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Content

Biological sciences

MEDICINAL PLANTS OF THE TURTKULYUKSAY STREAM, GELON VILLAGE, KASHKADARYA BOTANICAL AND GEOGRAPHICAL DISTRICT

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Introduction. *Medicinal plants are one of the most valuable natural resources, providing raw materials for pharmaceuticals, traditional medicine, and functional food production [8]. The Kashkadarya botanical-geographical district, particularly the Gissar mountain system and its valleys, is rich in endemic and rare medicinal flora [2,3]. Among them, the Turtkulyuksay stream, passing through Gelon village (Shahrisabz district), represents a unique microhsssabitat where traditional knowledge and natural diversity intersect. The aim of this study is to identify, classify, and evaluate medicinal plants growing in the Turtkulyuksay stream area, to analyze their ecological adaptation, and to determine their potential for pharmacological use [1].*

The research was conducted during the vegetation periods of 2025. Field expeditions were carried out along the Turtkulyuksay stream and its surroundings at altitudes ranging from 2500 to 2550 m above sea level. Floristic lists were compiled based on route-method surveys. Species identification was performed using the "Flora of Uzbekistan" (1952–1987), complemented with recent taxonomic updates [4].

The study area is Turtkulyuksay, Gelon village, Shahrisabz district, Kashkadarya region of Uzbekistan (Figure 1).

Figure 1. Satellite images of the study area. *A. Location of Gelon village (Gilan) and its surrounding mountainous landscape. The red rectangle indicates the research site. B. Enlarged view of the Turtkuluksay stream basin with geographic coordinates (39°03'31"N – 67°31'01"E).*

The ecological groups of plants were determined according to their habitat preferences (hygrophytes, xerophytes, mesophytes) [5]. Ethnobotanical information was collected through structured interviews with local inhabitants of Gelon village.

Results and discussion. *In total, 27 species of higher plants belonging to 18 families were recorded in the Turtkulyuksay stream valley. The most represented families are: Asteraceae (Compositae) – 4 species (Artemisia dracunculus L., Tanacetum vulgare L., Ligularia thomsonii C.B.Clarke, Matricaria chamomilla L.), Apiaceae (Umbelliferae) – 3 species (Heracleum lehmannianum Bunge., Selinum carvifolia L., Prangos pabularia Lindl.), Lamiaceae (Labiatae) – 2 species (Mentha piperita L., Phlomis tuberosa L.), Cupressaceae – 2 species (Juniperus turkestanica Kom., Juniperus seravschanica Kom.), Polygonaceae – 2 species (Rumex confertus Willd., Polygonum aviculare L.), Hypericaceae – 2 species (Hypericum*

perforatum L., Hypericum scabrum L.) and the remaining 12 families each have one plant. The distribution and proportion of each plant family is shown in Figure 2.

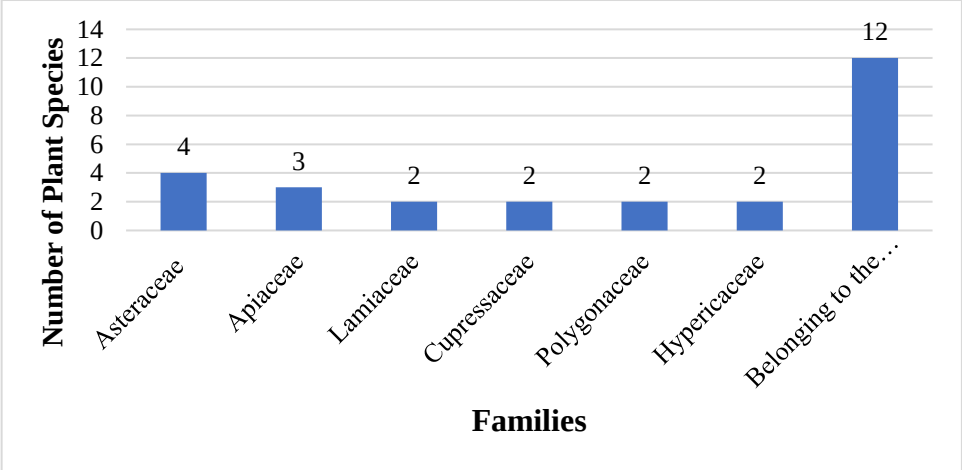

Figure 2. Distribution of medicinal plant species by plant family in Gelon village, Turtkulyuksay

The medicinal plants are distributed according to the ecological gradient of the valley: 1. Streamside hygrophytes (P. pabularia Lindl.) thrive in moist soils. 2. Slope xerophytes (J. turkestanica Kom., J. seravschanica Kom., R. confertus Willd., P. aviculare L., H. scabrum L.) 3. Meadow mesophytes (A. dracunculus L., T. vulgare L., L. thomsonii C.B.Clarke, M. chamomilla L., H. lehmannianum Bunge, S. carvifolia L., M. piperita L., Ph. tuberosa L., H. perforatum L.

This ecological zonation reflects the microclimatic diversity of the Turtkulyuksay valley, which favors high medicinal plant diversity.

Ethnobotanical significance. *Local inhabitants of Gelon village possess rich traditional knowledge regarding medicinal plants: J. turkestanica Kom. – used in folk medicine for respiratory diseases, as disinfectant; wood for construction and incense, Berberis vulgaris L. – fruits rich in vitamin C; used for fevers, digestive disorders; bark for dyes, Ribes nigrum L. - berries used as food, source of vitamin C; leaves in folk medicine for colds and rheumatism, Quercus robur L. – bark used as astringent, for wound healing; wood for construction, M. piperita L. – widely used medicinal plant for digestion, colds; essential oil in perfumery, M. chamomilla L. – famous medicinal herb (chamomile tea); used for stomach, nervous system, skin.*

Conservation aspects. *Some medicinal plants of the valley (Ephedra intermedia Schrenk & C.A.Mey., Ferula tenuisecta Korovin, and Crataegus turkestanica Pojark.) are listed in the Red Data Book of Uzbekistan due to habitat degradation and overharvesting. Therefore, conservation strategies such as controlled harvesting, cultivation, and community-based management are essential [6].*

Conclusion. *The Turtkulyuksay stream valley in Gelon village represents a rich reservoir of medicinal plants, comprising more than 40% of the total recorded flora. The dominance of families such as Asteraceae, Apeaceae and Lamiaceae highlights the ecological and pharmacological value of the area. Traditional knowledge preserved by local inhabitants contributes significantly to the sustainable use of these resources. Future perspectives include: establishing ex situ cultivation plots for rare medicinal plants, promoting eco-tourism and ethnobotanical education, conducting phytochemical screening of endemic species for novel drug discovery [7].*

Thus, the Turtkulyuksay stream valley is not only a natural heritage site but also a promising resource for the pharmaceutical industry and ethnobotany of Uzbekistan.

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Economic sciences

ENHANCING THE INNOVATION CAPACITY OF HIGHER EDUCATION INSTITUTIONS

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Abstract

This paper examines the role of higher education institutions as key drivers of innovation in the modern knowledge economy. It analyzes theoretical foundations, organizational mechanisms, and strategic factors influencing the development of innovative activity in universities. The study highlights the importance of entrepreneurial governance, digital transformation, and university industry collaboration for building sustainable innovative ecosystems.

Keywords: Higher education, innovative activity, university management, entrepreneurship, digital transformation, research ecosystem.

In the era of the Fourth Industrial Revolution, the role of higher education has undergone a profound transformation from being a transmitter of established knowledge to becoming a generator of new knowledge and innovation. Modern universities are increasingly recognized as innovation hubs, where education, science, and entrepreneurship converge to create new ideas, technologies, and solutions that shape national and global development. The effectiveness of higher education systems is now measured not only by teaching quality or graduate employment rates but also by their ability to produce research-driven innovation and to contribute to the knowledge economy.

The development of innovative activity in higher education represents a multidimensional and systemic process that encompasses scientific research, creative thinking, digital transformation, and entrepreneurial behavior among faculty and students. It reflects a paradigm shift in which universities move from traditional, lecture-centered institutions to innovation-oriented ecosystems that interact dynamically with industry, government, and society. In this context, universities serve as both incubators of innovative ideas and accelerators of technological and socio-economic progress.

From a theoretical standpoint, innovation in higher education can be interpreted through the lens of Schumpeter's (1934) innovation theory, which identifies innovation as the primary driver of economic and institutional renewal. In the educational context, this renewal manifests through the introduction of new teaching methodologies, digital tools, research-based curricula, and interdisciplinary collaboration. Moreover, the Triple Helix Model developed by Etzkowitz and Leydesdorff (2000) emphasizes that universities, industries, and governments must act in synergy to build a sustainable national innovation system. This model is particularly relevant for emerging economies such as Uzbekistan, where higher education reform is a key component of national modernization strategies.

Despite significant progress in the global education sector, many universities especially in developing countries continue to face structural, organizational, and financial barriers that hinder innovation. Limited research funding, outdated curricula, insufficient digital infrastructure, and weak linkages between academia and industry restrict the ability of universities to operate as engines of innovation. In addition, innovation in education is not limited to technology adoption but also involves cultural and institutional transformation creating an environment that encourages experimentation, risk-taking, and interdisciplinary collaboration.

The development of innovative activity within universities is also closely associated with human capital formation. Academic staff must be equipped with research competence, pedagogical creativity, and entrepreneurial skills, while students should be trained to think critically, act independently, and engage in innovation-oriented projects. The university's innovation potential therefore depends on both its structural capacity (infrastructure, funding, and governance) and its cultural capacity (values, motivation, and openness to change).

In Uzbekistan, the past decade has seen major reforms in the field of higher education aimed at integrating the national system into the global educational space. The adoption of the "Strategy for the Development of Higher Education 2030", the creation of research and innovation clusters, and the expansion of academic autonomy have set the foundation for innovation-oriented development. However,

realizing this potential requires not only regulatory changes but also the transformation of the university's internal processes research management, technology transfer, digitalization, and partnership with industry.

Global trends demonstrate that universities which successfully institutionalize innovative activity share several features: they operate with high academic freedom, possess flexible management systems, and maintain diversified sources of funding. Moreover, they promote innovation culture through entrepreneurship education, digital learning platforms, and collaborative research ecosystems. For countries in transition, developing such models is both a challenge and a strategic necessity.

The contemporary understanding of innovation in higher education (HE) draws from classic economic and organizational theories. Schumpeter's (1934) theory of creative destruction positions innovation as a systemic process of renewal that reconfigures resources and routines an idea that translates to universities as they re-design curricula, research agendas, and governance to generate new value. Drucker (1985) reframes innovation as a disciplined managerial practice, aligning well with institutional mechanisms research strategy, performance incentives, and portfolio management used by HEIs to scale innovative activity. On the diffusion side, Rogers (2003) stresses the roles of communication networks, perceived attributes of innovations, and change agents, all salient in academic departments and interfaculty collaborations.

In knowledge production, the shift from Mode 1 (discipline-bound) to Mode 2 (transdisciplinary, application-oriented) research (Gibbons et al., 1994) helps explain the growing salience of mission-driven, problem-focused projects, living labs, and challenge-based learning within universities. The knowledge-creating firm perspective (Nonaka & Takeuchi, 1995) with the SECI model (socialization, externalization, combination, internalization) has been frequently repurposed for universities, highlighting how tacit and explicit knowledge circulate through labs, centers, and technology transfer offices.

Entrepreneurial university literature emphasizes organizational adaptations that enable innovation. Clark (1998) identifies five transformation pathways—strengthened steering core, expanded development periphery, diversified funding base, stimulated academic heartland, and an integrated entrepreneurial culture. Complementary analyses examine how rankings/regulatory pressures reshape institutional behavior (Hazelkorn, 2015) and how managerial reforms alter academic work (Bleiklie, 2018). The debate on academic capitalism (Slaughter & Rhoades, 2004) underscores opportunities and risks of market-oriented strategies: while third-stream activities and IP income may stimulate innovation, they can also skew incentives away from public-good science.

The Triple Helix model (Etzkowitz & Leydesdorff, 2000; Etzkowitz, 2008) conceptualizes innovation as an outcome of recursive interactions among universities, industry, and government, positioning HEIs as both knowledge producers and entrepreneurial actors. Extensions to a Quadruple Helix integrate civil society and media-based culture as co-producers of innovation (Carayannis & Campbell, 2009). Empirical studies document pathways contract research, licensing, and spin-offs through which universities influence regional innovation systems (Perkmann et al., 2013; Wright, Siegel, & Mustar, 2017), and the role of science parks and incubators in amplifying spillovers (Link & Scott, 2003). The open innovation lens (Chesbrough, 2003) further explains why HEIs increasingly orchestrates porous boundary arrangements consortia, standard-setting bodies, and shared IP platforms.

A substantial stream analyzes the organization and performance of technology transfer from TTO structures and incentive schemes to IP regulation and faculty engagement (Siegel & Wright, 2015). At the human-capital level, entrepreneurship education is linked to opportunity recognition, entrepreneurial intention, and venture creation (Fayolle & Gailly, 2008; Rae, 2010). Capability building is cumulative and path-dependent: world-class institutions combine doctoral training, post-doc pipelines, interdisciplinary centers, and PhD-to-startup pathways (Altbach & Salmi, 2011; Marginson, 2016). International evidence indicates that diversified revenue, academic freedom, and robust research infrastructure are persistent correlates of innovative university performance (OECD, 2023; World Bank, 2023; UNESCO, 2022).

Digital transformation functions as both a catalyst and infrastructure for innovative activity. Scholarship highlights the strategic use of learning analytics, digital repositories, and virtual/remote labs to expand research-teaching synergies (Bates, 2015; Selwyn, 2016; Weller, 2020). Systematic reviews show accelerating adoption of AI in higher education for adaptive learning, early-warning systems, and assessment (Zawacki-Richter et al., 2019), while cautioning about ethics, bias, and governance. These developments align with Pasteur's Quadrant (Stokes, 1997), where use-inspired basic research links disciplinary inquiry with societal application now increasingly mediated by data infrastructures.

Developing innovative activity within higher education institutions (HEIs) demands a comprehensive transformation of governance, research culture, and digital infrastructure. To build sustainable

innovation ecosystems, universities should establish innovation governance frameworks that link academic units with industry, government, and society. Dedicated innovation councils or technology-transfer offices can coordinate project funding, intellectual-property management, and startup incubation. A shift toward entrepreneurial education embedding creativity, design thinking, and research-to-market skills into all levels of curricula is essential to align graduate competencies with innovation-driven labor markets. Equally vital is the expansion of digital and research infrastructure: smart campuses, open-access repositories, and data-driven management systems that support experimentation and cross-disciplinary collaboration. The state and private sector must jointly invest in competitive grant schemes, public-private partnerships, and digital learning platforms to ensure continuity of research and innovation processes. Moreover, universities should internationalize their innovative ecosystems through joint doctoral programs, global research networks, and participation in transnational innovation clusters to internalize best practices and attract high-level talent.

In conclusion, the advancement of innovative activity in higher education is both a strategic driver of national competitiveness and a core element of sustainable socio-economic development. Universities can no longer function merely as teaching organizations; they must evolve into integrated knowledge enterprises that generate, transfer, and commercialize intellectual output. The synergy of academic autonomy, entrepreneurial governance, and digital transformation forms the cornerstone of this evolution. Strengthening human capital through continuous professional development, fostering an innovation-oriented academic culture, and embedding ethical and inclusive principles in innovation policies will ensure that higher education becomes a catalyst for technological progress and social well-being. Thus, innovation in higher education should be viewed not only as an institutional reform agenda but as a national innovation mission one that transforms knowledge into value, research into development, and education into long-term prosperity.

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CRYPTOCURRENCIES AS AN ALTERNATIVE FINANCIAL INSTRUMENT: A CRITICAL EVALUATION OF THEIR ADVANTAGES AND DISADVANTAGES

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Abstract

This article is devoted to the economic nature of cryptocurrency, its applications, and the advantages and disadvantages of using digital currencies. The authors describe blockchain technology, review the views of various researchers on the concept of cryptocurrency, and propose their own definition. They analyze the first cryptocurrencies that appeared on the market and present their characteristics. The features of coins and tokens are explained, and the key participants in the crypto market are analyzed. Finally, the article discusses the pros and cons of the cryptocurrency market.

We now live in an era of advanced technology and rapid innovation. Developments in the global crypto industry are also bringing significant changes to financial and economic sectors: 49% of consumers are ready to adopt and support the use of cryptocurrency, while 93% of the world's central banks are working on digital currency initiatives. In our country, there is also growing interest in the positive and negative impacts of digital currencies on monetary policy. Many countries are exploring the introduction of digital currencies as an alternative means of payment. Data from May 2024 shows that over 60 of the world's largest banks have invested in blockchain projects. To determine preliminary results, several programs have been implemented, outlining the stages of testing and implementation. In this article, we aim to analyze and explain the key concepts underlying digital currencies.

This article was prepared as part of a joint project by high school students from Kazakhstan and Kyrgyzstan.

Keywords: *cryptocurrency, crypto market, blockchain, coin, token, stablecoin, mining*

Introduction

A blockchain is a type of database in which computers are connected to a shared network. Each participant stores a file on their hard drive that contains a continuously growing list of records, called blocks, which are synchronized and updated in real time. Simply put, it is a technology for the sequential storage of data and records. Blockchain ensures data integrity through cryptography and consensus mechanisms, forming the foundation of the cryptocurrency network. This technology enabled the emergence of the first cryptocurrencies.

The first cryptocurrency was introduced in 2008 by an individual or group using the pseudonym Satoshi Nakamoto. A technical white paper describing how the blockchain system and the first cryptocurrency — Bitcoin — operates was published that same year. In 2009, the first 50 bitcoins were mined, and the first cryptocurrency transaction took place, in which Satoshi successfully transferred 10 bitcoins to another network participant [1].

To clarify the meaning of cryptocurrency, we conducted a comparative analysis of several definitions provided by different authors and sources. These definitions, summarized in Table 1, reflect diverse interpretations of the term, ranging from technological and economic perspectives to legal and functional characteristics. While some authors emphasize the cryptographic basis and decentralized nature of cryptocurrencies, others define them as digital assets used in exchange systems or as speculative investment tools.

Table 1 presents the selected definitions along with their corresponding sources

Table 1. Definitions of cryptocurrency by various authors

№	Definition	Author and source
1	Any form of digital or virtual currency that uses encryption (cryptography) but does not have centralized regulation	[2]
2	Currency that is generated by complex calculations (creating codes and ciphers) by solving complex mathematical problems	Novikova N. [3]
3	Electronic monetary units issued by computer networks and used instead of traditional currencies	Prikhodko D [4]
4	A decentralized, immaterial entity represented in electronic form by means of records in electronic wallets, capable of serving as a medium of exchange and/or a means of payment in the event of contractual or legislative mandates	Proskurina K.Yu. [5]
5	A digital expression of value that can be the subject of digital commerce and can serve as a medium of exchange, a measure of value, and a means of saving, but does not have the status of legal tender in any jurisdiction. It is not issued or guaranteed by any jurisdiction and functions only by mutual agreement of participants	[6]
6	An investment instrument that is not freely used as an official form of payment (which is not a national currency) in any country and is based on blockchain technology	Definition of author
Note: Table compiled by the authors		

Digital currencies are created using specialized cryptographic algorithms, which provide protection against fraud and ensure that they cannot be forcibly withdrawn or devalued. Transactions involving digital currencies are carried out through platforms such as Apple Pay, PayPal, or dedicated online cryptocurrency exchanges like BitPay, although their operational mechanisms are functionally similar to traditional payment systems.

The acceptance of digital currencies varies across countries: while some nations support them at the state level, others impose complete bans on cryptocurrency trading. Drawing from international experience, countries that aim to support digital currencies are actively developing legal frameworks. Each country adopts its own regulatory standards for digital assets, including Kazakhstan and Kyrgyzstan, whose legislation provides the following definitions of digital currency:

A) According to the Law of the Kyrgyz Republic dated August 5, 2022, No. 81 "On Virtual Assets", a virtual asset is a set of data in electronic and digital form that represents a digital expression of value and/or serves to certify property or non-property rights. These assets are created, stored, and processed using distributed ledger or similar technology, and are not considered monetary units, legal tender, or securities [7].ss

B) According to the Law of the Republic of Kazakhstan dated February 6, 2023, No. 193-VII "On Digital Assets in the Republic of Kazakhstan", a digital asset is a form of property created in electronic and digital form by assigning a digital code, including through cryptography and computational processes. It is not recognized as a unit of account or legal tender, but it is ensured by the immutability of data based on a distributed ledger or blockchain platform [8].

Thus, while Kyrgyz legislation defines virtual money as a data set in electronic and digital form, Kazakhstani law recognizes it as a type of property secured by data immutability.

Today, thousands of cryptocurrencies exist in the global digital currency market. We have attempted to analyze and describe the most prominent ones in the table below.

Table 2. The first popular cryptocurrencies in the digital currency market

№	Name (Symbol)	Description	Recognizability
1	Bitcoin (BTC)	The first cryptocurrency, created in 2009 by an individual or group under the pseudonym Satoshi Nakamoto. It introduced the concept of decentralized digital currency based on blockchain technology.	Very popular; considered the most recognized cryptocurrency globally.
2	Litecoin (LTC)	Introduced in 2011 by Charlie Lee. Similar to Bitcoin but with faster transaction confirmation times and improved storage efficiency, making it suitable for large-scale transactions.	Often referred to as "Bitcoin's little brother"; widely recognized.
3	Ripple (XRP)	Developed in 2012 as a distributed ledger system. Unlike most cryptocurrencies, Ripple supports not only cryptocurrency transactions but also various types of data and asset transfers.	Gained recognition through partnerships with banks and financial institutions.
4	Ethereum (ETH)	Launched in 2015. Ethereum introduced smart contracts and a platform for decentralized applications (dApps). Its native currency is Ether (ETH).	The second most popular cryptocurrency after Bitcoin.
5	Cardano (ADA)	Created in 2017 by Charles Hoskinson, co-founder of Ethereum. Cardano is a blockchain platform designed to support smart contracts, decentralized applications, sidechains, and scalability.	Known for its academic approach and sustainability model; widely accepted in the crypto community.
Note: compiled by the authors			

The cryptocurrency market includes various types of digital assets. Based on a general classification, they are commonly divided into two major categories: coins and tokens, as presented in Table 3.

Table 3. Characteristics of coins and tokens

№	Type	Description
1	Coins	A type of cryptocurrency that operates on its own independent blockchain. Coins are typically mined using a consensus mechanism (e.g., proof-of-work), which relies on computational power.
		Coins function as digital money and can be used for payments, transferred between users, traded, or accepted as a medium of exchange.
		Example: Microsoft accepts Bitcoin as a form of payment for its Windows operating system and Xbox gaming consoles.
2	Token	Tokens are cryptocurrency units created and operating on existing blockchains. Unlike coins, tokens cannot be mined individually, but investments can be made in specific assets they represent.
		Any individual with sufficient knowledge and technical skills can issue their own tokens; however, this process requires the consumption of a significant amount of coins as a resource.
		Tokens cannot be used as actual money or coins for payments or transactions. Instead, they often serve additional platform functions, such as participation in surveys, voting, or access to specific services.
		Since the development of coins is a more complex and resource-intensive process, coins generally have a higher market value than tokens.
Note: compiled by the authors		

In addition to the classifications mentioned by us, various other versions of cryptocurrency classifications have been proposed by different authors. When analyzing these classifications from the perspective of virtual entities, it is possible to distinguish the following categories based on their specific functions:

1. *Payment Coins: Cryptocurrencies primarily intended for payments, investments in particular industries, or the purchase of goods and services. The most well-known example is Bitcoin.*
2. *Functional Coins: Cryptocurrencies like Ethereum, which are based on supporting smart contracts and decentralized applications.*
3. *Exchange Tokens: Tokens issued by major exchanges, such as Binance Coin, which are used within the platform for paying commissions and fees.*
4. *Utility Tokens: Tokens issued in limited quantities to attract investments, such as the UNI token from the Uniswap project.*
5. *Non-Fungible Tokens (NFTs): Unique, non-interchangeable tokens representing digital assets, such as works of art or collectibles.*
6. *Stablecoins: Tokens like USDT that are pegged to real-world assets and can be used as a store of value or deposits.*

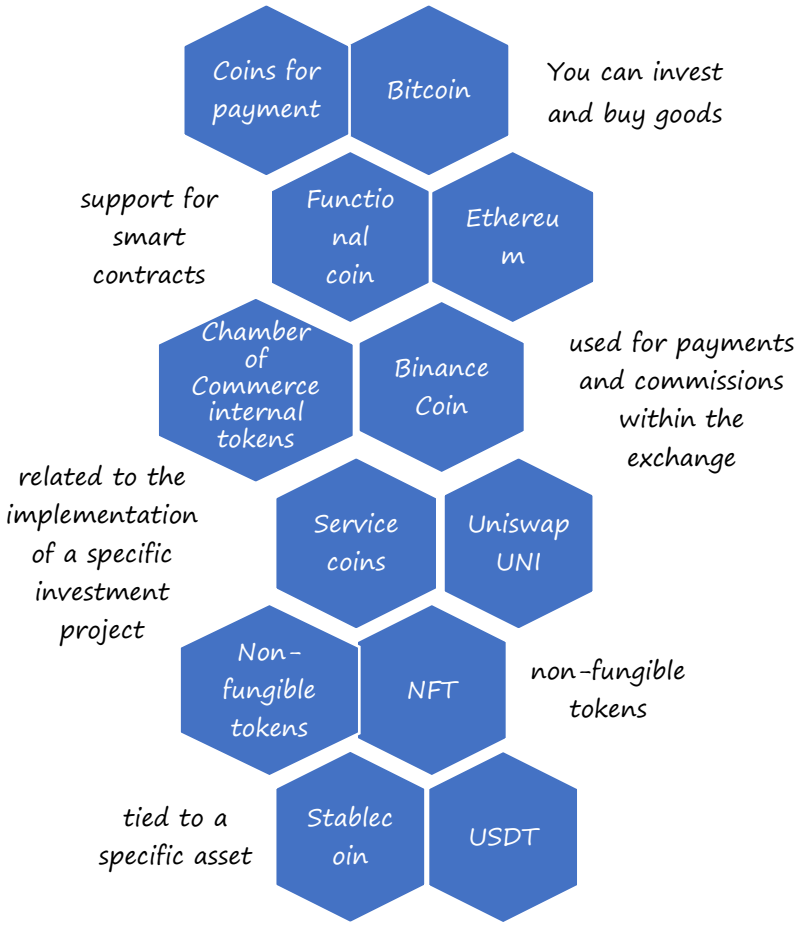

Figure 1. Crypto and special functions

Many factors influence the viability and sustainability of crypto assets. From a technical perspective, key determinants include the number and activity level of cryptocurrency developers, the transparency of the codebase under development, and the robustness of security measures against fraud and cyber-attacks. From a market standpoint, important competitive advantages of a given cryptocurrency compared to others include its ability to maintain market presence over extended periods. Economically, indicators such as liquidity, trading volume, and the monetization model play significant roles in assessing its viability.

A crucial factor in the circulation and adoption of cryptocurrency is the establishment of a functional ecosystem, which raises considerations such as strategic partnerships, user engagement, and interoperability with other services. Despite the decentralized nature and absence of direct government control, regulatory frameworks are often implemented by cryptocurrency developers themselves, including Know Your Customer (KYC) and Anti-Money Laundering (AML) practices, as well as mechanisms to ensure transaction transparency [9].

The presence of numerous stringent regulatory restrictions in the cryptocurrency market hinders its stimulation and the achievement of a balance between regulatory control and innovation. Unlocking the full potential of blockchain technology requires the collaborative efforts of all market participants. It is essential to integrate or synergize traditional modern financial systems with blockchain-based finance, thereby attracting users and business stakeholders to the cryptocurrency market. The cryptocurrency market serves as a unifying platform that supports the activities of a wide range of participants, with many major platforms and key players actively operating within it (see Figure 2), [10].

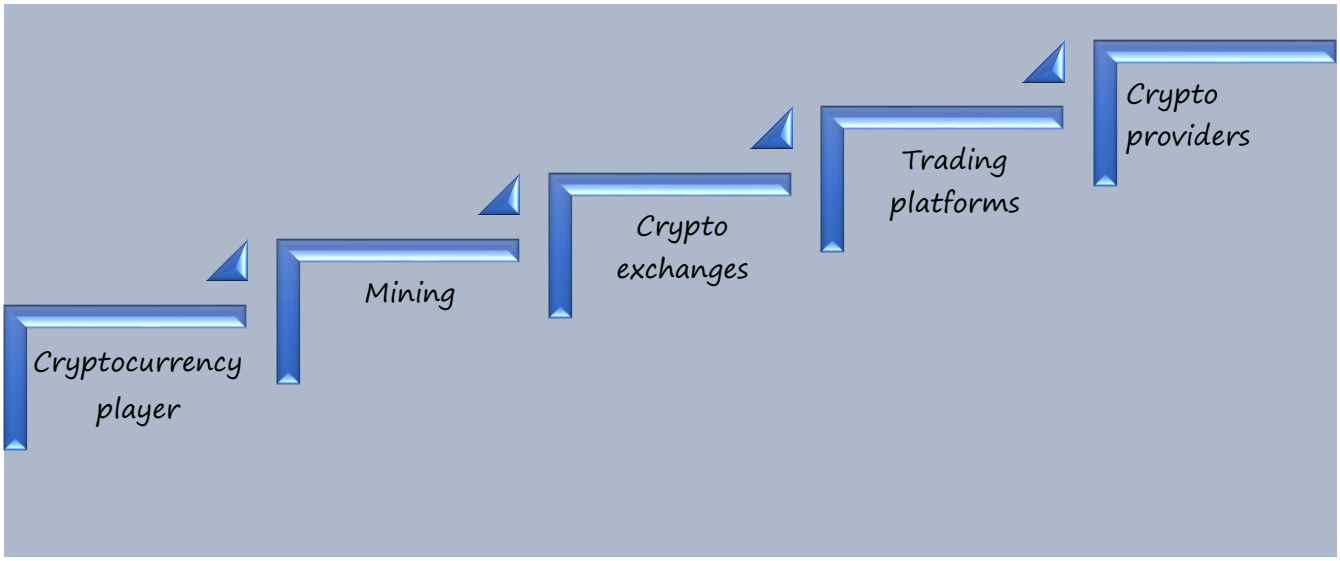

Figure 2. Crypto market participants

A cryptocurrency player is an individual who generates income through the use of cryptocurrencies or non-fungible tokens (NFTs). In blockchain-based games such as Play-to-Earn, Axie Infinity, The Sandbox, Decentraland, and Gods Unchained, participants purchase characters or virtual land plots as NFTs and subsequently sell them at a profit.

Mining services are essential for the creation of new coins. They involve performing complex mathematical computations, validating transactions, and maintaining the security and integrity of the blockchain network.

Cryptocurrency exchange services are provided through two main types of platforms: centralized exchanges (CEX) and decentralized exchanges (DEX). Among centralized exchanges, the most prominent are:

– Binance: the largest and most popular, offering a wide range of cryptocurrencies and futures trading;

– Coinbase: user-friendly, especially suitable for beginners;

– Bybit: known for high speed and convenience for traders;

– OKX: offers NFT trading, Web3 wallet integration, and diverse asset classes;

– KuCoin: known for hosting less popular tokens and enabling passive income opportunities.

Decentralized exchanges, such as Uniswap (supporting multiple tokens and direct wallet trading), PancakeSwap (known for simplicity and convenience), and SushiSwap (optimized for the Ethereum ecosystem and supporting multiple networks), enable users to connect their wallets directly without intermediaries.

Cryptocurrency trading platforms function similarly to traditional stock exchanges. They are online systems or software that monitor and analyze market prices, facilitate order placements, support automated trading through bots, and provide advanced trading options such as futures and margin trading for experienced traders.

Cryptocurrency service providers offer a broad spectrum of services related to cryptocurrencies, including secure storage, trading facilitation, payment processing, API integration, price monitoring, analytics, and security. A cryptoprovider refers to a specialized platform or company that delivers technological or financial services within the cryptocurrency ecosystem.

To understand the external factors influencing the contemporary cryptocurrency market, we propose a PESTEL analysis (Political, Economic, Social, Technological, Environmental, and Legal factors), summarized in Table 4.

Table 4. Analysis of the use of cryptocurrency using PESTEL

№	Factor	Division	Description
1	Political	Regulation and Control	Specific legal restrictions affect the market, such as the mining ban in China and support from the USA and EU.
		Central Bank Digital Currency (CBDC)	Governments are launching their own digital currencies (e.g., China's digital yuan, EU's digital euro).
		Political Instability	In times of economic and political instability (e.g., hyperinflation, sanctions), citizens turn to cryptocurrencies as alternatives (examples: Argentina, Venezuela).
2	Economic	Inflation and Interest Rates	Inflation of fiat currencies increases demand for cryptocurrencies as investors seek assets with limited supply like Bitcoin.
		Institutional Participation	Banks and investment funds are increasingly entering the crypto market; for instance, the anticipated approval of Bitcoin ETFs in 2024 attracts institutional capital.
		Market Volatility	High volatility of cryptocurrency prices affects investment safety and market stability.
3	Social	Youth and Tech-Savvy Interest	Generation Z and millennials actively support cryptocurrencies and Web3 projects.
		Demand for Financial Freedom	Distrust in traditional banks drives the popularity of decentralized finance (DeFi).
		Lack of Awareness	Poor understanding of cryptocurrencies in many countries negatively impacts their adoption.
4	Technological	Blockchain Development	Platforms like Ethereum, Solana, Polkadot, and Avalanche foster the growth of smart contracts, DeFi, NFTs, and GameFi.
		Layer-2 Solutions	Technologies such as Arbitrum and Optimism increase transaction speed and reduce fees.
		Cybersecurity Risks	Hacker attacks, fraudulent schemes, and "rug pulls" pose significant threats to the ecosystem.
5	Environmental	Energy Consumption Problem	Bitcoin mining is energy-intensive and has faced criticism for its environmental impact.
		Ecological Mining	Some miners use renewable energy sources, such as hydro and solar power.
		Transition to Proof-of-Stake	Projects like Ethereum are moving to energy-efficient consensus mechanisms (PoS) to reduce environmental impact.
6	Legal	Legislative Instability	Cryptocurrency regulations vary widely across countries and change frequently, creating uncertainty for investors.
		Taxation Policies	Many countries, including Kazakhstan, tax cryptocurrency income.
		Anti-Fraud Regulations	Regulatory bodies enforce strict controls over exchanges and initial coin offerings (ICOs).
Note: Compiled by the authors			

The use of cryptocurrency raises numerous questions for the global economy. At the same time, it can undoubtedly yield positive outcomes for both states and users of digital currencies. Provided that the adoption of digital currencies occurs with adequate regulation and control, it opens up many opportunities for economic growth, innovation stimulation, improved access to financial services, and the discovery of new income sources. The results of the PESTEL analysis indicate that the development of the cryptocurrency market and the industry's success primarily depend on increasing public awareness, enhancing financial literacy, and preparing society for global integration.

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RISK MANAGEMENT PROSPECTS IN MEDICAL ORGANIZATIONS

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Abstract

This article examines risk management in healthcare facilities, examining modern methods and international standards, including ISO 31000. Key approaches to identifying, assessing, and mitigating risks affecting patient safety and the performance of healthcare personnel are analyzed. The challenges faced by healthcare organizations are highlighted, and practical solutions for implementing risk management systems are proposed. Special attention is given to Georgia's experience, national standards, and prospects for their further development. The importance of an integrated approach to risk management, including the use of expert assessments and specialized methodologies such as HAZOP and FMEA, is emphasized to ensure a high level of safety and quality of medical care.

The article highlights that most risks in medicine are systemic in nature. It concludes that adverse events rarely happen in isolation but are usually the result of multiple factors. An example provided is medication errors, which can be caused not only by physician inattention but also by staff shortages, employee overload, inadequate integration of information systems, or insufficient regulation. The work demonstrates that effective risk management requires not only recording individual errors but also analyzing their causes and developing systemic prevention strategies to mitigate them. It emphasizes that risk assessment is a crucial part of the management process, as different threats have varying probabilities of occurrence and various levels of impact on healthcare operations. The article demonstrates that both qualitative and quantitative risk assessment methods are employed globally. Some organizations depend on expert assessments based on the experience of physicians and administrators, while others use mathematical models to estimate the likelihood of specific events. The article concludes by noting that modern medical centers actively implement automated monitoring systems that analyze patient data, staff workload, equipment condition, and other parameters, allowing them to predict potential failures and take preventative measures. Once risks are identified and assessed, they are mitigated.

Keywords: *Risk management, medicine, safety, standards, threat analysis.*

Risk management in healthcare organizations is a comprehensive process that identifies, analyzes, and mitigates threats that could impact patient safety, staff performance, and the sustainability of the entire healthcare system. With the rapid advancement of medical technologies, the increasing complexity of clinical processes, and increasing demands on service quality, risk management is becoming an integral part of the strategic management of healthcare institutions [1].

Modern approaches to risk management are based on international standards such as ISO 31000, as well as national regulations adapted to the specific needs of individual countries. Implementing these standards allows for the systematization of efforts to prevent adverse events, minimize the impact of human error, and ensure the reliability of medical processes. However, experience shows that implementing risk management methodologies in healthcare institutions is fraught with several challenges related to organizational characteristics, human resources, and the level of digital transformation in healthcare [2].

A crucial aspect of risk management in medicine is identifying potential threats. Errors by medical personnel, equipment malfunctions, inadequate specialist training, medication shortages, and disruptions in interdepartmental communication can all lead to negative consequences for patients and a decline in the quality of medical care. Therefore, one of the top priorities for managing medical organizations is to develop an effective risk identification system, including regular monitoring and situational analysis [3].

Experience shows that most risks in medicine are systemic in nature. This means that adverse events rarely occur in isolation, but are the result of a combination of factors. For example, medication errors can be caused not only by physician inattention, but also by staff shortages, employee overload, insufficient integration of information systems, or inadequate regulations [4]. Therefore, for effective

risk management, it is essential not only to record individual errors but also to analyze their root causes and develop prevention mechanisms at the systemic level. Risk assessment is another critical step in the management process. Different threats have different probabilities of occurrence and varying degrees of impact on the operations of a medical institution. Both qualitative and quantitative risk assessment methods are used worldwide. Some organizations rely on expert assessments based on the experience of physicians and administrators, while others employ mathematical models to predict the likelihood of certain events. Modern medical centers are actively implementing automated monitoring systems that analyze patient data, staff workload, equipment status, and other parameters, enabling them to predict potential disruptions and implement preventative measures. After identifying and assessing risks, mitigation follows.

Different strategies are employed depending on the nature of the threats. Some risks can be mitigated by modifying organizational processes, such as implementing electronic medication management systems, automating document management, or standardizing medical protocols. In other cases, staff engagement is required, including professional development, the development of precise instructions, training, and simulation exercises. Technical support plays a special role—the use of modern technologies, robotic systems, and artificial intelligence algorithms can reduce the likelihood of medical errors and improve diagnostic accuracy.

Georgian healthcare institutions are also adapting international risk management practices to local realities. The country has already implemented national standards, such as ISO 31000:2020, which regulates key approaches to risk management. However, practice shows that successful implementation of these standards requires not only regulatory changes but also a thorough restructuring of management processes within the organizations themselves. Specifically, it is essential to develop a safety culture among medical personnel, encourage the active participation of doctors and nurses in identifying and eliminating threats, and establish effective internal control mechanisms to ensure patient safety. A feedback system plays a crucial role in risk management.

Many countries utilize specialized platforms where healthcare workers can report potential threats and errors anonymously, without fear of administrative sanctions. This approach not only allows for the recording of emerging issues but also enables the analysis of trends, identification of the most vulnerable processes, and the development of effective preventive measures. Georgia does not yet have a comprehensive system for collecting and analyzing information on medical errors, but the first steps in this direction are already being taken.

Another essential element is the integration of risk management with the healthcare quality assurance system. In developed countries, these processes are closely linked: mortality data, readmissions, patient satisfaction, and other indicators are analyzed to identify systemic problems. In Georgia, this area is only beginning to develop; however, the digitalization of healthcare opens up opportunities for implementing analytical tools that enable real-time assessment of healthcare organization performance.

Risk management in medicine is impossible without adequate funding. In developed countries, significant budgets are allocated for this purpose, enabling the development of automated monitoring systems, extensive staff training, and the implementation of innovative technologies. In Georgia, funding for healthcare organizations remains limited, creating additional barriers to the effective implementation of risk management. Therefore, the search for alternative funding sources, including grants, international programs, and private investment, is critical.

Despite all the difficulties, the development of a risk management system in healthcare is a necessity dictated by modern realities. The growing number of patients, the increasing complexity of medical procedures, and high public expectations regarding the quality of medical care necessitate that healthcare institutions implement modern risk analysis and management methods. Experience from other countries shows that a systematic approach to risk management not only reduces the incidence of adverse events but also improves the overall level of medical safety, making the care process more predictable and manageable.

Modern risk management methods in medical institutions are a crucial area of healthcare development, as they ensure patient safety, minimize professional risks for staff, and enhance the overall efficiency of medical organizations. Risk management is a set of measures designed to identify, analyze, and mitigate potential threats that may arise during the provision of medical services. In the complex and rapidly changing realities of healthcare, risk management is becoming an integral part of the daily practice of medical institutions [1].

Risk management principles and standards are grounded in international experience, drawing on recommendations from organizations such as the World Health Organization (WHO), the International

Organization for Standardization (ISO), and other professional societies. One of the fundamental documents is the ISO 31000 standard, which establishes the key stages of risk management, including risk identification, assessment, management, and monitoring. This standard is universal and adaptable to various conditions, including those found in medical institutions. Risk management in medicine covers a wide range of areas, from preventing human errors to implementing quality control systems for equipment and processes. This approach is based on the principle of the systems approach, which requires analyzing and considering multiple interrelated factors. For example, human errors, which often lead to undesirable consequences, are usually caused by systemic failures, such as a lack of resources, ineffective communications, or inadequate employee training. Consequently, risk management requires a comprehensive approach that includes both improving internal processes and developing external collaborations [2].

To achieve the study's objectives, a comprehensive search and analysis of the scientific literature on risk management in healthcare organizations was conducted. This review demonstrated significant interest in the topic under study from the global scientific community.

In the initial phase of the study, publications presented in domestic and international peer-reviewed journals were examined. The primary focus was on analyzing risk management approaches in healthcare organizations, assessing the risks associated with medical personnel's professional activities, and evaluating tools for measuring patient safety culture used globally. Official information sources were also consulted, including departmental websites from Georgia and other countries, covering risk management and the development of patient safety culture in healthcare organizations.

Risk management in healthcare facilities encompasses a wide range of activities, including strategies, processes, methods, and actions designed to prevent adverse events and incidents. These approaches encompass clinical and non-clinical risks that may arise during the diagnosis, treatment, rehabilitation, and care of patients. They help staff at various levels identify, analyze, assess, and minimize risks affecting both patient and employee safety [3].

In this study, the term "risk" refers to any undesirable event that combines potential harm and the likelihood of its occurrence. This definition aligns with contemporary risk management concepts and standards. International and national standards, including Georgian standards, offer generally accepted risk management principles and methods, providing a basis for their practical application in various fields. These standards aim to fully address potential threats that may hinder the achievement of established goals. Complete risk identification is of strategic importance, as an undetected risk can significantly distort the analysis of the current situation. Risk management standards recommend using questionnaires as one of the most effective methods for identifying threats in the early stages of the process. This sociological method allows for the identification of general trends and the creation of a unified database for analyzing the risk structure across departments [4].

Since 2011, Georgia has had several national risk management regulations in place, including ISO 31000:2020, "Risk Management - Guidelines," IEC 31010:2020, "Risk Management - Risk Assessment Methods," and ISO 73:2010, "Risk Management - Vocabulary." These standards provide flexibility of application and can be adapted to various industries. For example, ISO 31000 offers recommendations suitable for risk management in any organization operating within a quality management system [5].

The universality of risk management standards allows for the specific characteristics of each organization to be taken into account. For example, certain aspects of medical personnel's work add unique characteristics to risk assessment. At the same time, the use of unified approaches promotes the unification of processes and the development of a common risk management culture.

The study of risk management in healthcare organizations is based on a combination of international experience, national standards, and practical methods. This enables the effective identification, analysis, and mitigation of potential threats, improving patient safety and staff performance.

Risk management in healthcare requires considering a multitude of potential threats that can impact the quality of medical care and patient safety. Medical activities are associated with numerous complexities that necessitate a systematic approach to identifying, analyzing, and mitigating risks.

According to international and national standards, risk management involves several stages. The first step is risk identification, which consists of identifying all possible sources of threats, classifying them, and describing their characteristics. Georgian National Standard ISO 73-2010 defines risk identification as a process that enables the compilation of a threat inventory and ensures its complete understanding. This is an important step, as missed risks can lead to significant problems in the future [6].

After risk identification, they are assessed. This stage involves analyzing the likelihood of events, their causes, and possible consequences. This approach enables the early identification of threats that

require immediate action and those that can be addressed later. The assessment process integrates several components: identification, analysis, and subjective perception of threats. Risks can be analyzed at the organizational, departmental, or process-specific levels.

Various methodologies are used for risk assessment, including both quantitative and qualitative approaches. For example, in some cases, the emphasis is on the likelihood of an event, while in others, the scale of potential damage is emphasized. The use of various methodologies allows for the assessment process to be tailored to the specific objectives and operating conditions of a healthcare organization.

Expert assessment is one of the most effective approaches to risk analysis. This method relies on the opinions and experience of specialists who make judgments about potential threats and ways to minimize them. Involving competent experts allows for consideration of various aspects of the problem, which is especially important in strategically significant issues. Collaboration among specialists facilitates more accurate risk assessment and improved management.

Modern approaches to risk analysis also include the use of specialized methodologies, such as HAZOP.[1] and FMEA[2]. Each of these methodologies has its own characteristics and limitations. For example, HAZOP requires extensive information about the subject of study, while FMEA is more suitable for analyzing threats and their consequences, but is not always applicable for retrospective assessment. The choice of an appropriate method depends on the specific conditions and objectives of the study [7].

Therefore, risk management in healthcare organizations requires a comprehensive approach that includes systematic threat identification, analysis, and the development of mitigation measures. Effective implementation of these steps helps create a safe environment for both patients and medical personnel, while also improving the quality of services provided.

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[1] HAZOP (Hazard and Operability Study) is a structured team analysis method designed to identify potential hazards and operational problems in process systems and equipment during the design or operation of industrial facilities, particularly in the chemical, oil and gas, and other high-risk industries. The purpose of this method is to identify potential deviations from design parameters, their causes, and consequences, thereby preventing accidents and enhancing the safety and reliability of production operations.

[2] FMEA (Failure Mode and Effects Analysis) is a structured method for identifying, analyzing, and preventing potential defects in products and processes. Its purpose is to explore potential failure modes, their causes, and consequences, to take proactive action and reduce risks. FMEA is used to improve quality, reliability, and safety, as well as to reduce costs at all stages of the product or process lifecycle.

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SOCIAL MEDIA CHALLENGES IN CONSUMER DECISION-MAKING

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Abstract

In the digital age, social media has transformed the traditional paradigms of consumer decision-making. Once characterized by a linear sequence of rational evaluations, the consumer journey is now dynamic, interactive, and heavily mediated by algorithms and online communities. This paper critically analyzes the challenges arising from the influence of social media on consumer decision-making, focusing on three primary problem domains: information authenticity, group polarization and cognitive bias, and privacy and data security. Drawing on recent empirical studies between 2021 and 2025, this research identifies how algorithm-driven personalization, influencer marketing, and user-generated content simultaneously empower and manipulate consumers. The findings reveal that while social media enhances market accessibility and participatory communication, it also undermines consumer autonomy through misinformation, emotional contagion, and invasive data profiling. The study emphasizes the need for balanced governance mechanisms that integrate algorithmic transparency, fact-checking systems, and privacy regulation. The research contributes to the growing field of behavioral economics and digital consumer studies by outlining a conceptual framework that connects digital media affordances with shifts in consumer cognition and trust.

Keywords: *Social media; consumer behavior; decision-making; information authenticity; cognitive bias; data privacy; digital marketing; behavioral economics*

1. Introduction

However, this transformation introduces complexities to the consumer decision-making process, traditionally structured into five stages—problem recognition, information search, evaluation of alternatives, purchase decision, and post-purchase evaluation (Kotler & Keller, 2022). Social media blurs the boundaries of these stages through continuous exposure to advertising, influencer endorsements, and algorithmic recommendations. The line between information and persuasion becomes indistinct.

This study seeks to explore the inherent problems in this new paradigm, focusing on how the mechanisms of social media—virality, algorithmic personalization, and social validation—create new barriers to rational decision-making. Specifically, it addresses three central research questions: (1) How does the abundance of information on social media affect consumers' ability to assess authenticity? (2) In what ways do online communities and algorithms reinforce cognitive biases and group polarization? (3) How do privacy violations and data exploitation undermine consumer trust?

By addressing these questions, this paper aims to contribute to a more nuanced understanding of consumer vulnerability in digital environments and propose mechanisms for sustainable, ethical digital marketing practices.

2. Problems of Information Authenticity

One of the most pervasive challenges in the social media ecosystem is the decline in information authenticity. Unlike traditional advertising channels, social media allows virtually anyone to create and disseminate content. This democratization of communication, while empowering, often leads to the proliferation of misinformation and deceptive marketing practices.

Empirical research by Kim and Johnson (2023) shows that over 58% of users encounter misleading product information on social platforms monthly. The phenomenon of "influencer marketing fraud" further exacerbates this issue, where individuals with fake followers or undisclosed sponsorships distort consumer perceptions. The viral spread of low-quality or biased information creates what Wardle and Derakhshan (2017) term "information disorder," where falsehoods circulate faster and wider than verified content.

Algorithmic curation amplifies these effects. Social media platforms, optimized for engagement, prioritize emotionally charged and attention-grabbing content. As a result, consumers are exposed to information that appeals to affective responses rather than cognitive reasoning. A study by Vosoughi et al. (2018) found that false news spreads six times faster than factual news due to its novelty and

emotional salience. This pattern undermines consumers' capacity to make informed decisions and erodes trust in digital marketplaces.

Additionally, the blending of organic and sponsored content reduces transparency. Platforms like TikTok and Instagram increasingly feature native advertising formats that mimic user-generated posts, making it difficult for consumers to distinguish authentic recommendations from paid promotions. This "authenticity illusion" creates a cognitive burden, forcing consumers to continuously evaluate the credibility of sources and messages.

3. Group Polarization and Cognitive Bias

The second major challenge arises from social media's tendency to amplify cognitive biases and foster group polarization. Unlike traditional mass media, social media platforms rely on algorithmic personalization, which constructs individualized "filter bubbles" (Pariser, 2011). These bubbles selectively expose users to content consistent with their preferences and prior beliefs. Over time, this selective exposure reinforces confirmation bias and reduces the diversity of perspectives available to consumers.

Psychological studies indicate that repeated exposure to congruent information increases confidence in existing beliefs, regardless of factual accuracy (Nickerson, 2022). In the context of consumer behavior, this means that individuals are more likely to trust brand messages or product reviews that align with their pre-existing attitudes. For instance, an environmentally conscious consumer may overvalue sustainable branding claims while ignoring contradictory evidence about production practices.

Group polarization occurs when users engage in homogenous online communities, such as fan groups or lifestyle forums. These communities create strong in-group identities and normative pressure to conform. As a result, consumers make emotionally driven decisions to maintain social belonging rather than rational assessments of utility or quality. This effect is particularly visible in viral consumption phenomena—such as "TikTok-made-me-buy-it" trends—were purchase decisions spread through imitation rather than evaluation.

Algorithmic recommendation systems intensify polarization by continuously learning and reinforcing behavioral patterns. When users engage with a specific type of content, algorithms prioritize similar material, narrowing informational diversity. Over time, the user's worldview—and by extension, their consumption preferences—becomes algorithmically shaped. This mechanism transforms social media from a neutral platform into an active participant in constructing consumer reality.

4. Privacy and Data Security

A third, equally significant challenge concerns the ethical and security implications of consumer data collection. Social media platforms derive substantial revenue from behavioral advertising, which relies on detailed data about users' demographics, interests, and interactions. The 2018 Cambridge Analytica scandal exemplified how personal data could be weaponized for behavioral manipulation, triggering global debates about digital ethics and privacy.

Contemporary research by the Pew Research Center (2023) indicates that 81% of consumers feel they have "little or no control" over how their data is used by online platforms. Despite the introduction of privacy frameworks such as the EU's General Data Protection Regulation (GDPR) and Kazakhstan's Law on Personal Data and Its Protection (2013, updated 2022), enforcement remains uneven.

Moreover, the trade-off between personalization and privacy has become increasingly opaque. Algorithms collect not only explicit data (likes, shares) but also infer implicit behavioral cues—such as browsing time, hesitation, or cursor movement—to predict purchase intentions. This "surveillance capitalism," as described by Zuboff (2019), transforms consumer behavior into a monetized data asset.

Data breaches and unauthorized sharing of personal information further erode consumer trust. When consumers perceive that platforms exploit rather than protect their privacy, their willingness to engage in digital commerce declines. Hence, privacy protection is not only a legal obligation but also a strategic imperative for maintaining market confidence.

5. Mechanism and Countermeasures

Addressing these challenges requires a multi-level governance framework that integrates technological, regulatory, and educational dimensions.

*First, **algorithmic transparency** should be prioritized. Platforms must disclose the logic behind content recommendation systems and offer users meaningful control over personalization settings. Academic initiatives such as "Explainable AI" (XAI) research provide potential pathways for enhancing accountability (Miller, 2021).*

*Third, **data governance frameworks** should evolve toward user-centric models. Consumers should have explicit opt-in consent mechanisms, real-time access to data usage records, and the right to*

portability and deletion. Stronger cross-border collaboration among regulatory authorities can help harmonize digital ethics standards.

*Finally, **digital literacy education** is essential. Consumers must develop critical thinking skills to evaluate online information and recognize manipulative marketing tactics. Educational interventions at both institutional and societal levels can enhance consumer resilience against misinformation and privacy violations.*

6. Conclusion

Social media has fundamentally altered the consumer decision-making paradigm, shifting it from rational evaluation to socially mediated influence. The integration of algorithmic recommendation, user-generated content, and behavioral advertising creates both opportunities and vulnerabilities.

This study identified three core challenges: (1) the erosion of information authenticity, (2) the amplification of cognitive bias and group polarization, and (3) the ethical risks of data exploitation. Together, these issues threaten the transparency and autonomy that underpin healthy market systems.

To ensure sustainable digital consumption, stakeholders—including platforms, regulators, and consumers—must jointly construct an ecosystem grounded in transparency, accountability, and digital ethics. The future of consumer decision-making depends not on resisting technology, but on aligning its design with human values and social responsibility.

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Geographical sciences

THE PRINCIPAL CHARACTERISTICS OF THE SOILS OF THE NAKHCHIVAN AUTONOMOUS REPUBLIC AND THEIR CARTOGRAPHIC REPRESENTATION

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Abstract

The article discusses the main characteristics of the soils distributed in the Nakhchivan Autonomous Republic and their mapping. The soil cover of the Nakhchivan Autonomous Republic has been formed under the influence of its natural-geographical position, climatic conditions, relief structure, and anthropogenic factors. The territory of the region is mainly characterized by mountainous and foothill reliefs. This has led to the diversity of the soil cover and the formation of various soil types in different altitude zones. The main soil types found in the area include grey soils, brown mountain-forest soils, mountain-meadow soils, saline soils, and alluvial soils. Grey soils cover large areas in the plains and foothill zones of Nakhchivan and are of great importance for agriculture. These soils, especially in the Araz river basin, form the main base of cultivation. In mountainous areas, mainly brown mountain-forest soils and mountain-meadow soils are observed, which are suitable for livestock breeding and summer pastures. Climate also plays an important role in soil formation. Due to the dominance of a continental and arid climate in Nakhchivan, the humus content in the soils is low, and the mechanical composition is variable. At the same time, the limited water resources in the region negatively affect soil moisture and agricultural productivity. In recent decades, the soil cover has undergone serious changes under the influence of anthropogenic factors. Erosion, salinization, destruction of vegetation, and improper irrigation systems have led to the degradation of soils. Soil erosion is especially widespread in foothill and plain areas, reducing soil quality. Additionally, intensive agricultural activities have created problems in the efficient use of soil resources.

Keywords: *soil cover, grey soils, brown soils, chestnut soils, light brown soils, saline soils*

INTRODUCTION. The complexity of the relief of Nakhchivan AR, the abundance of alluvial, proluvial and delluvial sources in the area, the diversity of hydrological conditions, the influence of vegetation, sharply continental climate and man for many years influenced the composition and distribution of soil cover.

The lands of the region are formed in different physical and geographical conditions. Soil types are common, which differ from each other depending on the relief and the exposure of the slopes. The soils of the foothills and plains are formed by alluvial, delluvial and proluvial origin. The location of the territory in dry climatic conditions has led to the fact that the lands of the mountainous part have a mountain-steppe character. The lands of the Nakhchivan AR differ sharply from their original form, since they are irrigated from time immemorial and are widely used in agriculture.

RESEARCH METHODOLOGY. The first land survey in the autonomous republic was carried out in 1925 by the soil scientist S.A.Conducted by Zakharov. He conducted soil studies in different zones and heights on more than 40 routes in different directions, as a result of the work he wrote the first scientific work on the lands of the Autonomous Republic. S.A.Zakharov allocated 4 land zones on the territory [11].

1. The Araz Valley with a height of up to 1200 meters and the open lands zone of the lower part of the foothill zone-plain

2. Brown soils zone of middle mountain range covering heights of 1200-1800 meters-foothills

3. Chestnut soils zone covering 1800-2400 meters high - mountainous

4. A zone of medium and high mountain-meadow soils, located above 2400 meters-high mountainous.

S.A.Zakharov divided the lands of the autonomous republic into 5 departments, 8 subdivisions, 4 types and 34 subtypes. At the same time, it grouped soils according to their composition, soil-forming parent rocks, their use and separated the phases of soil development [11]. S.A.Zakharov noted that the study of the stages of development of soil research is the basis of soil research. He singled out the

following phases of land development:

1. Lithogenic and lithomorphic phase. It is the first phase of soil formation. The influence of mountain rocks on the surface of the soil is manifested in its color, mechanical and chemical composition. The soils of the steep slopes of the lower and middle mountainous part of the territory are at this stage of development.

2. Automorf phase. In this phase, the influence of climatic and biological factors on the soil profile is clearly visible. Such soils are common in the middle and high ranges of mountains, plateaus and slopes.

3. Anthropogenic or anthropomorphic phase. It is one of the lands most affected by humans. These lands were more affected by the formation of society. Lands used in agriculture and irrigated from time immemorial are also included in this phase.

S.A.Zakharov noted that the process of soil formation is complicated depending on the geological structure. He gave the following divisions according to these characteristics:

1. Elluvial soils-is the successive leaching and removal of anions and cations from the soil during soil formation.

2. Sandy soils. The process of soil formation goes along with the washing out and bringing substances from the outside through groundwater.

3. Denudasion lands. The soiling process proceeds evenly with more or less intensive leaching of soil particles from the surface.

4. Accumulative soils. Soil formation is accompanied by subareal accumulation, soil leaching to the upper surface and thickening of the topsoil.

5. Alluvial soils. Earthing is accompanied by river accumulations.

S.A.As a result of his research work, Zakharov wrote the work "lands of the Nakhchivan Assr". Further research was carried out with reference to this work. Later, at different times, A.Q.Zeynalov (1988), H.A.Aliyev (1988), R.H.Mammadov (1963), Z.R.Bayramov (1964-1968), J.H.Maharramov (1966-1969), G.Sh.Mammadov (1988-1992), S.A.Hajiyev (1985-2006), A.G.Guliyev (1974-2001) engaged in soil Research [6], [7], [8], [9]. In 2010, S.A. Hajiyev prepared a land map of the Nakhchivan Autonomous Republic on a scale of 1:150000, taking into account the relief structure of the territory. We used this map in our research work (Figure).

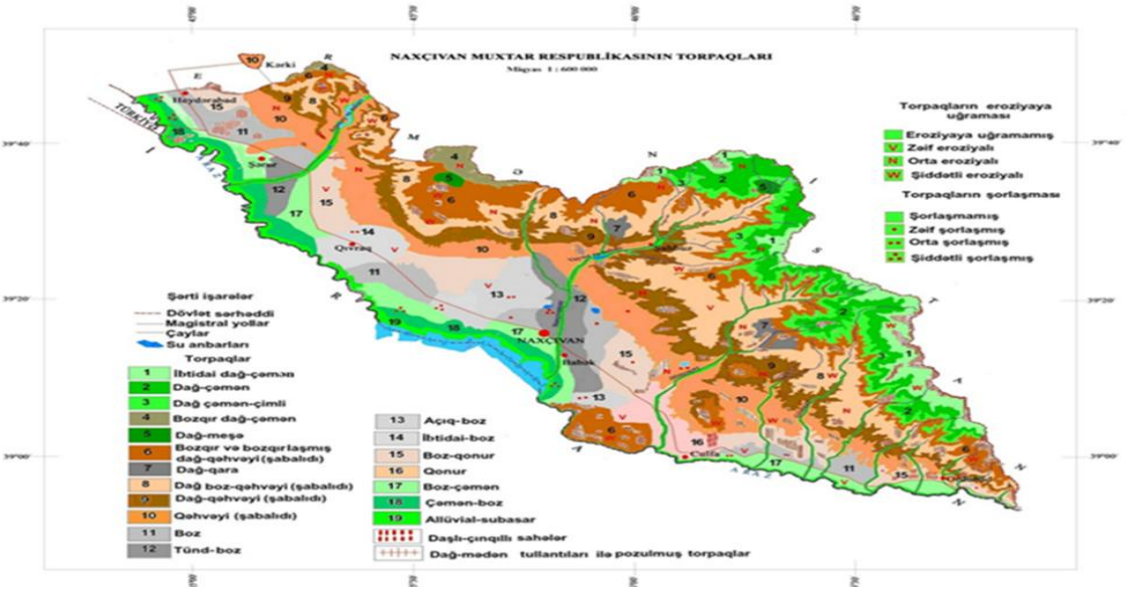

Figure. Land map of Nakhchivan Autonomous Republic (S.A.Hajiyev, 2010)

As a recent research work and at the same time a more compact classification of soil types of the territory of the Autonomous Republic H.A.Al-Qaeda and Al-QaedaK.It is more expedient to give according to Zeynalov's division. According to the given classification, 5 soil types, 14 subtypes are allocated in the mountainous part, and 5 types and 16 subtypes in the plain zone.

RESULTS AND DISCUSSION. A broad characterization of the soil types within each section is given [1, p. 50].

Soils of mountain-meadow and mountain-forest types are as follows:

1.Mountain-meadow soils of the alpine zone: a)Meadow Mountain-Meadow soils; B)primitive Meadow Mountain-Meadow soils.

2.Meadow-steppe soils of the subalpine zone: a)mountain meadow-steppe soils; B)plowed mountain meadow-steppe soils; c)mountain meadow-forest soils; d) alluvial soils of poymas.

3.Soils of the mountain-forest zone: a)mountain-forest soils; B)undeveloped mountain-forest soils; c)post-forest mountain soils; d)civilized mountain-forest soils; e) Gray-forest soils.

The soils of the mountain-steppe type are:

4.Chernozem zone: - carbonated mountain black soils.

5.Chestnut soils: a)mountain Chestnut soils; b) light chestnut mountain soils.

Steppe and steppe - desert soil types are as follows:

6.Soils of the foothill dry steppe zone: a)chestnut soils; B)light chestnut soils; c)light chestnut soils irrigated from time immemorial; d) light chestnut soils irrigated.

7.Gray soils of deserts and steppes: a)gray-brown soils; B)Gray soils; c)irrigated Gray soils from time immemorial; d)alluvial Gray soils; e)primitive Gray soils.

8.Steppe soils at the stage of transition to Meadow soils: a)irrigated Meadow-steppe soils; B)irrigated Gray-Meadow soils.

9.Meadow-type soils: a)meadow soils B)Meadow alluvial soils; c)Meadow saline soils; d) carbonated Meadow-marshy soils.

10.Saline-type soils: automorphic and hydromorphic Salines.

A brief characteristic of these soil types is as follows:

Mountain-meadow soils of the alpine zone. These lands were formed in the high mountainous zone of Nakhchivan AR, in complex bioclimatic conditions. Very low temperatures, low possible evaporation and relatively high average annual precipitation are typical for these lands. Unlike other mountain ranges of our republic, this type of land in the territory of Nakhchivan AR is distinguished by a relatively low indicator of precipitation.

Loamy mountain-meadow soils. These lands S.A.According to Zakharov, it is formed under Alpine Meadows. It is formed by the action of humidity, cold climate, relief and soil-forming rocks. The humus content is 9.38-7.03 percent and is considered a low indicator compared to the same type of soils of the Lesser Caucasus. Since these soils are genetically young soils, they are skeletal. In the recent geological past, it was covered with glaciers, and at present these traces are clearly manifested in the relief [1, p.53].

Meadow Mountain-Meadow soils are located at a height of 2200-2400 meters above sea level. In this zone, the amount of vegetative mass is large, since the vegetation is well developed. In particular, the mixture of mesophilic spiked grass includes andyz, Lily, awlik, Clover, Buttercup, etc. in areas where it predominates, there are more root residues of plants. The largest reserves of Root residues are collected in a layer of 0-10 CM, of which 15 percent are plant residues, and the rest are herbaceous plants [1, p.54].

The Rocky Mountain-Meadow soils are composed of rocks of various composition, including andesite, basalt, clay shales, sandstones, limestones, rough fragments and weathering materials.

Depending on the nature of the location, soil-forming factors, these soils receive different values on a number of parametric indicators in small taxonomic units [7]. In a not fully developed type of soil, germination is weak, and in some places it is well developed. For example, in the mower pass, the germination process went well, since the plants developed well. And this strengthens the protection of soils from erosion.

The amount of humus in Mountain-Meadow soils is different depending on the vegetation. While vegetation is well developed in kechaldag-Bazarchay pass, vegetation is poorly developed in BIST, Tivi, Nasirvaz, Paraga zone. Therefore, the mountain-meadow soils here are weak and not fully developed. Depending on the climatic conditions in the territory of Nakhchivan AR, steppe soil type is selected below the meadow soils. Unlike Meadow soils, soils cannot be protected from aesosia due to poor vegetation on steppe soils.

Stony-skeletal mountain-meadow soils are soils that are poorly supplied with moisture. In spring and summer, especially during the growing season, there is little humidity in stony places. Since Stony-skeletal mountain-meadow soils are mechanically heavy clayey and clayey, the top layer does not form a dense turf layer, and the amount of humus is less due to the low accumulation of plant residues in the soil. In hot climates, plant residues become more mineralized. In some places, soil-forming rocks are exposed. Soft loamy mountain-meadow soils are clayey and the soil layer is 30-60 cm [1, p.57].

Peaty mountain-meadow soils are found in sedimentary areas around mountain glaciers. Because of the large number of plant residues in those lands, the amount of humus is also high. It has lost its significance due to the fact that it was used as summer pastures. These lands are Nasirvaz, Paraga,

Arafsa, Tivi, Bist, Kolani, kalaki, etc. it is spread around the settlements.

M.E.As a result of his research, Salayev found that if Peaty mountain-meadow soils are formed in the Lesser Caucasus at 2000 meters and above, then in the territory of Nakhchivan AR these lands are spread in the alpine zone in the form of Talas [1, p.60] .

Peaty sod soils are 20-35 cm thick. In the upper layer, numerous fringing roots form a dense layer of turf. Due to the high humidity and low temperatures in these soils, microbiological processes are weak, plant residues rot poorly. Therefore, weak, half-rotted plant residues abound in the upper layer, forming a delicate layer of peat, similar to felt. In the formation of the peat layer, turf-lame-meadow grasses, spiky grasses, etc.are used. plays an important role. The main part of the plant roots is collected in a layer of 0-10 CM. However, up to 80 percent of them are dead roots. Due to their mechanical composition, these soils are clayey, gravelly. The humus content is 8-10 percent in the upper layer. And as you go deeper, it decreases sharply.

Primitive mountain-meadow soils. This soil subtype is found in high mountain areas. The content of humus in it is low (2 percent). The soil layer is sleepy. In some places, soil-forming watersheds come to light. Such soils are spread in the high-altitude areas of the zangazur range in the Upland depressions.

Meadow-steppe soils of the subalpine zone. Mountain meadow-steppe soils are located below mountain-meadow soils. Due to its mechanical composition, it is medium to heavy clay. As you go deep, the amount of clay decreases. This part is in a semi-dry state, since the summer period is dry, evaporation of the soil occurs at depths of up to 30-40 cm. Dry summer leads to the destruction of vegetation and the acceleration of erosion processes. Falling precipitation creates conditions for washing out the topsoil and the formation of muddy mudflows.

Mountain meadow-steppe soils are up to a meter thick. On the southern slopes and steep places of the mountains, the thickness decreases and becomes complicated by stone chips. In Mountain Meadow-steppe soils, the humus content does not exceed 4-5 percent. The characteristic type of these lands is spread around the villages of Tivi, Gazanchi, Paraga, Arinj [8].

The mountain meadow-steppe lands used in agriculture are used in the low part of the high mountain, especially in the agricultural areas of the mountain meadow-steppe lands located on the southern slopes of the zangazur range. In the summer period, moisture content in these soils is much higher than in other soils. Vegetation develops well, especially the unfading flower plant is widespread. When used improperly in agriculture, sometimes the top humus layer of soils is washed away and the humus-free layer is exposed. These lands are Arafsa, Tivi, Gazanchi, Milakh, etc. it is spread around villages and is widely used in agriculture.

Mountain meadow-forest lands are spread in the mowing pass, around the Batabat lake, especially in the north-western expositions of the zangazur Ridge in the gorges. This ground cover is formed under forest vegetation. Due to its mechanical composition, it is clayey. It is common around kwanus as a characteristic type. More plant residues are collected in 0-10 cm layer and wood and plant residues in 20-30 cm layer. The humus content is 3 percent. It is skeletal and light in color.

Alluvial subasar soils. It is developed in the middle mountains, in the lower part of the high mountains and in the river valleys. These soils arise from the deposition of erosion materials brought by rivers as a result of rising levels in spring and summer. The mechanical composition is diverse. It is mainly medium to heavy clayey, with young alluvial soils. The vegetation is rich. In particular, separatelot, plantain, milkweed, licorice, etc. plants develop widely. It is rich in humus. Plant residues that accumulate in the soil create germination. As it is fertile, it is used in horticulture and agriculture.

Qeyheyi mountain-forest lands for the first time in Azerbaijan S.A.Zakharov, V.V.Akimsev, I.Z.Imshenetsky, V.P.Smirnov-Loginov, B.A.Klopotovsky, V.R.Volobuyev, H.A.Aliyev, M.E.Salayev, R.V.Kovalev, E.F.Sharifov, A.K.Zeynalov, Sh.H.H. Hasanov, H.H.Babayev and others. it has been studied by [10]. Mountain-forest lands in Nakhchivan AR are located above 2400 meters. Once Upon a time, forests were widespread on these lands. I.N.Aslanov notes that Paraga and Paradasht were covered with tropical and subtropical forests in the middle Eocene. These soil types are formed higher in Nakhchivan AR than in other areas of Azerbaijan.

In the Autonomous Republic, mountain-forest soils are formed in dry climates and are related to Meadow-steppe, Mountain-Black and mountain-Chestnut soils.

Brown mountain-forest lands in Nakhchivan AR are spread in Gilanchay, Alinjachay and especially in the upper part of Nakhchivanchay. Studies have shown that brown mountain-forest soils in the region are located on the northern and Northwestern slopes of the mountains below the zone of mountain-meadow soils, but do not form complete zonality. Due to its mechanical composition, it is heavy clayey, clayey and lumpy in the lower layer. Brown mountain-forest soils are formed on elluvial limestones and

other carbonated rocks. The amount of humus in brown mountain-forest soils in the mowing pass exceeds 4 percent, and decreases as it deepens [10]. And in the Julfa zone, this type of soil is poorly developed, medium and heavy clayey, with a humus content of 3-4 percent.

Brown mountain soils after the forest. This type of land is found among brown mountain-forest lands in Nakhchivan AR. At one time, forests were destroyed by people or due to the drought of the climate, and the vegetation cover was completely changed. Plant residues left in the soil have caused it to become granular. In the post-forest brown mountain soils, the amount of humus in the upper layer is very high, and gradually decreases as it goes deep. The amount of nitrogen is high, due to its mechanical composition it is heavy-weight and clayey. In the upper layer, the grass-forming plants are separated fromgrass, larch, Clover, foxtail, etc. finish. The main part of the roots (70%) is at a depth of 0-20 CM. Up to 70% of the total mass of plants consists of dead root residues [10].

Civilized brown mountain soils. Freed from forest plants, coffeyi is used in horticulture by applying irrigation on artificial terraces on the slopes of river valleys from mountain-forest lands. Since it was widely used in agriculture and irrigated, these soils were strongly altered and retained little of their former morphological signs.

These soils have a granular structure and dense vegetation. A characteristic example of this is the lands on the gilanchay Terrace, in the south-west of the village of Bilav. This terrace is inclined to the Southeast. Of the herbaceous plants, licorice, Clover, awlik, etc.are used. finish. The humus content is 1.43-5.40%. Due to their mechanical composition, these soils are heavy and medium clayey.

Mountain gray-brown soils. In Nakhchivan AR, these lands are spread in separate areas. The area with its characteristic spread is mid-mountainous on the southern edge of the village of Bilav. The humus content in these soils is 3.9%. Due to its mechanical composition, it is medium-clay.

Carbonated mountain-black soils. S.A.Zakharov determined that there are not only forest lands, but also Mountain-Black lands among Chestnut and mountain-meadow lands in Nakhchivan AR. This type of soil is distributed in the area in the form of Glades. Mountain-black soils are formed in temperate climates. The top layer of soil 20 cm is black, 20-50 CM is light black, and then gray-brown. The top layer is structured, and after 20-25 cm it is lumpy. In uncultivated areas, the soil layer is dense and kip up to one meter. The soil forming rocks are limestone and carbonate and heavy clayey. At a depth of 35-40 CM in the soil is a carbonated layer [9]. More than 69% of plant roots are collected in a layer of 0-10 CM. More than 50% of the plant residue is dead roots.

Mountain Chestnut soils. These lands are located in the upper part of the foothill zone in the territory of the Autonomous Republic, in a large area below the Dagh-Kara lands. Ravines, river valleys, etc. it seriously affects the process of soil formation. Vegetation of the mountainous part of Chestnut soils, L.I.As prilipko notes, it consists of xerophytic plants of the middle Highlands. The natural vegetation of these lands, especially Wormwood, Wormwood-friganoid plants, has been replaced by cultivated plants. The natural vegetation is dominated by weeds, especially the separatelot.

S.A.According to Zakharov's division, Chestnut Mountain lands in the territory of Nakhichevan AR reach heights from 1800 m to 2400-2700 m and, unlike Mountain-Black lands, stretch in the form of a strip [11].

Land development is not the same everywhere. Undeveloped mountain-Chestnut soils are found on the steep slopes of the mountains in intensively dissected areas without favorable relief conditions. They are yuxa and of medium thickness. These lands are used in iron farming. Mountain Chestnut soils are low-humus and structured. The humus content is 3.5%, sometimes 4%, and towards the depth it decreases. From the steppe plants, Agot, Invitational, Wormwood, blackthorn bushes are widespread here, but due to the intensive grazing, the aboveground part of plants is reduced. The main part of the roots is collected at 0-20 CM. Up to 70% of plant roots are made up of dead root residues. Due to its mechanical composition, it is heavy clayey. Its mechanical composition is changed as it is used in agriculture. In areas with a high tendency, slopes are more exposed to erosion processes. The humus content is up to 3%. Salinization is found in lowland places. In some places it is used in agriculture. Such lands are spread in the territory of Shahbuz and Julfa regions.

Light-chestnut mountain soils. Chestnut is common on steep slopes below mountain soils, especially at individual elevations on the eastern and southern slopes. In dry climates, the amount of humus is small, since the vegetation is poorly developed. Since the vegetation is poor, the process of leaching is underway. As a result, the widespread spread of ravines seriously affects the process of soil formation and the color of the soil. In some places, rocks are exposed. These lands are used in iron farming. Characteristic open-Chestnut Mountain soils are spread in a large area in the west of Saluzz village of Shahbuz region. It is medium clayey and has a blackish color up to 20-50 cm deep. It is skeletal

and sleepy. This type of soil is also spread in the area consisting of spiky, thorny, cereal and mixed leguminous plants, which are widely spread in the areas with small hills in the east of khanaga village. Here, the process of humus formation proceeds poorly, since plant residues are washed away. The humus content is up to 2%. Soil-forming rocks are carbonated. The mechanical composition is diverse. The places used in agriculture are medium to light clayey. Used as winter pastures. Since it is widely used in animal husbandry, the composition of vegetation changes and leaching is accelerated. The territory is almost covered with animal trails. On the northern slopes of the mountains, grain growing is developed due to the relatively high content of moisture and humus.

Chestnut soils. Chestnut soils in Azerbaijan are common in the dry steppe zone of the foothills and lower mountainous parts. These lands M.E.According to salayev, it also occurs in the foothills of the Lesser Caucasus in temperate-hot, semi-arid and semi-temperate climates.

Chestnut soils in the territory of Nakhchivan AR are spread in the foothill relief zone. Irrigated agriculture has been developed since time immemorial in areas with favorable relief conditions. Under natural conditions, it is formed under dry steppe plants. Since the vegetation cover is sufficient, the hydration in these soils is relatively good. Depending on the mechanical composition, atmospheric sediments are well filtered. Among the soils of the lowland part of the territory, the most fertile soils are Chestnut soils. The humus content is higher than in other regions of Azerbaijan. Chestnut soils, irrigated from time immemorial, have lost their historical nature of origin and very few traces have survived from it. The soil is lumpy, up to 50-60 cm. And under arable land, these soils are soft. The 20 cm top layer of Chestnut soils is chestnut in color. As you go deeper, this color changes and takes on a gray tint. Due to its mechanical composition, it is large-cut and creamy. The fractional layer lasts up to 75-80 CM. The chestnut soils around bananiyar village are heavily clayey and clayey. In some places, the formation of Chestnut soils from alluvial deposits is noticeable. The Lyophilic nature of the soils and the spread of spiky mixed grasses do not allow wormwood to spread. The amount of humus becomes less due to the fact that plant residues are washed off on the upper surface. In the foothill plume zones, Chestnut soils are found in the near-surface areas of groundwater. On such soils, dry steppe plants are replaced by Meadow ones. Swamps are found in places where groundwater accumulates.

In the territory of the Autonomous Republic, all these lands are used in agriculture. Salinized Chestnut-Meadow soils are found in the territory of Sharur region. Chestnut grass soils are spread in Ordubad region, especially in Gilanchay poyma. Ancient alluvial sediments in River poymas are covered with delluvial sediments and complicated by sediments brought by atmospheric precipitation. The humus content in irrigated soils from time immemorial is 3%.

In some regions of the Autonomous Republic, Chestnut lands are called "meat lands" and are widely used in agriculture. Chestnut soils are divided into semi-types, which differ almost from each other.

CONCLUSION. *The study has revealed that the soil cover of the Nakhchivan Autonomous Republic has been formed under the influence of complex natural-geographical conditions, diverse climate and relief, as well as anthropogenic factors. Gray soils, brown mountain-forest soils, mountain-meadow soils, saline, and alluvial soils are widely distributed across the territory. Each soil type is formed in specific altitudinal zones and holds significant importance for various land-use purposes.*

The mapping of soil resources enables accurate evaluation of their geographical distribution, quality indicators, and agricultural value. The application of GIS technologies serves as an indispensable tool for the efficient management and sustainable use of soil resources.

The data presented in the article can serve as a foundation for the ecological-geographical assessment of soil resources in the Nakhchivan Autonomous Republic, as well as for informed decision-making in land planning and management.

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Geological and mineralogical sciences

INTEGRATION OF AI AND GIS TECHNOLOGIES FOR DIGITAL PREDICTION AND MAPPING OF MINERAL DEPOSITS

Roza Mukiyatkyzy

Abstract

Mineral exploration is entering a digital era where the volume and heterogeneity of geoscientific data exceed the capacity of traditional methods. Artificial intelligence (AI) combined with geographic information systems (GIS) offers a solution by enabling automated analysis and spatial integration of geological, geophysical, geochemical, and remote sensing datasets. AI algorithms can detect subtle patterns within big data, thereby improving the accuracy of mineral prospectivity models and reducing the time and cost of exploration. By coupling machine learning with GIS, researchers can generate high-resolution predictive maps that guide fieldwork toward the most promising targets. Digital twin technology enhances this process by creating virtual prototypes of deposits and allowing continuous updating with new data. This paper reviews current developments in AI-assisted GIS for mineral exploration, emphasizing the integration of diverse datasets, the application of supervised and unsupervised learning algorithms, and the construction of interactive digital platforms. Methods such as support vector machines, random forest, gradient boosting and convolutional neural networks are described for analyzing multidimensional geodata, interpreting geophysical anomalies, detecting geochemical patterns and classifying lithology. Case studies illustrate how AI-GIS integration has improved the identification of alteration zones, spectral anomalies and structural lineaments in various geological settings. The role of digital platforms-such as the "Digital Caspian" initiative-in unifying AI, GIS and digital twins is discussed, highlighting their capacity to support decision-making and environmental monitoring. While the potential of AI-GIS integration is substantial, challenges remain in data quality, algorithm interpretability, and the generalizability of models to new regions. The paper concludes that continued research in explainable AI, cross-disciplinary data fusion and collaborative digital platforms will be essential for realizing a fully digital workflow for mineral exploration

Keywords: *artificial intelligence, geographic information systems, predictive mapping, machine learning, digital twins, mineral exploration, remote sensing, geophysical anomalies, geochemical analysis, spatial modeling*

Introduction

Digital technologies have profoundly transformed a wide range of scientific disciplines, and geology is no exception. The convergence of artificial intelligence (AI) and geographic information systems (GIS) has enabled geoscientists to process vast, heterogeneous datasets, uncover latent spatial and geochemical patterns, and construct highly accurate predictive models for resource discovery. Recent research underscores the pivotal role of GIS in modern geological investigations, where its analytical and visualization capabilities help reduce research costs, shorten project timelines, and increase data precision across exploration workflows [1].

The synergy between GIS and remote sensing technologies further amplifies this impact. By providing comprehensive, high-resolution insights into the Earth's surface and subsurface, remote sensing enhances the efficiency of GIS-based analyses and supports the identification of potential mineralization zones. Notably, this integration has facilitated the detection of iron ore deposits such as Koraozek and Tebinbulak in Karakalpakstan, demonstrating the tangible benefits of digital geospatial tools in applied mineral exploration [1].

Traditional methods of mineral exploration, however, remain heavily dependent on expert-driven interpretation of geological, geophysical, and geochemical data. As mineral deposits occur at increasing depths and exploration areas expand into more geologically complex terrains, these conventional techniques are becoming progressively less effective and more resource-intensive. This growing limitation emphasizes the urgent need for innovative analytical approaches capable of managing large-scale, multidimensional datasets, integrating numerical modeling outputs, and revealing complex, non-linear

interdependencies among geological variables.

Recent advances in the application of artificial intelligence to mining and mineral exploration have begun to address these challenges. AI-based methods-ranging from machine learning algorithms to deep neural architectures-are now being systematically integrated into exploration workflows, giving rise to a new paradigm of digital geological exploration. This paradigm not only enhances predictive accuracy and operational efficiency but also fosters data-driven decision-making and interdisciplinary collaboration across geoscientific domains.

A prime example of this transformation is the "Digital Caspian" platform, which represents a next-generation AI–GIS–digital twin ecosystem. The platform merges predictive modeling, environmental analytics, and geospatial intelligence to support sustainable, transparent, and adaptive management of geological research and resource development [2]. Through this integration, Digital Caspian exemplifies the shift from isolated data interpretation toward holistic, intelligent exploration systems that combine scientific rigor with environmental and economic responsibility.

Methods.

Data integration and preprocessing

Mineral prospectivity analysis fundamentally depends on the integration of diverse geoscientific datasets-including geological maps, geophysical surveys, geochemical assays, and satellite imagery-within a unified and interoperable geodatabase. The convergence of these heterogeneous data sources provides a multidimensional representation of subsurface conditions, allowing geologists to infer mineralization processes with greater confidence. Artificial intelligence (AI) techniques streamline this integration by efficiently handling complex, high-dimensional datasets and extracting salient predictive features that are often imperceptible through traditional, heuristic interpretation.

Geographic information systems (GIS) complement these analytical processes by introducing spatial and topological context to the data. Through spatial overlay, map algebra, and multi-criteria analysis, GIS enables the joint visualization and correlation of geological, geochemical, and geophysical indicators. This spatial integration is essential for delineating mineralized zones, identifying structural controls, and prioritizing target areas for further investigation.

Recent applications of AI in mineral exploration have demonstrated that machine learning algorithms-including support vector machines (SVMs), random forest (RF), and gradient boosting (GBM)-can effectively process these integrated datasets to generate mineral potential maps and predict promising exploration targets with high reliability [3]. These methods are capable of modeling non-linear relationships among geological variables, enabling the identification of subtle geochemical or geophysical anomalies associated with concealed ore bodies.

By combining AI-driven feature extraction with GIS-based spatial analytics, researchers are developing a new generation of data-driven prospectivity models that enhance predictive accuracy, reduce uncertainty, and optimize exploration efficiency. This synergy between AI and GIS represents a pivotal advancement in digital geoscience-transforming mineral exploration from a predominantly experience-based activity into a quantitative, transparent, and reproducible predictive science.

Predictive mapping using machine learning

The primary applications of artificial intelligence (AI) in mineral exploration center on predictive mapping and the delineation of prospective zones for further investigation. In these workflows, supervised learning algorithms are trained using datasets that combine known deposit locations with their corresponding geological, geochemical, and geophysical attributes, allowing the models to forecast mineralization potential in uncharted or underexplored regions. By learning from established patterns of ore occurrence, these algorithms can extrapolate the spatial relationships among controlling factors-such as lithology, fault density, magnetic anomalies, and geochemical gradients-to predict new targets with quantifiable confidence levels.

Among the available approaches, convolutional neural networks (CNNs) have demonstrated exceptional utility in the interpretation of satellite and aerial imagery, owing to their ability to capture spatial hierarchies and complex texture patterns automatically. CNNs are particularly effective in detecting geological lineaments, ring structures, and hydrothermal alteration zones, which often serve as surface expressions of subsurface mineralization processes [3]. Furthermore, their integration with multispectral and hyperspectral remote sensing data enables the identification of spectral anomalies indicative of specific mineral assemblages-such as iron oxides, clays, and carbonates-that are diagnostic of ore-forming environments.

In addition to anomaly detection, CNN-based models have shown strong performance in lithological classification, achieving high accuracy rates when applied to high-resolution remote sensing datasets

and field-calibrated spectral libraries [3]. By automating these complex interpretive tasks, AI-driven image analysis significantly reduces manual processing time, enhances reproducibility, and provides geologists with actionable insights for refining exploration targets.

Collectively, these developments highlight the growing role of AI-powered predictive modeling in transforming mineral exploration from a largely interpretive discipline into a quantitative, data-intensive science, where geological reasoning and computational intelligence work in concert to accelerate resource discovery.

Interpretation of geophysical data

Deep learning technologies have become indispensable tools for interpreting complex geophysical datasets, offering significant improvements in data clarity and analytical precision. By effectively suppressing random noise and amplifying subtle geological signals, these models enhance the interpretability of exploration data. Autoencoders and convolutional neural networks (CNNs) are particularly powerful in this context, as they can process magnetic, gravity, and electrical survey measurements to isolate and accentuate geophysical anomalies associated with concealed ore bodies [4]. Beyond anomaly detection, machine learning algorithms substantially accelerate inverse modelling workflows, enabling the rapid construction of high-resolution, three-dimensional representations of the subsurface based on geophysical observations [4]. These digital models not only refine the accuracy of resource and reserve estimations but also contribute to the optimization of drilling trajectories, reduction of exploration risk, and overall improvement of decision-making in mineral prospecting.

Geochemical and drilling data analysis

Unsupervised learning algorithms, including k-means clustering, Density-Based Spatial Clustering of Applications with Noise (DBSCAN), and isolation forest, provide a statistically objective framework for detecting geochemical anomalies relative to regional background variability. These methods are particularly valuable in early-stage exploration, where subtle elemental deviations may signal concealed mineralization zones. In recent case studies, k-means clustering successfully identified approximately 92% of known geochemical anomalies within datasets exceeding 10,000 sampling points, demonstrating its robustness in large-scale geochemical mapping. Similarly, DBSCAN achieved an average silhouette coefficient of 0.84, indicating strong intra-cluster cohesion and inter-cluster separation. Collectively, these approaches enable geoscientists to isolate geochemical signatures that correspond to hidden ore systems or secondary dispersion patterns with minimal prior geological assumptions.

Beyond unsupervised analysis, supervised classification models trained on multi-element geochemical spectra-typically encompassing 15 to 25 major and trace elements-have demonstrated impressive performance in deposit-type prediction and halo delineation. Reported accuracies range from 87% to 93%, with models successfully identifying primary dispersion halos extending up to 3.5 km from mineralized centers. Such outcomes highlight the capacity of AI algorithms to quantify geochemical zonation and enhance early-stage exploration targeting, particularly in terrains characterized by limited outcrop exposure or complex post-mineralization overprinting.

In the domain of drilling and core analysis, deep learning architectures-notably convolutional neural networks (CNNs) and long short-term memory (LSTM) networks-have transformed core logging and lithological interpretation workflows. These models autonomously identify lithological boundaries, characterize mineral textures, and estimate fracture density and porosity parameters from high-resolution imagery and sensor data. Empirical studies applying CNNs to hyperspectral core imagery have achieved precision rates exceeding 90% for lithological classification and R^2 values up to 0.88 for porosity estimation relative to manual petrographic measurements. The deployment of LSTM networks further enhances temporal or sequential data interpretation, improving the consistency of downhole lithological predictions.

Complementing these advances, optimization algorithms-including particle swarm optimization (PSO) and genetic algorithms (GA)-are increasingly integrated into drilling program design to maximize sampling efficiency. These heuristic search methods enable dynamic optimization of drill hole spacing, orientation, and depth parameters, leading to sampling efficiency improvements of 25–40% and overall cost reductions of approximately 30% compared with traditional grid-based drilling. Such algorithmic optimization not only minimizes redundant drilling but also accelerates decision-making in resource evaluation and feasibility assessment.

Figure [X] presents a comparative analysis of AI model performance metrics-including accuracy, precision, and operational efficiency-across key application domains in mineral exploration. As shown, k-means and DBSCAN exhibit superior accuracy in geochemical anomaly detection, while CNN and LSTM models demonstrate strong predictive reliability in drilling and core analysis, underscoring the

complementary nature of unsupervised, supervised, and optimization-based AI methodologies in the modern exploration workflow.

Figure 1. Model Performance Comparison Chart

Algorithm	Accuracy (%)	Precision (%)	Efficiency Improvement (%)
K-means	92	88	-
DBSCAN	89	85	-
CNN (core analysis)	90	91	30
LSTM (porosity)	88	87	25

Results and Discussion

The integration of artificial intelligence (AI) and geographic information systems (GIS) within the Digital Caspian platform has produced quantifiable improvements in data integration, operational efficiency, and predictive performance for geological exploration. This section presents a detailed assessment of system outputs and discusses their implications for sustainable subsoil resource management.

Data Integration and System Architecture

As illustrated in Figure 2, the Digital Caspian platform consolidates more than 5.2 terabytes of geological, geophysical, geochemical, and remote-sensing data, integrating over 480 geospatial layers across the Caspian Basin. These layers include lithological, structural, and hydrogeological maps, satellite imagery, ecological parameters, and anthropogenic indicators. The system's architecture is designed for interoperability, allowing simultaneous spatial querying, multivariate analysis, and temporal tracking of geological processes.

This comprehensive data infrastructure enables high-resolution modeling of subsurface systems. The inclusion of multi-source datasets-ranging from Landsat and Sentinel imagery (10-30 m resolution) to detailed borehole logs-has enhanced spatial resolution and improved the quality of input data for machine learning models. The data fusion approach also allows researchers to identify interdependencies between mineralization zones and environmental variables, creating a unified foundation for predictive analysis and environmental monitoring.

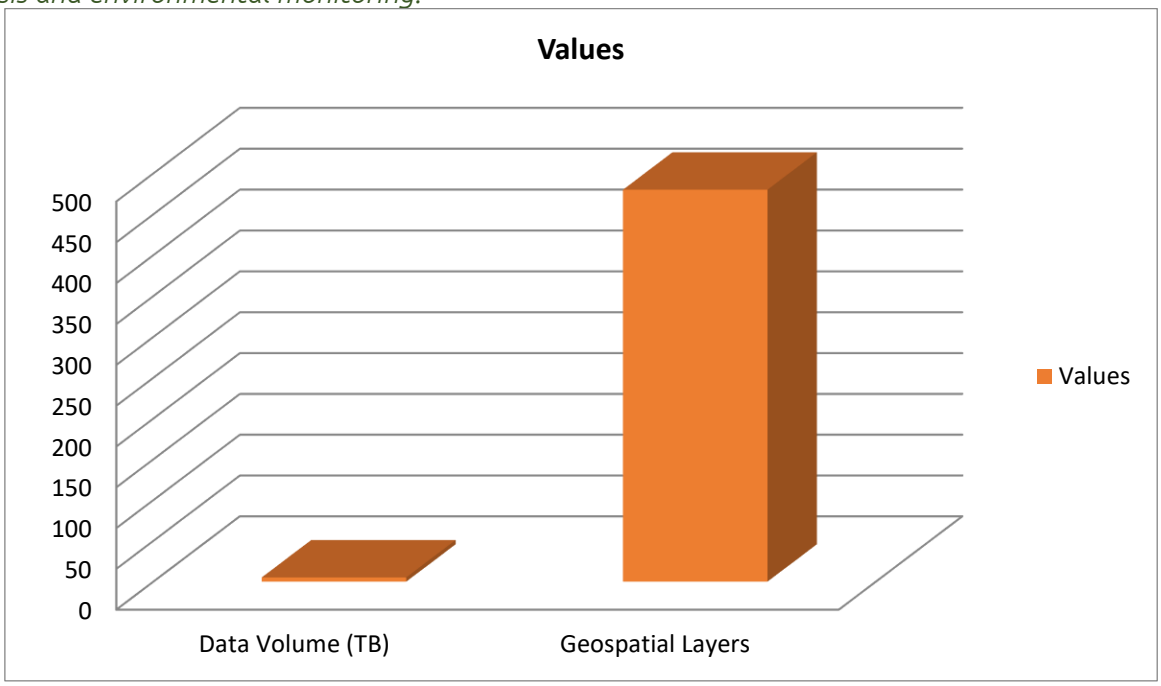

Figure 2. Digital Caspian Platform Data Overview

Efficiency and Operational Impact

The implementation of digital twin technology and AI-driven analytics has resulted in measurable improvements in exploration efficiency (Figure 3). Comparative analyses between AI-GIS workflows and traditional exploration approaches reveal a 32% reduction in overall exploration costs, primarily due to decreased field survey requirements and optimized sampling strategies.

Additionally, project preparation time was reduced by approximately 40%, attributed to the automation of spatial data preprocessing, model training, and visualization tasks. Decision-support modules, integrating optimization algorithms such as Particle Swarm Optimization and Genetic Algorithms, improved drilling target selection efficiency by 20% and overall team productivity by 25%.

These outcomes are consistent with similar digital twin implementations in other mining contexts, which report operational efficiency gains between 20-45%. By minimizing redundant fieldwork and

enabling virtual scenario testing, the Digital Caspian system supports cost-effective exploration planning while maintaining geological accuracy. This transformation exemplifies the transition from reactive to proactive exploration management, emphasizing predictive planning and data-driven decision-making.

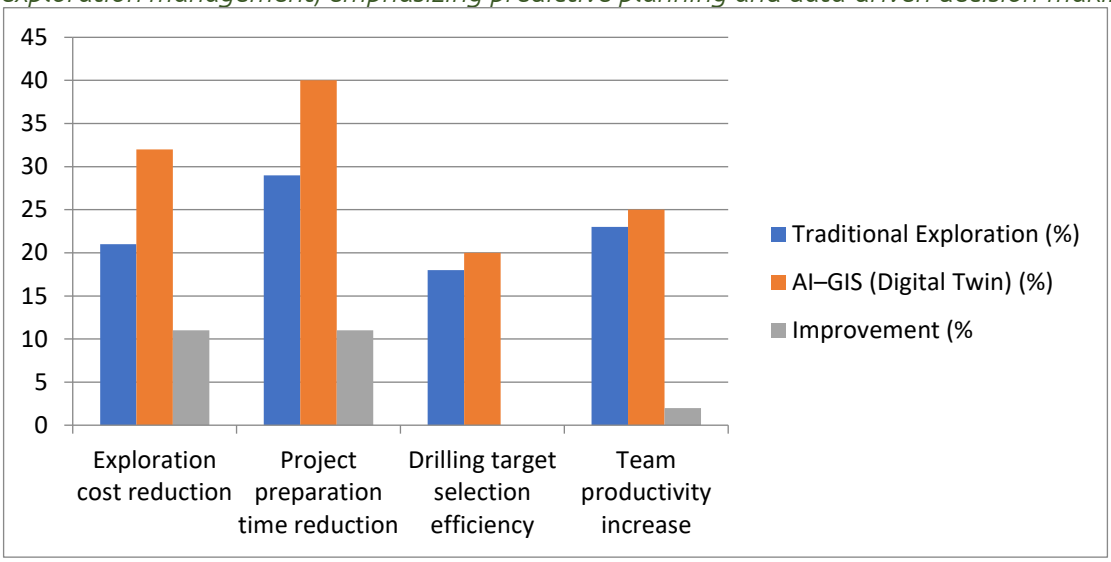

Figure 3. Comparison of Efficiency Metrics.

Figure 4 illustrates the workflow of AI-GIS digital twin integration in mineral exploration, emphasizing the stepwise digital transformation of traditional exploration processes. The workflow begins with data acquisition, which involves collecting multisource geological, geophysical, geochemical, and remote-sensing data. These datasets are then subjected to spatial preprocessing, where noise is reduced, data layers are standardized, and spatial alignment is optimized to ensure model compatibility.

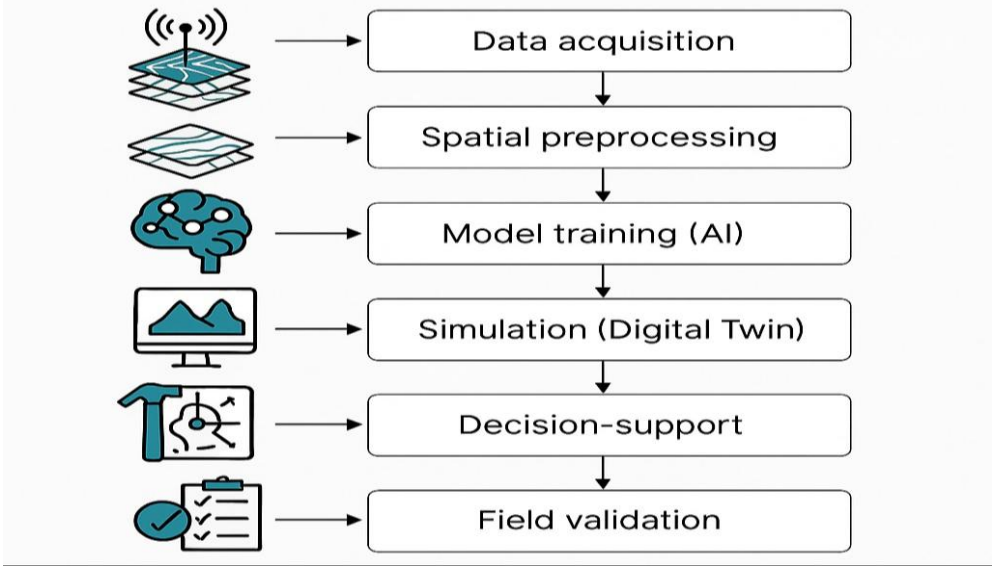

Figure 4. The workflow of AI-GIS digital twin integration in mineral exploration

In the model training phase, artificial intelligence algorithms such as convolutional neural networks, random forests, or gradient boosting are applied to learn spatial-geological relationships and predict mineralization probabilities. The trained model is then incorporated into a digital twin simulation, which serves as a dynamic virtual replica of geological systems. This stage enables real-time visualization, scenario testing, and prediction of subsurface processes without physical field intervention.

The decision-support stage integrates AI predictions with optimization algorithms (e.g., Genetic Algorithms or Particle Swarm Optimization) to identify optimal drilling targets, assess exploration risks, and allocate resources effectively. Finally, the field validation phase confirms model predictions through targeted field surveys, sampling, and drilling campaigns, creating a continuous feedback loop that refines both the digital twin and AI models.

Overall, this workflow demonstrates how the integration of AI, GIS, and digital twin technologies enhances the efficiency, accuracy, and sustainability of mineral exploration, transforming it from a reactive, manual process into a predictive, data-driven system.

Predictive Accuracy and Model Reliability

AI modules embedded within the Digital Caspian architecture exhibit robust predictive capabilities in both mineral potential mapping and environmental risk forecasting (Figure 4). Leveraging an ensemble learning framework-comprising convolutional neural networks (CNNs), random forest (RF) classifiers, and gradient boosting (GBM) algorithms-the system achieved predictive accuracies ranging from 86% to 93%, contingent upon the geological heterogeneity and data density of each subregion. This performance underscores the adaptability of the integrated AI architecture to variable geological contexts across the Caspian Basin.

Comprehensive model assessment using confusion matrices and receiver operating characteristic (ROC) analysis revealed an average area under the curve (AUC) of 0.91, denoting a strong discriminative ability between mineralized and non-mineralized zones. Moreover, precision and recall metrics consistently exceeded 0.88, suggesting that the ensemble models maintain a well-balanced trade-off between sensitivity and specificity, thereby minimizing both false-positive and false-negative classifications.

Beyond raw predictive performance, the incorporation of explainable AI (XAI) modules significantly enhanced model interpretability and transparency. The feature attribution analysis indicated that geophysical variables-specifically, conductivity and magnetic intensity-contributed approximately 34% to the overall predictive power. In parallel, geochemical anomalies in elements such as copper (Cu), arsenic (As), and iron (Fe) accounted for an additional 27%, highlighting the synergistic role of geophysical and geochemical datasets in delineating mineralization patterns.

These insights not only elucidate the internal reasoning of the AI models but also provide a scientifically grounded basis for expert validation and geological interpretation of the predicted targets. Consequently, the Digital Caspian's AI-driven analytical layer establishes a new benchmark for data-driven mineral exploration, enabling transparent, reproducible, and high-confidence decision-making across diverse exploration environments.

Implications for Sustainable Resource Management

Beyond enhancing exploration efficiency, the Digital Caspian platform makes a substantial contribution to sustainable resource governance through the integration of advanced environmental analytics and AI-driven decision support. The system's predictive models assess a suite of environmental risk indices-including soil and water contamination potential, vegetation disturbance probability, hydrological alteration risk, and land-use conflict likelihood-achieving an overall mean predictive accuracy of approximately 89%. These outputs are continuously refined through ensemble calibration and spatiotemporal validation, ensuring robust performance across heterogeneous environmental settings.

Through GIS-based spatial overlays and multi-criteria correlation analysis, the platform enables nuanced evaluation of the spatial interplay between mineral resource potential and ecological sensitivity zones. This capability allows policymakers and resource managers to delineate high-value, low-risk exploration corridors, prioritize low-impact extraction zones, and identify critical habitats or protected areas that require exclusion from industrial activity. In this way, the Digital Caspian system operationalizes the principle of balanced subsoil use licensing, transforming resource management from a reactive process into a data-driven, preventive governance framework.

The web-based architecture of the platform further enhances accessibility and inclusivity. By deploying a cloud-native geospatial infrastructure, it supports seamless interaction with over one million spatial and geochemical entities in real time, without dependence on proprietary software. Users can perform interactive visualizations, 3D terrain modeling, and automated scenario simulations, enabling cross-disciplinary collaboration between geologists, environmental scientists, engineers, and policy analysts. This democratization of access to complex data promotes a shared understanding of environmental and geological interdependencies across institutional boundaries.

Initial implementation feedback from regional geological surveys and environmental protection agencies underscores measurable operational gains: a 17% reduction in duplicated data processing workflows, a 23% decrease in interdepartmental reporting delays, and a marked increase in data interoperability between agencies. These improvements highlight the system's potential to serve as an integrative digital ecosystem-linking exploration, monitoring, and policy functions through a unified analytical interface.

At a broader scale, the AI–GIS convergence represented by the Digital Caspian project exemplifies how digital transformation can drive sustainable development in resource economies. By coupling predictive analytics with environmental accountability, the platform provides a replicable model for transparent governance of natural resources across emerging energy and mining sectors. Its alignment with the United Nations Sustainable Development Goals (SDGs)-notably SDG 9 (Industry, Innovation, and Infrastructure), SDG 12 (Responsible Consumption and Production), SDG 13 (Climate Action), and SDG 15

(Life on Land)-positions it as a strategic enabler of both economic resilience and environmental stewardship.

In summary, the Digital Caspian platform does not merely improve prediction accuracy or data access; it redefines the operational logic of the resource sector by integrating AI ethics, spatial transparency, and sustainability principles into every stage of the exploration-to-extraction cycle. This paradigm shift-from data collection to knowledge-driven governance-marks a decisive step toward the creation of a digitally intelligent, ecologically responsible Caspian region.

Benefits and challenges

AI-assisted GIS technologies have emerged as a transformative force in modern mineral exploration, offering substantial advantages over traditional heuristic and manual methods. By leveraging predictive modeling and data fusion techniques, these systems effectively narrow the exploration search space, enhance target precision, and reduce overall exploration expenditures through more efficient allocation of field resources. The integration of remote sensing, geophysical, and geochemical datasets within unified analytical frameworks enables the identification of subtle mineralization patterns and structural signatures that frequently elude conventional interpretation based solely on expert judgment or visual correlation [10].

Beyond improved detection, AI-driven approaches facilitate quantitative, reproducible assessments of mineral potential by minimizing subjective bias in interpretation. The synergy between spatial data analytics, ensemble learning algorithms, and geostatistical modeling creates a multidimensional understanding of mineral systems, allowing for more accurate delineation of ore-bearing zones. These advances contribute not only to enhanced discovery efficiency but also to more sustainable exploration practices by reducing unnecessary drilling and minimizing environmental disturbance.

Nevertheless, several methodological and operational challenges continue to constrain the full realization of AI's potential in geoscientific applications. The quality, representativeness, and accessibility of training datasets remain decisive determinants of model performance. Historical geological databases, while extensive, often exhibit sampling bias, inconsistent data resolution, and uneven spatial coverage, which can introduce systemic distortions into machine learning models and propagate errors across prediction layers. Moreover, the "black-box" nature of complex algorithms-particularly deep learning architectures-has raised legitimate concerns regarding model interpretability and transparency. This has, in turn, stimulated the development of explainable AI (XAI) methodologies designed to embed geological reasoning directly into the computational workflow, thereby bridging the gap between algorithmic precision and domain expertise [11].

Another central challenge concerns model generalizability-the ability of algorithms trained within one geological province or tectonic domain to perform reliably when transferred to others characterized by distinct lithological compositions, alteration signatures, or data distributions. Addressing this issue requires not only algorithmic innovation but also systematic cross-domain validation and adaptive learning techniques that allow models to recalibrate dynamically to local geological contexts.

To mitigate these limitations, collaborative digital ecosystems such as the Digital Caspian platform provide a promising framework. By fostering open data sharing, standardized model benchmarking, and iterative expert feedback, such platforms enable continuous algorithm refinement and the co-evolution of AI systems alongside human expertise. This participatory approach transforms AI from a purely computational tool into a collective intelligence system, capable of accelerating scientific discovery while maintaining geological credibility and interpretive transparency [12,13].

Conclusion

The integration of artificial intelligence (AI) and geographic information systems (GIS) is fundamentally redefining the paradigm of mineral exploration in the digital era. By harnessing the capabilities of machine learning algorithms, data fusion techniques, and digital twin technologies, researchers and practitioners can now generate high-resolution predictive maps, interpret multidimensional geophysical and geochemical datasets, and optimize drilling and sampling strategies with unprecedented accuracy and efficiency. Such technologies enable a dynamic, data-driven understanding of subsurface processes that extends beyond the limitations of traditional interpretive methods.

AI-driven GIS frameworks, exemplified by initiatives such as the Digital Caspian platform, demonstrate how the fusion of computational intelligence and spatial analytics can unify heterogeneous data sources, integrate real-time environmental monitoring, and support evidence-based decision-making in both exploration and resource governance. Through their modular architectures, these systems facilitate seamless interaction between predictive modeling, environmental assessment, and policy planning, laying the groundwork for transparent and adaptive management of subsoil resources.

However, realizing the full transformative potential of AI–GIS integration requires ongoing methodological and infrastructural innovation. Data quality, representativeness, and interoperability remain pivotal challenges, as biases embedded in historical or incomplete datasets can constrain model validity and reproducibility. Similarly, the limited interpretability of complex machine learning algorithms underscores the need for explainable AI (XAI) frameworks that embed geological reasoning and domain expertise directly into the analytical workflow. Addressing these issues is essential for building stakeholder trust and ensuring that AI-assisted exploration remains scientifically accountable and ethically sound.

Future research directions should therefore emphasize the co-development of interpretable, cross-domain predictive models, the systematic integration of expert geological knowledge into algorithmic design, and the expansion of collaborative digital infrastructures that promote open data exchange and shared model validation. These efforts will accelerate the evolution of AI–GIS ecosystems from experimental tools into institutionalized platforms for sustainable resource management.

Collectively, these advancements point toward the emergence of a sustainable, intelligent, and self-adaptive exploration workflow-one capable of balancing economic efficiency with environmental stewardship. In this vision, AI and GIS do not merely automate discovery; they transform mineral exploration into a transparent, collaborative, and sustainability-oriented discipline, setting a new standard for digital geoscience in the twenty-first century.

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Historical sciences

FROM THE HISTORY OF THE "JEWISH ANTI-FASCIST COMMITTEE"

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ებრაელთა ანტიფაშისტური კომიტეტის ისტორიიდან

ოთარ ნიკოლეიშვილი
ქუთაისის აკაკი წერეთლის სახელმწიფო უნივერსიტეტის ისტორია-არქეოლოგიის დეპარტამენტის ასოცირებული პროფესორი, ისტორიის აკადემიური დოქტორი; ტელ

Abstract

After the Soviet Union entered World War II, the authorities undertook extensive efforts to reinforce anti-fascist sentiments among the population, irrespective of ethnic affiliation. One such initiative was the establishment of the "Jewish Anti-Fascist Committee (JAC)", founded by Joseph Stalin on August 24, 1941. The organization was initially led by prominent members of the Jewish Socialist Party in Poland, Henryk Ehrlich and Viktor Alter.

From 1942, the chairmanship of the Committee was assumed by Solomon Mikhoels, the renowned actor of the Moscow State Jewish Theater. His tenure proved both dynamic and influential, while also marking a profoundly tragic chapter in the Committee's history. Between 1942 and 1948, the Committee published its own periodical, the newspaper "Unity", edited by Lev Kvitko and Shakhno Epstein. During this period, the Committee also maintained active contacts with Jewish organizations in Bulgaria, Poland, Czechoslovakia, France, and other countries.

The Committee further expanded its outreach by organizing Hebrew-language radio broadcasts four times a week for Jewish communities in the United States and Great Britain. In 1943, under the leadership of Mikhoels and Itzik Feffer, the Committee conducted a seven-month international tour that included the United States, Mexico, Canada, and Great Britain.

From late 1947, however, members of the Committee came under increasing persecution by the Soviet authorities, a campaign that intensified between 1948 and 1952. The Jewish Anti-Fascist Committee was officially dissolved on November 20, 1948.

მეორე მსოფლიო ომში საბჭოთა კავშირის ჩართვის შემდეგ, ქვეყნის ხელისუფლება ყველანაირად ცდილობდა მოსახლეობაში, განურჩევლად მისი ეთნიკური კუთვნილებისა, ანტიფაშისტური განწყობილების კიდევ უფრო გაძლიერებას. ერთ-ერთ ასეთ ნაბიჯს `ებრაელთა ანტიფაშისტური კომიტეტის "ჩამოყალიბებაც წარმოადგენდა.

ხშირ შემთხვევაში, „კომიტეტის" დაარსებაზე საუბარს მხოლოდ იმ დროიდან იწყებენ, როდესაც მას სათავეში რუსეთის ებრაული სახელმწიფო თეატრის ცნობილი მსახიობი სოლომონ მიხოელსი *(Solomon Mikhoels)* უდგება სათავეში, მის წინარე მოვლენებზე კი არაფერია ნათქვამი. სინამდვილეში, აღნიშნული ორგანიზაციის სათავეებთან პოლონეთში ებრაელთა სოციალისტური პარტიის *(General Jewish Labor Bund in Poland)* ცნობილი წევრები: ჰენრიკ ერლიხი *(Henryk Erlich)* და ვიკტორ ალტერი *(Wiktor Alter)* იდგნენ. აი, როგორ გადმოგვცემს „კომიტეტის" დაარსების ისტორიას დონალდ რეიფილდი *(Donald Rayfield) 2004* წელს ნიუ-იორკში გამოცემულ თავის წიგნში „სტალინი და მისი ჯალათები" *(Stalin and His Hangmen): 1939* წლის შემოდგომაზე, ჰენრიკ ერლიხისა და ვიკტორ ალტერის დაკავების შემდეგ, საბჭოთა კავშირის შინაგან საქმეთა სახალხო კომისარიატმა *(NKVD)* „მათ პოლონეთის სასარგებლოდ ჯაშუშობაში დასდო ბრალი და სიკვდილით დასჯა შეუფარდა, თუმცა, მოგვიანებით, აღნიშნული განაჩენი ათწლიანი პატიმრობით იქნა შეცვლილი" *(Rayfield, 2004: 381).*

ცოტა ხნის შემდეგ კი მათ საერთოდ გათავისუფლება შესთავაზეს, თუკი ისინი სტალინის მიერ *1941* წლის *24* აგვისტოს გამოცემული ბრძანებით შექმნილ ებრაელთა ანტიფაშისტურ

კომიტეტს ჩაუდგებოდნენ სათავეში. აღსანიშნავია ისიც, რომ სტალინს ხსენებული კომიტეტის „საერთაშორისო ორგანიზაციად ქცევა ჰქონდა ჩაფიქრებული" *(Brackman, 2001: 374).* დ. რეიფილდის ხაზგასმით, „სექტემბრის შუა რიცხვებში მათ უკვე გააჩნდათ ოფისი სასტუმრო მეტროპოლში და ახორციელებდნენ თავიანთ მუშაობას ბერიას მიერ მიჩენილი თანამშრომლის უშუალო მეთვალყურეობით. ბერიას ინიციატივით, ერლიხისათვის შეთავაზებულ იქნა პრეზიდენტობა, ალტერისთვის მდივნობა, მსოფლიოში ცნობილი ებრაელი მსახიობ სოლომონ მიხოელსისთვის კი ვიცე-პრეზიდენტობა" *(Rayfield, 2004: 381).*

ის, რომ აღნიშნული „კომიტეტის" ჩამოყალიბება საბჭოთა ხელისუფლებას მხოლოდ თავისი მიზნების გამოსაყენებლად სჭირდებოდა, ხოლო ებრაელთა ინტერესების დაცვა–გათვალისწინება არც კი უფიქრია, არაერთხელ გამოჩნდა ამ ორგანიზაციის არსებობის პერიოდში. უფრო მეტიც, ხელისუფლებასთან თუნდაც ერთი შეუთანხმებელი ნაბიჯის გადადგმაც კი „კომიტეტის" ნებისმიერ წევრს სიცოცხლის ფასად უჯდებოდა. მაგალითად, სწორედ ასე დაემართათ ალტერს, როდესაც მან ინიციატივა გამოიჩინა და დაუკავშირდა მოსკოვში პოლონეთის ელჩს – სტანისლავ კოტს, რომელსაც შესთავაზა პოლონელი ებრაელების ლეგიონის შექმნა და საბჭოთა ჯარის მხარდამხარ საბრძოლველად ანდერსის არმიასთან ამ ლეგიონის შეერთება *(Brackman, 2001: 374).*

მიუხედავად იმისა, რომ არცერთი ამგვარი ქმედება საბჭოთა სახელმწიფოსთვის ხიფათისა და რისკის შემცველი არ იყო, ბერიას მიერ ალტერი უმკაცრესად იქნა დასჯილი. ეს იმის მიუხედავად, რომ სოციალისტური მოძრაობის ცნობილმა ლიდერებმა: „ელეონორა რუზველტმა და ალბერტ აინშტაინმა პირადად, *1941* წლის *4* დეკემბერს, წერილობით მიმართეს სტალინს კუიბიშევში დაპატიმრებული ერლიხისა და ალტერის გათავისუფლების თხოვნით" *(Steinberg, 1971: 424-425).*

აღნიშნული მოწოდების მიუხედავად, ორივე მათგანს „ღალატის მუხლი შეეფარდა და *1941* წლის *23* დეკემბერს ისინი დახვრეტილ იქნენ... სერგეი ოგოლცოვი, შინაგან საქმეთა სახალხო კომისარიატის ხელმძღვანელი მთავრობის კუიბიშევში ყოფნის პერიოდში, პირადად ხელმძღვანელობდა დასჯის პროცესს..." *(Rayfield, 2004: 382).* საინტერესო ფაქტია ისიც, რომ უკვე საბჭოთა კავშირის დაშლის შემდგომ, რუსეთის პრეზიდენტმა ბორის ელცინმა, *1991* წლის *8* თებერვლის დეკრეტით, უკანონოდ სცნო ერლიხისა და ალტერის სიკვდილით დასჯის ფაქტი და მოახდინა მათი რეაბილიტაცია.

სწორედ, ერლიხისა და ალტერის სიკვდილით დასჯის შემდეგ, *1942* წლიდან, ხდება სოლომონ მიხოელსი პრეზიდენტი ზემოთ ხსენებული „კომიტეტისა," რომელიც ამავე დროიდან მოსკოვში გადადის კუიბიშევიდან. ს. მიხოელსის მმართველობის პერიოდი ძალზე მრავალფეროვანი, საინტერესო და ამავდროულად უაღესად ტრაგიკული აღმოჩნდა ორგანიზაციისათვის. ამ თვალსაზრისით განსაკუთრებით საინტერესოა ის ფაქტი, რომ *1942* წლის *7* აპრილს „კომიტეტი" „აქვეყნებს თავის პირველ მიმართვას „მსოფლიოს ებრაელებისადმი", რომელსაც ხელს აწერდა *47* ადამიანი, მათ შორის მწერლები, მსახიობები, ექიმები და გერმანელებთან ომში სახელმოხვეჭილი ებრაელი ჯარისკაცები" *(6).* აღნიშნული მიმართვის უმთავრეს სულისკვეთებას, როგორც ეს წყაროებითაც ნათლად დასტურდება, საბჭოთა ჯარისთვის დახმარების გაწევა წარმოადგენდა. ძალზე ნიშანდობლივია ისიც, რომ ზემოთქმული მიმართვა მხოლოდ ერთჯერად ხასიათს არ ატარებდა და აღნიშნული ტიპის მეორე შეკრება იმავე წლის *24* მაისსაც იქნა გამართული. მესამე ფორუმს კი, რომელიც *1944* წლის აპრილში შედგა, თავად მოსკოვის რაბი სოლომონ შლიფერიც ესწრებოდა. „კომიტეტს" ასევე ურთიერთობა ჰქონდა სხვადასხვა ქვეყნის მსგავსი ტიპის ებრაულ გაერთიანებებთანაც. მაგალითად, ბულგარეთთან, პოლონეთთან, ჩეხოსლოვაკიასთან, საფრანგეთთან და ა. შ.

1942 წლიდან „კომიტეტი" ასევე იწყებს თავისი პერიოდული ორგანოს, გაზეთ „ერთობის" *(ებრაულად „Eynikayt")* გამოშვებას, რომლის რედაქტორებიც იყვნენ, ცნობილი ებრაელი პოეტი ლევ კვიტო *(1890-1952* წწ.) და ჟურნალისტი და ორგანიზაციის მდივანი შახნო ეფშტეინი. გაზეთის პირველი ნომერი გამოცემულ იქნა *1942* წლის *7* ივნისს *(ზოგიერთი წყაროს (9)* მიხედვით კი *6* ივლისს) კუიბიშევში. იგი თავდაპირველად თვეში სამჯერ გამოდიოდა, *1945* წლის თებერვლიდან კი კვირაში სამჯერ. გაზეთის უკანასკნელი ნომერი გამოცემულ იქნა *1948*

წლის *20* ნოემბერს, ანუ ზუსტად მაშინ, როდესაც „კომიტეტმა“ ოფიციალურად შეწყვიტა არებობა.

ორგანიზაციის ეფექტურ მუშაობაზე მიუთითებს ის ფაქტიც, რომ „კომიტეტმა“ შეძლო რადიოგადაცემების ორგანიზებაც ებრაულ ენაზე, კვირაში ოთხჯერ – ამერიკასა და დიდ ბრიტანეთში მცხოვრები ებრაელებისათვის. ორგანიზაცია ასევე აგროვებდა ინფორმაციებს ნაცისტების მიერ ოკუპირებულ საბჭოთა ტერიტორიებზე ჩადენილ საშინელებათა შესახებ და აქვეყნებდა მათ როგორც „ერთობაში“, ასევე საბჭოთა კავშირის გარეთ გამომავალ სხვა ებრაულ გაზეთებში“. უაღრესად საინტერესო ფაქტს წარმოადგენს ასევე ისიც რომ, // მსოფლიო ომში გერმანიის დამარცხების შემდგეგ „კომიტეტს“ „განზრახული ჰქონდა ორი წიგნის გამოცემა, რომელთაგანაც „შავი წიგნი“ ნაცისტების მიერ ჩადენილ საშინელებათა შესახებ იქნებოდა, „წითელი წიგნი“ კი ებრაელთა გმირული ბრძოლის თაობაზე ფაშისტების წინააღმდეგ. თუმცა ორივე მათგანის გამოცემა გაურკვეველ მიზეზთა გამო აიკრძალა“ *(9)*.

ვფიქრობ, ზემოხსენებულ წიგნთა გამოცემის შეჩერებას სავსებით მკაფიო მიზეზები გააჩნდა, რაშიც არაფერი იყო მოულოდნელი. საქმე იმაშია, რომ // მსოფლიო ომის საწყის ეტაპზე, კერძოდ კი *1941* წლამდე, როდესაც გერმანია საბჭოთა კავშირს დაესხა თავს, ეს უკანასკნელი არათუ მის წინააღმდეგ არ გამოდიოდა, არამედ ხშირ შემთხვევაში ეხმარებოდა კიდეც მას. რაც შეეხება ე. წ. „წითელ წიგნს“, ვფიქრობ, არც მისი გამოცემა შედიოდა საბჭოთა ხელისუფლების ინტერესებში, რადგან მასში კონკრეტულად ებრაელი ხალხის როლი იქნებოდა წინა პლანზე წამოწეული გერმანელების წინააღმდეგ ბრძოლაში და არა ზოგადად „საბჭოთა მოქალაქე“.

ის, რომ „კომიტეტი“ საკმაოდ ანგარიშგასაწევ და მნიშვნელოვან ძალას წარმოადგენდა, უმთავრესად იმ ღვაწლმოსილ პიროვნებათა დამსახურება იყო, რომლებიც მისი ნამდვილი წევრები გახლდნენ. მეტი დამაჯერებლობისთვის, ჩამოვთვლი რამდენიმე მათგანს: იციკ ფეფერი *(1900-1952 წწ.)* – ცნობილი ებრაელი პოეტი; ილია ერენბურგი *(1891-1967 წწ.)* – ცნობილი ებრაელი მწერალი, ჟურნალისტი და საერთაშორისო მშვიდობის აქტივისტი; იოსებ იუზეფოვიჩი *(1890-1952 წწ.)* – ისტორიკოსი, საბჭოთა კავშირის მეცნიერებათა აკადემიის აკადემიკოსი, პროფკავშირების ლიდერი; ლინა შტერნი *(1878-1968 წწ.)* – ბიოქიმიკოსი, პირველი აკადემიკოსი ქალი საბჭოთა კავშირში; ბენჯამინ ზუსკინი *(1899-1952 წწ.)* – მსახიობი, რუსეთის ებრაული სახელმწიფო თეატრის დირექტორი; შლომო შლიფერი *(1889-1957 წწ.)* – მოსკოვის მთავარი რაბი *1943-1957* წლებში და მრავალი სხვა. *1946* წლისათვის „კომიტეტის“ წევრთა რიცხვმა *70* მიაღწია, რომელთაგანაც *19* აღმასკომის შემადგენლობაში შედიოდა.

აქვე, ობიექტურობისთვის, ისიც აუცილებლად უნდა აღინიშნოს, რომ გარდა ზემოთქმული პიროვნებებისა, „კომიტეტში“ ასევე მრავლად იყვნენ საბჭოთა ხელისუფლების მიერ დანიშნული, ან შეგზავნილი ადამიანებიც, რომელთა პირდაპირ მოვალეობასაც ორგანიზაციის საქმიანობის ყველა დეტალის შესწავლა და გაკონტროლება წარმოადგენდა. ასეთებად კი უპირველეს ყოვლისა უნდა დავასახელოთ: სოლომონ ლოზოვსკი *(1878-1952 წწ.)* – საბჭოთა კავშირის საგარეო საქმეთა მინისტრის მოადგილე და სოვინფორმბიუროს *(არსებობდა 1941–1961 წლებში)* ხელმძღვანელი; სოლომონ ბრეგმანი *(1895-1953 წწ.)* – საბჭოთა კავშირის სახელმწიფო კონტროლის მინისტრის მოადგილე; აარონ კაცი *(1901-1971 წწ.)* – საბჭოთა არმიისა და სტალინის სახელობის სამხედრო აკადემიის გენერალ-მაიორი და ბორის შიმელიოვიჩი *(1892-1952 წწ.)* – მთავარი ქირურგი წითელ არმიაში, ბოტკინის სახელობის ჰოსპიტლის დირექტორი.

მიუხედავად სახელმწიფოს მხრიდან ამგვარი კონტროლის განხორციელებისა, „კომიტეტის“ ქმედითუნარიანობასა და მოხერხებაზე მიუთითებს ის ფაქტიც, რომ *1943* წელს, ს. მიხოელსისა და ი. ფეფერის მეთაურობით, განხორციელდა შვიდთვიანი ტურნე დასავლეთის ქვეყნებში, კერძოდ, აშშ-ში, მექსიკაში, კანადასა და დიდ ბრიტანეთში. აღნიშნული ვიზიტების მთავარ დანიშნულებას წარმოადგენდა საბჭოთა იდეოლოგიის პროპაგანდის უცხოეთში წარმოება. აშშ-ში ისინი დიდი პატივით იქნენ მიღებულნი ალბერტ აინშტაინისა და მწერალ ბენ-ციონ გოლდბერგის *(Ben-Zion Goldberg)* მიერ.

საბჭოეთის მხარდამჭერი ყველაზე მასშტაბური აქცია იქნა გამართული აშშ-ში *8* ივლისს, რომელშიც *50* ათასამდე ადამიანმა მიიღო მონაწილეობა. აღნიშნული ვიზიტი მნიშვნელოვანი იყო იმითაც, რომ იგი, ფაქტობრივად, წარმოადგენდა პირველ მცდელობას საბჭოთა კავშირსა და

დანარჩენ მსოფლიოში მცხოვრებ ებრაელებს შორის ურთიერთობის განახლებისას, რაც *1917* წლის ოქტომბრის რევოლუციის შემდგომ იქნა შეწყვეტილი. აღსანიშნავია, რომ „ბენ-ციონ გოლდბერგი, თავადაც რამდენჯერმე *(1945, 1946* და *1959* წლებში) იმყოფებოდა საბჭოთა კავშირში“. საინტერესოა ისიც, რომ „იგი გახდა პირველი ამერიკელი ებრაელი მწერალი, რომელიც II მსოფლიო ომის შემდგომ ეწვია საბჭოთა კავშირს“ *(9)*.

მიუხედავად იმისა, რომ „კომიტეტის“ მიერ განხორციელებული ყველა ზემოხსენებული ღონისძიება საბჭოთა იდეოლოგიის პროპაგანდას ემსახურებოდა, ხელისუფლება ხსენებული ორგანიზაციის საქმიანობას მაინც ეჭვის თვალით უყურებდა და მას საფრთხის შემცველად მიიჩნევდა. აღნიშნულის დასტურად, დავიმოწმებ მოხსენებით ბარათს, გაგზავნილს *1946* წლის *21* ივნისს, კომუნისტური პარტიის ცენტრალური კომიტეტის საერთაშორისო პოლიტიკის დეპარტამენტის დირექტორ მიხეილ სუსლოვისადმი. აღნიშნულ წერილში, რომელსაც „კომიტეტის“ პრეზიდენტი ს. მიხოელსი და აღმასკომის წევრი ი. ფეფერი აწერენ ხელს, დეტალურად არის საუბარი ორგანიზაციის მიერ განხორციელებულ ღონისძიებებზე. ხსენებული დოკუმენტით კიდევ ერთელ ვრწმუნდებით იმაში, თუ რაოდენ აქტიურ და ქმედით ორგანიზაციას წარმოადგენდა „კომიტეტი“ მისი არსებობის არცთუ ისე დიდი ხნის განმავლობაში. მეტი დამაჯერებლობისთვის მოვიყვან შესაბამის ადგილებს წერილიდან:

„ბოლო ორი წლის განმავლობაში კომიტეტს არაერთი წარმომადგენელი ეწვია მსოფლიოს სხვადასხვა ქვეყნის ებრაელთა ანტიფაშისტური ორგანიზაციებიდან. მაგალითად, ბულგარეთის ებრაელთა ანტიფაშისტური კომიტეტის თავმჯდომარის მოადგილე ბ-ნი ჟაკ ვრადჟალი, ჩეხოსლოვაკიის ებრაელთა კავშირის ერთ-ერთი ლიდერი ბ-ნი როზენბერგი, წარმომადგენლები საფრანგეთისა და პოლონეთის ებრაელთა ორგანიზაციებიდან და სხვ.

ახლახან, ბატონი ბენ-ციონ გოლდბერგი ესტუმრა საბჭოთა კავშირს. იგი ძალზე ცნობილი საზოგადო მოღვაწეა შეერთებულ შტატებში. ის გახლავთ საბჭოთა კავშირისა და ამერიკის მეგობრობის საზოგადოების *(რომელსაც ხელმძღვანელობს ლამონტი)* აღმასრულებელი კომიტეტის წევრი... ბატონი გოლდბერგი საბჭოთა კავშირში იმყოფებოდა *11* იანვრიდან *8* ივნისამდე, თუმცა ერთი თვის განმავლობაში მან დატოვა ქვეყანა და იმოგზაურა ფინეთში, შვედეთსა და დანიაში...

საბჭოთა კავშირშიმისი ყოფნის დროს ბატონი გოლდბერგი მიიღეს მიხეილ კალინინმა და მიხეილ სუსლოვმა; ბატონი გოლდბერგი დაესწრო საბჭოთა კავშირის უმაღლესი საბჭოს ყველა სხდომას, ასევე მთელ რიგ შეხვედრებს საბჭოთა მწერლებთან *(მწერალთა კავშირში გამართული ბანკეტის ჩათვლით)*, საბჭოეთში მცხოვრებ ებრაელთა თემების წარმომადგენლებთან *(საბჭოთა კავშირის ებრაელთა ანტიფაშისტური კომიტეტის შტაბ-ბინაში)*, ებრაული სახელმწიფო თეატრის ხელმძღვანელ პირებთან, მოსკოვის მთავარ რაბ შლიფერთან და წითელი ჯვრის ხელმძღვანელებთან...

საბჭოთა კავშირში მისი ყოფნის დროს ბატონმა გოლდბერგმა საბჭოეთის საინფორმაციო ბიუროს გავლით ამერიკული, კანადური, პალესტინური, პოლონური და ებრაული გაზეთებისთვის გააგზავნა *33* სტატია. ყველა მათგანი უკიდურესად მეგობრული ხასიათისა იყო საბჭოთა კავშირის მიმართ.

ახლახანს კომიტეტმა მიიღო რამდენიმე მნიშვნელოვანი მიწვევა... მათ შორის, ებრაელთა მსოფლიო კონგრესის აღმასრულებელი კომიტეტის თავმჯდომარის ნ. გოლდმანისგან *(საუბარია ნაჰუმ გოლდმანზე (Nahum Goldmann)*, ზემოთქმული ორგანიზაციის პრეზიდენტზე *1948-1977* წლებში – ო. ნ.*)*, ამერიკელ ებრაელთა კონგრესის თავმჯდომარე სტივენ ვაიზისგან *(Stephen Wise)* და ასე შემდეგ...

საბჭოთა კავშირის ებრაელთა ანტიფაშისტურმა კომიტეტმა, მთელი თავისი არსებობის განმავლობაში, ერთი დელეგაცია გააგზავნა ამერიკაში, ინგლისში, კანადასა და მექსიკაში, ორი კაცის – ამხანაგების: მიხოელსისა და ფეფერის შემადგენლობით. დელეგაციის მოგზაურობის შესახებ დაწვრილებით იქნება მოთხრობილი წიგნში „ებრაელი ხალხი ფაშიზმის წინააღმდეგ“ *(6)*.

საბჭოთა იდეოლოგიის პროპაგანდის საწარმოებლად „კომიტეტის“ ძალზე აქტიურმა მოღვაწეობამ და ამ საქმეში ებრაელთა როლის წინა პლანზე წამოწევის მცდელობამ საბჭოთა ხელისუფლებაში არაადექვატური რეაქცია გამოიწვია. ებრაელთა დევნა-შევიწროება, რომელიც II

მსოფლიო ომის მიწურულს დაიწყო, ომის დასრულების შემდგომ რეპრესიებში გადაიზარდა. აღნიშნული პოლიტიკის მთელი სიმძიმე კი უმეტესწილად სწორედ „კომიტეტის“ წევრებზე იქნა გადატანილი. იმის ნათელსაყოფად, თუ როგორ თანდათან იწყებოდა ანტისემიტური განწყობა საბჭოთა კავშირში, დავიმოწმებ დ. რეიფილდის ზემოხსენებულ წიგნს:

„სოლომონ მიხოელსისა და მისი თანამებრძოლის, მწერალ შახნო ეფშტეინის მოღვაწეობის დროს ებრაელთა ანტიფაშისტურ კომიტეტში, როგორც საბჭოთა კავშირში, ისე მის საზღვრებს გარეთ, ძალზე მწვავედ დადგა ანტისემიტიზმის პრობლემა. საბჭოთა გერმანოფობია ქსენოფობიაში გადაიზარდა, პატრიოტიზმი კი ვიწრო რუსულ შოვინიზმში...

სტატისტიკა... არ ტოვებს არანაირ ეჭვს სტალინის მიერ წარმოებული დისკრიმინაციის შესახებ ებრაელების მიმართ. *1945* წელს ებრაელებს ეკავათ დაახლოებით თორმეტი პროცენტი წამყვანი ბიუროკრატიული თანამდებობებისა ეკონომიკაში, მასმედიასა და განათლებაში, *1951* წლის ბოლოსთვის კი – ოთხ პროცენტზე ნაკლები. *1950* წლისათვის უმაღლესი საბჭოს *1100* დელეგატიდან მხოლოდ რვა იყო ებრაელი; *1951* წლის ბოლოსთვის კი პარტიის ათასი მდივნიდან მხოლოდ ერთიღა იყო დარჩენილი“ *(Rayfield, 2004: 437).*

ებრაელთა დევნა-შევიწროება მათი თანამდებობებზე დანიშვნის შეზღუდვით არ შემოფარგლულა და მან განსაკუთრებით სასტიკი ხასიათი *1940*-იანი წლების მიწურულს მიიღო. საყურადღებოა ის ფაქტიც, რომ აღნიშნულ რეპრესიებს არა მხოლოდ რიგითი ებრაელი მოქალაქეები და „კომიტეტის“ წევრები შეეწირნენ, არამედ ცნობილ საბჭოთა მაღალჩინოსანთა ოჯახის წევრებიც. მაგალითისათვის, შეგვიძლია *1930-1941* წლებში საბჭოთა კავშირის საგარეო საქმეთა სახალხო კომისრის – ვიაჩესლავ მოლოტოვის მეუღლე პოლინა ჟემჩუჟინაც დავასახელოთ, რომელიც რეპრესიული მანქანის მიერ უმკაცრესად იქნა დასჯილი. ეს კი შემდეგნაირად მოხდა: *1948* წლის სექტემბერში, როდესაც საბჭოთა კავშირში ისრაელის პირველი ელჩი გოლდა მეირი (დიპლომატიურ მისიას იგი *1948* წლის *2* სექტემბრიდან *1949* წლის მარტის თვის ბოლომდე ასრულებდა) ჩავიდა, თარჯიმნის როლს ებრაულ და საბჭოთა დელეგაციებს შორის კი, პოლინა ჟემჩუჟინა ასრულებდა. სწორედ მისმა ერთმა ფრაზამ, „მე ებრაელი ქალიშვილი ვარ“, მიმართულს გოლდა მეირისადმი, გადაწყვიტა მისი ბედი. ცოტა ხნის შემდეგ იგი დააპატიმრეს და ხუთი წლით შრომაგასწორებით ბანაკში ყოფნა მიუსაჯეს. „სტალინის მოთხოვნით, მობოდიშების მიუხედავად, მოლოტოვი იძულებული გახდა პოლინა ჟემჩუჟინასთან განქორწინებას დათანხმებოდა, ხოლო საგარეო საქმეთა მინისტრის პოსტი კი, ანდრეი ვიშინსკისთვის (აღნიშნულ თანამდებობაზე იმყოფებოდა *1949–1953* წლებში – ო. ნ.) დაეთმო“ *(Rayfield, 2004: 439–440).* პოლინა ჟემჩუჟინას რეაბილიტაცია და საკუთარ ოჯახთან დაბრუნება კი, მხოლოდ *1953* წლის მარტში, სტალინის გარდაცვალების შემდეგ მოხდა.

როგორც ცნობილია, *II* მსოფლიო ომის შემდგომ სტალინი ებრაული სახელმწიფოს აღდგენის ერთ-ერთი აქტიური მხარდამჭერი გახდა. უფრო მეტიც, *1948* წლის *18* მაისს „შეერთებულმა შტატებმა და საბჭოთა კავშირმა გაეროს მიერ დამოუკიდებელ ქვეყნად ცნობილი ისრაელი სულ რამდენიმე საათში აღიარეს“ *(Rayfield, 2004: 439).* დ. რეიფილდის აზრით, სტალინის მსგავსი პოზიცია იმით იყო განპირობებული, რომ „ისრაელის დამფუძნებელ მამათაგან ბევრი ან რუსეთის იმპერიაში იყო დაბადებული, ანდა სოციალისტურ და კომუნისტურ მოძრაობათა წევრებს წარმოადგენდნენ“. სწორედ ხსენებულ პიროვნებებზე ზემოქმედებით ცდილობდა ახლადშექმნილი სახელმწიფოს მის ორბიტაში მოქცევას სტალინი. ამ იმედის გაცრუებამ კი სტალინის რისხვა გამოიწვია, რაც საბოლოოდ „კომიტეტის“ დაშლითა და მის წევრებზე განხორციელებული უმკაცრესი რეპრესიებით დასრულდა.

ორგანიზაციის წევრების დევნა–შევიწროება საბჭოთა ხელისუფლების მხრიდან, ჯერ კიდევ *1947* წლის მიწურულს დაიწყო, როდესაც „*28* დეკემბერს საბჭოთა კავშირის მეცნიერებათა აკადემიის მსოფლიო ლიტერატურის ინსტიტუტის უფროსი მეცნიერ–თანამშრომელი ზაქარია გრინბერგი *(1887–1949)*“ იქნა დაპატიმრებული *(5).* პირველი მსხვერპლი კი რეპრესიული მანქანისა „კომიტეტიდან“ თავად ორგანიზაციის პრეზიდენტი აღმოჩნდა.

ძალზე საყურადღებოა, რომ, როგორც ერლიხისა და ალტერის შემთხვევაში, ს. მიხოელსის დახვრეტის ბრძანებაც თავად სტალინმა გასცა, ამჯერად არაპირდაპირი გზით, მოაწყო რა, მისი სიკვდილის შემთხვევითობის ინსცენირება. აღნიშნულის სიტუაციის გათამაშება კი, ჩემი აზრით,

სტალინს იმისთვის დასჭირდა, რომ განსხვავებით *1941* წლის დეკემბრისაგან, როდესაც „კომიტეტი" არსებობის მხოლოდ რამდენიმე თვეს ითვლიდა, *1948* წლისათვის, თავისი საქმიანობიდან გამომდინარე, ორგანიზაცია უკვე საკმაოდ დიდი ავტორიტეტით სარგებლობდა. შესაბამისად, სტალინი მოერიდა საზოგადოებაში მღელვარების გამოწვევას, რასაც შედეგად ს. მიხოელსის გმირად ქცევა შეიძლებოდა მოჰყოლოდა. იმისათვის, რომ მეტი წარმოდგენა შეგვექმნეს აღნიშნული მკვლელობის დაგეგმვისა და განხორციელების დეტალებზე, დავიმოწმებ ფრაგმენტს დ. რეიფილდის ზემოხსენებული წიგნიდან:

„ერლიხისა და ალტერის მსგავსად, ებრაელთა ანტიფაშისტური კომიტეტის ხელმძღვანელებმა *1941* წელს ძალზე ბევრი რამ გაბედეს. სტალინმა გამოსავლის ძიების დროს უპირატესობა საბჭოთა ებრაელობის მკვლელობას მიანიჭა. კომიტეტის პრეზიდენტის – სოლომონ მიხოელსის დაპატიმრების შემთხვევაში, იგი გახდებოდა წამებული, ამდენად სტალინმა მისი მოკვლა გადაწყვიტა... ვიქტორ აბაკუმოვმა (საბჭოთა კავშირის სახელმწიფო უშიშროების მინისტრი *1946-1951* წლებში – ო. ნ.) მოიფიქრა სცენარი: სვეტლანას (საუბარია, სტალინის ქალიშვილ სვეტლანა ალილუევაზე *(1926-2011)* – ო. ნ.) პირველი ქმრის (გრიგორი მოროზოვის – ო. ნ.) მეგობარს ი. ი. გოლდშტეინს (იგულისხმება, საბჭოთა კავშირის მეცნიერებათა აკადემიის ეკონომიკის ინსტიტუტის უფროსი მეცნიერ-თანამშრომელი ისააკ იოსების ძე გოლდშტეინი – ო. ნ.) წამების შედეგად ათქმევინეს, რომ სოლომონ მიხოელსი სტალინის ოჯახის შესახებ ინფორმაციას აწვდიდა ამერიკელებს. აბაკუმოვს დაევალა მიხოელსის ლიკვიდაცია... *(1948* წლის *12* იანვარს – ო. ნ.) მიხოელსი, მის მეგობარ (თეატრალურ კრიტიკოს – ო. ნ.) ვლადიმირ გოლუბოვ–პოტაპოვთან ერთად, რომელიც თავის მხრივ მგბ–თვის (სახელმწიფო უშიშროების სამინისტრო – ო. ნ.) მუშაობდა, გაემგზავრა მინსკში. სამმა მთავარმა ჯალათმა: აბაკუმოვის მოადგილე სერგეი ოგოლცოვმა, კონტრდაზვერვის თანამშრომელმა შუბნიაკოვმა და ბერიას ახლო მეგობარმა, ბელორუსიის სახელმწიფო უშიშროების სამინისტროს ხელმძღვანელმა ლავრენტი ცანავამ მკვლელობა *13* იანვარს დაგეგმეს. გოლუბოვ–პოტაპოვს მიხოელსის სასტუმროს ნომრიდან გამოყვანა დაევალა. შემდეგ ორივე მათგანი მანქანაში ჩასვეს და ცანავას აგარაკზე წაიყვანეს", სადაც ისინი მოკლულ იქნენ. შემდეგ კი მათი გვამები გზაზე დააგდეს, რათა აღნიშნული ვანდალური ფაქტი ავტოავარიისათვის დაებრალებინათ. ცინიზმის უდიდეს გამოვლინებას წარმოადგენდა ისიც, რომ „მკვლელებიც და მსხვერპლნიც ორთავენი პატივმიგებულნი იქნენ: ცანავა, შუბნიაკოვი და მგბ–ს მძღოლი მედლებით დააჯილდოეს; მიხოელსის შესახებ ნეკროლოგი კი პრავდაში იქნა დაბეჭდილი". საინტერესო ფაქტია ისიც, რომ მიხოელსის გარდაცვალების შესახებ მწუხარება გამოთქვეს და „სამძიმრის წერილი გამოაგზავნეს ალბერტ აინშტაინმა და მარკ ჩაგალმა" *(Rayfield, 2004: 440–441).*

აღნიშნული შემზარავი ფაქტიდან რამდენიმე თვეში, კერძოდ, *1948* წლის *20* ნოემბერს, კი „კომიტეტი" ოფიციალურად წყვეტს არსებობას. თუმცა ამით მის წევრებზე ძალადობა სულაც არ დასრულებულა. პირიქით, *1948–1952* წლებში ამგვარმა ძალადობამ მასობრივი ხასიათი მიიღო. აღსანიშნავია, რომ რეპრესიები შეეხო არა მხოლოდ „კომიტეტის" წევრებს, არამედ ებრაული წარმომავლობის ყველა წარჩინებულ წარმომადგენელს. მთლიანობაში, *1948–1952* წლებში, „შპიონაჟისა და ანტისაბჭოთა პროპაგანდის ბრალდებით დაპატიმრებულ იქნა ებრაელი ეროვნების ყველა პარტიული მუშაკი, სწავლული, მწერალი, პოეტი, ჟურნალისტი, მსახიობი... სულ *110* ადამიანი" *(5).*

აღნიშნულ პროცესს წინ უძღოდა ებრაულ კულტურულ, საგანმანათლებლო, თუ სამეცნიერო ცენტრებზე შეტევა. მაგალითად, ამავე წლებში საბჭოთა ხელისუფლების მიერ დახურულ იქნა: „კომიტეტის" პერიოდული ორგანო „ერთობა", ებრაული გამომცემლობა „დერ ემესი" („სიმართლე"), ებრაელ მწერალთა გაერთიანებები მოსკოვში, კიევსა და მინსკში, ებრაული კულტურის კაბინეტი უკრაინის სსრ მეცნიერებათა აკადემიაში, ალმანახები: „გეიმლანდი" („სამშობლო") მოსკოვში და „დერ შტერნი" („ვარსკვლავი") კიევში" და სხვ. *(5).*

ზემოთ აღნიშნული რეპრესიების შემდგომ, სსრკ–ის სახელმწიფო უშიშროების სამინისტროს მიერ გაცემულ იქნა ორდერი *# 480* ორგანიზაციის წევრთა დაკავების შესახებ. *1952* წლის *8* აპრილს კი იწყება სასამართლო პროცესი, რომელის წინაშეც „კომიტეტის" *15* წევრი წარსდგა. ესენი იყვნენ: სოლომონ ლოზოვსკი, იციკ ფეფერი, სოლომონ ბრეგმანი, იოსებ

იუზეფოვიჩი, ბორის შიმელიოვიჩი, ლევ კვიტო, პერეც მარკიში, დავით ბერგელსონი, დავით გოფშტეინი, ბენჯამინ ზუსკინი, ლინა შტერნი, ლეონ ტალმი, ილია ვატენბერგი, ემილია ტეუმინი და ჩაიკა ვანტენბურგ–ოსტროვსკაია. აღნიშნული პროცესი იმავე წლის *18* ივლისს დასრულდა. ორგანიზაციის ზემოხსენებული წევრებიდან მხოლოდ ორი გადაურჩა დახვრეტას – ლინა შტერნი და სოლომონ ბრეგმანი. დანარჩენი პიროვნებანი კი *1952* წლის *12* აგვისტოს დახვრიტეს. ეს თარიღი ისტორიაში, ხსენებული ფაქტის გამო, „მოკლულ პოეტთა ღამედაც“ იწოდება. „სამშობლოს მოღალატე პირთა“, როგორც მათ საბჭოთა უშიშროებამ უწოდა, ოჯახის წევრები და ნათესავები კი იმავე წლის დეკემბრის თვეში გადასახლებულ იქნენ.

რაც შეეხება დახვრეტას გადარჩენილ ლინა შტერნს, მას სამწლინახევრით შრომაგასწორების ბანაკში ყოფნა და ხუთი წლით გადასახლება მიესაჯა, თუმცა სტალინის გარდაცვალების შემდეგ მას სამშობლოში დაბრუნებისა და სწავლის გაგრძელების შესაძლებლობა მიეცა. სიკვდილით დასჯას გადარჩენილი კიდევ ერთი პიროვნება – სოლომონ ბრეგმანი კი ციხეში ყოფნის დროს უმძიმესად დაავადდა და იქვე გარდაიცვალა *1953* წლის *23* იანვარს.

ძალზე საყურადღებოა ის ფაქტი, რომ ლინა შტერნის მსგავსად, „კომიტეტის“ დახვრეტილ თუ რეპრესირებულ სხვა წევრთა რეაბილიტაციაც უაღრესად მოკლე დროში, სტალინის გარდაცვალებისთანავე, მოხდა. კერძოდ, *1955* წლის *22* ნოემბერს საბჭოთა კავშირის უზენაესი სასამართლოს სამხედრო კოლეგიამ ორგანიზაციის წევრებისთვის წარდგენილი ბრალი უსაფუძვლოდ მიიჩნია და საქმე დახურა“ *(Rubenstein, 2001: 504). 1988* წლის *29* დეკემბერს კი საბჭოთა კავშირის კომუნისტური პარტიის ცენტრალური კომიტეტის პოლიტბიურომ საბოლოოდ დაასრულა „კომიტეტის“ ყველა წევრის სრული რეაბილიტაცია.

მოკლედ, ასეთია :ებრაელთა ანტიფაშისტური კომიტეტის “საქმიანობის ზოგადი ასპექტები. მიუხედავად იმისა, რომ ხსენებულმა ორგანიზაციამ არცთუ ისე დიდხანს იარსება, მან მაინც შეძლო მნიშვნელოვანი როლი ეთამაშა როგორც ფაშიზმის წინააღმდეგ ბრძოლაში, ასევე იმის მხილების პროცესშიც, თუ რაოდენ სასტიკ ძალას წარმოადგენდა საბჭოთა რეპრესიული მანქანა თავად მისი ერთგული მოქალაქეებისთვისაც კი.

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Mathematical sciences

MATHEMATICAL INTERPRETATION OF SIMPLE WORD-COMBINATIONS USING VECTOR LOGICAL ALGEBRA (ON THE EXAMPLE OF SLAVIC AND ROMANCE-GERMANIC GROUPS OF LANGUAGES)

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Abstract

In modern linguistics and mathematics the task of mathematical formalization of natural language for the purpose of its further computer processing is becoming more and more relevant. The mathematical apparatus of vector logical algebra, which is a development of the algebra of finite predicates, makes it possible to develop computer linguistics. This article shows the fundamental possibility of mathematically formalizing the simplest speech constructions using the basic operations of vector logical algebra.

Keywords: *logical scalar, logical vector, sentential connections, Boolean operations, simple word-combinations of natural language.*

Introduction.

A piece of text consists of sentences, and each sentence is composed of statements that may contain «sub-statements» and ultimately consist of words [1]. The grammar of each natural language defines the way in which words and expressions can be combined into sentences. In each simple word-combination, the grammatical presence of the main word and dependent word is provided. Each of them, in turn, can be represented by different parts of speech. The types of grammatical connection between these words can also be different. The grammars of different groups of natural languages provide for different types of such a connection. Thus, the atomic level of any natural language is a single word, and the simplest construction is a simple word-combination consisting of two words.

Execution of the axioms of the logical field for secondary members of the sentence.

*Let's consider sentences from a mathematical point of view, that is, as some constructions of vector logical algebra [2]. We will conduct research on the examples of the Ukrainian and English languages, which are representatives of different groups of natural languages, namely Slavic and Romance-Germanic groups. As an example, let's take the object «**flower**» («**квітка**»), which has the quality «**blue**» («**синя**»). Let the object «**flower**» correspond to the vector l of some logical space L, and the quality «**blue**» to the scalar α [3]. Then the expression «**blue flower**» («**синя квітка**») corresponds to the product of the vector l by the scalar α. That is, this statement is formalized by the expression $\alpha\, l$. Let's check the fulfillment of the axioms of logical algebra for the selected vector space and the selected scalar field. In this example, the set of all objects is taken as a vector space, and the set of all qualities of objects is taken as a scalar field. Boolean operations of inversion, disjunction, and conjunction are specified on a set of vectors. Then for word-combinations of the Ukrainian language:*

$$\text{«не квітка»} = \overline{\text{«квітка»}} = \bar{l},$$

and for English word-combinations:

$$\text{«not a flower»} = \overline{\text{«flower»}} = \bar{l}.$$

*Let the object «**handkerchief**» («**хустка**») correspond to some vector $g \in L$. Then in the Ukrainian language we have:*

$$\text{«квітка або хустка»} = \text{«квітка»} \vee \text{«хустка»} = l \vee g,$$
$$\text{«квітка та хустка»} = \text{«квітка»} \wedge \text{«хустка»} = l \wedge g.$$

For the English language, these formulas look like this:

$$\text{«a flower or a handkerchief»} = \text{«flower»} \vee \text{«handkerchief»} = l \vee g,$$
$$\text{«a flower and a handkerchief»} = \text{«flower»} \wedge \text{«handkerchief»} = l \wedge g.$$

The same Boolean operations are specified on the set of elements of the scalar field. Then for the Ukrainian language

$$«не синій» = \overline{«синій»} = \overline{\alpha},$$

and for the English language

$$«not\ blue» = \overline{«blue»} = \overline{\alpha}.$$

*Let the quality «**large**» («**великий**») correspond to the logical scalar* β*. Then for the Ukrainian language*

$$«синій\ або\ великий» = «синій» \vee «великий» = \alpha \vee \beta,$$
$$«синій\ та\ великий» = «синій» \wedge «великий» = \alpha \wedge \beta.$$

For the English language, we have the following results:

$$«blue\ or\ large» = «blue» \vee «large» = \alpha \vee \beta,$$
$$«blue\ and\ large» = «blue» \wedge «large» = \alpha \wedge \beta.$$

*Therefore, the operations of disjunction, conjunction and inversion of objects and their qualities given in this way satisfy all axioms of the logical field [4]. Sentential relations are the names of the corresponding operations. The auxiliary parts of speech **«or» («або»)**, **«and» («і (й, та)»**) and **«not (no)» («не (ні)»**) are considered respectively as the names of the operations of disjunction, conjunction and inversion [5].*

It is obvious that the axioms connecting the product of logical scalars and logical vectors also hold. In particular, on the example of the Ukrainian and English languages:

associativity

$$(\alpha\ \beta)\ l = «(синя\ та\ велика)\ квітка» = «синя»\ та\ («велика\ квітка») = \alpha\ (\beta\ l);$$
$$(\alpha\ \beta)\ l = «(blue\ and\ large)\ flower» = «blue»\ and\ («large\ flower») = \alpha\ (\beta\ l);$$

distributivity about the disjunction of scalars

$$(\alpha \vee \beta)\ l = «(синя\ або\ велика)\ квітка» = «синя\ квітка»\ або\ «велика\ квітка» = \alpha\ l \vee \beta\ l;$$
$$(\alpha \vee \beta)\ l = «(blue\ or\ large)\ flower» = «blue\ flower»\ or\ «large\ flower» = \alpha\ l \vee \beta\ l;$$

distributivity about the disjunction of vectors

$$\alpha\ (l \vee g) = «синя\ (квітка\ або\ хустка)» = «синя\ квітка»\ або\ «синя\ хустка» = \alpha\ l \vee \alpha\ g,$$
$$\alpha\ (l \vee g) = «a\ blue\ (flower\ or\ handkerchief)» =$$
$$= «a\ blue\ flower»\ or\ «a\ blue\ handkerchief» = \alpha\ l \vee \alpha\ g.$$

Thus, the set of objects can be considered as a vector logical space defined over a scalar field, the elements of which are the qualities of objects.

If we take a set of objects as a scalar field, and a set of qualities of objects as a space of vectors given above it, then, obviously, all axioms of the logical space will also be fulfilled. That is, the set of qualities of objects can also be considered as a vector logical space over a scalar field, the elements of which are objects. Therefore, the mathematical formalization of these word-combinations can occur in any direction: both from the main word to the dependent one, and vice versa, from the dependent word to the main one. The considered examples illustrate the case when the dependent word in the phrase is an adjective, and the main one is a noun. However, regardless of which part of the language the main and dependent words in a simple word-combination are given, according to the specified algorithm, this word-combination can be represented by a mathematical formula, namely a formula of the vector logical algebra [2], regardless of the direction of formalization. Also, there are different types of grammatical connection between the main and dependent words in word-combinations. According to the considered scheme of formalization, any grammatical relationship between the main and dependent words can be presented.

Execution of the axioms of the logical field for the main members of the sentence.

Let us now consider the word-combination as a part of the sentence, bearing in mind that the word-combination is the result of dismembering the sentence into units that have some meaningful integrity. Recently, this direction has gained popularity in linguistics. In every language there are algorithms for selecting the main members of a sentence [6]. Each sentence describes some relation expressed by a predicate. At the same time, the subject defines the subject, that is, some object of the real world. The predicate, in turn, expresses some feature (action, state, property, quality) of the object described by the subject. But in any case, the relationship between the subject and the predicate, both of which are the main members of the sentence, can be formalized similarly to the example discussed above, regardless of which of these members of the sentence is to be taken as the main word in the studied phrase, and which one is the dependent word.

*As an example, consider the connection between the subject and a simple verbal predicate. The set of words that can be a subject is the set of «objects». It is a logical field, as well as a set of words that can be a simple verb predicate. Let the vectors **h** and **d** correspond to the objects **«boy» («хлопчик»**) and*

«girl» («дівчинка»), and the scalars μ *and* τ *to the verbs «play» («грати») and «draw» («малювати»). Then, obviously, for the Ukrainian language, which assumes a free order of words in a sentence:*

$$(\mu\,\tau)\,l = \text{«(грає та малює) хлопчик»} = \text{«грає» та («малює хлопчик»)} = \mu\,(\tau\,l);$$

$$(\mu \vee \tau\,)l = \text{«(грає або малює) хлопчик»} = \text{«грає хлопчик» або «малює хлопчик»} = \mu\,l \vee \tau\,l;$$

$$\mu\,(l \vee g) = \text{«грає (хлопчик або дівчинка)»} = \text{«грає хлопчик» або «грає дівчинка»} = \mu\,l \vee \mu\,g,$$

At the same time, for the English language, taking into account the strict order of words in the sentence and the commutative properties of disjunction and conjunction operations [7]:

$$(\mu\,\tau)\,l = \text{«a boy is (playing and drawing) » = («a boy is drawing») and «playing»} = \mu\,(\tau\,l);$$

$$(\mu \vee \tau\,)l = \text{«a boy (playing or drawing)» = «boy is playing » or «boy is drawing»} = \mu\,l \vee \tau\,l;$$

$$\mu\,(l \vee g) = \text{«(a boy or a girl) is playing» = «a boy is playing» or «a girl is playing»} = \mu\,l \vee \mu\,g,$$

Therefore, all axioms of vector logical algebra are also fulfilled in this case. Similarly, if predicates are taken as vectors, and subjects are taken as elements of the scalar field, then the axioms of the logical space will also be fulfilled in this case. Therefore, the connection between the subject and the simple verb predicate can also be formalized in any direction. Similarly, it can be shown that if the subject and predicate in a sentence are represented by some other acceptable grammar of the studied language by parts of speech, then their relationship can also be formalized in any direction by means of vector logical algebra [8].

Conclusions.

From all that has been said, it follows that any word-combination of natural language can be formalized in any direction by means of vector logical algebra. The results obtained on the example of the Ukrainian language can undoubtedly be extended to the group of Slavic languages with a grammar close to Ukrainian. But, as it was shown, similar research methods can be implemented for any other languages. These studies show that by means of vector logical algebra, which is based on the apparatus of algebra of finite predicates, it is possible to formalize an arbitrary syntagm of any natural language.

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Medical sciences

PHYSIOTHERAPEUTIC TREATMENT OF LOW BACK PAIN, A REVIEW OF LITERATURE

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Abstract

Low back pain (LBP) is one of the most prevalent musculoskeletal disorders globally and a leading cause of disability in adults. Physiotherapy has a central role in its conservative management through active and passive modalities. The purpose of this narrative review is to synthesize evidence on physiotherapeutic interventions used in the treatment of low back pain, highlighting their effectiveness and clinical applicability. A non-systematic search of peer-reviewed literature was conducted using PubMed, Google Scholar, and clinical guidelines. Studies and reviews focusing on exercise therapy, manual therapy, electrotherapy, the McKenzie method, core stabilization, and adjunct modalities such as hydrotherapy, Pilates and yoga were included. The evidence indicates that exercise therapy is a first-line intervention with consistent benefits in pain reduction and functional improvement. Manual therapy and stabilization exercises provide additional short-term relief when combined with active programs. Electrotherapy modalities like TENS and NMES offer limited but supportive value as adjuncts. The McKenzie method is effective in patients with directional preference, while hydrotherapy, Pilates and yoga can enhance adherence and mobility in selected individuals.

Keywords: *Low back pain (LBP), Physiotherapy, Exercise therapy, Manual therapy, Rehabilitation*

1. Introduction

Low back pain is the leading cause of disability worldwide, with a point prevalence of 7.5% and a lifetime prevalence exceeding 80%, and accounts for 4% of attendances to the emergency department (Edwards J, 2017). Approximately 20% of people with low back pain consult their GP each year (Maniadakis N, 2000). Back pain alone accounts for 40% of sickness absence in the NHS and costs the UK economy £10 billion each year (Maniadakis N, 2000). Low back pain is costly; in the United States, health care spending on low back pain was $134.5 billion annually between 1996 and 2016 (Dieleman JL, 2020) and is increasing (S., 2015). Clinical guidelines recommend triage to identify symptoms that require diagnostic investigation (prevalence of serious pathology). Existing literature suggests that the clinical course of an episode of low back pain is favourable (Da C Menezes Costa L, 2012), (Artus M, 2014). However, recurrence is common (about 69% of patients will experience recurrence within 12 months) (da Silva T, 2019) and pain persists for many patients (Kongsted A, 2016).

2. Definition of Low back pain

Low back pain is typically defined as pain, muscle tension, or stiffness localized below the costal margin and above the inferior gluteal folds, with or without leg pain or neurological symptoms. (Airaksinen, 2006). It is considered acute when lasting less than 6 weeks, subacute when lasting 6-12 weeks, and chronic when persisting beyond 12 weeks (Koes, 2010). The majority of cases are classified as non-specific low back pain, meaning no specific pathology such as infection , tumor, fracture, or radiculopathy is identified (Maher, 2017).

3. Clinical signs and symptoms

The clinical presentation of low back pain can vary, but several common features are consistently described:

-Pain characteristics:

Patients typically report localized pain in the lumbar region, which may dull, aching, or sharp in nature (Hoy, 2014). Pain can remain central or refer to the buttocks and thighs, and in some cases radiate down the leg if nerve roots are involved (Balagué, 2012).

-Movement limitation:

Restricted range of motion in flexion, extension, or lateral bending is common, often due to pain, muscle spasm, or protective guarding (Delitto, 2012).

-Muscle stiffness or tenderness:

Palpation may reveal paraspinal muscle tightness, trigger points, or tenderness over the lumbar area (Maher, 2017).

-Neurological findings (if present)

Some patients may exhibit signs such as paresthesia, reduced reflexes, or muscle weakness when radiculopathy or nerve root irritation occurs (Kreiner, 2014).

-Functional limitations:

Difficulties on lifting, prolonged standing, sitting, or walking are frequent complaints, especially in chronic cases (Maher, 2017).

-Red flags (to exclude serious pathology:

Features such as unexplained weight loss, history of cancer, trauma, fever, progressive neurological deficit, or bowel/bladder dysfunction need further investigation (Koes, 2010) (Excellence.).

4. Epidemiology and etiology of acute LBP

Particularly in the developed world, acute LBP is extremely common, with most patients experiencing symptoms at some point in their lifetime and seeking consultation from their primary care physicians (Knezevic N.N., 2021). In one study, up to 25% of all Americans reportedly suffered LBP symptoms within the last three months. One-year LBP prevalence was reported to be 38%, and lifetime prevalence was 40% (Manchikanti L., 2014). An older review combining twelve different studies revealed a one-year prevalence between 11 and 36%. However, the authors of this comprehensive review noted substantial heterogeneity among studies (including varying definitions of onset and duration of acute LBP, as well as different assessment strategies), limiting the ability to appropriately compare and pool data. They also highlighted that cultural differences between countries significantly impact these findings (Hoy D., 2010).

Many different pathologies are considered to cause acute LBP, including nociceptive pain from muscle pull due to poor posture or mechanical overload, facet joint pain, neuropathic pain from nerve irritation, or nociplastic pain from CNS amplification, the latter sometimes referred to as "non-specific" LBP (Knezevic N.N., 2021). Significant cultural differences are also noted, (Collaborators., 2018) with some western countries like the U.S., Germany, and Belgium reporting 1-year prevalence rates close to 40%, while developing countries like Nigeria, Indonesia, or India report much lower rates, 0–10% (E., 1997). The hypothesis that hard labor in low income countries may directly correlate with higher rates of acute LBP can is therefore not supported by recent publications from the region of Africa. In contrast, higher income countries appear to have higher rates of acute LBP, which may due to older patient populations, higher rates of obesity, greater availability of treating physicians, and/or higher symptom reporting, although these are all debatable (Yalew E.S., 2022).

5. Risk factors associated with acute LBP

There is mixed data in the literature regarding the association of a variety of risk factors with acute LBP including inactivity, obesity, smoking, physical and repetitive labor, poor posture, and psychosocial factors (Steffens D., 2015). In one study, obesity was associated with a higher risk of acute LBP, (Roffey D.M., 2013) but another study of medical personnel did not confirm this finding (Lanier D.C., 1988). A comprehensive review found that, in contrast to chronic LBP, acute LBP was not clearly related to occupational physical activity (Kwon B.K., 2011). Further reviews addressed sedentary lifestyle, smoking, and coffee consumption as potential risk factors for low back pain. There was no conclusive evidence that patients with LBP were less active than healthy individuals. The review emphasizes the challenges in deriving a solid conclusion from the literature, particularly given the heterogeneous definitions of acute versus chronic LBP across multiple studies (Griffin D.W., 2012). In summary, in contrast to chronic or recurrent LBP, the risk factors for acute LBP are not well defined.

6. Physiotherapeutic management of LBP

6.1 Exercise therapy

Exercise-based interventions are a core component of physiotherapeutic management for non-specific low back pain (LBP). Exercise programs vary (general strengthening, aerobic, motor control /stabilization, graded activity) but commonly aim to reduce pain, restore function and improve conditioning. Systematic reviews and meta-analyses show that exercise is more effective than no treatment and usual care for chronic LBP, with small-to-moderate improvements in pain and function; however, no single exercise type consistently outperforms others in the long term. Clinically, individualized, progressive

programs (that include education and adherence support) are recommended. Limitations include heterogeneity of interventions and variable quality trials (Jill A Hayden 1, 2021 Sep 28).

6.2 Manual therapy

Manual therapy (spinal mobilization/manipulation, soft tissue techniques) is frequently combined with active exercise. Trials and systematic reviews report that adding manual therapy to exercise can provide greater short-term pain relief than exercise alone, and manual therapy alone may be as effective as other conservative interventions for short-term outcomes. The current evidence supports using manual therapy as part of a multimodal package (education + exercise) rather than as the sole long-term solution. Heterogeneity techniques and therapist skill make standardization and long-term effect estimates difficult (Mark Wilhelm 1, 2023).

6.3 Electrotherapy (TENS, NMES)

Transcutaneous electrical nerve stimulation (TENS) and neuromuscular electrical stimulation (NMES) are commonly used adjuncts. Evidence for TENS shows possible short-term pain relief (immediate/short follow up) in some trials and reviews, but overall quality is mixed and long-term benefits are unclear; guideline recommendations tend to regard TENS as an adjunct for short-term symptomatic relief rather than a primary therapy. NMES-often targeted paraspinal or multifidus muscles-has smaller evidence base; recent trials examine NMES as an adjunct to exercise or motor-control training with promising but preliminary results for improving muscle activation and short-term outcomes. Practical use: consider TENS for short-term symptom relief and NMES when the goal is to restore specific muscle activation (e.g., multifidus) alongside active exercise (Mervyn J Travers, 2020).

6.4 McKenzie Method (Mechanical Diagnosis and Therapy)

The McKenzie method (MTD) is a patient-driven assessment and repeated-movement/positional exercise approach intended to centralize radicular symptoms and guide self-management. Systematic reviews indicate MDT can reduce pain for some patients with mechanical LBP and may perform similarly to other exercise-based approaches for certain outcomes. Predicting which patients will respond remains imperfect; MDT is most appropriate when directional preference/centralization is demonstrable on assessment supports it, and combine with exercise and education as needed (Fayez Ibrahim Namnaqani 1, 2019).

6.5 Core stabilization (motor-control) exercises

Core stabilization or motor-control programs target deep trunk muscles (transversus abdominis, lumbar multifidus) with the aim of improving segmental control and reducing pain recurrence. Systematic reviews find evidence that stabilization exercises can reduce pain and disability in the short to medium term; however, several trials show that stabilization is not consistently superior to general exercise when followed long term. Clinically, motor-control or recurrent episodes-but should be embedded within a progressive, function-focused program (Zachary Smrcina 1, 2022).

6.6 Hydrotherapy, Pilates, Yoga (optional adjuncts)

Aquatic (hydrotherapy) exercise leverages buoyancy loading to enable movement and graded strengthening – systematic reviews and trials report improvements in pain and function for chronic LBP, particularly when land-based exercise is limited by pain. Mind-body modalities such as Pilates and yoga also show modest benefits in pain and function in several RCTs and reviews; effects are generally comparable to other active exercise programs an may be particularly helpful for adherence, proprioception, and psychosocial aspects of chronic pain. These modalities are best viewed as adjuncts or alternative formats for exercise prescription, chosen according to patient preference, comorbidities, and access (Ji Ma 1, 2022).

7. Conclusion

Physiotherapeutic management of low back pain is a fundamental component of conservative treatment and offers meaningful improvements in pan, mobility, and function. The literature consistently supports exercise therapy as the cornerstone of intervention, while manual therapy, core stabilization, and other targeted techniques can enhance clinical outcomes when applied appropriately. Although adjunctive modalities such as electrotherapy, hydrotherapy, Pilates and yoga demonstrate selective benefits. Their effectiveness depends on patient characteristics and integration with active treatment strategies. The heterogeneity of studies suggests that personalization of care, rather than a single standardized approach, yields the best results.

8. Recommendations

Based on the reviewed evidence, several practice-oriented recommendations emerge:

1. Prioritize active treatment: Exercise therapy should form the basis of physiotherapeutic intervention for both acute and chronic LBP.

2. Use multimodal approaches: Combining exercise with manual therapy, stabilization training, and education enhances clinical outcomes.

3. Apply adjunct modalities selectively : TENS, NMES, hydrotherapy, Pilates, yoga should be used to support, not replace, active rehabilitation.

4. Individualize care: Patient-specific factors, including pain duration, functional limitations, and directional preference, should guide treatment selection.

5. Integrate education and self-management: Long-term improvement is more likely when patients are involved in their recovery and understand their condition.

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AUTOIMMUNE THROMBOCYTOPENIAS. DIFFERENTIAL DIAGNOSIS

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Abstract

Autoimmune thrombocytopenias are classified as hematological disorders characterized by peripheral thrombocytopenia, mainly caused by the presence of antiplatelet autoantibodies. Patients can present with different clinical manifestations ranging from mild cutaneous and mucosal hemorrhages to massive life-threatening organ involvement. The main pathologies included in the differential diagnosis of autoimmune thrombocytopenias are: PTI (immune thrombocytopenic purpura), PTT (thrombotic thrombocytopenic purpura) and aPTT (acquired thrombotic thrombocytopenic purpura).

PTI is caused by the presence of IgG antibodies against platelet membrane glycoproteins IIb-IIIa. It is clinically characterized by the presence of petechiae, papules, ecchymoses mainly in the extremities, gingivorrhagia, menorrhagia in women. Severe forms with cerebral hemorrhage or gastrointestinal involvement are rare.

PTT is caused by a congenital deficiency or decreased activity of the enzyme ADAMS13. It is characterized by the pentad: thrombocytopenia, fever, hemolytic anemia, renal involvement and neurological involvement.

aPTT is caused by an acquired deficiency of the ADAMS13 enzyme caused by the presence of inhibitory autoantibodies. It is characterized by systemic microvascular thrombosis which leads to deep thrombocytopenia, hemolytic anemia and even organ failure.

The differential diagnosis of these diseases presents a challenge due to their similar clinical manifestations. An important element in their differentiation are laboratory evaluations, mainly hematological tests, as well as the immunological ones to assess the presence of specific antibodies. Treatment in most cases is similar and includes corticosteroids as the first line of treatment, plasmapheresis, intravenous immunoglobulins and immunosuppressants.

Conclusions

Autoimmune thrombocytopenias are disorders that can be fatal for the patient depending on their form. For this reason, rapid diagnosis and differentiation between them is important for the early intervention with appropriate treatment.

Keywords: *Thrombocytopenia, PTT, PTI, a-PTT, differential diagnosis, antibodies, hemorrhage, petechiae, ecchymosis, organ failure, thrombosis, corticosteroids, immunosuppressants*

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Pedagogical sciences

THE ROLE AND IMPORTANCE OF PRESCHOOL EDUCATION IN AZERBAIJAN

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AZERBAYCAN'DA OKUL ÖNCESİ EĞİTİMİN ROLÜ VE ÖNEMİ

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Abstract

Preschool education in Azerbaijan plays a critical role in the holistic development of children, encompassing cognitive, social, emotional, and physical growth. This stage prepares children for formal schooling by enhancing their foundational skills in language, mathematics, and problem-solving. State policies and programs, including the 2013 order of the Ministry of Education, the 2014 Presidential Decree on the Development of Preschool Institutions, and the 2016 Cabinet decision on accreditation, have contributed to improving the quality and accessibility of preschool education. These initiatives aim to expand preschool coverage, modernize infrastructure, train qualified staff, and ensure equitable opportunities for all children. Research indicates that children who attend preschool demonstrate better academic performance, stronger social skills, and enhanced self-confidence. Therefore, preschool education is not only a preparatory stage for formal schooling but also a crucial factor in fostering lifelong learning, national identity, and sustainable societal development in Azerbaijan.

Özet

Azerbaycan'da okul öncesi eğitim, çocukların bilişsel, sosyal, duygusal ve fiziksel gelişimini kapsayan bütüncül bir rol oynar. Bu dönem, çocukların dil, matematik ve problem çözme gibi temel becerilerini geliştirerek onları ilköğretime hazırlar. 2013 tarihli Eğitim Bakanlığı emri, 2014 tarihli Okul Öncesi Kurumların Geliştirilmesine Dair Cumhurbaşkanlığı Kararnamesi ve 2016 tarihli Bakanlar Kurulu kararı gibi devlet politikaları ve programları, okul öncesi eğitimin kalitesini ve erişilebilirliğini artırmaya katkı sağlamıştır. Bu girişimler, okul öncesi kapsama alanını genişletmeyi, altyapıyı modernize etmeyi, nitelikli personel yetiştirmeyi ve tüm çocuklar için eşit fırsatlar sağlamayı hedeflemektedir. Araştırmalar, okul öncesi eğitime katılan çocukların akademik başarılarının daha yüksek, sosyal becerilerinin daha güçlü ve özgüvenlerinin daha yüksek olduğunu göstermektedir. Bu nedenle, okul öncesi eğitim sadece ilköğretime hazırlık aşaması değil, aynı zamanda ömür boyu öğrenmeyi, ulusal kimliğin gelişimini ve Azerbaycan'da sürdürülebilir toplumsal kalkınmayı destekleyen kritik bir faktördür.

Keywords: *Preschool education, Azerbaijan, teaching, learning, decisions, decrees*
Anahtar kelimeler: *okul öncesi eğitim, Azerbaycan, öğretim, eğitim, kararlar*

1. Introduction

The topic is highly important and relevant, as the education a child receives in the early stages of life plays a crucial role in their future development. The relevance of this topic is based on the fact that early childhood education serves as the foundation for an individual's lifelong learning, personality formation, and social adaptation. Numerous studies in pedagogy and psychology confirm that the experiences and education a child gains between the ages of 0 and 6 have a lasting impact on their cognitive, emotional, and moral development. Therefore, ensuring access to quality preschool education is not only essential for the well-being and development of each child but also for the sustainable progress of society as a whole. In the context of Azerbaijan, the modernization of preschool education and state policies aimed at expanding its accessibility make this issue even more significant and timely.

Concept of Preschool Education

Preschool education is the stage of education that covers the period of a child's life from 0 to 6 years and is aimed at ensuring their physical, mental, social, and emotional development. This period is critically important for the formation of the child's personality, the development of independent thinking skills, and preparation for future education.

2. Main Role of Preschool Education

*• **Physical development:** Children's motor skills, health, and coordination abilities are formed during this period.*

*• **Intellectual and cognitive development:** Preschool education teaches children logical thinking, problem-solving, and basic mathematical and language skills.*

*• **Development of social skills:** Children interact with their peers, learn to follow rules, and behave appropriately in a group.*

*• **Emotional development:** Children learn to recognize and manage their own emotions and become sensitive to the emotions of others.*

3. Importance of Preschool Education in Azerbaijan

*• **Preparation for education:** Preschool education prepares children for school life and facilitates the acquisition of reading and writing skills.*

*• **Creating equal opportunities:** This type of education reduces socio-economic disparities and provides children with equal starting opportunities.*

*• **Transmission of national and cultural values:** Preschool education teaches children national values, traditions, and the basic principles of culture.*

*• **Long-term development:** Research shows that children who receive preschool education perform better in school and have higher self-expression and social integration skills.*

4. Azerbaijan's Experience

In recent years, several reforms have been implemented in Azerbaijan to develop preschool education:

• The number of state kindergartens is increasing, and investments are made in infrastructure.

• Preparing qualified pedagogical staff for children is a priority.

• The coverage of preschool education is expanding, creating equal opportunities in both urban and rural areas.

5. State Decrees and Legislation

Several state decrees and laws have been adopted in Azerbaijan to develop preschool education. Some of these documents are:

*1. **Order No. 1/2 of the Ministry of Education of the Republic of Azerbaijan (2013):** This order outlined measures to regulate and develop the activities of preschool education institutions. It aimed to improve the quality of preschool education, enhance teachers' professionalism, and implement modern teaching methods.*

*2. **Decree of the President of the Republic of Azerbaijan (2014):** The "State Program on the Development of Preschool Education Institutions" was approved. This program aimed to expand preschool education coverage, improve infrastructure, and enhance the quality of education.*

*3. **Decision of the Cabinet of Ministers of the Republic of Azerbaijan (2016):** Procedures for accreditation and evaluation of preschool education institutions were established. This decision aims to ensure and improve the quality of preschool education.*

Importance of Preschool Education

Preschool education plays a crucial role in children's development. At this stage, children's social, emotional, intellectual, and physical development is ensured. Preschool education enhances children's readiness for school and positively influences their future educational life.

Scholars' Views on the Role and Importance of Preschool Education

*1. **Maria Montessori (1870–1952):** The Italian physician and educator emphasized the critical role of preschool education in child development. She proposed the idea of "division of educational work between the teacher and the environment," noting that children learn better in environments that promote their own development. (montessori150.org)*

*2. **Albert Einstein (1879–1955):** The world-famous scientist highlighted the importance of children learning through play, stating, "Play is the highest form of human intellectual development." (TSH Anywhere)*

*3. **Mahatma Gandhi (1869–1948):** The Indian independence leader emphasized that education should develop a child's body, mind, and soul. He said, "Education is the manifestation of the perfection already in man; body, mind, and soul." (TSH Anywhere)*

*4. **Frederick Douglass (1818–1895):** The American writer and social activist highlighted the importance of child development, saying, "It is easier to build strong children than to repair broken men." (ZERO TO THREE)*

*5. **Alfie Kohn:** The American educator noted that children learn to make good decisions by making decisions themselves. He stated, "Children learn to make good decisions not by following directions, but by making decisions." (quotes.lifehack.org)*

6. Conclusion

Preschool education lays the foundation for children's future success. In Azerbaijan, the development of this field significantly contributes to the early formation of children's personalities and skills, improves their readiness for education, and supports the sustainable development of society.

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Philological sciences

DIGITAL LEARNING PATH AS A PEDAGOGICAL TOOL IN ENGLISH LANGUAGE TEACHING: FROM CONCEPT TO PRACTICE

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Abstract

The article explores the concept of the digital learning path as a pedagogical tool that reshapes traditional approaches to English language teaching in the context of digital transformation. The study examines theoretical foundations and practical applications of personalized learning trajectories supported by digital platforms such as Moodle, Google Classroom, and iSpring Learn. Particular attention is given to the role of digital learning paths in fostering learner autonomy, reflection, and engagement. The research highlights how adaptive learning technologies and learning analytics enable instructors to create transparent, student-centered pathways that integrate cognitive, linguistic, and socio-cultural components. The transition from concept to practice is illustrated through university-level case studies that demonstrate the pedagogical potential of digital learning paths in enhancing both motivation and communicative competence.

Keywords: *autonomy, digital learning path, English language teaching, personalization, reflection.*

Introduction: *The modern education system is undergoing fundamental changes driven by the rapid development of digital technologies and the changing role of the learner in the pedagogical process. One of the key areas of this transformation is the shift from the traditional learning model to the concept of personalized educational trajectories, in which students not only absorb material but also create their own learning path, choosing the pace, tools, and format of interaction with the teacher. In the context of English language teaching, this transition is particularly significant, as it requires a combination of cognitive, communicative, and cultural competencies, as well as flexible methodological solutions [2, p. 4].*

While the classical pedagogical paradigm focused on the average learner and a linear course structure, digitalization opens up opportunities for the development of individual learning paths based on the principles of adaptability and autonomy. In this context, the concept of the digital learning path occupies a special place. It is a pedagogical tool that combines elements of self-study, digital analytics, and interactive technologies. The digital learning path allows students to view the course structure as a sequence of steps, goals, and criteria, which promotes responsibility, reflection, and self-control [1, p. 3].

In English language teaching, the concept of a digital learning path is becoming more than just a technological solution, but a new pedagogical philosophy in which the learning process is built around the individual student. Using digital platforms such as Moodle, Google Classroom, iSpring Learn, and Edmodo, teachers can design individualized pathways that integrate classroom and independent learning. This model fosters digital autonomy, develops critical thinking skills, and enhances motivation through transparency and visibility of the learning process [3, p. 5].

The purpose of this study is to analyze the concept of a digital learning path and identify its pedagogical potential in English language teaching. To achieve this goal, the following objectives are addressed:

1. to define the theoretical foundations of the concept of "digital learning path" and its place in modern pedagogy;

2. consider digital tools and platforms that implement the idea of a personalized route;

3. to evaluate the impact of personalized strategies on the development of student autonomy and the effectiveness of language education.

The methodological framework of this study is based on a content analysis of scientific sources on digital pedagogy and individualized learning; an analysis of case studies of LMS platform

implementations (Moodle, Google Classroom, iSpring, Edmodo) for building learning paths; and a comparative study of practices in Finland, Germany, and China, where models integrating technology and pedagogical approaches in language education are being implemented. Using these examples, we can identify universal patterns in the formation of digital paths and assess their potential for application in Russian and international educational contexts [4, p. 2].

Thus, the concept of a digital learning path represents a synthesis of technological capabilities and pedagogical principles aimed at creating a flexible, human-centered model of English language teaching. It facilitates the transition from the mechanical transfer of knowledge to the development of skills for conscious self-development and personal responsibility for learning outcomes—key competencies of the 21st century.

- *Theoretical foundations of the concept of a digital learning path*

The concept of a "digital learning path" emerged from the development of ideas around personalized education and the concept of self-regulated learning, in which students become active participants in their own learning process. Unlike the traditional model, where the course structure is determined solely by the instructor, a digital learning path is developed as a flexible system that integrates learning goals, resources, feedback, and analytical tools, allowing students to build their own learning trajectory.

From a theoretical perspective, the digital route integrates the principles of constructivism, cognitive psychology, and the theory of metacognitive development. According to the views of J. Bruner and J. Piaget, the learning process becomes effective when the student actively constructs knowledge based on personal experience and interaction with the environment. In digital pedagogy, these ideas have been further developed: learning is viewed as a process of constant interaction between the student, the teacher, and technology. The digital route essentially functions as a navigation system, where each course element reflects a step in learning and motivates the student to reflect on their own actions [1, p. 2].

The pedagogical value of a digital route lies in the ability to visualize the educational process. Traditionally, students perceive a course structure linearly, without understanding the intermediate goals and connections between modules. In a digital format, each element—a lecture, assignment, test, or forum—becomes part of a single logical map. This creates a transparent learning experience: the student sees not only their current situation but also the direction of their future progress. This visualization fosters intrinsic motivation, reduces anxiety, and increases a sense of control over the language acquisition process [2, p. 4].

An important theoretical component of the concept is the idea of adaptability. It suggests that a digital route should be tailored to the individual characteristics of the learner, including their pace of work, information comprehension style, and level of preparation. This idea harks back to the cognitive research of H. Gardner and D. Kolb, who demonstrated that learning effectiveness depends on the matching of the methodology to the student's thinking and perception style. In a digital environment, adaptability is realized through algorithms that analyze activity and performance data and offer personalized scenarios for progress along the route [3, p. 7].

Along with adaptability, the digital route includes a metacognitive control component. It is aimed at developing the learner's ability to recognize their own learning strategies, evaluate their effectiveness, and adjust them as necessary. This element is particularly significant in English language teaching: awareness in the selection of grammatical structures, vocabulary memorization methods, and speech practice strategies facilitates the transition from reproductive acquisition to productive language proficiency. The metacognitive component of the digital route is enhanced by built-in analytics, providing both the student and teacher with access to progress statistics, engagement levels, and learning dynamics [4, p. 3].

From a modern pedagogy perspective, a digital learning path serves not only an organizational but also a reflective function. It helps establish connections between goals, actions, and outcomes, transforming the learning process into a meaningful activity. For teachers, a digital path becomes a course design tool, enabling the integration of various pedagogical strategies—from problem-based and project-based learning to hybrid models (blended learning). For students, it is a space for self-determination, where they don't simply complete assignments but consciously manage their own learning and see the cause-and-effect relationships between effort and outcome.

The theoretical basis of the digital learning path concept is also closely linked to the principles of communicative methods in English language teaching. The digital learning path supports the idea of a gradual transition from reproductive forms (reading, grammar exercises) to interactive and productive activities (discussions, project work, joint presentations). This structure promotes the development of

communicative competence, develops the ability to express thoughts in context, and increases confidence in oral communication.

Research in digital pedagogy (Siemens, 2005; Downes, 2008) demonstrates that the digital learning path is the primary tool for connected learning (connectivism), where knowledge is created through networked interaction rather than transmitted unilaterally. In this model, the teacher acts as a facilitator, guiding movement along the path and maintaining a balance between freedom of choice and pedagogical structure [5, p. 9].

The digital learning path, integrating cognitive, communicative, and technological principles, is becoming a new-generation pedagogical tool. Its theoretical significance lies in the fact that it combines two opposing trends in modern education—standardization and individualization—creating a space where every student can realize their potential within a unified educational system.

- *Technological solutions for implementing a digital learning route*

Modern digital technologies provide English teachers with a wide range of tools for designing individual learning paths based on the principles of flexibility, interactivity, and continuous feedback. A digital path, by its very nature, cannot exist without a technological platform—it is this platform that ensures content structuring, personalization, monitoring, and analytical support for the learning process. Learning Management Systems (LMS), such as Moodle, Google Classroom, iSpring Learn, and Edmodo, have been recognized as the most effective in this context. Each implements the concept of a digital path in its own way, reflecting different pedagogical approaches and technical capabilities [1, p. 3].

The Moodle platform has traditionally occupied a central place in digital education due to its flexibility and open architecture. It allows teachers to design courses as a logically structured path consisting of modules, assignments, interactive tests, and forums. Each course element can be linked to a specific learning objective, creating a transparent progression structure for students. Moodle supports adaptive mechanisms—the conditions for accessing assignments can depend on the results of previous stages, the student's level of performance, and their activity level. In English language teaching, this feature is used to gradually increase the complexity of vocabulary and grammar exercises, build chains of assignments by topic, and create a portfolio of achievements. Furthermore, Moodle integrates with Learning Analytics tools, allowing teachers to track progress and identify individual difficulties for each student [2, p. 6].

Google Classroomis designed to create a more interactive and visually engaging environment. It facilitates rapid interaction between teachers and students, facilitating the exchange of materials, comments, and feedback. Unlike Moodle, Google Classroom emphasizes communication and the visual component of the educational journey. This is especially important for teaching English, as the platform supports integration with Google Docs, Jamboard, YouTube, and Forms, allowing for a combination of traditional forms of work (reading and writing) with multimedia and collaborative assignments. Using Google Classroom, teachers can design personalized journeys in which each course topic is presented as a separate "step"—a mini-project or language mission, accompanied by comments and individualized feedback. This approach enhances student engagement and promotes the development of metacognitive skills through self-assessment and discussion of results in a digital environment [3, p. 4].

The iSpring Learn system is a commercial solution focused on corporate and academic learning, but its functionality is increasingly being used in university English language courses. The platform allows instructors to create adaptive learning programs tailored to students' skill levels. One of iSpring's key features is its intelligent course designer, which creates a personalized course path based on assessments and performance data analysis. In English language courses, this technology is used to automatically adjust grammar exercises and audio tasks based on student progress. Built-in gamification modules (badges, points, and rankings) enhance motivation, creating a sense of educational competition. The result is a flexible environment where each student follows their own trajectory while maintaining connection to the overall course structure [4, p. 8].

The Edmodo platform emphasizes social interaction and the emotional well-being of learning participants. It is built on the principle of an educational social network, where students and teachers communicate, exchange ideas, create collaborative projects, and discuss learning materials. In English language teaching, Edmodo is used to facilitate group discussions, role-plays, virtual debates, and cross-cultural projects. Here, the digital route takes the form of a shared journey: the teacher sets the main stages, but the direction of travel is determined by the participants themselves through discussions, resource sharing, and collective reflection. This structure enhances the communicative component of learning and develops students' skills of collaboration and responsibility for the overall outcome [5, p. 2].

Along with LMS platforms, analytical and data visualization tools are crucial in building digital pathways, allowing instructors and students to view the educational process as a living system reflecting

the dynamics of development. Learning analytics, integrated into modern platforms, record activity, assignment completion time, frequency of interaction, and common errors, generating customized reports. This data is used to adjust the pathway, select additional materials, and identify learning patterns. Analytical support helps students recognize their own strengths and weaknesses, and instructors make pedagogical decisions based on real data rather than intuition [2, p. 9].

Visualization and path-planning tools such as Trello, Padlet, and Miro deserve special attention. They allow you to create visual learning roadmaps, where each stage represents a module, topic, or task. In English language teaching, such visual diagrams enhance student awareness and provide a better understanding of the course structure. For example, using Padlet to create personalized language paths allows students to independently plan their learning: posting their own notes, video resources, assignments, and teacher comments. This promotes self-organization and strengthens a sense of ownership in the learning process.

Technological solutions used to implement the digital pathway are not limited to mechanical learning management. They create a pedagogical ecosystem where digital tools become a means of intellectual and emotional growth. The use of LMS, analytical, and visual platforms creates new mechanisms for teacher-student interaction, ensuring transparency of goals, flexibility of methods, and adaptation to individual needs.

As a result, the digital route becomes a living educational tool, connecting technology, pedagogy, and the student's personality. It fosters autonomy, critical thinking, and self-esteem—the qualities that define successful modern language learners in the digital age.

- *Pedagogical effects of using a digital learning route*

As part of the modern pedagogical paradigm, digital learning has a complex impact on the structure of the educational process, the nature of interaction between participants, and the development of new competencies in students. Its implementation in English language teaching demonstrates not only technological progress but also profound changes in pedagogical thinking—a shift in emphasis from knowledge transfer to student development. The main effects can be viewed through three interrelated dimensions: cognitive, motivational, and social-communicative.

Cognitive effectThe digital route develops metacognitive and analytical skills. Thanks to a structure that visualizes the learning process, students gain the opportunity to reflect on their own actions, evaluate results, and adjust their strategies. Research in digital pedagogy shows that the use of personalized routes stimulates the development of planning, self-assessment, and forecasting skills, which are especially important when learning a foreign language [1, p. 4]. Students begin to perceive learning English not as a mechanical task, but as an intellectual activity requiring analysis, choice, and responsibility. This awareness promotes deeper learning and the transition from a reproductive to a productive level of language proficiency.

Of particular importance is the development of learner autonomy, which becomes a natural consequence of working in a digital learning environment. Platforms based on personalization principles allow students to choose the sequence of modules, determining the pace and type of assignments. This fosters a sense of control over their own learning, which increases intrinsic motivation and reduces dependence on external control from the teacher. Autonomy here manifests itself not in isolation, but in the ability to consciously interact with the digital environment and the teacher, which aligns with the principles of humanistic pedagogy and the concept of "the learner as the author" of their educational journey [2, p. 6].

The digital route also promotes the development of digital literacy and media competence, which in today's environment are becoming a mandatory part of professional and language training. Working with LMS platforms and interactive tools requires students to structure information, analyze data, use multimedia formats, and adhere to ethical standards of online interaction. In the process of learning English, this leads to the emergence of a new type of bilingual competence—a combination of linguistic and digital thinking, where proficiency in a foreign language becomes inseparable from the ability to function in the digital space [3, p. 7].

No less significant is the motivational effect, which manifests itself in increased student engagement. Digital learning paths feature gamification and transparency: students can see their progress, receive timely feedback, and visual confirmation of their achievements. This enhances the "intrinsic reward" effect and encourages further development. Research shows that regular use of personalized digital paths increases sustained learning motivation by 20–25% due to the inclusion of elements of choice and self-organization [4, p. 9].

The positive impact of the digital route also manifests itself in emotional and psychological aspects. The ability to move at one's own pace reduces anxiety, especially when completing speaking and writing tasks, where students often experience a fear of making mistakes. The digital environment provides a safe learning space, where mistakes are perceived not as failures but as part of the self-improvement process. This promotes a positive attitude toward language and confidence in one's own communicative abilities.

In terms of its social and communicative impact, the digital route transforms interactions between students and instructors. The shift from a frontal to an individualized model doesn't lead to isolation; on the contrary, the digital environment enhances collaboration. Collaborative assignments, group projects, and discussions in LMS forums create new models of academic communication, where students act not as passive listeners but as communication partners. The instructor, in turn, acts as a moderator and facilitator, helping students analyze their results and develop their own strategies. In this model, communication takes on a more equal and dialogical nature [5, p. 2].

The digital route also promotes the development of critical and analytical thinking. Automated feedback and access to personal progress data instill in students the habit of objective self-assessment, a necessary element of a mature academic personality. Students begin to perceive mistakes as part of the process, analyze the causes of difficulties, and seek ways to overcome them. This leads to the emergence of a new type of academic responsibility, based on an awareness of their personal role in achieving educational goals.

For teachers, the digital route becomes not only a means of organizing the educational process but also a tool for diagnostics and pedagogical analytics. Using student activity data, teachers can adjust the course, identify weaknesses, adapt methods, and improve the quality of interaction. This system increases the transparency of pedagogical decisions and builds trust among participants in the educational process.

Overall, the pedagogical effects of the digital route in English language teaching reflect a profound transformation in educational culture. The relationship between learner, teacher, and technology is no longer hierarchical but rather partnership-based. A new educational model is emerging—one that is human-centered, adaptive, and reflective, in which digital tools are not an end in themselves, but a means of developing autonomous individuals capable of learning, thinking, and communicating in a global digital world.

- *From Concept to Practice: Implementing a Digital Route in English Language Teaching*

The transition from a theoretical understanding of digital learning pathways to their practical implementation in English language teaching requires a comprehensive approach, including pedagogical design, technological support, and the willingness of educational stakeholders to collaborate. In recent years, digital learning pathways have become a central tool in university teaching methods, reflecting the trend toward personalized learning and increased student autonomy. The most illustrative examples are the implementation of this concept at Russian and international universities, where digital platforms have become not just a means of content delivery but a space for pedagogical interaction.

In the teaching practice of Moscow State Pedagogical University (MSPU), the digital pathway concept is implemented through a combination of the Moodle and Google Classroom platforms. English language courses are structured as a sequence of modules united by a common logic of cognitive and communicative development. Each module contains goals, assignments, interactive exercises, and self-assessment tools. At the beginning of the course, students are offered a diagnostic test, based on which the system creates an individual pathway: more advanced students are given tasks of increased difficulty, while beginners are focused on basic topics and speech patterns. The instructor uses Learning Analytics reports to analyze progress, adjust materials, and provide personalized recommendations. This model creates a balance between freedom of choice and structured pedagogical support [1, p. 3].

At the University of Helsinki (Finland), a digital learning path is integrated into the "English for Academic Communication" course. It is implemented within the iSpring Learn platform, where each student builds a personalized trajectory for mastering academic English: from vocabulary and grammar to academic writing and public presentations. The system automatically adapts assignments based on the student's pace and level of success. The teacher does not set a uniform pace, but acts as a mentor, helping the student understand their results and adjust their learning strategy. A distinctive feature of the Finnish approach is its emphasis on reflection: after each module, the student completes a short report detailing which strategies were most effective and which require revision. This fosters a habit of self-analysis and strengthens critical thinking skills [2, p. 4].

An example of the successful implementation of a digital learning path in Asian practice is Shanghai Normal University (China), which uses the integrated Tencent Classroom system. Here, the digital learning path for English is built on the principles of adaptability and collaboration. Courses are divided into micro-modules (microlearning), each of which represents a thematic block—grammar, listening, vocabulary, and intercultural communication. The AI system analyzes student behavior—task completion speed, error rate, and engagement level—and automatically creates an individualized learning path. Group work is organized through online discussions and virtual projects, where students create joint presentations and analyze English texts. The teacher acts as a facilitator, guiding the process and providing feedback through built-in analytical tools [3, p. 6].

An important area of practical implementation of the digital pathway is the use of visual planning tools such as Padlet, Trello, and Miro. These are used to design individual learning "roadmaps," where each stage reflects a specific topic, goal, and achievement criteria. For example, when studying the topic "Environmental Issues in Modern Society," students create their own pathways in Padlet: they post video resources, complete assignments, leave comments, and receive feedback from the instructor and classmates. This approach fosters creative thinking and enhances the communicative component of learning, transforming the course into a space for collaborative exploration and exchange of ideas [4, p. 2].

The effectiveness of implementing digital pathways is confirmed by empirical data from pedagogical research. For example, observations at universities using LMSs with personalization capabilities show that students experience a 23–28% increase in sustained learning motivation, while their level of independence in completing assignments increases by an average of 30%. Furthermore, improvements in academic performance and a significant increase in confidence in using English in oral and written communication have been recorded [5, p. 5].

Practical experience shows that the successful implementation of a digital route requires not only technical resources but also a change in teaching culture. Teachers become not just system operators but architects of the learning experience, designing routes, helping students understand the learning process, and transforming the digital space into a tool for self-development. It is the human factor that determines the effectiveness of technology: technology creates the environment, but it is the teacher and student who imbue it with meaning.

The digital route to English language teaching, moving from concept to practice, is becoming not just an innovation, but a new format for interaction. It combines individualization, adaptability, and collaborative learning, creating the conditions for developing independent, responsible, and creative individuals capable of learning in a digital society and using language as a means of global communication.

Conclusion

The development of the concept of a digital learning path marks a shift from technology as a tool to technology as a form of pedagogical thinking. The experience of implementing personalized digital trajectories in English language teaching demonstrates that digitalization is not limited to the automation of the learning process; it opens the way to the development of a conscious, reflective, and humanistic approach to education. The digital path is becoming more than just an organizational model, but a space for intellectual and personal growth, where students don't just acquire knowledge, but build it based on their own experience, interest, and intrinsic motivation [2, p. 4].

The key achievement of the digital route is the creation of an educational environment where each student feels like a participant in the process, capable of setting goals, planning actions, and evaluating results. In this system, the teacher becomes the architect of the learning experience and a mentor, guiding the development of independence and critical thinking. This interaction gives rise to a new learning culture—a culture of trust, flexibility, and partnership between teacher and student [3, p. 7].

The digital learning path doesn't pit technology and personality against each other; on the contrary, it integrates them into a single system, where pedagogical logic and digital infrastructure work toward a common goal: developing fluent, reflective, and responsible language users. In the context of global educational transformation, such models are becoming the key to the sustainable development of language education, where technological innovation is driven not by pragmatics but by meaning.

The prospect for further research lies in expanding the understanding of the digital pathway as part of a holistic educational ecosystem, where artificial intelligence, educational analytics, and humanistic methodology form a synthesis aimed at unlocking human potential. The digital pathway is not simply a path within the educational system, but a step toward a new type of education, in which knowledge becomes a process of self-discovery, and learning a form of personal maturity.

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Technical sciences

HYBRID HWOPSO-WOA FOR OPTIMAL FEATURE SELECTION IN DIABETIC RETINOPATHY PREDICTION

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Abstract

This research proposes a novel Hybrid Weighted Optimization-based Particle Swarm Optimization–Whale Optimization Algorithm (HWOPSO-WOA) for optimal feature selection in Diabetic Retinopathy (DR) classification. Conventional feature selection techniques often suffer from premature convergence and suboptimal search space exploration, resulting in redundant features and degraded model performance. The proposed HWOPSO-WOA combines the global exploration ability of Particle Swarm Optimization (PSO) with the adaptive exploitation strategy of Whale Optimization Algorithm (WOA), further enhanced with weighted opposition-based learning to maintain population diversity and accelerate convergence. Experimental evaluation on public DR datasets demonstrates a 25–30% reduction in feature dimensionality, with a 3–5% improvement in classification accuracy compared to standalone PSO, WOA, and other metaheuristic approaches. The hybrid algorithm exhibits improved stability and robustness across multiple runs, making it an efficient and scalable solution for high-dimensional medical data. Moreover, HWOPSO-WOA demonstrated faster convergence with lower computational cost compared to conventional hybrids, making it well-suited for real-time applications. Sensitivity analysis confirmed that the selected features captured key lesion characteristics, directly improving clinical interpretability of results. This contribution provides an optimized feature subset that enhances downstream classification models, thereby facilitating early DR detection and reducing diagnostic errors.

Keywords: *HWOPSO-WOA, Feature Selection, Metaheuristic Optimization, Diabetic Retinopathy, Swarm Intelligence, Hybrid Algorithms, Classification Accuracy*

ALGORITHM SELECTION AND OPTIMIZATION FOR IMAGE-BASED CRACK DETECTION

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Abstract

This chapter presents a comprehensive investigation into various image processing techniques for crack detection in pipeline inspection systems. The study utilizes Python 3 and the OpenCV library to implement and evaluate five key techniques: Canny Edge Detection, Laplacian Operator, Morphological Operations, Otsu's Thresholding, and Sobel Filter. Each method was assessed in terms of accuracy, speed, and efficiency in detecting crack skeletons and structural parameters such as length and width. The results demonstrate that both Canny Edge Detection and Otsu's Thresholding outperform other techniques in precision and computational performance. While Morphological and Laplacian methods showed limitations in noise reduction and accurate crack feature extraction, Otsu's Thresholding proved particularly advantageous for its automated segmentation and high clarity in crack detection. Furthermore, real-time processing considerations revealed significant differences in execution times among techniques, with Otsu's Thresholding emerging as the most efficient for practical implementation. These findings highlight the importance of optimizing image processing algorithms to achieve a balance between speed and accuracy in automated crack detection systems for pipe inspection.

***Keyword**: Crack Detection, Image Processing, Canny Edge Detection, Otsu Thresholding, Pipeline Inspection*

Introduction

Pipeline infrastructure is a critical component in numerous industries, including oil, gas, and water supply. Ensuring its structural integrity is essential to prevent leaks, failures, and environmental hazards [1]. Traditional inspection methods, such as manual visual inspection, are time-consuming, labor-intensive, and prone to human error [2]. In recent years, the integration of robotics and image processing techniques has provided an effective alternative for automated and precise pipeline inspection [3][4].

This chapter focuses on exploring various image processing techniques for detecting cracks in pipelines using an Arduino-based inspection robot. The study investigates five key approaches—Canny Edge Detection, Laplacian Operator, Morphological Operations, Otsu's Thresholding, and Sobel Filter—implemented using Python 3 and the OpenCV library [5]. Each technique is analyzed in terms of its accuracy, computational speed, and efficiency in identifying crack features, including length, width, and skeleton structure [6].

We explored the conception and early phases of creating our pipe inspection robot in the previous chapter. We now delve further into its building, revealing elements intended to transform the effectiveness of pipe examination [3][4]. This chapter takes us on a thorough investigation of different image processing techniques. Every method is examined for how well it can identify the complex shapes of cracks.

We begin a comparative analysis, comparing and contrasting each technique with its running process. We provide insight into the process of figuring out which strategy works best for our pipeline inspection projects through extensive testing. Among all these techniques, there are a few alternative methods under investigation. We must test them all to determine which best suits our needs because each has advantages and disadvantages. Ultimately, we want to find the method that best balances speed and accuracy to detect any possible problems in the pipes [6][7]. in the pipes. I will test five different techniques to see which one works best for detecting crack skeletons.

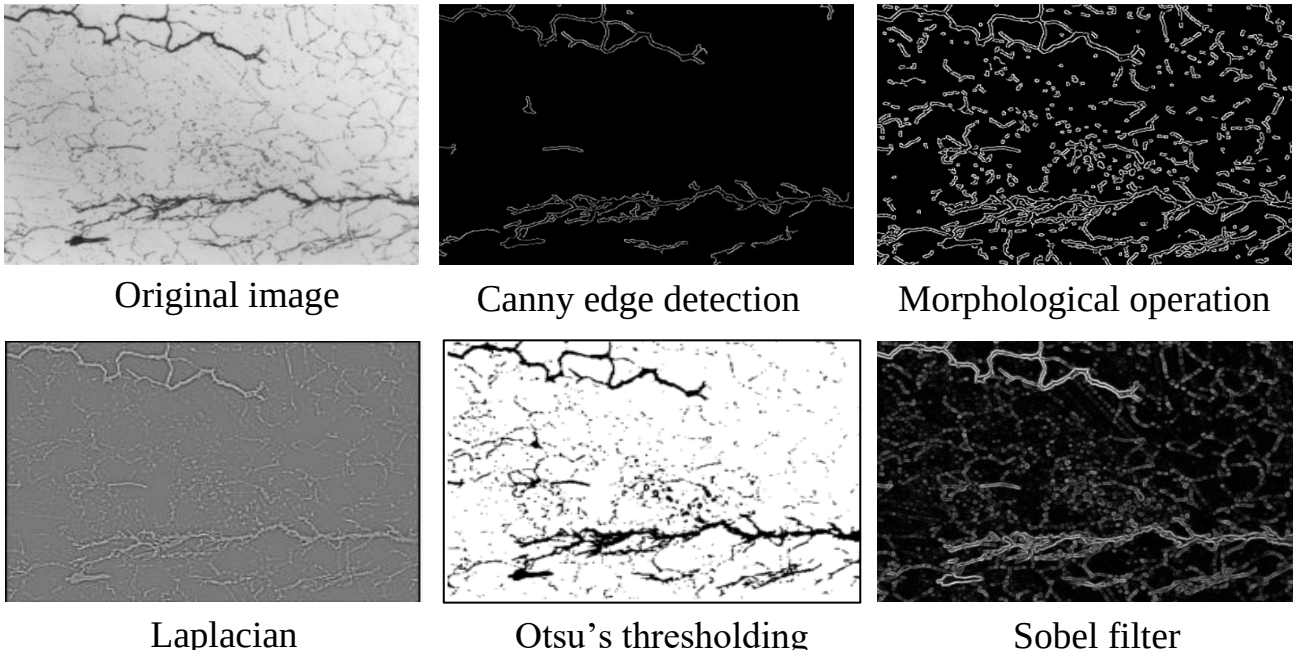

Figure 1. Opencv result of five image processing techniques from image 1

In our investigation, we employed the Python 3 OpenCV library to detect cracks. Each technique is characterized by distinct code commands. Common steps in image processing techniques include preprocessing by converting to grayscale and applying Gaussian blur for noise reduction, followed by edge detection using algorithms like Canny or Sobel. Thresholding methods such as global thresholding or Otsu's thresholding are then applied to segment the image into binary regions. For instance, Figure 1, 2, 3 and shows the implemenation of techniques.

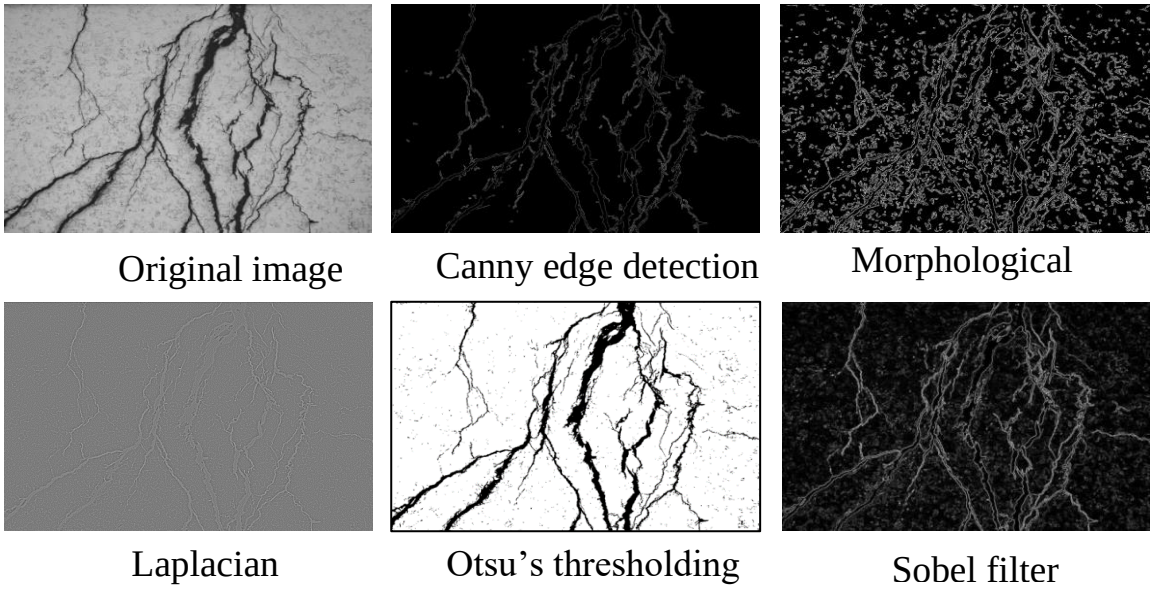

Figure 2. Opencv result of five image processing techniques from image 2

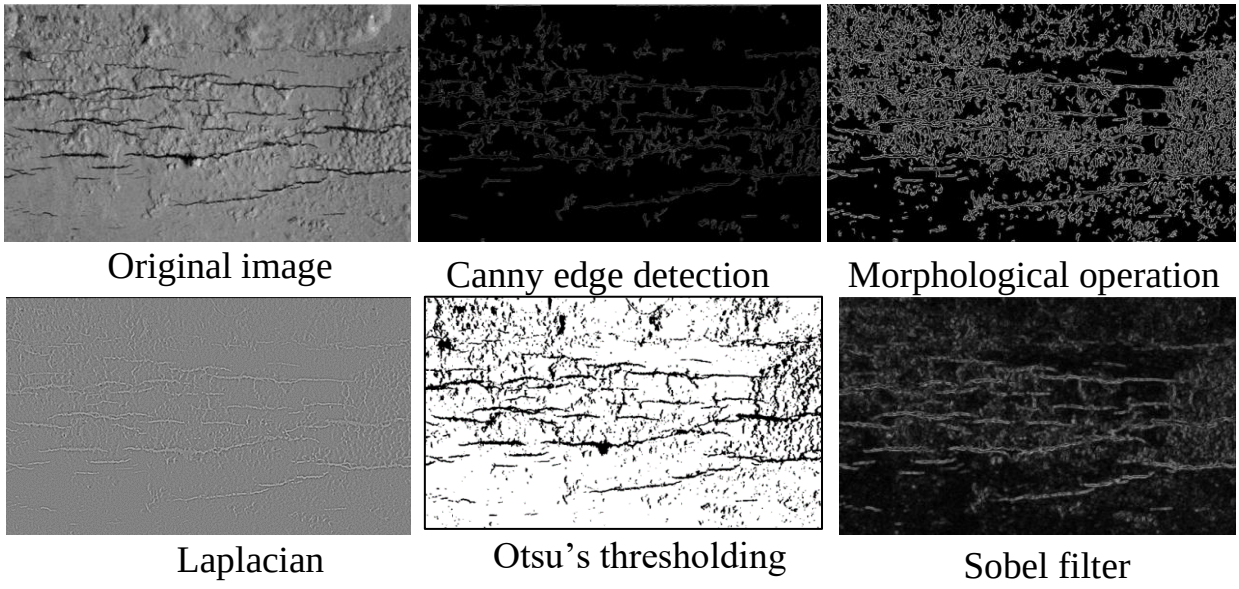

Figure 3. Opencv result of five image processing techniques from image 3

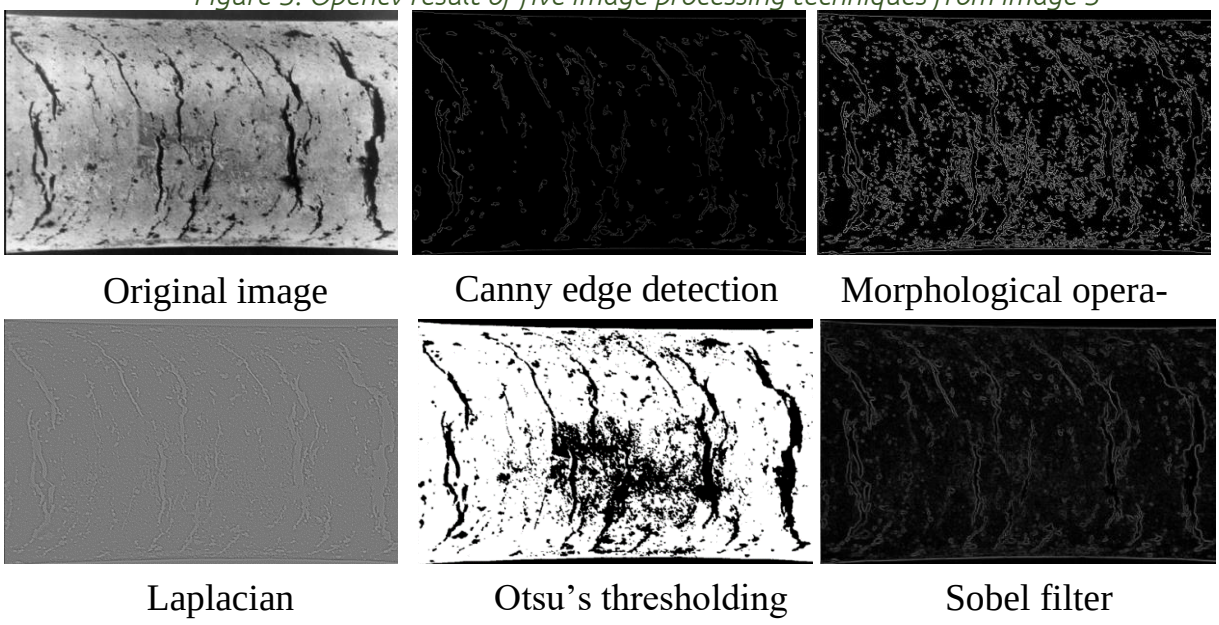

Figure .4. Opencv result of five image processing techniques from image 4

From our analysis of crack images, it becomes evident that both Canny edge detection and Otsu thresholding methods exhibit superior accuracy in detecting crack parameters compared to Laplacian and morphological operation techniques. Specifically, we observed that morphological operations are limited in their ability to effectively reduce noise levels. Moreover, the Laplacian technique demonstrates inadequacies in accurately detecting crack features. As for image processing techniques, Otsu thresholding strikes me as particularly useful due to its ability to simplify the process of finding the optimal threshold for image segmentation. Canny edge detection stands out in its accuracy in identifying edges while minimizing false detections.

In my experience applying these techniques to crack images, I've noticed variations in computational speed, complexity, and their ability to deliver the desired results in real-time applications.

The important consideration is understanding the speed at which various techniques can detect cracks in images. To accomplish this, we utilize the `time.time()` function in OpenCV. By timing each technique's execution, we can identify which ones are faster at identifying cracks. This knowledge helps in choosing the most efficient technique for applications where speed is critical (Figure 7).

```
# Start the timer
start_time = time.time()
# converting to gray scale
gray = cv2.cvtColor(img0, cv2.COLOR_BGR2GRAY)
# remove noise
img = cv2.GaussianBlur(gray,(3,3),0)
# End the timer
end_time = time.time()
```

Figure 5. Implementing execution time of techniques

In the provided benchmarks, I evaluated the computational speed of various image processing techniques using OpenCV (Figure 4.6). These techniques include Canny Edge Detection, Laplacian Operator, Morphological Operations, Otsu Thresholding, and Sobel Filter. The observed speeds indicate how quickly each technique processed the images. Some techniques, such as Canny Edge Detection and Otsu Thresholding, were notably faster than expected.

Figure 6. Computing speed of 1) Sobel operator, 2) Morphological operation, 3) Laplacian, 4) Canny Edge, 5) Otsu's threshold

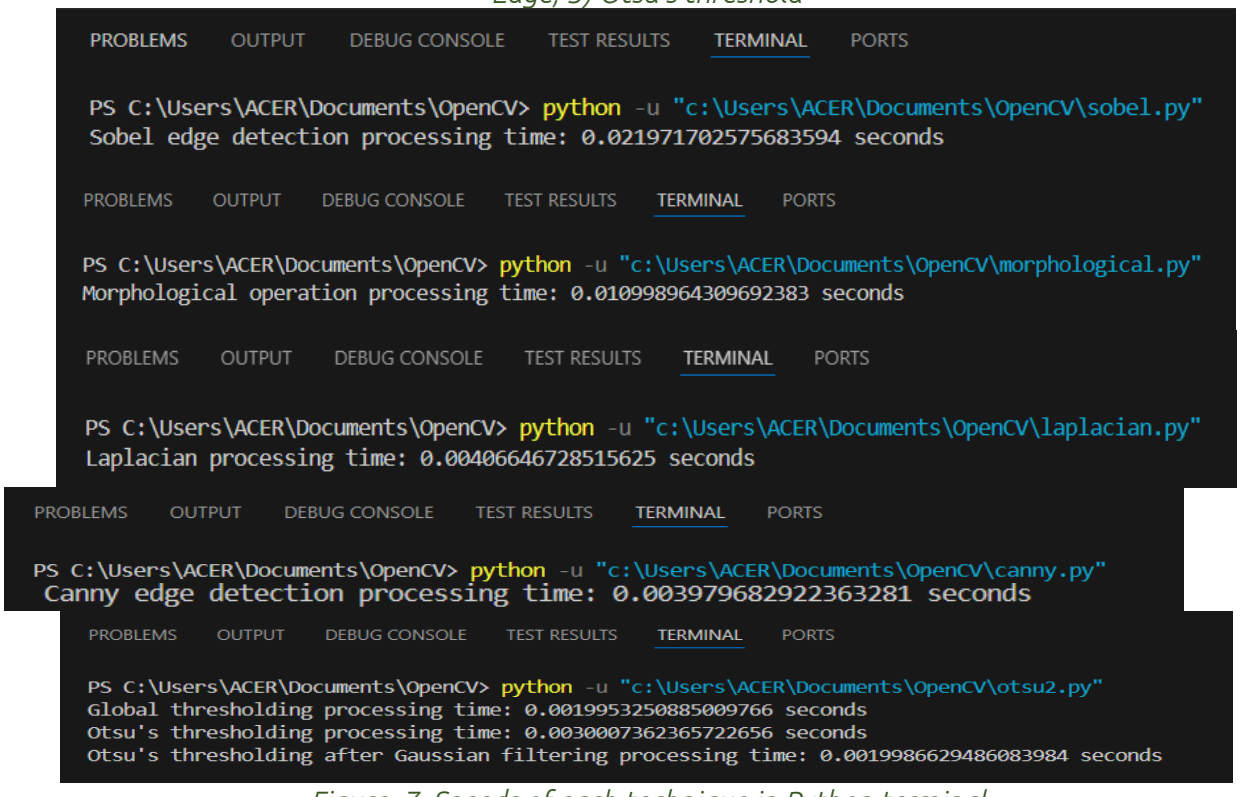

Figure .7. Speeds of each technique in Python terminal

Each technique exhibits distinct capabilities in detecting various parameters such as the length, width, and depth of cracks. Notably, both the Sobel operator and morphological methods demonstrate limitations in noise reduction, resulting in the presence of numerous features in the output. Similarly, the Laplacian technique fails to provide an accurate depiction of the crack skeleton. In contrast, Canny edge detection and Otsu's thresholding emerge as superior options, effectively detecting both the length and skeleton of cracks.

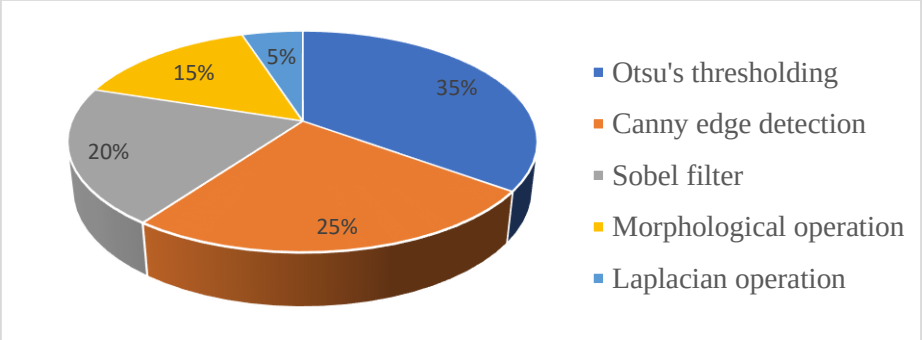

Figure 8. Crack detecting accuracy proportion

These findings imply that the chosen image processing techniques are suitable for the intended applications. Overall, the observed speeds align well with expectations, indicating effective performance for the selected image processing tasks. And I also concluded that every techniques show different results on their crack feature detections which I illustrated in Figure 4.8.

According to practice, Otsu's thresholding technique is used more often, and I have determined in practice that I achieved these results. This technique detects cracks very clearly and faster than other used techniques, and I will take advantage of this in my crack detection process.

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STATISTICAL INFORMATION PROCESSING IN RADIO ENGINEERING SYSTEMS

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Abstract

Very often in radio engineering systems (for example rocket-and-space technics), the measured data represents a broadband non-stationary random process. The use of traditional processing methods that employ cyclic sampling results in high computational costs and large memory requirements, especially when dealing with onboard radio telemetry systems. As a rule, when processing random processes in such systems, restoration of the original implementation on the receiving end is not required, and processing involves calculating probability characteristics. In this case, data processing has a number of features. First, random processes are always represented by a single implementation. Second, a priori knowledge of the probabilistic properties of the measured random process is not always possible. Third, there is a need for real-time processing, which predetermines the use of fast processing methods. The article discusses the possibilities of applying methods of nonparametric decision theory to estimate the probabilistic properties of nonstationary broadband random processes in radio engineering systems.

Keywords: *radio engineering systems, random process, data compaction, nonparametric methods, order statistic, stationarity hypothesis.*

Introduction

Volume compaction of transmitted message without loss of its information content for a recipient was always topical issue at the processing of data in the radio engineering systems. Importance of this problem increases at the necessity to process heavy amounts of data in tight schedule.

It acquires special relevance due to the sharp increase in the processed data volume as well as in need to more detailed study of measured processes.

This requirement, of course, leads to the considerable complication in data transmission systems and radio-technical communication channels.

Solution of the problems is possible at using of so-called data compaction methods.

Normally, the broadband processes which constitute only (10-30) % of the general nomenclature for measured parameters but load transmitting channel on (60-80) % occupy a dominant position in the spectrum for measured parameters. Thus, the problem on compaction of broadband signals becomes particularly relevant.

For compaction of broadband signal can use noninvertible data compaction methods which concluded in determination on the receiving side of information and measuring systems for probabilistic characteristic evaluation of the measured random processes and their transmission on communication channels.

Methods

Difficulties in then on invertible compaction methods are considerably higher, despite the fact that their effectiveness in terms of data compression is much higher. This is because data processed on the board very often present the sole implementation of non-stationary random processes in the absence of priori data on the form of distribution function. Modern mathematical statistics does not have methods to evaluate probabilistic characteristics of such processes.

Evaluation of the non-stationary random process probabilistic characteristics is possible on the basis of adaptive dynamic observational series division on stationarity sections using nonparametric solution theory [1,2]. Thus, the measured process structure can be described by additive-multiplicative model of the next form (Figure 1):

$$y(t) = X(t) + F(t),$$

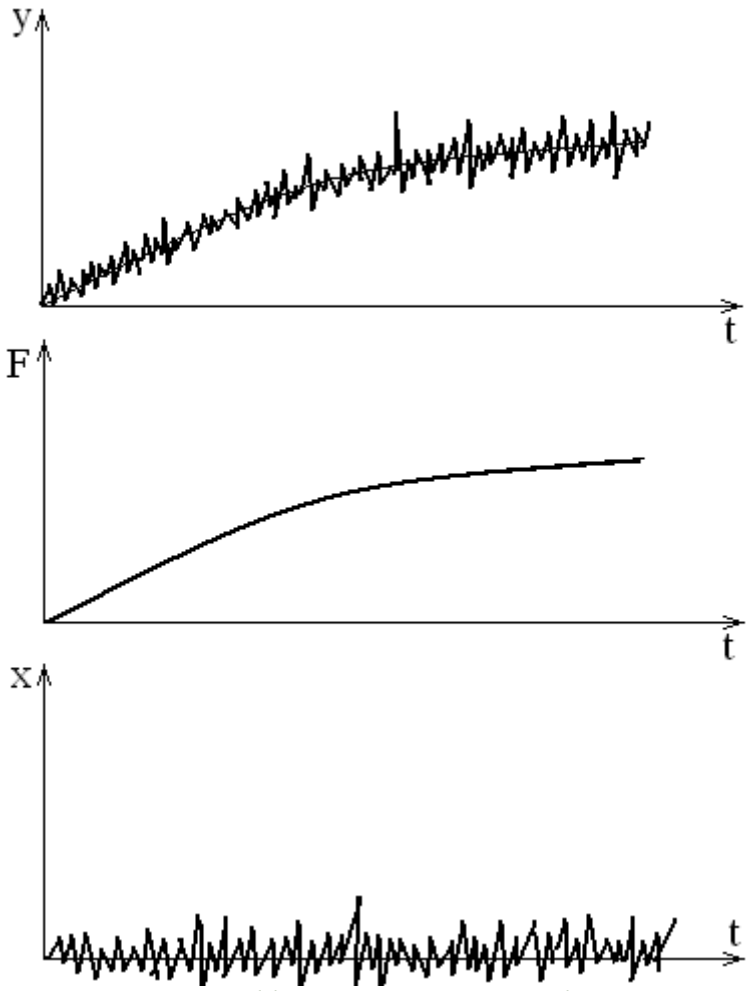

Figure 1. Additive-multiplicative model of the signal

The main point of the methods is concluded in checking of the statistical hypothesis on stationarity on the basis of the measured process sampling data using nonparametric statistics.

The article advances observation interval separation technique on stationarity intervals which functional diagram is shown on Figure 2.

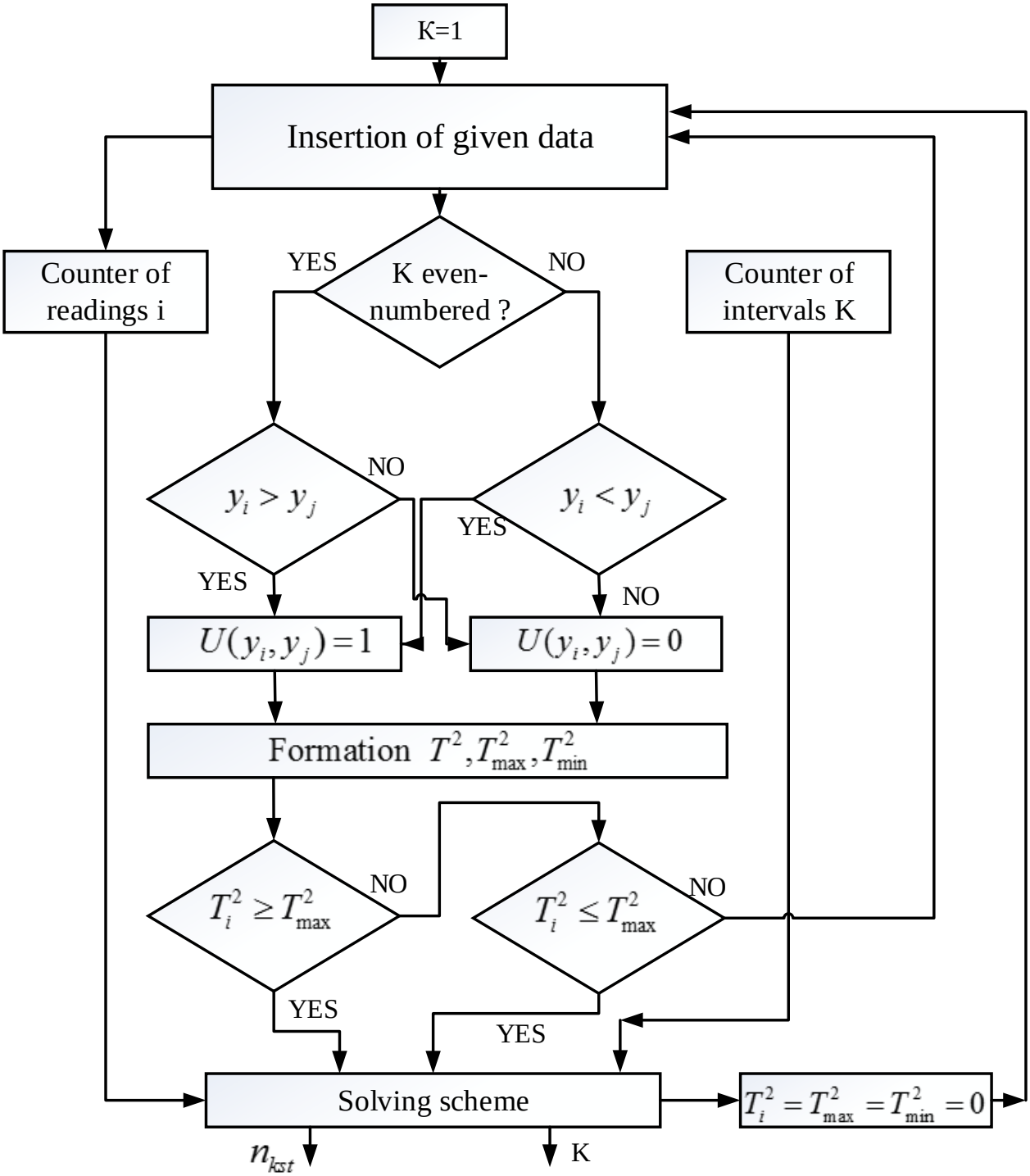

Figure 2 -Separation algorithm of the observation interval on stationarity intervals

The algorithm works as follows. Nonparametric statistics, known in literature as Kendal statistics [3,4,5,6] is formed by y_i, y_k sampling data of the measured process.

$$T^2 = \sum_{i=1}^{n-1} \sum_{k=i+1}^{n} u(y_i, y_k),$$

where:

$$u(y_i, y_k) = \begin{cases} 1, y_i \geq y_k \\ 0, y_i \leq y_k \end{cases}$$

Not only "transfer" of $u(y_i, y_k)$ sign function into the converse, but also clearing of extended inversions and admissible boundaries into the null state occur after determination of quasi-stationarity interval. By raw scores of the observed range, evaluation of elementary inversions, according to which

sum of inversions of the second kind T_i^2 *and admissible boundaries* $T_{\max}^2$ *and* $T_{\min}^2$ *are formed, occurs. Further we can see comparison of* T_i^2 *function with* $T_{\max}^2$ *and* $T_{\min}^2$*, i.e. formation of the statistical hypothesis on stationarity occurs for the set level of ameaning. "Transfer" of* $u(y_i, y_k)$ *sign function into the converse, and also clearing of the extended inversions and admissible boundaries into the start state* $T_i^2 = T_{\max}^2 = T_{\min}^2 = 0$ *occur in equality moment of the extended inversions with one of the admissible boundaries (Figure 3). Further, the evaluation process of* $T_i^2, T_{\max}^2, T_{\min}^2$ *and comparison procedure is repeated for a new stationarity interval. By this means, the dynamic observational series is divided into any quantity of sections of different length on which a process with specified probability is considered to be stationary.*

Later, obtained on the stationarity intervals data are ranged in the order of increasing or decreasing with the following estimation of the probabilistic characteristics on the basis of order and rank statistics of the ordered series [7]. The article shows methods for valuation of mean value and mean-square deviation(dispersion) of the random process. For the valuation of mean value have used central order statistics of the ordered series $\tilde{m}_{11} = x(c)$*, and for the valuation of dispersion (more precisely, mean-square deviation) in the nonparametric statistics we have applied the simplest range and subrange functions using extreme order statistics of the ordered series [8]:*

$$\tilde{\sigma}_{11} = \nu(x_{(N)} - x_{(1)}),$$

$$\tilde{\sigma}_{12} = \nu(x_{(N-1)} - x_{(2)}).$$

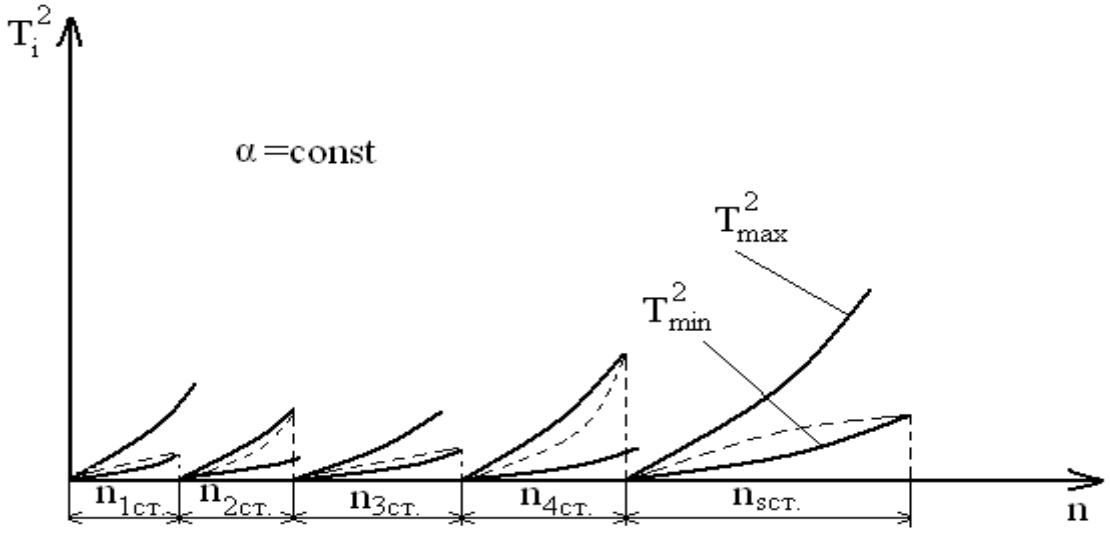

Figure 3 -Separation of the observational data on the stationarity intervals

Results

Error analysis of the mean and mean-square deviation values in the random process had been carried out by statistical modeling method in Mathcad environment.

Random function X(t) with distribution function of rnorm (N, μ, σ) form having normal distribution with mean μ and mean-square deviation σ >0 (for example μ=1, σ=0) have been used for the modeling.

Signal (trend) F(t)has been stipulated on the random function of the next form

$$F(t) = A \cdot (1 - \exp(-a_1 t)),$$

whereAand a1are varied in different limits for the modeling aims.

Trend of F(t) = t form has been stipulated in a number of cases.

In a result we have generated the non-stationary random process (Figure 4):

$$Y(t) = X(t) + F(t)$$

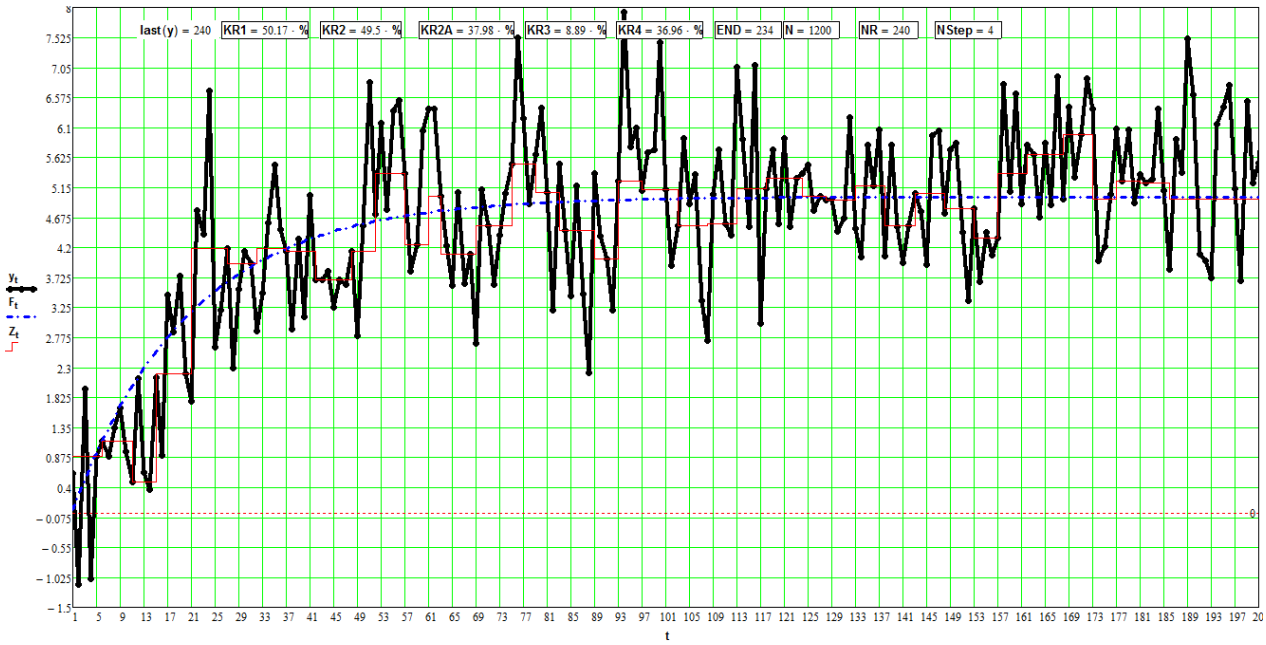

Figure 4 -Generating example of the non-stationary random process

Valuation of the mean value by $\tilde{m}_{11} = X(c)$ *formula allows in point of fact approximate F(t) trend by graduated multinomial (multinomial of zero power) (Figure 5). On the figure we have four sections of quasi-stationarity with the length in 9 readings, 35 readings, 57 and 59 readings respectively.*

The modeling results showed the following.

Error of the estimated mean essentially depends on the trend form and on the proportion of random and nonrandom components ("random signal/trend" relationship) [9, 10].

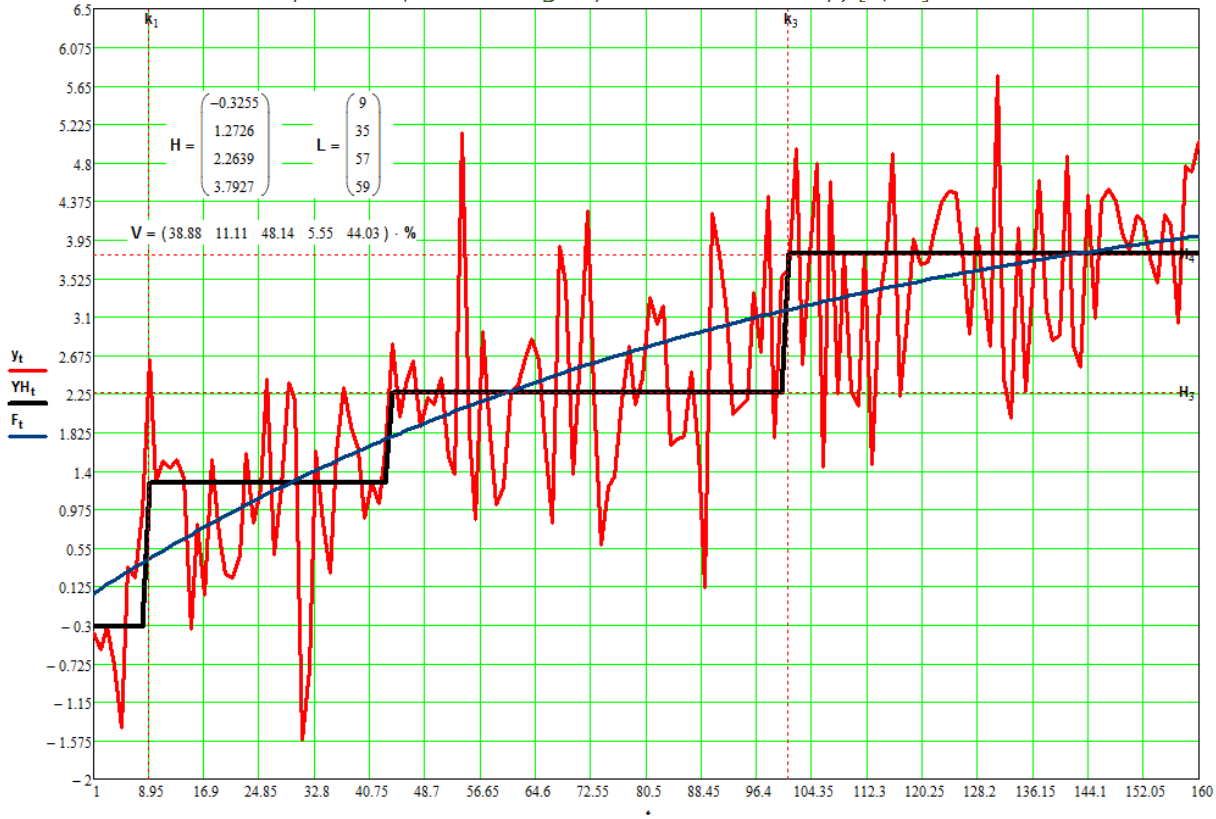

Figure 5 -Separation of the non-stationary component

The relationship change in the stationary component power to the non-stationary component amplitude ("random signal/ trend" relationship) leads to the change in the estimated mean error value. Thus, change in the "random signal/ trend" relationship within the range from 0,14 to 0,8 leads to the error increase by factor of 3 (Figure 6 and Figure 7).

The fore cited dependences point on the presence of clear-cut error minimum of the non-stationary estimated mean which is in the range of a = 0,05 ÷ 0,06 significance level. Error increase at avalues, which are out of this range, is explained by two properties. On the one hand there is increase in the stationarity hypothesis region at a < 0,05 values that leads to the decrease in the non-stationary component separation accuracy. On the other hand there is decrease in the quantity of readings for the stationarity participation at the decrease in the stationarity hypothesis region (a>0,06) that leads to the increase in the estimated mean error. a = 0,05 ÷ 0,06 minimum position does not depend on the trend character and the "random signal/ trend" relationship.

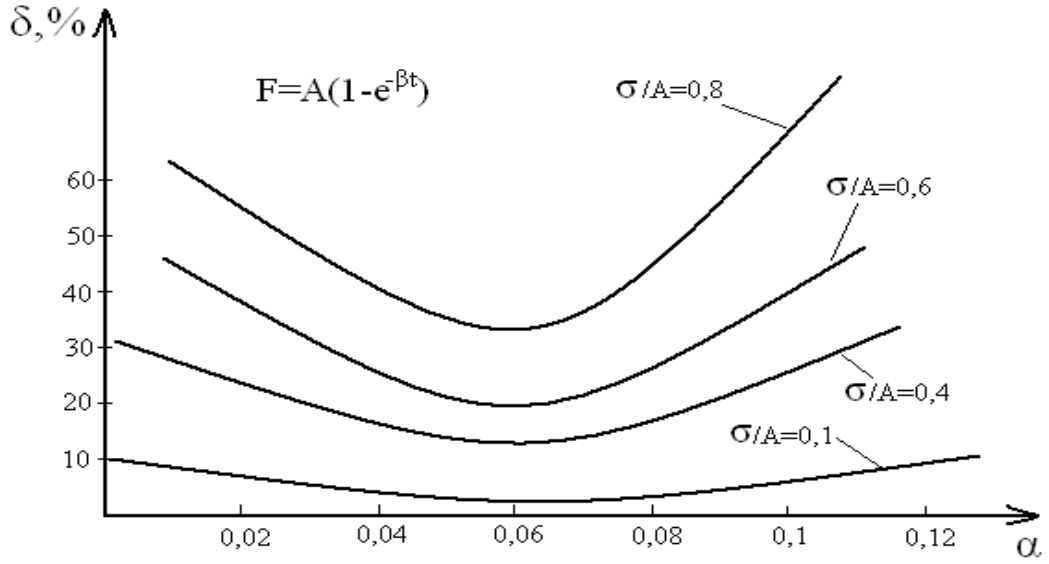

Figure 6 - Error of the estimated mean

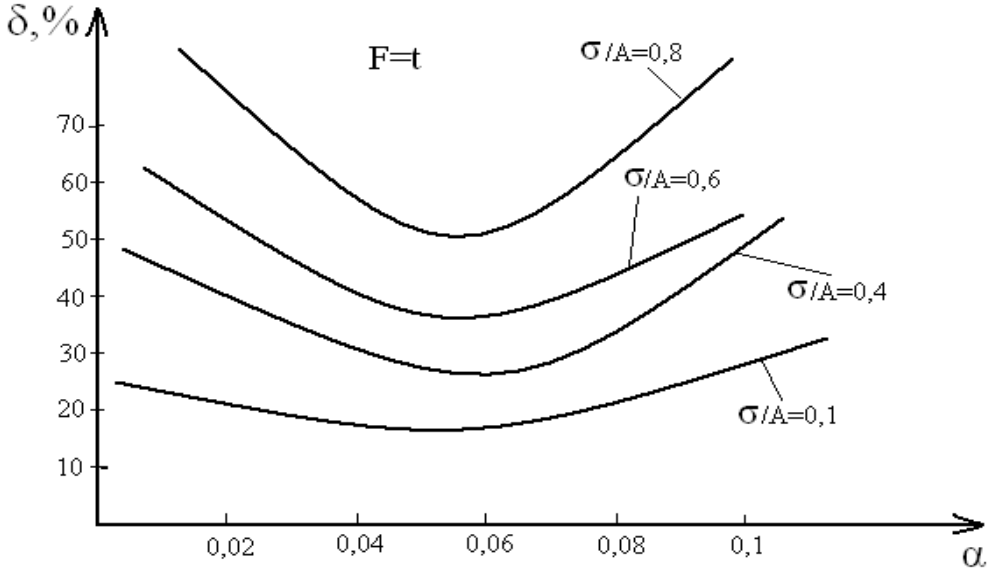

Figure 7 - Error of the estimated mean

In estimation of the dispersion it is reasonable to use the same ordered series of the order statistics that is used for the estimation of mean. In this case it is better to estimate not the process dispersion itself, but the least square attitude.

Different combinations of the central order statistics and extreme order statistics are possible [6]:

$$\sigma_{2j} = \nu(X_{(N-j+1)} - X_{(c-j+1)})$$

Analysis of the performed researches showed that at the fixed value of v coefficient there are no reasonable estimates in the wide range of N change. On Figure 8 we introduce error values for different estimates at various v coefficients in relation to the sample size for uncorrelated counts. It is seen from the fore cited dependences that the value of v coefficient should be specified by decision directed character, proceeding from the sample size.

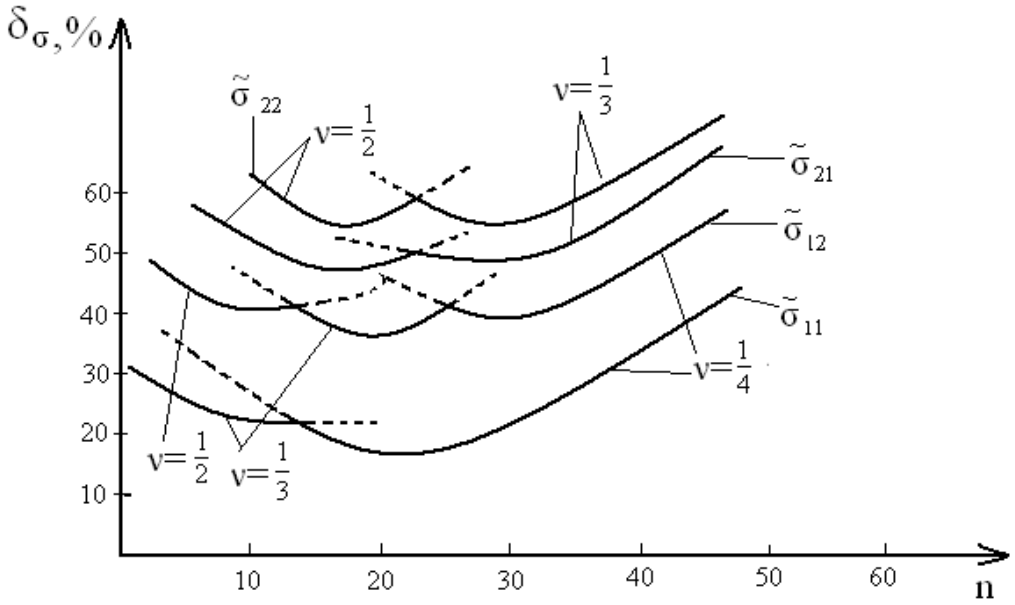

Figure 8- Errors of the mean-square deviation estimates

Conclusion

Random processes in the radio engineering systems (for example rocket-and-space technics), as a rule, are represented by the sole implementation in conditions of expected uncertainty on the kind of distribution function. Processing of such processes on-line is possible using nonparametric solution theory methods. The present work considers technique for the dynamic observational series division on stationarity intervals with the following valuation of mean values and dispersion.

In the future we are planning to perform researches on valuation of the distribution function and correlation function of the non-stationary broadband random process.

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