)$ for all $1 \leq p \leq n$ and $1 \leq q \leq m$. Hence, we can present the ALDSFDM $D = (s_{pq})_{n\times m}$ as follows:

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$$\mathrm{D} = \begin{pmatrix} \left(\langle \mathfrak{f}_{A_1}(C_1), \mathfrak{g}_{A_1}(C_1), \mathfrak{h}_{A_1}(C_1)\rangle, \langle \alpha_{A_1}(C_1), \beta_{A_1}(C_1), \gamma_{A_1}(C_1)\rangle\right) & \cdots & \left(\langle \mathfrak{f}_{A_1}(C_m), \mathfrak{g}_{A_1}(C_m), \mathfrak{h}_{A_1}(C_m)\rangle, \langle \alpha_{A_1}(C_m), \beta_{A_1}(C_m), \gamma_{A_1}(C_m)\rangle\right) \\ \left(\langle \mathfrak{f}_{A_2}(C_1), \mathfrak{g}_{A_2}(C_1), \mathfrak{h}_{A_2}(C_1)\rangle, \langle \alpha_{A_2}(C_1), \beta_{A_2}(C_1), \gamma_{A_2}(C_1)\rangle\right) & \cdots & \left(\langle \mathfrak{f}_{A_2}(C_m), \mathfrak{g}_{A_2}(C_m), \mathfrak{h}_{A_2}(C_m)\rangle, \langle \alpha_{A_2}(C_m), \beta_{A_2}(C_m), \gamma_{A_2}(C_m)\rangle\right) \\ \vdots & \cdots & \vdots \\ \left(\langle \mathfrak{f}_{A_n}(C_1), \mathfrak{g}_{A_n}(C_1), \mathfrak{h}_{A_n}(C_1)\rangle, \langle \alpha_{A_n}(C_1), \beta_{A_n}(C_1), \gamma_{A_n}(C_1)\rangle\right) & \cdots & \left(\langle \mathfrak{f}_{A_n}(C_m), \mathfrak{g}_{A_n}(C_m), \mathfrak{h}_{A_n}(C_m)\rangle, \langle \alpha_{A_n}(C_m), \beta_{A_n}(C_m), \gamma_{A_n}(C_m)\rangle\right) \end{pmatrix}$$

Step IV: Compute the weight of the criteria. If the weight of criteria isn't taken equally, then there are two ways to calculate these values similar to calculating the weight of experts: subjective and objective weighting.

Subjective weighting: The weight of criteria can be computed subjectively by using one of the following ways:

(i) The weight of criteria (denote ω_q for all $1 \leq q \leq m$) can be taken as real numbers such as $\omega_q \geq 0$ and $\sum \omega_q = 1$.

(ii) The weight of criteria can be attained by using the four-tuple linguistic table (provided in linguistic term table). After the weight of criteria can be obtained by using this values.

Objective weighting: We can compute the weight of criteria objectively by using the entropy measure function as explained in the following way:

Take the ALDSFDM $D = (s_{pq})_{n\times m}$ (found in the previous step) where $s_{pq} = \left(\left(f_{A_p}(C_q), g_{A_p}(C_q), h_{A_p}(C_q)\right), \left(\alpha_{A_p}(C_q), \beta_{A_p}(C_q), \gamma_{A_p}(C_q)\right)\right)$ for all $1 \leq p \leq n$ and $1 \leq q \leq m$. Then calculate the entropy measure of the criteria C_q as follows:

$$E(C_q) = 1 - \frac{2}{5n} \sum_{p=1}^{n} \left(|\mathfrak{f}_{A_p}(c_q)^2 - \mathfrak{h}_{A_p}(c_q)^2| + |\frac{\mathfrak{g}_{A_p}(c_q)}{2} - 0.25| + (|\alpha_{A_p}(c_q)^2 - \gamma_{A_p}(c_q)^2| + |\beta_{A_p}(c_q)^2 - 0.25|) \right).$$

After, the weight vector $\Omega = (\omega_1, \omega_2, \ldots, \omega_m)$ of the criterion is computed by using the following formula:

$$\omega_q = \frac{1 - E(C_q)}{\sum_{q=1}^{m} 1 - E(C_q)}, \forall 1 \leq q \leq m.$$

Step V: Find the weighted aggregated decision matrix. We weight the ALDSFDM D by considering the weight vector Ω for criteria by using the scalar multiplication on LDSFSs and so we construct the weighted aggregated linear Diophantine spherical fuzzy decision matrix (WALDSFDM) $D' = (s'_{pq})_{n\times m}$. Hence, s'_{pq} of D' is obtained as follows:

$$s'_{pq} = \begin{pmatrix} \langle 1 - (1 - \mathfrak{f}_{A_p}(C_q))^{\omega_q}, (\mathfrak{g}_{A_p}(C_q))^{\omega_q}, (\mathfrak{h}_{A_p}(C_q))^{\omega_q} \rangle, \\ \langle 1 - (1 - \alpha_{A_p}(C_q))^{\omega_q}, (\beta_{A_p}(C_q))^{\omega_q}, (\beta_{A_p}(C_q) + \gamma_{A_p}(C_q))^{\omega_q} - (\beta_{A_p}(C_q))^{\omega_q} \rangle \end{pmatrix}$$

for all $1 \leq p \leq k$ and $1 \leq q \leq m$. If we take $s'_{pq} = \left(\left(f'_{A_p}(C_q), g'_{A_p}(C_q), h'_{A_p}(C_q)\right), \left(\alpha'_{A_p}(C_q), \beta'_{A_p}(C_q), \gamma'_{A_p}(C_q)\right)\right)$, then the WALDSFDM is constructed as:

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$$\mathbf{D}' = \begin{pmatrix} s'_{11} & s'_{12} & \dots & s'_{1m} \\ s'_{21} & s'_{22} & \dots & s'_{2m} \\ \vdots & \dots & \vdots & \\ s'_{k1} & s'_{k2} & \dots & s'_{km} \end{pmatrix}.$$

Step VI: Calculate the PIS and NIS. We first transform the elements of WALDSFDM into real numbers by applying the score function given in Definition 2.7. Thus, the score matrix $D^* = \left(s^*_{pq}\right)_{k\times m}$ is found as:

$$\mathbf{D}^* = \begin{pmatrix} s^*_{11} & s^*_{12} & \dots & s^*_{1m} \\ s^*_{21} & s^*_{22} & \dots & s^*_{2m} \\ \vdots & \vdots & \dots & \vdots \\ s^*_{k1} & s^*_{k2} & \dots & s^*_{km} \end{pmatrix}$$

where $s^*_{pq} = SF(s'_{pq}) = SF\left(\left(f'_{A_p}(C_q), g'_{A_p}(C_q), h'_{A_p}(C_q)\right), \left(\alpha'_{A_p}(C_q), \beta'_{A_p}(C_q), \gamma'_{A_p}(C_q)\right)\right)$

for all $1 \le p \le n$ and $1 \le q \le m$. Next, we determine the PIS S^+ and NIS S^-. Let $\mathcal{B}_C$ and $\mathcal{C}_C$ represent the sets of benefit type and non-benefit type criteria, respectively. The PIS S^+ and NIS S^- are then computed as follows:

$$S^+ = \{S^+(C_1), S^+(C_2), \dots, S^+(C_m)\},$$

$$S^- = \{S^-(C_1), S^-(C_2), \dots, S^-(C_m)\}$$

Here,

$$S^+(C_q) = \{(max_p\, s^*_{pq} | C_q \in \mathcal{B}_C), (min_p\, s^*_{pq} | C_q \in \mathcal{C}_C) | 1 \le p \le n\},$$

$$S^-(C_q) = \{(min_p\, s^*_{pq} | C_q \in \mathcal{B}_C), (max_p\, s^*_{pq} | C_q \in \mathcal{C}_C) | 1 \le p \le n\}$$

for all $1 \le q \le m$.

Step VII: Obtain the relative closeness index and find the ranking. To calculate the relative closeness index, we determine the distances of PIS and NIS from each alternative A_p. These distances are obtained using the Euclidean distance formula:

$$d(A_p, S^+) = \sqrt{\sum_{q=1}^{m} \left(A_p(C_q) - S^+(C_q)\right)^2} \;,$$

$$d(A_p, A^-) = \sqrt{\sum_{q=1}^{m} \left(A_p(C_q) - S^-(C_q)\right)^2}.$$

Next, we compute the relative closeness index of each alternative A_p to assess its proximity to the PIS and its distance from the NIS using the following equation:

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$$R(A_p) = \frac{d(A_p, S^-)}{d(A_p, S^-) + d(A_p, S^+)}$$

for all $1 \leq p \leq n$.

To conclude, we rank the alternatives from highest to lowest based on the relative closeness index $R(A_p)$.

3.2. An Application

In coal mining operations, effective emergency preparedness is essential for mitigating the impact of explosion disasters [14]. Suppose that $A = \{A_1, A_2, A_3, A_4, A_5\}$ represents a set of emergency plans evaluated by experts in the field. These plans are assessed based on multiple critical criteria to ensure optimal response and recovery. The key evaluation criteria include c_1: gas, c_2: $casualty$, c_3: $smoke$, c_4: feasibility, c_5: facility.

The objective is to analyze and rank these emergency plans based on their effectiveness in handling an explosion disaster. By considering these factors, decision-makers can select the most suitable plan to enhance safety, response efficiency, and recovery in coal mining emergencies and construct the following decision matrix:

	c1						c2					
	f	g	h	alpha	beta	gamma	f	g	h	alpha	beta	gamma
A1	0,85	0,24	0,45	0,25	0,34	0,18	0,73	0,31	0,48	0,34	0,11	0,23
A2	0,77	0,41	0,52	0,34	0,21	0,22	0,82	0,51	0,43	0,13	0,25	0,21
A3	0,95	0,41	0,38	0,41	0,25	0,18	0,77	0,62	0,43	0,31	0,25	0,21
A4	0,82	0,41	0,38	0,41	0,21	0,11	0,91	0,61	0,53	0,38	0,21	0,22
A5	0,73	0,61	0,53	0,41	0,21	0,18	0,83	0,51	0,68	0,31	0,21	0,15

	c3						c4					
	f	g	h	alpha	beta	gamma	f	g	h	alpha	beta	gamma
A1	0,63	0,45	0,38	0,41	0,28	0,11	0,81	0,41	0,32	0,31	0,23	0,31
A2	0,58	0,43	0,41	0,31	0,23	0,15	0,78	0,45	0,31	0,51	0,11	0,18
A3	0,86	0,41	0,38	0,41	0,23	0,17	0,89	0,38	0,46	0,46	0,32	0,11
A4	0,73	0,61	0,48	0,25	0,31	0,18	0,83	0,63	0,47	0,38	0,21	0,17
A5	0,73	0,61	0,58	0,41	0,23	0,16	0,81	0,32	0,58	0,38	0,31	0,14

	c5					
	f	g	h	alpha	beta	gamma
A1	0,78	0,17	0,45	0,33	0,12	0,27
A2	0,83	0,21	0,43	0,72	0,13	0,14
A3	0,83	0,21	0,38	0,51	0,18	0,17
A4	0,76	0,58	0,43	0,31	0,23	0,33
A5	0,93	0,21	0,41	0,41	0,21	0,13

Then the steps of the constructed method and obtained the weight of criteria as $\Omega = (0{,}1272, 0{,}1195, 0{,}1101, 0{,}1338, 0{,}1368)$. Then the weighted decision matrix is calculated:

	c1						c2					
	f	g	h	alpha	beta	gamma	f	g	h	alpha	beta	gamma
A1	0,2144	0,8340	0,9034	0,0359	0,8718	0,8040	0,1448	0,8694	0,9161	0,0484	0,7682	0,8390
A2	0,1705	0,8928	0,9202	0,0515	0,8200	0,8248	0,1852	0,9227	0,9041	0,0165	0,8474	0,8299
A3	0,3168	0,8928	0,8842	0,0649	0,8383	0,8040	0,1610	0,9445	0,9041	0,0434	0,8474	0,8299
A4	0,1960	0,8928	0,8842	0,0649	0,8200	0,7552	0,2500	0,9427	0,9270	0,0555	0,8299	0,8345
A5	0,1534	0,9391	0,9224	0,0649	0,8200	0,8040	0,1908	0,9227	0,9550	0,0434	0,8299	0,7972

	c3						c4					
	f	g	h	alpha	beta	gamma	f	g	h	alpha	beta	gamma
A1	0,1037	0,9158	0,8990	0,0564	0,8692	0,7843	0,1993	0,8875	0,8586	0,0484	0,8215	0,8549
A2	0,0911	0,9113	0,9065	0,0400	0,8506	0,8115	0,1834	0,8987	0,8549	0,0910	0,7443	0,7950
A3	0,1946	0,9065	0,8990	0,0564	0,8506	0,8228	0,2557	0,8786	0,9013	0,0791	0,8586	0,7443
A4	0,1342	0,9470	0,9224	0,0312	0,8790	0,8280	0,2111	0,9400	0,9039	0,0620	0,8115	0,7889
A5	0,1342	0,9470	0,9418	0,0564	0,8506	0,8173	0,1993	0,8586	0,9297	0,0620	0,8549	0,7687

	c5					
	f	g	h	alpha	beta	gamma
A1	0,1871	0,7848	0,8965	0,0533	0,7483	0,8360
A2	0,2152	0,8078	0,8910	0,1598	0,7565	0,7642
A3	0,2152	0,8078	0,8760	0,0930	0,7909	0,7848
A4	0,1773	0,9282	0,8910	0,0495	0,8179	0,8593
A5	0,3049	0,8078	0,8852	0,0696	0,8078	0,7565

Next, the PIS and NIS value are found and by using this values relative closeness indexes are calculated:

	A_1	A_2	A_3	A_4	A_5
$R(A_i)$	0,5129	0,5351	0,5820	0,3433	0,4571

According to the table above, we see that the best result is A_3. This result is the same as the results in the initial source from which the problem was taken.

CONCLUSION

This study introduced an entropy-based TOPSIS method within the spherical linear Diophantine fuzzy environment, providing an effective approach for solving complex multi-criteria decision-making problems. By integrating spherical fuzzy sets and linear Diophantine

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fuzzy sets, the proposed methodology enhances the ability to model and process uncertainty while ensuring a structured decision-making framework. The inclusion of entropy measures further improves the objectivity of criterion weight determination, mitigating the limitations associated with subjective weight assignments in traditional MCDM methods. The results obtained from numerical examples demonstrate the applicability and robustness of the proposed approach, highlighting its potential for real-world decision-making scenarios. The findings suggest that the entropy-based TOPSIS method not only improves decision accuracy but also enhances reliability when dealing with uncertain and imprecise data.

Future research directions include extending the proposed methodology by incorporating additional fuzzy set extensions, such as complex fuzzy sets and hesitant fuzzy sets, to further improve decision-making capabilities. Additionally, applying the method to large-scale real-world datasets in various domains, such as healthcare, finance, and supply chain management, would provide deeper insights into its practical effectiveness. Moreover, exploring hybrid approaches that combine the entropy-based TOPSIS method with other MCDM techniques, such as VIKOR or COPRAS, could further enhance decision-making accuracy and flexibility in complex environments.

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DİL EVRİM TEORİSİ İÇİN MATEMATİKSEL BİR YAKLAŞIM

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ÖZET

Bir organizmanın kendisinin kopyalarını oluşturabildiği veya başka bir benzer organizmaya dönüşebildiği birçok doğa süreci, popülasyon genetiği veya dil evrimsel dinamiği modelleri uygulamalı bilimlerde yaygın olarak kullanılır. Bu çalışmada sistemde öngörülemez yörüngelerin oluşumunu hızlandırmanın matematiksel yollarını belirtmek için bir popülasyon dil dinamiğindeki öğrenme doğruluğunun kombinasyonundan yararlanıyoruz. Bu yörüngelerin, beş dil içeren seçilmiş bir popülasyon için dil dinamiğinde sonunda kaotik bir sürece yol açan çatallanmalar oluşturduğunu kanıtlıyoruz.

Anahtar Kelimeler : Dil öğrenimi ile nüfus dinamikleri, yerel olmayan çekirdek ile farklılaşma, sayısal işlem, kararlılık ve yakınsama, kaotik davranış.

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FINITE-SUM OPTIMIZATION: ADAPTIVITY TO SMOOTHNESS AND LOOPLESS VARIANCE REDUCTION

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Abstract:

In the context of finite-sum optimization, variance-reduced gradient methods (VR) perform an iteration based on the gradient of a single function (or mini-batch) and achieve superior convergence rates compared to traditional stochastic gradient descent (SGD). This efficiency is primarily attributed to a lower-variance stochastic gradient estimator that reuses historical gradients. Another significant research development in continuous optimization over the past decade involves adaptive algorithms such as AdaGrad, which adjusts the learning rate dynamically, either coordinate-wise or globally, in response to previous gradients, thus adapting to the geometry of the objective function. The success of adaptive methods like RMSprop and Adam in deep learning further highlights their practical efficacy. In this paper, we introduce AdaLVR, which integrates the AdaGrad framework with loopless variance-reduced gradient estimators like SAGA or L-SVRG, providing a simple construction and effective analysis. We demonstrate that AdaLVR benefits from the strong convergence properties of VR methods, combined with the adaptive qualities of AdaGrad. Specifically, for L-smooth convex functions, we establish a gradient complexity of $O(n + (L + \sqrt{nL})/\varepsilon)$ without requiring prior knowledge of L. Experimental results validate AdaLVR's superior performance compared to current state-of-the-art approaches. Additionally, we empirically show that combining RMSprop and Adam with variance-reduced gradient estimators leads to even faster convergence rates.

Keywords: Convex optimization, variance reduction, adaptive algorithms, loopless.

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A MODEL OF A NON-EXPANDING UNIVERSE DRIVEN BY THE VACUUM SPACE PROPERTIES

Ryuji Takahashi, Ahmed Al-Farsi, Zhang Wei

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Abstract:

This study introduces a non-expanding model of the universe, based on the constancy of the fine-structure constant and Einstein's theory of relativity, assuming that the permittivity of vacuum space decays over time. The model explains the observed Redshift, the so-called "expansion" of the universe, and its age, aligning with the predictions of the "Big Bang" model. Moreover, it offers a fresh perspective on the unexplained "accelerated expansion" of the universe and the enigmatic “Dark Matter,” which the Big Bang model fails to account for. The model posits that the universe originated in an “extremely cold” rather than “extremely hot” state, which provides an explanation for the cosmic microwave background radiation and the universe's age, while avoiding the singularity and inflationary issues of the "Big Bang" theory. It further predicts that galaxies could ultimately collapse into black holes, as these black holes should share the same space-time properties as the vacuum state in the early universe. This approach supports the cyclic universe theory without violating the first law of thermodynamics.

Keywords: Cosmic microwave background, dark energy, dark matter, universe model

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GENERALIZATION OF TSALLIS ENTROPY THROUGH Q-DEFORMED ARITHMETIC

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Abstract:

It is well-known that Tsallis entropy, SqS_qSq, serves as a generalization of Shannon entropy, SSS, by introducing alternative exponential and logarithmic functions. In this paper, we introduce a novel approach where a deformation via a scaling function applied to the differential operator leads to the creation of a q-deformed calculus and arithmetic. This framework not only generalizes exponential and logarithmic functions but also extends other conventional mathematical functions. The modified q-deformed differential operator results in an updated integral operator that integrates functions together with a weight function. For every differentiable function, a corresponding q-deformed partner function can be identified, allowing the generalization of algebraic relations inherent to the original functions. As a practical application of this approach, the work examines the generalization of exponential and logarithmic functions and shows how their relationship with thermodynamic functions—particularly entropy—yields a q-deformed expression. Consequently, applying a specific scaling function to the differential operator produces a q-deformed arithmetic, thereby contributing to the generalized formulation of Tsallis entropy.

Keywords: q-calculus, q-deformed arithmetic, entropy, exponential functions, thermodynamic functions.

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ESTIMATION OF FUNCTIONAL RESPONSE MODEL USING SUPERVISED FUNCTIONAL PRINCIPAL COMPONENT ANALYSIS

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Abstract:

Functional linear regression faces the challenge of dimension reduction, as it is considered an infinite-dimensional problem compared to multivariate linear regression. The main goal is to reduce the dimensions of both functional responses and predictors. One typical method is to apply functional principal component analysis (FPCA) to the functional predictors and use the leading functional principal components (FPCs) for prediction. While the leading FPCs capture a significant portion of the variation in the functional predictors, they may not necessarily be strongly correlated with the functional response, which could affect the prediction accuracy. This paper proposes a supervised FPCA method for functional response models, where FPCs are obtained by considering the correlation with the functional response. This approach is expected to improve prediction accuracy over the traditional FPCA method.

Keywords: Supervised, functional principal component analysis, functional response, functional linear regression.

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CLOSED-FORM SOLUTION OF SECOND ORDER LINEAR ORDINARY DIFFERENTIAL EQUATIONS

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Abstract:
A novel method is proposed to obtain closed-form integral solutions for nonhomogeneous second-order linear ordinary differential equations by utilizing the particular solution of the corresponding homogeneous part. The process begins by transforming the equation into a simpler Riccati equation, from which the general solution of the nonhomogeneous second-order linear differential equation is extracted in the form of a closed integral equation. This technique is applied to solving the Schrödinger equation for hydrogen-like atoms, demonstrating its effectiveness. Additionally, a generic nonhomogeneous second-order linear differential equation is solved to further illustrate the versatility of the method.

Keywords: Closed form, Second order ordinary differential equations, Schrödinger equation, Nonhomogeneous differential equations

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ECONOMIC FORECASTING MODEL IN PRACTICE USING REGRESSION ANALYSIS: THE RELATIONSHIP BETWEEN PRICE, DOMESTIC OUTPUT, GROSS NATIONAL PRODUCT, AND TREND VARIABLES IN OIL PRODUCTION

Kwame Adom, Amina Osei, Kofi Baidoo

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Abstract:

In recent years, oil has increasingly become a pivotal factor influencing various sectors of the economy. This influence is evident as shifts in oil prices or announcements by major oil organizations, such as the Organization of the Petroleum Exporting Countries (OPEC), have far-reaching impacts on the global economy, both directly and indirectly. This makes it crucial for economists and analysts to continuously monitor oil prices and forecast future fluctuations. A significant determinant of oil prices is the supply, which is heavily influenced by the number of active drilling wells. Thus, exploring the relationship between wellhead activity and other critical economic variables can provide valuable insights into the oil supply mechanism. This study examines the interconnections between wellhead counts and three primary economic factors: oil price, domestic output, and Gross National Product (GNP) adjusted for inflation. Additionally, trend variables are incorporated into the model to account for the fluctuations in oil consumption over time. The paper employs econometric techniques to estimate the model parameters, conducts tests to validate the findings, and draws conclusions based on the results.

Keywords: Price, domestic output, GNP, trend variable, oil drilling activity.

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OPTIMIZING SPATIAL INTERPOLATION USING A MULTI-LAYER INVERSE DISTANCE WEIGHTING MODEL FOR ADVANCED REGRESSION AND CLASSIFICATION TASKS IN SPATIAL DATA ANALYSIS

Kwame Adebayo, Chipo Mutasa, Samuel Okello, Nia Ncube

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Abstract:
This research introduces the Multi-Layer Inverse Distance Weighting Model (ML-IDW), combining the principles of multi-layer neural networks (ML-NNs) and the Inverse Distance Weighting (IDW) method. The ML-IDW model leverages the computational strengths of ML-NNs, which consist of learnable non-linear functions applied to input features, while incorporating IDW's ability to capture anisotropic spatial dependencies. This hybrid approach provides a robust framework for nonlinear spatial interpolation and advanced learning from intricate spatial data. We train the ML-IDW model using gradient descent and backpropagation, comparing its performance to traditional spatial interpolation models such as Kriging and standard IDW in both regression and classification tasks. Experiments conducted with simulated spatial datasets of various complexities demonstrate that ML-IDW outperforms conventional methods, showing reduced mean square error in regression tasks and an improved F1 score in classification tasks.

Keywords: Deep Learning, Multi-Layer Neural Networks, Gradient Descent, Spatial Interpolation

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APPLICATION OF LEGENDRE TRANSFORMATION TO PORTFOLIO OPTIMIZATION

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Abstract:

This study investigates the application of the Legendre Transformation Method (LTM) to the Hamilton-Jacobi-Bellman (HJB) equation, which is commonly used in optimal control problems. The research outlines the methodology for formulating the HJB equation within the context of mathematical finance by utilizing Ito's lemma and the maximum principle theorem. By applying LTM and dual theory, the HJB equation is transformed into a linear Partial Differential Equation (PDE). Additionally, the Optimal Investment Strategy (OIS) and the optimal value function are derived under the assumption of an exponential utility function. The study also presents numerical results, highlighting that the OIS, under exponential utility, is directly proportional to the appreciation rate of the risky asset and inversely proportional to the instantaneous volatility, predetermined interest rate, and risk aversion coefficient. Lastly, the results indicate that the optimal fund size increases with the risk-free interest rate, which aligns with existing findings in the literature.

Keywords: Legendre transformation method, Optimal investment strategy, Portfolio optimization

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ON DECOMPOSITION OF MAXIMAL PREFIX CODES IN DATA CLASSIFICATION

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Abstract:

This paper explores the characteristics and applications of maximal prefix codes in various domains such as computer science, data processing, and classification. The primary focus is on the decomposition of these codes into their prime factors using a computational approach based on finite state automata, particularly flower automata. We investigate the decomposition of maximal prefix codes and their essential properties, including an efficient linear-time algorithm for finding the prime decomposition. For computational analysis, we utilized the GAP computer algebra system, which provides powerful tools for operations in free semigroups, monoids, and automata theory.

Keywords: Maximal prefix code, data classification, flower automata, prefix code decomposition.

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APPROXIMATION TO THE HARDY OPERATOR IN TOPOLOGICAL SPACES

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Abstract:

In this study, we investigate a Hardy type operator defined on a family of open subsets of a Hausdorff topological space. The subsets are indexed by non-negative real numbers and follow a totally ordered structure. We establish two-sided estimates for the operator's norm, a compactness criterion, and limits for its approximation numbers. Previous work has focused on bounds for approximation numbers in one-dimensional settings; however, our approach does not restrict the dimension of the Hausdorff space. Although bounds for the norm and compactness conditions were previously known, our method distinguishes itself by utilizing domain partitions for the problems under consideration.

Keywords: Approximation numbers, boundedness and compactness, Hardy operator, Hausdorff spaces.

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LOCALIZED MESHFREE METHODS FOR SOLVING 3D HELMHOLTZ EQUATION

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Abstract:

This paper presents the development of localized meshfree methods, specifically the radial basis function-generated finite difference (RBF-FD) method and the Hermite finite difference (RBF-HFD) method, to design stencil weights and spatial discretization for solving the Helmholtz equation in three dimensions. The numerical analysis investigates the convergence and stability of these methods in irregularly shaped domains. These localized methods combine the benefits of the RBF method, finite difference methods, and Hermite finite difference approaches to address the issue of ill-conditioning that can hinder the convergence rate in global RBF methods. Furthermore, numerical experiments demonstrate the efficiency and applicability of these methods for solving problems with complex geometries. A comparative analysis of the convergence and accuracy of both schemes is performed by solving a test problem.

Keywords: Radial basis functions, Hermite finite difference, Helmholtz equation, stability.

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IDENTIFYING ENVIRONMENTAL FACTORS AFFECTING THE SPREAD OF MALARIA IN AFRICA: A REGRESSION APPROACH

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Abstract:

This study explores malaria, a prevalent infectious disease in Africa caused by Plasmodium parasites, with a particular focus on understanding the environmental and socioeconomic factors influencing its spread. Utilizing data from Ghana, the research seeks to identify key variables that contribute to malaria transmission rates. To isolate significant explanatory variables while mitigating overfitting, various regression techniques including linear Poisson regression, ridge, lasso, and elastic net penalties were applied. The study used cross-validation to optimize model parameters and enhance prediction accuracy. The effectiveness of these methods was evaluated using multiple simulated datasets. Applying these methods to the Malaria data from Ghana's Ministry of Health, the study highlighted critical factors influencing malaria's prevalence, yielding results that align with existing literature on the subject.

Keywords: Malaria, Poisson regression, Environmental factors, Africa, Socioeconomic determinants

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