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International Conference:
Modern Information Technologies for Society

Book of Abstracts

Editors:

- Małgorzata Plechawska-Wójcik
- Karolina Rybak
- Grzegorz Kozieł

Polish Information Processing Society

Lublin 2025

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Preface

The International Conference *Modern Information Technologies for Society (MITS'2025)*, organized by the Department of Computer Science at Lublin University of Technology in cooperation with the Polish Information Processing Society, Lublin Branch, the Lublin Scientific Society, and the Hieronim Łopaciński Provincial Public Library in Lublin, Poland, has a long-standing tradition and is the eighth event in its series.

The origins of this conference trace back to the seminar *"3D Technologies in Museum Studies"* held by the Institute of Computer Science (ICS) on 15 January 2018 at the Zamoyski Museum in Kozłówka, Poland. The first international conference, *"IT in Cultural Heritage Management" (IT-CHM'18*), was held on 16–18 October 2018 in Lublin. It was a direct outcome of two scientific expeditions conducted by ICS researchers to Central Asia in 2017 and 2018. The scientific activities of ICS staff in Central Asia soon became a permanent element of the institute's research calendar, inspiring subsequent expeditions and new editions of the conference. On 22 May 2019, the next conference in the series, *IT-CHM'19*, was held in the Registan complex in Samarkand, Uzbekistan.

The following international conferences were organized within the project *"3D Digital Silk Road"*, funded by NAWA under the International Academic Partnerships Programme. Due to the pandemic, the event took the form of a web conference, *"The Silk Road – the Cultural Heritage of Asia and Europe"*, held on 8–9 January 2021. The presented papers were later published in two monographs: *Intangible Cultural Heritage of the Silk Road from the Area of Modern Uzbekistan* (eds. Marek Miłosz and Gafurdjan Mukhamedov) and *Tangible Cultural Heritage of the Silk Road from the Area of Modern Uzbekistan* (eds. Elżbieta Miłosz and Dilbar Mukhamedova). The next conference, *"IT in Cultural Heritage of the Silk Road" (IT-CHSR'21)*, was hosted by Lublin University of Technology on 13–15 December 2021. Based on oral and online presentations, two more monographs were published: *Cultural Heritage of Uzbekistan: from Petroglyphs to the Present Days* (eds. Jerzy Montusiewicz and Bakhodir Eshchanov) and *Computer Technologies in Sharing the Cultural Heritage and Education of the Silk Road from Uzbekistan* (eds. Jerzy Montusiewicz and Utkir Abdullaev). The closing conference of the *3D Digital Silk Road Project* took place on 7–9 September 2022 in Tashkent, Chirchik, and Samarkand, Uzbekistan.

Following tradition, another international conference, *"IT in Cultural Heritage" (IT-CH'2023)*, was held on 24–26 October 2023 in Lublin. The presented papers were published in the monograph *Protection, Sharing and Management in the Area of Cultural Heritage and in the Field of Digital History* (eds. Aziz Mullaev and Mariusz Dzieńkowski).

The cooperation between the staff of the Department of Computer Science (formerly ICS) and universities and museums in Central Asia, particularly in Uzbekistan, Kazakhstan, and Kyrgyzstan, continues to flourish. A tangible outcome of this collaboration is this year's conference in Lublin, which included oral, poster, and online sessions.

The International Conference: Modern Information Technologies for Society (MITS'2025) was held on 11–12 December 2025. The event brought together an international group of researchers from both Europe and Asia working in the broad field of information processing techniques, both computerized and traditional, applied for the benefit of society. The presented methods and approaches represented a wide range of disciplines, from the exact sciences to the humanities.

The conference provided researchers with an opportunity to exchange experiences, ideas, and scientific interests in areas such as 3D technologies in cultural heritage, artificial intelligence, software and device accessibility, language processing, digital history and archives, inclusive digital tools, data and signal processing, security systems, and general ICT applications. Participants presented their work during oral, poster, and virtual sessions.

The papers collected in this volume were prepared by authors representing academic institutions and organizations from Uzbekistan, Kazakhstan, Kyrgyzstan, China, as well as several European countries, including Spain and Poland.

We would like to express our sincere gratitude to all contributors for their valuable input to this book.

Małgorzata Plechawska-Wójcik, Karolina Rybak, Grzegorz Kozieł
(Lublin University of Technology, Lublin, Poland)

Abstracts

Digital Modelling of the Cultural Heritage of the Silk Road: Experience and Prospects of Uzbekistan

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The digital transformation of the humanities has opened new approaches to studying and preserving historical and cultural heritage. One of the most dynamically developing directions is digital modelling, which enables the recording, analysis and visualisation of material culture objects in an interactive form. For Uzbekistan – located at the heart of the Great Silk Road – this practice holds particular significance, as the country is home to numerous architectural and archaeological monuments that reflect a millennia-long history of cultural exchange between East and West.

In recent years, projects for 3D digitisation and virtual reconstruction of historical monuments in Samarkand, Bukhara and Khiva have been actively developing in the republic. In collaboration with international partners, particularly within the framework of the "3D Digital Silk Road" initiative, modern methods of laser and photogrammetric scanning, 3D modelling and visualisation in virtual reality (VR) environments have been implemented. The resulting digital replicas of architectural sites not only ensure their preservation, but also serve as valuable resources for museums, educational programs and virtual tourism.

Uzbekistan's experience demonstrates that the integration of digital modelling technologies into the field of historical and cultural studies promotes the development of scientific infrastructure, the formation of digital memory and international cultural exchange. The future of this direction lies in creating a unified database of Silk Road monuments, expanding interdisciplinary cooperation and applying artificial intelligence to the analysis of digital sources.

Keywords

Digital history; 3D Digital Silk Road; Khiva; Samarkand; Bukhara

Digital History of Central Asia: 3D Technologies and Virtual Methods of Cultural Heritage Preservation

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In recent decades, digital technologies have become an integral part of historical research, opening up new opportunities for recording, analysing and interpreting the past. Central Asia, with its rich cultural heritage, has become the focus of international scientific projects aimed at its preservation through the tools of digital history. One of the most promising directions is the use of 3D scanning, 3D modelling and virtual and augmented reality (VR/AR) technologies for documenting and reconstructing architectural monuments and archaeological sites.

Within the framework of the "3D Digital Silk Road" project and several local initiatives in Uzbekistan, high-precision laser and photogrammetric scanning methods have been tested, allowing the creation of digital replicas of the architectural complexes of Samarkand and Khiva. These models not only ensure the preservation of visual information about monuments at risk of destruction, but also serve as tools for virtual reconstruction and educational use. Integrating 3D data with historical sources and Geographic Information Systems (GIS) contributes to a deeper understanding of the spatial and cultural connections of the Great Silk Road era.

The aim of the study is to demonstrate the potential of digital history as an interdisciplinary field that unites historians, engineers and IT specialists to address issues of cultural heritage preservation. The experience of Central Asia shows that 3D technologies not only preserve the memory of the past but also create new forms of public access, virtual museums and digital memory of the region.

Keywords

3D modelling; digital history; GIS; VR

Use of TLS Scanning Technology for a 3D Inventory of Relief Changes in the Loess Gully Catchment Area in Mareczki (Nałęczów Plateau, Poland E)

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The loess relief of the Nałęczów Plateau is characterised by the occurrence of a set of distinctive forms, among which gullies stand out the most. These forms are relatively young, and their formation and development is mainly associated with human agricultural activity. At present, intensive relief changes are observed within some parts of the gullies, where a process of piping is taking place, leading to the formation of new forms and the development of existing ones. They are usually located in places that are difficult to access, and the dense vegetation makes field surveys even more difficult. An additional problem is their complex morphology, which makes them not well mapped by ALS scanning. Thus, their accurate inventory requires the use of a different technology, adequate to the complexity of the forms.

Field research was conducted in spring 2025 in the catchment of the loess gully “Mareczki” (0.82km2) located on the Nałęczów Plateau, west of Wąwolnica. The catchment is used agriculturally as arable land, while its bottom and the gully there, which is the main focus of interest, is covered with forest and shrubs. TLS scanning of representative piping forms was carried out, allowing rapid and highly accurate data collection of their morphology. Once the point clouds were cleaned, high-accuracy data were obtained, accurately representing the whole forms and all their details. The data were analysed to determine the type and intensity of the morphogenetic processes taking place, volume calculations, and morphometric features. Repeated measurements are planned in order to delineate active zones, monitor the changes taking place, determine the intensity of morphogenetic processes, and quantify them.

Keywords

geomorphology; loess relief; piping; lidar scanning; relief changes

IT Technologies in the Study and Preservation of Christian Churches in Samarkand

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Modern IT technologies have become an integral part of the humanities, particularly in the study and preservation of cultural and spiritual heritage. One of the most relevant applications of these technologies is the research and digital reconstruction of Christian churches in Samarkand – unique monuments of architecture, art and history. Due to the effects of time, natural factors and human activity, many of these sites face the threat of destruction, which calls for innovative approaches to their preservation.

This paper explores the main directions of using information technologies for the study and documentation of Christian churches in Samarkand. Special attention is given to 3D modelling, photogrammetry, laser scanning and virtual and augmented reality technologies, which make it possible to create accurate digital replicas of architectural sites. These models are used to analyse architectural features, conduct virtual restorations and organise online exhibitions, making cultural heritage accessible to a wider audience.

The study also highlights the importance of Geographic Information Systems (GIS) and databases for systematising information about the churches – including their historical evolution, architectural characteristics and current state of preservation. The application of artificial intelligence and machine learning enables automated image analysis and the detection of structural damage to architectural elements.

Thus, the use of IT technologies in the study and preservation of Christian churches opens new prospects for interdisciplinary research and practical restoration. The integration of digital tools provides a deeper understanding of cultural values, enhances the effectiveness of preservation efforts and promotes the spiritual and cultural heritage among diverse social groups.

Keywords
IT technologies; cultural heritage; Christian churches; 3D modelling; digital reconstruction; virtual reality; architectural preservation

From Stone to Screen: Digital Heritage Preservation in Open-Air Petroglyph Museums

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This article examines the role of digital technologies in the protection and study of the cultural heritage of open-air petroglyph museums. Petroglyphs, unique monuments of ancient art, are at risk of destruction due to natural and anthropogenic factors. Modern digital methods, such as 3D scanning, photogrammetry, geographic information systems, and the use of drones, enable the precise recording, monitoring, and digitization of objects. The creation of digital archives and virtual museums ensures long-term data preservation and expands access to cultural treasures for researchers and the general public. Furthermore, the implementation of augmented and virtual reality technologies promotes the popularization of cultural heritage and the development of the region's tourism potential. Thus, digitalization is becoming a crucial tool in the preservation and transmission of historical and cultural heritage to future generations.

The digitization of exhibits in The Petroglyphs of Cholpon-Ata Open-air Museum near Lake Issyk-Kul in Kyrgyzstan is presented in detail. A significant portion of the rock art in the museum is degrading due to weather conditions (high-mountain plateau) and poor conservation. Terrestrial 3D laser scanning and close-range photogrammetry were used. The most valuable rock art stones from the open-air museum were scanned. The resulting 3D models of the stones constitute a valuable virtual museum, preserving examples of ancient art. Thanks to the scanner's built-in GPS receiver, the location of the rocks was fixed.

Keywords
digital technologies; petroglyphs; cultural heritage; 3D scanning; GIS; virtual museum; preservation

Generating 3D Models of Historic Liturgical Vestments – Challenges and Practical Applications

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Historical garments, including secular attire (such as noblemen's kontuszes, courtly and women's dresses) and liturgical vestments (chasubles, dalmatics, copes), are traditionally archived as photographic series documenting them from multiple perspectives, accompanied by descriptive catalog cards. In museum practice, these objects are usually displayed on hangers within wall-mounted glass cases, and less frequently on mannequins positioned in freestanding vitrines. Historical liturgical vestments were typically made of silk, velvet, damask, or brocade; in the 19th century, they were also sewn from noblemen's kontusz sashes (their wearing was banned during the partition period). The vestments were richly embroidered with silk, silver, and even gold threads, creating sacred, floral, and geometric motifs.

The objective of this study is to explore the possibilities of archiving historical liturgical vestments through the creation of digital 3D models using structured-light scanning (SLS) and close-range photogrammetry (NPG). A pilot 3D digitization campaign was conducted at the Archdiocesan Museum of Religious Art in Lublin, with additional vestments provided by the Museum of the John Paul II Catholic University of Lublin. Two chasubles from the 18th and 19th centuries, mounted on mannequins, were scanned using an Artec Eva structured-light scanner combined with close-range photogrammetry.

The resulting textured 3D mesh models exhibit a high level of geometric and chromatic detail, making them suitable for both long-term digital archiving and online presentation. The combination of SLS and NPG techniques enables the acquisition of precise dimensional data as well as detailed surface color reproduction. The presented technological approach proves particularly useful within the rapidly evolving domain of digital exhibition practices, enhancing the preservation, accessibility, and interpretative potential of textile heritage.

Keywords
historic liturgical vestments; 3D model; 3D scanning; SLS; NPG

The Use of AR and VR Technologies in Teaching History in General Education Schools

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This article examines the possibilities, advantages, and effectiveness of employing Augmented Reality (AR) and Virtual Reality (VR) technologies in the teaching of history in general education schools. The didactic potential of presenting historical events, monuments, and cultural heritage objects in an interactive and immersive manner using AR and VR technologies was analysed. Furthermore, the study assessed the impact of these technologies on students' historical thinking, memory, and perception of historical events. The research findings indicate that the use of AR and VR technologies significantly enhances students' interest, motivation, and comprehension of historical subjects.

Keywords
AR technologies; VR technologies; history education; immersive environments; digital pedagogy; experiment

On the Usability of Isolation Forest for 3D Mesh Analysis and Watermarking

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Three-dimensional assets have become a key element in the fields of electronic entertainment, medicine, and engineering. Unfortunately, 3D models contain large amounts of data that are not easily suitable for analysis or simple algorithms. Unlike standard datasets with separate observations and a fixed number of features that can be directly analysed, here the vertices (data points) are distributed in a highly irregular way. This creates challenges in applying many algorithms. This study thoroughly examines the usability of the traditional Isolation Forest (IF) method as a new tool for 3D mesh analysis. Due to the unusual nature of 3D model data, it was necessary to generate a special multidimensional feature vector (FV) for each vertex. The FV captures information about the local surface curvature around a vertex. As shown by experimental results, the IF analysis can identify geometric details, dense and complex regions, strong bends, and folds in the mesh. Vertices in these areas are classified as anomalies by IF. Several scenarios and models were analyzed, including different neighbourhood sizes around a vertex, meshes with tens of thousands of vertices, and low-poly models. The results reveal significant steganographic potential, which led the authors to apply these findings to 3D mesh watermarking as a practical example. Using IF, a new steganographic method was developed that offers higher transparency, by hiding data in areas of complex geometry. The study demonstrates the high potential of Isolation Forest for analysing and watermarking 3D models, marking an important step towards wider use of Isolation Forest in this field.

Keywords
isolation forest; 3D mesh analysis; 3D model; watermarking; steganography

Towards the Democratisation of 3D Archiving – iPhone LiDAR System: Lemko Gravestones in the Village of Bałucianka (Poland) – a Case Study

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Cemetery archiving often involves digitising grave registers and creating cemetery maps with information about tombstones. Although the Ministry of Digital Affairs announced at the end of 2021 the development of a central digital search for cemeteries and burial sites, these activities will not include cemeteries and tombstones located in areas from which, due to geopolitical changes, populations were forcibly relocated abroad or to new territories. Over the years, these tombstones have been subject to natural degradation and devastation. Local historians, recognising this, have been working in the Lemko region (Beskid Niski) since 1986 to describe and physically rebuild selected cemeteries, formalising their activities by establishing the "Magurycz" Association. With the current development of 3D computer technologies, it has become possible for individuals to become involved in documenting surviving tombstones – the time has come for 3D archiving to become more democratic. Tombstones, which are objects of cultural heritage, resemble sculptures in their artistic form and size, so close-range photogrammetry (NPG) or terrestrial laser scanning (TLS) are currently used for their 3D digitisation.

The article describes a method for creating a 3D archive of all 10 of the more than 100-year- old tombstones in a small cemetery in the former Lemko village of Bałucianka (approximately 8 km south of Rymanów Zdrój). The LiDAR system on an iPhone 16 Pro Max smartphone with the Scaniverse app was utilised to generate meshed 3D digital models. Data acquisition was carried out in the "Medium Object" mode (range up to 2.5 m) and processed in the "Area" mode (5 mm resolution) and "Detail" mode (for textured objects). A quick scan of sections of the cemetery was also performed to gather data on the tombstones' locations. The resulting digital 3D models were of good quality; all preserved inscriptions are legible, and the "Measure" tool allows for measurements. Exporting the 3D models to .obj format and transferring them to widely available graphics programmes enables further processing. The generated models can also be easily shared online and become a public resource.

Keywords
LiDAR system; iPhone; 3D model; 3D scanning; Lemko region; heritage culture

3D Archiving of Historic Architectural Structures for Conservation and Redevelopment: a Case Study of the H. Łopaciński Provincial Public Library Building in Lublin

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The renovation and revitalisation of historic buildings supervised by heritage conservation authorities pose significant challenges for both owners and designers. Traditional documentation methods, including sketches as well as conceptual and technical drawings, are time-consuming and, when multiple design variants are required, become prohibitively expensive. Modern reverse-engineering techniques can substantially facilitate and accelerate these processes.

This article presents a procedure for creating digital documentation of a historic building using a three-dimensional point cloud generated through Terrestrial Laser Scanning (TLS). Measurements were carried out for the façade of the municipal library, located in a structure built between 1935 and 1939 that connects two wings of an eighteenth-century Piarist monastery, as well as for the entrance hall and a room containing traditional drawer-based catalogues. Due to the complex geometry of the façade, including arched arcades, the digitisation process required several dozen scans of both the exterior and interior, which were subsequently merged into a unified point-cloud model. The recording of surface colour information enabled the detailed reproduction of the nearly 100-year-old floor in the hall, whose pattern is intended for reuse in the upcoming revitalisation project. Exporting the data in the universal .e57 format ensured rapid integration with specialised design software.

The achieved spatial accuracy – on the order of millimetres with respect to the physical structure – and the ability to extract all required measurements directly from the 3D digital model give this approach a clear advantage over traditional documentation techniques based on isolated geometric measurements. Moreover, the generated mesh model of the room containing the traditional library catalogues offers additional educational and dissemination potential by presenting the library's history in a virtual form.

Keywords
historic architectural objects; 3D models; 3D scanning; TLS; reverse engineering

Digital History of Art – Prospects and Opportunities as Exemplified by Polish Sacred Cultural Heritage in the USA

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Traditional documentation of historical architectural objects typically consisted of architectural plans, manually acquired measurements, sketches, and a series of photographs accompanied by descriptive notes regarding their positioning and context. With the accelerating development and increasing accessibility of digital technologies, including advanced 3D graphics, new possibilities have emerged for contemporary art historians.

At present, the process of cultural heritage digitization can be conceptually divided into two distinct yet complementary stages. The first involves shape and color acquisition, carried out primarily by specialists representing broadly defined computer science and engineering disciplines, such as scanning engineers and computer graphics experts, supported when needed by art historians. The second stage encompasses historical classification and description of architectural components and interior furnishings, conducted by domain experts in art history, both in situ and through analysis of the digital outputs obtained during the previous phase.

The purpose of this study is to demonstrate the effective collaboration between specialists from both areas of expertise. The 3D digitization process, based on terrestrial laser scanning (TLS) and near photogrammetry (NPG), enabled the generation of precise point cloud and mesh-based digital models of Polish churches: St. Josephat in Milwaukee, Wisconsin, and St. Archangel in Radom, Illinois, USA.

High-detail models – based on scans of 2mm accuracy and texture-mapped using color data from NPG – were utilized for the detailed documentation of church interiors, architectural elements, furnishings, stained-glass windows, paintings, and inscriptions.

The ability to freely explore and magnify any part of the model made it possible to substitute physical examination of fragile or not easily accessible heritage elements with an analysis of their digital twins. The resulting 3D models constitute a form of permanent archival record of the historical architectural state of these monuments at the time of scanning.

Keywords
digital history of art; Polish sacred cultural heritage; 3D scanning; 3D model

Some Considerations on the Importance of 3D Modelling Technology in the Study of the Archaeological Heritage of Southern Uzbekistan

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In Uzbekistan, the study, preservation, and transmission of historical and cultural heritage monuments to future generations has become a matter of great significance. In this regard, adopting new approaches to archaeological heritage, as well as the restoration, conservation, museumification, and popularisation of ancient monuments, represents some of the most pressing contemporary tasks. The article notes that, as the scope of scholarly data expanded through the stages of studying the archaeological sites of Southern Uzbekistan, increasing attention was given to elucidating historical and cultural processes and to the crucial role of archaeological sources in achieving historical reconstructions. At the same time, it emphasises that the potential for applying modern technological advances in the field of ancient historical reconstruction, as well as the extent to which interdisciplinary approaches address these research tasks, has not yet been sufficiently realised. The distinctive features of Bronze and Early Iron Age architecture in Southern Uzbekistan have been identified. The discussion emphasises the importance of determining essential dimensions, adhering to the laws of geometric symmetry and architectural design principles, and the relevance of the scientific and practical outcomes of reconstructing structures based on 3D modelling technology.

Keywords

3D modelling; culture; archaeological heritage; Southern Uzbekistan; Bronze Age; architecture; site; museumification

3D Reconstruction of the Mausoleum of Amir Temur: Integrating Cultural Heritage with Technology

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This joint project by the Samarkand State Museum-Reserve and SMARTCHAIN (authors of the NazzAR platform) presents a comprehensive 3D reconstruction of the Mausoleum of Amir Temur. The work combines digital heritage documentation methods with modern visualisation technologies. The primary aim was to achieve a high-precision restoration of both the preserved and the lost architectural elements of the complex, including the left wing (madrasah) and right wing (khanqah), based on existing foundations and verified historical sources. The research utilised a diverse source base, including: the Album of Measured Drawings with a historical commentary by N. I. Veselovsky (1905) featuring the works of A. V. Shchusev and P. P. Pokryshkin; the archaeological observation report by Z. Zabelina (1943); the restoration project by E. Nurullaev (1996); as well as recommendations from the Museum-Reserve's General Director, M. K. Samibayev, and the Academic Council.

The methodology combined detailed 3D modelling, photogrammetry for digitising individual elements, 3D scanning, and artificial intelligence tools (for refining geometry and textures), followed by integration into the Unreal Engine and Unity game engines (programmed in C#). The model was verified using archival materials and expert evaluations, ensuring the scientific accuracy of the reconstruction. The results include high-realism visualisations and a demonstration video for museum visitors; the next stage involves deploying an interactive VR experience and integration into the metaverse.

The novelty of the project lies in its interdisciplinary approach, which brings together museum professionals and IT experts, as well as in the practical synthesis of archival science, 3D scanning, artificial intelligence, and real-time rendering. The resulting digital twin of the Mausoleum of Amir Temur serves as a tool for education (museum communication and AR/VR navigation), research (comparative analysis of architectural versions), and preservation (long-term data storage and reuse). Furthermore, the project establishes a reproducible production pipeline applicable to other cultural heritage sites.

Keywords
3D reconstruction; Mausoleum of Amir Temur; cultural heritage; digital heritage documentation; photogrammetry; 3D scanning; artificial intelligence; virtual reality; real-time rendering; digital twin

A Culture of Spatial Education Supported by 3D Printing Technology

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Public landscape space, our surroundings, should be regarded as a shared resource for all users and intentionally and responsibly shaped to meet their needs. The unattractive and inefficient spatial solutions we face stem from a lack of knowledge and skill in the culture of landscape design. This is caused by the insufficient spatial education in the Polish educational system (formal education) and a perceived lack of agency among space users. The educational gap in landscape design can be addressed by the "Landscape Space Game", a teaching tool based on simple shapes symbolising architectural objects (e.g., buildings) and landscape elements (e.g., trees, shrubs), generally called pawns, and a board representing the surroundings (e.g., street, river). The game mechanics mirror real spatial design – fostering silent cooperation between users without full awareness of each other's intentions. The game has been refined over several years. With the advent of 3D design and 3D printing technology, a new edition of the game has been developed. Benefits of using 3D printing include:

- enhanced durability of the pieces through durable materials,
- increased visual and tactile appeal thanks to a wide range of colours and structural variations,
- greater accessibility through customisation options,
- scalability by enabling users to share source 3D models for self-printing.

Similar to environmental education, the Landscape Space Game, supported by additive technologies, has the potential to educate a generation that consciously shapes their environment.

Keywords
3D printing; education; landscape; integration; game

The Use of AI and 3D Printing in the Reconstruction of Historical Monuments, on the Examples of Krzyżtopór Castle in Ujazd and the Palace in Bychawa

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Renovating architectural structures is one way to conserve cultural heritage for future generations. However, for structures that have already been partially destroyed or vandalised, reproducing their appearance is mainly achievable through reconstruction. Using the examples of the ruins of two historic monuments: Krzyżtopór Castle in Ujazd, which has been undergoing renovation for over a decade, and the Palace in Bychawa, we can illustrate how artificial intelligence supports the reconstruction process of these historic structures. The AI output data can include video recordings of the ruins, photographs of the site (from different periods), pictures of reproductions of paintings and preserved engravings of the buildings, as well as descriptions from literature. For all these sources, the final product is a 3D model, allowing spatial visualisation of the structure. The quality and accuracy of the final 3D model largely depend on the form of the input data. These 3D models can be utilised to create miniature, three-dimensional replicas of monuments, both in their current state and from earlier periods.

Keywords
3D printing; AI; reconstruction; Krzyżtopór Castle in Ujazd; Palace in Bychawa

3D Models of the Silk Road Small Artefacts in ICT Education

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Department of Computer Science (Lublin University of Technology) has been involved in long-term activities regarding 3D digitization of the Silk Road heritage. As the result, gigabytes of data were collected and processed, including clouds of points in 3D space, 3D mesh models, photographs, descriptions, etc. Such rich collection of materials, altogether with their rich historical legacy, motivated the authors to use some of them as an aid during the teaching process, especially during the computer graphics course conducted as the part of Computer Science studies. After analyses involving teaching outcomes and informal interviews, it was revealed that the Computer Science students achieved better outcomes, and that they were more engaged in learning activities. The study-covered period spans over almost the entire last decade. In future, the authors would like to focus more on gathering students' attitude data towards the inclusion of 3D models of the Silk Road heritage during the course of studies.

Keywords: 3D models; Silk Road; heritage; education; ICT; computer graphics

Artificial Intelligence as a Tool for Historical and Cultural Analysis: Studying Masculinity in Russian Travels to the Pamirs through the Case of Bronislav Grombchevsky

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In the modern world, artificial intelligence (AI) has become a universal instrument of scientific inquiry, transforming methods of data processing, textual analysis and cultural interpretation. Today, AI is applied not only in technical and natural sciences but also in the humanities – to uncover hidden patterns in historical sources, reconstruct narratives, and reinterpret cultural models.

This study focuses on the use of AI technologies – natural language processing (NLP), topic modelling and emotional-semantic analysis – to examine the writings of Russian travellers of the late nineteenth century. The focus is on Bronislav Grombczewsky (1855-1926), a Polish national, Russian officer and explorer whose expeditions to the Pamir Mountains in the 1880s and 1890s became part of the geopolitical rivalry between Russia and Great Britain known as the Great Game.

Using AI algorithms, the research performs a linguistic and discourse analysis of Grombchevsky's expedition reports and memoirs to identify representations of masculinity, heroism and imperial identity. AI helps to reveal how, through language, metaphors and descriptions of nature, the image of the "male explorer" was constructed – as a symbol of imperial superiority and scientific authority.

The study combines digital text analysis methods with the principles of gender history and cultural anthropology, demonstrating the potential of artificial intelligence as a tool for reinterpreting historical narratives in new and insightful ways.

Keywords
artificial intelligence; Pamirs; masculinity; Russian travellers; natural language processing; Great Game; cultural analysis

Cognitive Transformation of Negotiation Processes in the Age of Artificial Intelligence

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The rapid digitalisation of society and the rise of artificial intelligence (AI) are fundamentally transforming negotiation processes. This paper explores how cognitive and emotional mechanisms influence decision-making and trust formation in interactions involving AI systems. It highlights the neurocognitive differences in how humans perceive artificial agents compared with human counterparts, which affect empathy, cooperation, and ethical reasoning. The study also examines mindfulness and emotional intelligence as key moderators that help negotiators adapt to algorithm-driven communication environments and reduce cognitive bias. Integrating insights from social psychology, neuroscience, and game theory, the paper argues that traditional models of negotiation must be redefined to account for the presence of non-human participants and technological mediation. Negotiation in the AI era is not only a strategic process but also a new form of social cognition, in which emotional regulation, self-awareness, and technological literacy determine the quality of outcomes and the sustainability of agreements.

Keywords
negotiation; artificial intelligence; emotional intelligence; trust; cognitive mechanisms; digital transformation

One Approach to Improve Stroke Segmentation: a 3D U-Net Ensemble on Non-Contrast CT

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The aim of this study is to develop and evaluate the performance of a neural network ensemble based on three instances of the 3D U-Net architecture to enhance the accuracy and robustness of ischaemic stroke segmentation in medical imaging. The study proposes the adaptation of an ensemble approach that accounts for the specific characteristics of various medical data types and improves prediction quality by combining the outputs of multiple models. This approach helps to increase segmentation accuracy, reduce result variability, and make the model more resilient to noise in the data. The research utilises a dataset of CT brain scans from 50 patients with confirmed acute ischaemic stroke, collected by the International Tomography Center of the Siberian Branch of the Russian Academy of Sciences. All data are accompanied by manual segmentations of ischaemic lesions performed by experienced radiologists. Each scan underwent preprocessing procedures, including brain extraction, intensity normalisation, and contrast enhancement. Three identical 3D U-Net models were independently trained with different random weight initialisations to introduce prediction diversity. Their outputs were integrated using a weighted voting scheme based on the Dice coefficient of each model. Model performance was evaluated using standard segmentation metrics such as sensitivity, specificity, precision, and Dice score. The proposed ensemble achieved the highest Dice coefficient of 0.7008, surpassing single-model and existing approaches, including modified 3D U-Net and transformer-based architectures. A comparative analysis with previous studies confirmed the ensemble's ability to reduce random errors and enhance the reliability of ischaemic region detection. This outcome highlights the effectiveness of using an ensemble of deep learning-based architectures for medical image analysis.

Keywords
3D U-Net; CT; ischaemic stroke; deep learning; segmentation; ensemble of models

Polish National Dance Music Identification Based on a Convolutional Neural Network Utilizing Adaptive Feature Fusion

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Fusion techniques may introduce more promising results into the music recognition field when incorporated with prominent pre-trained classifiers including ResNet50 and VGG16. What is more, presenting a larger collection of data samples can also lead to attaining more notable outcomes. Hence, an innovative model based on feature fusion of four distinct inputs such as Mel-spectrograms, spectrograms, scalograms, and Mel-Frequency Cepstral Coefficients has been proposed. In addition, classification methods, previously pre-trained on ImageNet, were applied as its core. The dataset utilized in this study was derived from Polish national dance music consisting of five national dances such as the Kujawiak, the Polonez, the Mazur, the Oberek, and the Krakowiak. In addition, it was decided to create and later compare two separate datasets with 3 and 10-second audio samples. The adaptive attention model is proposed to adjust the extremely important features. The attained results were compared with one of the most popular classification metrics such as testing accuracy, testing loss, precision, recall and F1-score. The Shapley Additive exPlanations were employed to assess which parts of the input feature maps are the most essential to the model. As a result, the current approach demonstrates outstanding results, exceeding 94% accuracy. Therefore, the study not only defines a new standard for recognizing Polish national dances but also emphasizes the broader promise of multi-representation fusion as a model for next-generation audio classification.

Keywords
machine learning, convolutional neural networks, Polish national dance music identification, Shapley Additive exPlanations, feature fusion

Machine Learning Methods for Analysing Haematological Parameters in Patients with Chronic Kidney Disease

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Kidney failure is a disease syndrome that develops because of progressive destruction of the kidney structures by a chronic disease process. One of the most common symptoms associated with chronic renal failure is anaemia. The accompanying symptoms are among the basic complaints reported by patients and determine the subjective perception of the disease. The cause of anaemia is mainly related to insufficient erythropoietin production in relation to the degree of anaemia. The aim of this study is to determine the degree of renal failure, indicating the onset of anaemia based on the results of patients. The clinical material studied includes patients diagnosed with chronic renal failure treated between 1994 and 1998 at the Stefan Kardynał Wyszyński Province Specialist Hospital in Lublin. The analysed group of patients received routine clinical examinations, which determined the biochemical and haematological parameters of the examined individuals. The level of creatinine, which increases with the destruction of renal parenchyma, was adopted as an indicator of the degree of renal failure. The application of machine learning methods for regression and classification tasks allowed the analysis of the relationship between biochemical and haematological parameters of patients with renal failure. The following models were used: Linear Regression, Logistic Regression, K-Nearest Neighbours, Random Forests, and XGBoost. The models were validated using the k-fold cross-validation. The results confirmed the significant impact of creatinine levels on anaemia. A negative correlation was found between creatinine levels and haematological parameters, as well as significant differences between these parameters depending on gender and the severity of renal failure.

Keywords
machine learning; regression; classification; renal failure; anaemia; haematological parameters; medical diagnostics

Using Artificial Intelligence to Study the Gender History of Science in Central Asia

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The development of artificial intelligence (AI) methods opens up new opportunities for rethinking the gender history of science in Central Asia – a region where the interaction of colonial heritage, the Soviet modernisation project and post-Soviet transformations has shaped the specific structure of scientific communities. Despite women's significant contributions to the development of education, medicine, engineering and the humanities, their role often remains marginalised in historiography. The main problem is the fragmentary nature of sources, their dispersion across archives, and limited accessibility, which hinders systematic analysis.

Currently, the use of natural language processing (NLP), network analysis, and machine learning methods to create a digital corpus of texts – from archival documents and scientific publications to oral histories and media materials from the 20th and 21st centuries – appears to be extremely promising.

With the help of AI, it is possible to identify discursive models, representations of gender, and the dynamics of professional interactions within scientific communities. This approach will allow us to reconstruct not only the quantitative aspects of women's participation in science, but also the qualitative aspects – the symbolic, institutional and communicative forms of their presence.

The use of AI in gender and historical-scientific research contributes to the formation of a new methodology for digital humanities, combining source analysis with computational methods. Due to the application of AI, it is possible to visualise networks of scientific connections, map educational and institutional trajectories, and identify hidden patterns in the development of scientific knowledge in the region. The tool of AI allows us to broaden our understanding of the role of gender in the history of science in Central Asia and propose new approaches to studying the scientific heritage of the Global South.

Keywords
artificial intelligence; central Asia; digital humanities; natural language processing; scientific communities

Intelligent Revision Algorithms: Current State and Challenges

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Research on human memory and retention has revived interest in systems that optimize review schedules to maximize learning while minimizing study time. This paper surveys the current state of intelligent revision frameworks and outlines key challenges for the next generation of tools. As a compact case study, Gutek, an open-source, Java/Spring framework engineered for low-code extensibility is examined. It leverages dependency injection, reflection, and Spring Data JPA to automate component discovery and data persistence, enabling rapid integration of new revision algorithms, card types, and statistical charts with minimal coding effort. Additionally, Gutek supports bidirectional revision (regular and reverse modes) and already implements representative spaced-repetition strategies, while maintaining comparatively low code complexity. Based on this landscape analysis, a concrete roadmap is articulated. First, a fully featured API is proposed to support multi-device deployments, i.e., web for desktops, native extensions for mobile, and the existing desktop app, ensuring synchronization, offline-first operation, and privacy safeguards. Second, future work directions are outlined, focused on foreign-language learning to calibrate optimal scheduling parameters and to train a deep learning model that predicts revisions under real-world constraints. Third, steps toward a deployable framework for public institutions, emphasizing maintainability, accessibility, localization, and robust governance are discussed. Finally, cross-cutting challenges are identified: reproducible benchmarks beyond accuracy (e.g., latency, energy, cognitive load), explainability of scheduling decisions, handling drift, and standards for interoperable decks, logs, and models. The goal is to bridge systems engineering with learning science to deliver customizable, trustworthy, and scalable intelligent revision infrastructure.

Keywords
customizable algorithms; intelligent revision; learning optimization; spaced repetition; two-way memory training; educational software

The Use of Artificial Intelligence Technologies to Study The History of Russian Explorers and Expeditions to the Pamir Mountains in the Last Quarter of the 19th and Early 20th Century

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In the second half of the 19th and early 20th centuries, the Pamir and the Pamir region became the arena for intensive geographical, military and scientific expeditions by the Russian Empire, aimed at exploring a strategically important region located at the intersection of the interests of Russia, British India and China. A huge body of sources – from official reports and accounts to travellers' diaries, field maps, ethnographic notes and photographs – provides a unique opportunity for comprehensive interdisciplinary analysis. However, a significant portion of these materials are still scattered across archives in Russia, Uzbekistan, Tajikistan and the United Kingdom, which complicates their systematisation and interpretation.

Modern artificial intelligence (AI) technologies open up new perspectives for studying this topic. The use of machine learning and natural language processing (NLP) methods allows for the automated recognition and analysis of archival texts, including handwritten documents and memoirs of expedition participants (I. V. Mushketov, A. P. Fedchenko, G. E. Grumm-Grzhimailo, D. L. Ivanov, N. L. Korzhenevsky, and others). Neural network models are capable of identifying hidden thematic and spatial connections between sources, reconstructing travel routes and mapping changes in the scientific exploration of the region.

The use of AI in the processing of geographic data (geoparsing, toponym recognition) and visual materials (computer vision for analysing old photographs and maps) allows not only to refine the localisation of objects, but also to trace the dynamics of the perception of the Pamirs in scientific and imperial cartography. Semantic search and archival data clustering technologies make it possible to create integrated digital databases that combine disparate collections of documents and visual artefacts.

Thus, the introduction of AI into the study of the history of Russian expeditions to the Pamirs contributes to the transition from traditional source analysis to the digital reconstruction of historical space. This approach not only increases the accuracy and completeness of the study of the scientific heritage of travellers, but also forms new methodological horizons for historical informatics, historical geography and digital humanities in general.

Keywords
artificial intelligence; Pamirs; Russian explorers; expeditions; natural language processing; historical informatics; digital humanities; cartography

Comparative Analysis of Offline Reinforcement Learning Models for Book Recommendation Systems

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Recommendation systems play a vital role in personalising content on e-commerce and e-reading platforms. Traditional methods, such as collaborative filtering and supervised learning, often fail to capture users' long-term preferences or the sequential nature of interactions. Reinforcement learning (RL) provides a rule-based framework for modelling recommendations as a sequential decision-making process aimed at maximising user satisfaction. However, collecting online interaction data to train RL models is costly and risky, prompting the use of offline reinforcement learning (offline RL), which learns from static historical data. This study compares several offline RL algorithms, including Batch-Constrained Q-Learning (BCQ), Conservative Q-Learning (CQL), and Implicit Q-Learning (IQL), in the context of book recommendations. Experiments were conducted using the Goodreads dataset, which represents real-world interactions between users and books. The results show that conservative approaches, such as CQL, achieve higher stability and better recommendation accuracy, as measured by NDCG@10 and Recall@10, than less-constrained methods. The analysis also reveals a strong relationship between the dataset's diversity and policy performance. The research highlights the potential of offline RL as a promising avenue for developing data-efficient and privacy-preserving recommendation systems without the need for costly online exploration.

Keywords
offline reinforcement learning; recommender systems; book recommendation

Detection of Automated and Fake Accounts on Social Media Using Behavioural Analysis and Language Models

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Identifying fake and automated user accounts is essential in modern social media. Their number is constantly rising, making them progressively harder to differentiate from genuine user accounts. This large volume reduces trust, challenges the credibility of information, and necessitates greater vigilance online. Fake accounts are detected through their online activity or by analysing the content they publish. Despite heightened awareness, distinguishing real accounts from fake ones remains difficult. The scale of the problem continues to grow, making accurate verification increasingly challenging. In this paper, the authors propose assessing the credibility of social media accounts using artificial intelligence. Behavioural analysis, encompassing user activity and interaction patterns, will be employed alongside machine learning models such as Random Forest, BERT, and a hybrid model (Fusion). These models are capable of effectively recognising and classifying the accounts under examination. The research compares the effectiveness of these machine learning models. Results confirm the approach's success. Findings indicate that models incorporating diverse features outperform those relying on a single data type. Selecting suitable features improves the classification of user account credibility. The outcomes could aid in developing tools for automatic fake account detection and support information filtering on social media.

Keywords
social media; artificial intelligence; account classification; behavioural analysis

Application of Artificial Intelligence and Machine Learning in Medicine: Current Status and Future Prospects

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The World Health Organization (WHO) global strategy on digital health for 2020–2025 emphasises the need to ensure equal access to digital medical technologies for all patients. One of the key directions of healthcare digitalisation is the use of artificial intelligence (AI) and machine learning (ML) in cardiology. These technologies significantly impact all stages of the medical process – from early diagnosis and prediction of cardiovascular events to the development of personalised treatment approaches and the improvement of surgical accuracy.

Modern ML algorithms enable physicians to rely not only on subjective clinical experience but also on objective analysis of large datasets, promoting a shift towards preventive, patient-centred healthcare models.

Keywords
artificial intelligence; machine learning; cardiology; risk prediction; personalised medicine; digital health

Analysis of Interface Quality in Selected Computer Games

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The objective of this study was to evaluate the usability of user interfaces in selected computer games by integrating subjective and objective research methods. Four widely recognized titles were analyzed: Fortnite (battle royale), Genshin Impact (story-driven action RPG), Infinity Nikki (adventure game with dress-up elements), and The Sims 4 (life simulation). These games were selected based on their global popularity, functional comparability, and diversity in interface design.

The research employed three methodological tools: the System Usability Scale (SUS) questionnaire, a custom-designed comparative survey, and eye-tracking analysis. Four commonly utilized interface components: settings, shop, tutorial, and inventory were examined. The study involved 20 student participants, whose visual behavior was recorded, followed by a post-test questionnaire.

Usability was assessed in terms of users' efficiency and accuracy in locating specific interface elements. Objective eye-tracking metrics (fixation count, gaze path entropy, and stimulus duration) were analyzed alongside subjective evaluations. The findings revealed both consistencies and divergences between perceived and actual usability. Fortnite achieved the highest SUS scores and was most frequently selected in the comparative survey, yet also exhibited a high number of fixations and extended stimulus durations. Conversely, The Sims 4 received the lowest subjective ratings and demonstrated elevated scanpath entropy, indicating dispersed visual attention. Participants frequently overestimated their performance, underscoring the importance of integrating behavioral data with self-reported assessments in interface evaluation.

The triangulated methodological approach confirmed that combining behavioural and declarative data yields a more comprehensive understanding of usability. The results highlight the critical role of clarity, consistency, and visual organization in the design of game interfaces.

Keywords

computer game interfaces; user interfaces; eye tracking; System Usability Scale

Assessing the User Experience Dimensions in a Gamified Health Application

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The current increase in the importance and popularity of medical mobile applications in everyday life creates a non-negligible need for evaluating the key aspects of User Experience (UX), particularly usability, user engagement, and user satisfaction. This paper presents the results of a pilot study assessing the aforementioned UX areas by utilising the Mobile Application Rating Scale (MARS) questionnaire. This is the standardised survey designed specifically for the evaluation of the health-related mobile applications' quality, including user engagement, aesthetics, subjective quality, as well as elements of usability. The Waterful application was examined, which is an Android mobile application that supports the following daily fluid intake. It offers the gamification features characterised by the daily fluid intake target, as well as the challenges for which the user can earn badges. The research was conducted on the group of English-speaking participants that represents a diversified research group in respect of demographic factors such as age or gender. The recruited participants are proficient in using mobile applications on the Android system and interacted with the same English-language user interface during the experiment. This paper demonstrates the preliminary results of MARS-based medical application analysis, highlighting strengths and weaknesses of the application itself.

Keywords
interface quality assessment, mobile health app, MARS, usability, accessibility

The Impact of Interface Design and Styling on Information Readability and Retention

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The work presents the results of research on the influence of interface structure and styling on users' ability to read and remember information. The aim of the study was to empirically confirm whether the graphic design and layout of interface elements significantly affect the perception and processing of content. To achieve this, two experiments were conducted using questionnaires and eye-tracking technology. Each experiment was designed to test a separate research hypothesis, and the analysis of the collected data confirmed the positive impact of well-considered design on readability (based on a study of three e-commerce websites) and information retention (based on a study involving three custom applications).

The results indicated that engaging and intuitive interfaces support effective information processing, whereas non-intuitive solutions, such as hiding key data behind user interactions, significantly reduce the accuracy of information retrieval. An example of this was an application in which product prices were revealed only after hovering over images, which negatively affected users' accuracy in survey responses. On the other hand, overly simplified designs, although rated as clearer and more memorable, may fail to meet users' needs for emphasizing important details. This suggests the necessity of balancing minimalism with the functional highlighting of content.

In summary, the experiments demonstrated that clean and minimalist interfaces most effectively support users in performing simple tasks; however, the effectiveness of a given design depends on its context of use and user expectations. The findings confirm both research hypotheses and provide a foundation for developing design guidelines for interfaces optimized for readability and information retention.

Keywords
user experience; interface design; information retention; interface readability; information comprehension questionnaire; information retention survey; eye tracking

Comparative Evaluation of Human-Designed and AI-Created Interfaces in Scientific Journal Websites

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The level of usability and accessibility of scientific journal websites is a fundamental element of effective information transfer, and their level largely shapes the experience and satisfaction of users. Consequently, these issues must be considered at each stage of website development, encompassing the analysis of user needs, the design and implementation of the interface, and the subsequent testing, maintenance, and development of the website. In recent years, there has been a growing popularity of the universal design (UD) approach, and tools using artificial intelligence are also having an increasing impact on the website creation process. The study described involved two separate experiments, with some participants participating in both. In the initial phase, a comparison was conducted between the existing website of the journal and a prototype that had been manually crafted by a designer in accordance with Universal Design principles. In the second stage of the experiment, the same website was compared with two versions of prototypes generated by different AI tools. The evaluation of the websites, encompassing their usability, accessibility and impact on user satisfaction, was conducted employing an array of research methodologies, encompassing eye tracking, a proprietary questionnaire and automated tools for verifying compliance with WCAG 2.1 AA criteria. The results suggest that combining AI-based generation with human-centred refinement provides the most effective strategy for designing scientific journal websites, ensuring both high accessibility and a positive user experience.

Keywords
scientific journals portals; user interfaces; usability; accessibility; universal design; AI; eye tracking

Tilted Fibre Bragg Grating Spectrum Features Extraction

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Tilted fibre Bragg gratings (TFBGs) are commonly used as optical sensors to detect various physical and chemical parameters. These measurements are usually indirect, relying on analysing light intensity transmitted at specific wavelengths or within particular spectral regions. The selection of these wavelengths is typically done manually by the researcher. However, any change in the grating's properties requires redefining the wavelength selection. Since TFBG spectra are most sensitive to external changes either within the cladding mode region or at the Bragg resonance shift, these spectral areas are often used for sensing.

This need for manual wavelength range selection prompted the development of a method for automatically extracting spectral features from TFBG transmission data. The proposed approach allows for the automated identification of cladding mode minima, the spectral range where they appear, and the position of the Bragg resonance. It also calculates the amplitudes (heights) of these spectral features.

The algorithm introduced detects key components of TFBG spectra for both S and P polarised light. It independently identifies the cladding mode region, along with its local minima and maxima, and determines the location and intensity of the Bragg resonance for gratings with tilt angles up to 6 degrees. This work paves the way for fully automating spectral feature selection in TFBG-based sensor systems.

Keywords
TFBG; Bragg; feature; fibre; light; spectrum; optic

Deep Learning Application in Polarisation Plane Rotation Measurement with TFBGs Cascade

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TFBG sensors are vital in modern optical engineering, as their unique properties enable precise measurement of parameters like the light polarisation plane rotation (LPPR) angle, offering advantages over other sensors for applications requiring high accuracy and stability. The complex, often noisy optical spectra obtained from TFBG sensors require advanced signal processing techniques. Current methods, which rely on traditional spectral processing such as fast Fourier transform (FFT) or discrete wavelet transform (DWT), often lack accuracy because they struggle to handle noise and interference effectively, especially over wide measurement ranges where signal variability is high.

This research introduces a new approach to TFBG sensor data analysis using a deep neural network, specifically a Convolutional Neural Network (CNN). The CNN can directly learn relevant features from raw data, eliminating the need for complex preprocessing. It will be trained on both simulated and experimental data from cascaded and rotated TFBGs, designed to increase signal variability as a function of polarisation angle, thus creating a robust training dataset.

With its ability to learn complex patterns from large datasets, we anticipate the CNN will better detect subtle changes in the cladding modes than existing algorithmic methods. The main hypothesis is that this CNN approach will significantly improve the stability and accuracy of LPPR angle measurements across the full range of 0° - 180°, reducing the mean absolute error compared to state-of-the-art DWT- or FFT-based algorithms by effectively learning intricate patterns from extensive data.

This AI-based method will enable a fully automated, highly precise optical sensor. This work aims to advance the field by demonstrating how machine learning can overcome the limitations of traditional signal analysis, potentially enabling more accurate and reliable TFBG sensors and fostering further improvements in sensing technologies.

Keywords

tilted Bragg grating; optical fibre; deep learning; machine learning; artificial intelligence

Spatial Data Processing in Pathfinding on Grid Graphs

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Algorithms for finding paths on grid graphs play a key role in modern information systems. They are widely used in areas such as navigation systems, computer games, robotics, and even the planning of optimal evacuation routes during emergencies. These algorithms help find the shortest or most efficient path between two points in a structured environment, and their performance can significantly affect the overall efficiency of the system.

This study focuses on how different algorithms handle spatial data and how various factors influence their performance. The main goal is to understand how map structure, size, and spatial configurations affect the speed and accuracy of pathfinding algorithms.

To ensure fair and consistent testing, a custom simulator was developed. It can generate and analyze maps with different spatial patterns. Experiments were conducted on 300 unique grid maps of five sizes and three layout types: Perlin noise, random, and maze.

Each map (except mazes) was tested with two types of movement costs: uniform and varied. In addition, the start and goal points were positioned either horizontally/vertically or diagonally across the map. The study also examined what happens when an obstacle appears on a path that had already been planned. In total, over 225,000 tests were run, making the results very reliable.

The study showed that an algorithm's efficiency depends on the map's layout, size, and structure, as well as the positions of the start and end points. The results show that there is no one best algorithm – each works better in different conditions and for various goals.

Keywords

grid graphs; spatial data processing; pathfinding

Light Polarisation Plane Rotation Angle Measurement

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Tilted fibre Bragg gratings (TFBG) have become a significant type of sensing element, valued for their high accuracy, resistance to interference, compact size, and relatively low manufacturing cost. Among the measurable quantities, they can be used to determine the rotation of the light polarisation plane (LPPR) within an optical fibre. Traditional TFBG-based methods rely on monitoring the optical power at a specific wavelength, which limits both the measurement range and its accuracy. Other approaches use more advanced processing algorithms that analyse selected parts of the TFBG transmission spectrum using the fast Fourier transform (FFT) or the discrete wavelet transform (DWT). However, these techniques do not guarantee consistently high precision across the entire range of angles, because the FFT and DWT coefficient functions exhibit similar variations with rotation angle.

This work demonstrates that connecting two TFBGs in a cascade and rotating them relative to each other produces cladding-mode minima characteristic functions (MCFs) that are mutually shifted by the LPPR angle. This shift allows direct incorporation of the minima values into an algorithm for estimating the LPPR angle from the measured spectrum. Additionally, the derived MCF functions show significantly lower noise levels than previously used FFT-based or DWT-based characteristics. This behaviour led to the development of a new calculation method that operates directly on the recorded spectra. A calibration procedure was performed using MCF values obtained at 2° intervals over rotation angles from 0° to 180°, followed by the creation of an algorithm that selects the most suitable MCF functions for angle estimation. The proposed approach provides consistent measurement accuracy across the entire 0–180° range and enhances overall stability. Compared to existing techniques, the method reduces MAE by 2.6% and MSE by 66%.

Keywords
TFBG; Bragg; polarisation plane; rotation; cladding modes; optical spectrum analysis

Extraction of Features from the Spectrum of a Tilted Fibre Bragg Gratings (TFBG) Using Artificial Intelligence Methods

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Tilted fibre Bragg gratings (TFBG) are a vital part of modern optical sensors, but their spectra are highly complex and sensitive to environmental factors. Traditional spectrum analysis methods often fall short at automatically identifying cladding mode minima, limiting measurement accuracy, possibility of its automatization and the practical application of TFBGs in sensor systems. This work aims to utilise artificial intelligence techniques to extract features from the light spectrum propagating through a TFBG, enabling faster, more reliable, and repeatable identification of spectral features. As part of the research, a hybrid AI system based on ensemble learning was developed, and selected machine learning algorithms were employed, including deep learning models using convolutional neural networks. The analysis involved spectra recorded under laboratory conditions, with varying stress and temperature levels, and the training set was further enriched with synthetically generated data.

Results show that the algorithms significantly outperform conventional methods in accurately identifying spectral minima and resisting noise. The models effectively detected cladding modes, ghost mode and Bragg resonance. Additionally, the use of ensemble learning markedly reduced analysis time – by more than an order of magnitude – compared to traditional approaches.

This research demonstrates that incorporating machine learning into TFBG spectrum analysis can greatly enhance the efficiency of modern measurement systems and offers a promising pathway for advancing fibre-optic sensors.

Keywords

tilted fibre Bragg grating; artificial intelligence; ensemble learning; convolutional neural networks; LSTM networks; random forest; feature extraction

The Phenomenon of Beauty in Mathematics

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This article is devoted to the study of the place of the phenomenon of beauty in mathematics. Mathematics is interpreted not only as a tool for solving problems, but also as a field that reveals the scientific and aesthetic aspects of beauty through symmetry, harmony, proportion and unexpected connections. The article examines in detail the mathematical definition of beauty, examples such as Euler's formula, the golden ratio, fractals and symmetry groups. Through an analysis of the literature, the objective and subjective aspects of beauty are discussed based on Plato, G. Hardy, H. Poincaré, and modern scientific works (for example, the neurological studies of Z. Zeki). The role of beauty in teaching methods and its connection with nature and art are emphasised. The article serves to enrich discussions in the fields of philosophy of mathematics, aesthetics and pedagogy.

Keywords
beauty in mathematics; symmetry; fractal;, golden ratio; Euler's formula; aesthetics; harmony; proportion; mathematical beauty; elegance; neuroscience and mathematics; teaching methodology

The VR Animation of Rigid Bodies with Dedicated Motion Development in Immersion Study

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Movement animation is a common part of present graphics technology, widely used in games, films, and virtual realistic environments. Motion capture technology is becoming increasingly popular as a primary animation method, enabling detailed and realistic representation of character movement in three-dimensional systems. This approach is primarily used for humanoid figures with complex trajectories. Rigid bodies, on the other hand, are frequently animated operating on keyframes or body physics. This study presents a novel approach to rigid body animations, which primarily relies on motion capture technology.

The presented study utilized a Vicon system to acquire motion recordings of a remote-controlled car. After post-processing of the C3D files, a dedicated rigging of the 3D object was performed, based on the corresponding car model. After combining the motion, skeleton, and model, a 3D animation was obtained, which was further transferred to the prepared VR environment.

The developed animation was sampled in the ablation study, which aimed to evaluate the impact of animation export settings on the participants' perceptions and immersion. The IGroup Presence Questionnaire (IPQ) assessed 10 users. The results revealed differences in the perception of animation smoothness and perceived realism of the content.

Keywords
realistic movement; rigid body animation; immersion; VR animation; IPQ survey

Developing a Color Discrimination Model for Heritage Apparel and Accessories Based on Computational Algorithms

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Heritage apparel and accessories embody the culture, history, and aesthetics of a specific region or nation, and their colors reflect profound social levels, religious beliefs, and lifestyles of the wearers. However, existing studies on their colors are fragmented and inefficient, leading to a limited understanding of their color characteristics and hindering deeper insight into the culture behind. To address these challenges, this study has developed an advanced color discrimination model for heritage apparel and accessories using computational algorithms and has introduced Bonpo apparel and accessories as a case study to validate the model. By applying the Fuzzy C-Means (FCM) algorithm, the Elbow method, and the Gaussian Mixture Model (GMM), this model systematically captures and discriminates key color characteristics, including color ratios, the LAB color space, Euclidean distance, and color co-occurrence frequency. This systematic color-discrimination model for heritage apparel and accessories can be applied to both further studies and new designs.

Keywords
color discrimination model; Gaussian Mixture Model; heritage apparel

Creating a Digital Map of Cultural Centres of the Silk Road in Central Asia

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The development of digital technologies opens new opportunities for studying and visualising historical heritage. One of the most relevant projects in this field is the creation of a digital map of the cultural centres of the Silk Road in Central Asia. The purpose of this study is to combine historical data, archaeological sources and modern methods of digital information processing to visually represent the processes of cultural exchange in the region.

The key points of the research include Khiva, Bukhara, Termez and Kashgar – cities that for centuries have been intersections of trade, religious and intellectual routes. The project utilises geographic information systems (GIS), 3D visualisation and digital archives, which make it possible to reconstruct the spatial structure of ancient trade routes and document the architectural and spiritual heritage of these centres.

The use of digital tools contributes to the preservation of both tangible and intangible values, increasing the accessibility of historical sources for researchers and the general public. The digital map becomes not only an analytical tool but also an educational platform that brings together science, culture and technology.

The implementation of this project allows for a deeper understanding of Central Asia's role as a key region of civilisational interaction and presents its cultural heritage in a modern digital format.

Keywords
GIS; digital history; 3D visualisation

Ayazkala, the Historical and Legendary Fortress of Ancient Khorezm

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This article is devoted to the history of Ayozkala, a historical fortress. It covers the issues of virtualisation, using modern technologies without damaging history. There are many cultural heritage sites in the Republic of Uzbekistan, such as Samarkand, Shahrisabz, Bukhara, Khiva, Tashkent, Termez. The country's cultural heritage sites include archaeological monuments, architectural structures, attractions and monumental works of art. Currently, new museum expositions are being organised mainly in architectural structures. 8210 objects are registered in the republic, of which 4788 are archaeological and 2267 are architectural structures. The article dicusses the issues of digitising them using the example of fortresses located in the territory of Khorezm in ancient times.

Keywords
Frost; castle; myth; Tolstov; Ayozkala I; Ayozkala II; Ayozkala III; burj; shinak; Y. Gulomov; G. Khodzhaniyazov; M. Mambetullayev; A. Sagdullayev

Digital Platforms on the History and Cultural Heritage of Uzbekistan: National and International Significance

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This article examines the processes of formation and development of digital platforms dedicated to the history and cultural heritage of Uzbekistan. In the context of the global digitalisation of information resources, the preservation and popularisation of national historical and cultural assets through modern technologies has acquired special importance.

Particular attention is given to the analysis of existing digital projects – national archival portals, virtual museums, electronic databases, and educational platforms – as well as international initiatives involving Uzbekistan, such as UNESCO's Silk Roads Online Platform and the Central Asian Heritage Digital Network.

The paper explores the legal, organisational, and technological foundations of digital platforms' operations and evaluates their role in strengthening Uzbekistan's scientific and cultural links with the global community. Special focus is placed on assessing the impact of digital technologies on public perception of historical heritage, as well as on the development of digital humanities and historical informatics in the country.

The research findings contribute to a deeper understanding of the significance of digital platforms as tools for the preservation, study, and international promotion of Uzbekistan's historical and cultural heritage.

Keywords
digital history; digital archives; cultural heritage; digitalisation; virtual museums; electronic resources; information technologies; historical informatics; national identity; Uzbekistan; digital humanities; international cooperation; digital platforms; historical memory; digital heritage

Digital Technologies in Cultural Heritage Preservation: a Case Study of Confucius and Confucianism Museums in China

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This study investigates the integration of digital technologies in creating and managing cultural heritage centres, referencing modern practices from the People's Republic of China. It emphasises how digital platforms, intelligent management systems, virtual museums, big data analytics, and AI-driven cultural services have transformed the operations of cultural heritage institutions. The results show that digitalisation improves cultural communication, broadens public access to cultural resources, boosts community participation, and fosters innovative ways to preserve cultural heritage.

Through an analysis of the Chinese experience, the study identifies key factors that can be applied in other contexts, including the development of digital infrastructure, the use of immersive technologies, and the promotion of interactive cultural services. The research examines the conditions and practices of digital transformation in both large-scale and small-scale Confucian heritage museums in China, including the Chinese Confucianism Museum (中国儒学馆) in Quzhou, the Southern Confucianism Museum of Ushi County (乌什县南孔儒学馆), the Beijing Confucius Temple and Guozijian Museum (北京孔庙和国子监博物馆), and the Confucius Museum in Qufu (孔子博物馆).

The results show that smaller museums – mainly serving schoolchildren and university students – tend to use interactive educational panels, touch-screen displays, immersive exhibitions, and "3D communication" technologies that stress educational and moral-ethical content. Larger museums, on the other hand, effectively integrate AR/VR experiences, virtual tours, mobile applications, digital catalogues and archives, 3D reconstructions, and multimedia theatrical installations. Overall, the study offers practical recommendations for policymakers, leaders of cultural institutions, and researchers aiming to develop modern, technologically advanced cultural environments.

Keywords
digital technology; digital infrastructure; cultural heritage digitization; interactive education; museum; Confucianism museums

Interactive Platforms for Studying the History of Central Asia: From School Courses to Virtual Museums

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Modern digital technologies open up new opportunities for studying and promoting historical heritage. One of the most promising directions is the creation of interactive educational platforms that make the history of Central Asia accessible and engaging for diverse audiences – from school students to researchers.

The aim of the project is to develop and analyse digital tools that contribute to the preservation of cultural heritage and the involvement of society in the process of historical understanding. Special attention is given to the creation of virtual museums, interactive maps and multimedia courses based on the principles of inclusion, openness and adaptability. Such platforms allow users not only to receive information, but also to interact with historical materials through visualisation, 3D modelling and gamified elements.

The study examines examples of implementing digital solutions in the educational programmes of Uzbekistan, Kazakhstan and Kyrgyzstan. The use of interactive platforms helps increase young people's interest in national history, develop critical thinking and strengthen cultural identity.

The creation of virtual museums and digital archives also plays an important role in preserving intangible heritage – folklore, music and oral traditions. These technologies make it possible to digitise and systematise unique materials, providing broad public access to them.

Thus, interactive digital tools have become a key element of modern historical science, uniting technology, education and the cultural heritage of Central Asia within a single virtual space.

Keywords
interactive platforms; Central Asia; history; virtual museums; digital technologies; cultural heritage; educational programmes; cultural identity

Information Technologies in Storytelling About Lublin on the Example of a Local Government Cultural Institution

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The institution's main goal is to safeguard cultural heritage and recover historical memory. Aware of the limits of traditional methods for engaging modern audiences, the Centre has strategically adopted information technologies to turn extensive historical data into accessible and multidimensional narratives. The foundation of the Centre's work is a comprehensive, modular database system (developed since 2012) designed to organise, connect, and publicly share archival and historical information about Lublin and the region. The system is built around four core modules that enable the construction of detailed historical narratives: People, Places, Events, and Sources. Module People contains records of former inhabitants, linking them by family, profession, and residence. Module Places organises information on geographical space from the 14th to the 21st century, using historical cartographic materials to record spatial transformations. Module Events enables the chronological description of historical and personal incidents (e.g., births, occupations, building renovations), connecting people and places across specific time intervals. Module Sources systematically organises and verifies the source materials (archival documents, press, oral history testimonies) that validate the data in the other three modules.

The integration of few modules supports unique storytelling applications. First is Historical Geoportal of Lublin (Lublin HGIS) – an essential part of the database that allows researchers and the public to create interactive maps. It enables the visual presentation of historical facts within their true spatial context and allows users to compare street layouts and locations across different historical periods, thus clarifying spatial changes. The second is "Lublin. 43 thousand" Project – the most symbolic application, which uses the database to reconstruct knowledge and restore the identity of the estimated 43,000 pre-war Jewish inhabitants of Lublin. The aim is to commemorate each individual within their spatial and temporal context. The third is Digital Library and Virtual Models – the Centre employs the dLibra system for publishing digital resources and has developed virtual models, such as the reconstruction of Lublin.

Essentially, the Centre utilises its IT infrastructure not just as an archive but as an innovative digital storytelling platform that forges extensive connections between fragmented data points, transforming them into engaging, publicly accessible, and continually updated narratives that revive the memories of lost communities.

Keywords
interface quality assessment; mobile health app; MARS, usability; accessibility

Digital Mapping of the Territorial Distribution of Nomadic Herders in Ancient Khorezm

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The development of digital technologies provides new tools for historical and geographical analysis as well as for visualising spatial structures of the ancient world. This study focuses on the application of Geographic Information Systems (GIS) and 3D modelling to reconstruct the territorial distribution and lifestyle of nomadic herders in ancient Khorezm – a region where the interaction between sedentary and nomadic cultures shaped social, economic and political dynamics.

The methodology includes the creation of a GIS database combining archaeological, topographical and historical-cartographic sources about campsites, pastures and seasonal migration routes of herding communities. Spatial analysis using a Digital Elevation Model (DEM) and satellite imagery makes it possible to identify patterns in the selection of territories and the dependence of settlement on natural and geographical factors – such as water resources, soil conditions and livestock migration paths.

Based on the obtained data, a three-dimensional landscape model of ancient Khorezm is developed, visualising the dynamics of nomadic movement and interaction with the sedentary centres of agricultural civilisation. This approach not only helps refine the structure of the region's economic and cultural life but also creates new forms of representing historical knowledge in a digital environment.

The results of the study demonstrate the potential of digital methods in the humanities and show that the use of GIS and 3D modelling can become an effective tool for preserving and promoting the historical and cultural heritage of Central Asia.

Keywords
GIS databases; DEM; digital cartography; 3D modelling

Cooperation Between IT Specialists and Society in the Digitization of Cultural Heritage – Experiences from Two Projects

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The digitization of humanity's cultural heritage is not only an IT project, but also an organizational one, affecting many objects and areas of society (an interdisciplinary project). Cultural heritage objects are protected or overseen by various institutions. These institutions are primarily museums, but also other entities, such as religious associations and local governments. During digitization, cultural heritage objects should be made available to IT teams carrying out the work. This work often requires long-term (1–2 days) access to the object. This usually creates conflicts with their everyday operations. Museums are open to tourists; other objects continue to function; and those closed for use remain closed. Even small museum objects must be removed from display during digitization and made available to IT teams (and secured for this period), which usually means limited visitor access. For large objects, excluding them from tourist exploration is practically impossible.

These problems are discussed in this article based on two completed digitization projects: "3D Digital Silk Road", funded by the Polish National Agency for Academic Exchange, and "Research on the national cultural heritage of the Polish community in the US and the creation of digital memory collections," funded by the Polish Minister of Education and Science. Both projects were implemented in two different locations around the world, with significantly different cultural backgrounds. Approaches and methods for addressing the identified problems are presented, from appropriate object-scanning methodologies to organizational solutions.

Keywords
cultural heritage digitalization; organizational challenges; cooperation with society; interdisciplinary projects; Silk Road project; Polish US community project

Integration of Humanities and Digital Technologies in Historical Research (on the Example of the Republic of Uzbekistan)

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The article examines current trends in the integration of the humanities and technical sciences within the framework of digital transformation. Particular attention is paid to the development of digital history, the implementation of geographic information systems (GIS), 3D modelling, and virtual archaeology in historical and archaeological studies. The experience of digitising Uzbekistan's historical and cultural heritage is analysed, including projects such as: Digital Samarkand, Virtual Khiva, e-Heritage UZ, as well as initiatives of the Center for Islamic Civilization, the Academy of Sciences, and the Institute of Archaeology. The study concludes that the application of innovative digital tools expands the source base, improves historical reconstruction methods, and enhances the preservation and popularisation of cultural heritage. The paper emphasises the interdisciplinary nature of digital humanities as a vital component in the modernisation of historical research and cultural policy.

Keywords

digital history; digital humanities; GIS; 3D modelling; cultural heritage; virtual archaeology; Uzbekistan; interdisciplinarity

Using Geographic Information Systems (GIS) in the Study of the History of Polish Schools in Uzbekistan During the Second World War

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The use of Geographic Information Systems (GIS) in research plays a crucial role across diverse disciplines – from ecology and geography to economics, medicine, urban studies and history. GIS combines maps with databases, enabling the analysis of spatial relationships between objects, phenomena and processes. The goal of this work is to study the spatial-temporal dynamics and contextual background of the functioning of Polish schools and educational institutions for Polish citizens in Uzbekistan during 1941–1945.

The history of the 20th century, marked by complex and often contradictory events, had a direct impact on social and political processes worldwide. Today, historians and researchers in Soviet studies – a relatively new academic field – are comprehensively examining historical events of the Soviet period. Since Uzbekistan's independence, historians have had broad access to archival sources, enabling them the reconstruction of the country's true history based on newly available materials – a process that continues to this day.

The fate of the Polish population, particularly Polish children who found themselves in Uzbekistan during World War II, continues to attract public attention. Between September 1939 and June 1941, large numbers of Polish citizens ended up in Soviet territory. On October 1, 1941, the Council of People's Commissars and the Central Committee of the All-Union Communist Party (Bolsheviks) decided to resettle 100,000 Polish citizens in the Uzbek SSR. However, due to logistical constraints, this number was reduced on November 19, 1941, to 35,000 people; the rest were relocated to the Kyrgyz SSR and southern regions of Kazakhstan.

Keywords
Geographic Information Systems (GIS); Uzbek SSR; Union of Polish Patriots; Kompoldet (Committee for Polish Children); Uprosobtorg (Administration for Social Welfare Trade)

Creating a Digital Archive on the History of Scientific Expeditions and Natural Science Research in Turkestan (19th–20th Centuries): Structure and Prospects

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The initiative to create a digital archive that brings together sources on the history of scientific expeditions and natural science research in Turkestan during the late 19th and early 20th centuries is both highly relevant and forward-looking. The digitisation and systematisation of archival materials – such as field diaries, expedition reports, maps, photographs and correspondence – will help preserve and make accessible a unique body of scientific heritage related to this issue.

At the core of the proposed digital archive there is the expeditionary activity of Russian and local scholars who contributed to the production of knowledge about the natural resources and spatial organisation of the region during the period of imperial scientific exploration of Turkestan. Among these figures there were prominent researchers such as I. V. Mushketov, L. S. Berg, A. P. Fedchenko, N. A. Severtsov, and N. L. Korzhenevsky, whose works shaped geological and geographical knowledge of Turkestan. Of particular interest are materials that represent the activities of regional intellectuals, local scholars and experts who participated in researches, served as translators and shared their empirical knowledge – thereby creating a distinctive form of *“border science”*, understood here as a synthesis of imperial (central) and local (peripheral) scientific experience.

The project applies key digital humanities tools and standards as metadata structuring, geocoding, route visualisation and the TEI and Dublin Core frameworks – combined with the principles of open science, such as transparency, collaboration, data sharing and open methodologies. This approach enables a new, conceptually grounded perspective on the history of the scientific “discovery” and representation of Turkestan.

The creation of the digital archive will make it possible to reconstruct scientific networks, geography of research and the transformation of representation frameworks within a broader Central Asian context. It will also provide a new research infrastructure for historians of science, archivists and digital heritage specialists.

In the long term, the project envisions the establishment of an integrated digital environment for collaboration among researchers from Russia, Uzbekistan and other countries, studying the history of science and colonial knowledge in the region.

Keywords
digital archive; scientific expeditions; Turkestan; natural science; digital humanities; open science; colonial knowledge; scientific heritage

The Digital Library of the Hieronim Łopaciński Provincial Public Library in Lublin as a Tool for the Protection and Promotion of the Region's Cultural Heritage

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The Digital Library of the Hieronim Łopaciński Provincial Public Library in Lublin is a vital tool for protecting, digitising, and sharing the cultural heritage of the Lublin region. Since its inception, the library has been collecting, processing, and providing digital access to materials of significant historical, scientific, and artistic value – including manuscripts, old prints, maps, photographs, regional periodicals, and social documents. The goal of the digital library is not only to preserve the original collection for future generations but also to offer broad, free access to cultural resources for users in Poland and abroad.

During the Conference, the stages of developing the digital library will be showcased – from the Lublin Virtual Library to the current project "Culture Without Barriers", co-financed by European Union funds. This initiative has allowed for a significant expansion in digitisation, the adoption of modern information technologies, and the promotion of new publications from the library collection. Special focus will be given to activities that promote local history and cultural identity through the release of educational, historical, and artistic materials.

An important part of the Digital Library's work is the digitisation of unique materials, ensuring the long-term preservation of digital resources and their accessibility for persons with disabilities. The presentation aims to highlight the role of the Digital Library of the Provincial Public Library in Lublin as a modern platform blending tradition with technology, supporting the safeguarding of the region's cultural heritage and fostering the digital identity of the local community while advocating for open and unrestricted access to culture.

Keywords
digital library; cultural heritage; digitization; Lublin region; open access

Some Reflections and Considerations on the Problem of Modelling Historical Processes

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The in-depth analysis of historical processes, the identification of cause-and-effect relationships between historical events, and the reconstruction of missing historical links are increasingly being carried out through computer-based modelling. This article presents reflections on the potential of modelling, the significance of computer technologies in the humanities, and current issues related to the use of artificial intelligence in historical research. The evolution and typology of modelling are also discussed. In addition, the article presents scientific conclusions derived from research conducted by Russian and English scholars.

The introduction of modeling into historiography represents a natural and essential stage in the development of an interdisciplinary approach. The multifaceted and interrelated nature of historical processes makes it difficult to analyze them comprehensively using only traditional source-based and descriptive methods. This article, situated within the framework of ongoing scholarly efforts to address this challenge, opens new horizons for methodological advancement in the study of history.Through modeling, the dynamics of historical events can be examined by means of simplified structural representations. On the one hand, this helps to eliminate inconsistencies and gaps in historical data; on the other, it provides a means to empirically test historical theories. In particular, statistical and simulation models allow for a thorough investigation of alternative scenarios of historical events and the assessment of their probable consequences.This methodology not only enriches the scientific style of historiography but also serves as an important tool for identifying new facts and uncovering causal relationships. The application of modeling in such fields as modern archaeology, historical demography, and military history lays a foundation for the analytical and empirical advancement of historical science.

Keywords
historical modelling; historiography; computer modelling; artificial intelligence; generative AI; machine learning; deep learning; 3D reconstruction; historical informatics; simulation modelling

The Role of Social Networks in Representing the Ethnic Culture of the Khorezm Oasis Population

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Modern digital communications have significantly transformed the ways of preserving and promoting ethnocultural heritage. Social networks, as an integral part of public life, have become a powerful tool for representing ethnic identity, cultural traditions and spiritual values. In this context, studying the role of social media in highlighting the ethnic culture of the Khorezm Oasis population acquires particular relevance.

The Khorezm region, known for its centuries-old cultural synthesis and ethnic diversity, has become a kind of centre for the digital revival of traditions. On platforms such as Facebook, Instagram, Telegram and YouTube, materials related to folk festivals, folklore, national cuisine, traditional crafts and oral heritage are actively shared. Such publications not only create a positive image of the region but also contribute to strengthening the cultural identity of the younger generation.

A special role is played by representatives of local cultural centres, researchers and bloggers who, using digital technologies, create interactive archives, video projects and online exhibitions dedicated to the ethnic features of Khorezm. These initiatives form a new type of collective memory – a "digital ethnoculture" that unites local and global narratives.

The use of social networks also promotes intercultural dialogue: multilingual publications, comments and collaborative online projects help foster mutual understanding among ethnic communities. Thus, digital media serve not only as channels of information, but also as platforms for preserving intangible cultural heritage. At the same time, issues of credibility and authenticity of published content, the ethics of digital representation of traditions and the protection of cultural symbols from commercialisation remain relevant. Solving these problems requires the involvement of specialists in ethnology, sociology and digital technologies.

Therefore, social networks play a dual role – they are both a tool of cultural communication and a space for forming new ethnic self-representation. The experience of the Khorezm Oasis demonstrates that the digital environment can become an effective platform for preserving and popularising ethnocultural heritage, strengthening national identity, and fostering international cultural cooperation.

Keywords
social networks; Khorezm Oasis; ethnic culture; digital ethnoculture; cultural heritage; Uzbekistan; intercultural dialogue; cultural identity

Information Technologies in Service of Society: Digital Tools for Understanding Migration Trends in Uzbekistan

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The study shows how digital and information technologies contribute to the analysis and comprehension of migration trends in Uzbekistan during the period 1991–2024. Since the country's independence, migration processes have undergone noticeable and significant transformation, shaped by economic reforms, regional mobility and globalisation. The research focuses on the growing role of digital tools – such as online databases, electronic archive materials and e-statistical portals – in documenting and interpreting these changes. By integrating quantitative migration data with qualitative historical materials, this study illustrates how digital methods improve both the accessibility, availability and reliability of migration research.

The article also presents examples of national and international digital initiatives that support the collection, preservation, and dissemination of information on migration trends, involving open-access archives and state e-statistics platforms. Exclusive attention is paid to how these technologies assist inclusive access for researchers, policymakers and the public, strengthening proof-based decision-making and promoting transparency in migration management.

Additionally, the research describes how digital transformation not only modernises historical research but also fosters social awareness of migration mobility patterns in Uzbekistan. The paper concludes that the digitalisation of migration research shows a significant step towards building a more informed and interconnected academic atmosphere in Central Asia.

Keywords

migration trends; Uzbekistan; information technologies; digital tools; e-statistics; historical research; Central Asia; social awareness

Universal Design of a 3D Water Tower Model for the Blind

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The work describes an interdisciplinary project that applies universal design principles to create 3D tactile models of architectural structures. It details the recreation of a non-existent neo-Gothic water tower formerly located at Plac Wolności in Lublin, using advanced CAD modelling and 3D printing techniques. The model was designed in Autodesk Inventor 2024 based on archival photographs. The design process followed guidelines for tactile symbols, where the minimum height of reliefs for recognition is 0.4–0.8 mm, and the ideal Braille height is 0.9 mm with a dot diameter of 1.6 mm. The innovation of the project lies in integrating three key accessibility elements: a physical 3D model for tactile exploration, a Braille labelling system, and interactive audio description. The audio description system is built on the ESP-WROOM-32 module with a touch button interface. The model features a modular design, including a base with space for the audio system and the main tower. Using 3D printing technology saves time and reduces material consumption compared to traditional methods. These solutions serve as an effective example of universal design, allowing visually impaired individuals to fully experience the spatial qualities of an architectural object through multisensory exploration-touch, Braille information, and auditory description. The interactive 3D model can function as an educational and cognitive tool, especially for people with visual impairments.

Keywords
universal design; 3D model; 3D printing; architectural accessibility; audio description

The Phenomenon of Identity Crisis in Adolescence in the Context of Gaming Activities and Virtual Worlds: Can Cyberspace Supplement Essential Elements for Resolution?

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In the twenty-first century, digitisation has profoundly transformed human experience, reshaping how individuals perceive themselves, interact with others, and create meaning. Identity, once rooted in stable social roles, now emerges as a flexible and multifaceted construct shaped by online communication, social networks, and algorithmic mediation. Adolescence, a key developmental period for identity formation, is particularly sensitive to these transformations. According to Erik Erikson (1996), the adolescent stage is characterised by a psychosocial crisis – 'identity versus role confusion' – where individuals seek coherence between internal values and external expectations. This article explores how virtual worlds and gaming activities influence the resolution of this crisis, emphasising both adaptive and maladaptive outcomes, integrating Eriksonian theory with sociocultural approaches from Vygotsky and analytical psychology of Adler and Jung.

Adolescents often employ compensatory mechanisms to restore internal balance and maintain a coherent sense of self, frequently through symbolic or virtual activities such as digital games, social media, and virtual worlds. Vygotsky's sociocultural theory emphasises symbolic mediation, where digital tools like avatars, hashtags, and algorithms shape identity. Adler and Jung highlight compensation as a mechanism to balance perceived inferiority and unconscious tendencies, which can be constructive or maladaptive in digital spaces.

Virtual worlds allow adolescents to experiment with autonomy, competence, and social belonging. Constructive compensation enhances confidence and self-awareness, whereas maladaptive patterns, such as escapism or dependency, may reinforce alienation. Empirical findings (e.g., Soldatova et al., 2024) indicate that balanced engagement with online personas correlates with adaptive coping, while excessive immersion risks disorientation and anxiety. Case examples from gaming and instant messaging illustrate cyberspace's dual role in supporting identity resolution through social bonds, self-expression, and skill development, yet potentially fostering over-reliance or social anxiety.

Integrating Eriksonian, Adlerian, Jungian, and sociocultural perspectives, this study underscores that cyberspace can supplement essential developmental needs – autonomy, belonging, and achievement – if engagement is reflective and balanced. The findings have implications for educators, psychologists, and policymakers, advocating for digital literacy as psychological literacy and suggesting avatar-based interventions to facilitate self-exploration.

Keywords
Identity crisis; Adolescence; Digital identity; Virtual worlds; Gaming activities; Compensatory mechanisms; Sociocultural mediation

Digital Religion and the Organisation of Online Religious Rituals on Internet Platforms

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Modern advances in digital technologies are increasingly influencing the religious sphere, transforming the forms of faith expression, communication, and participation in rituals. The concept of "digital religion" reflects the integration of traditional spiritual practices into the virtual space, where the internet becomes a new platform for prayers, sermons, religious education and collective ritual actions.

The COVID-19 pandemic became a catalyst for this process: many religious communities in Uzbekistan, Central Asia and around the world began conducting worship services, Friday sermons, festive ceremonies and lectures online. Platforms such as YouTube, Zoom, Telegram and Facebook became not only means of communication but also a kind of "digital temples" uniting believers regardless of geographical boundaries.

The online format provides inclusion opportunities for those who, for various reasons, cannot physically attend religious centres – elderly people, individuals with disabilities, migrants and students abroad. Thus, digital religion contributes to the preservation of spiritual connections and cultural identity in the context of globalisation.

However, the development of digital rituals raises new questions: how can the sacredness and sincerity of religious experience be preserved in the virtual space? What are the ethical and theological boundaries of digital rituals? These questions have become subjects of study within 21st-century digital anthropology and religious studies.

In Central Asia, there is a gradual formation of digital religious archives, live broadcasts of Friday khutbahs and online courses for studying the Qur'an and other sacred texts. These initiatives not only enhance spiritual literacy but also create a new format for dialogue between religion and modern technologies.

In the long term, digital religion may become a tool of cultural diplomacy and interfaith understanding, where Internet platforms serve as bridges between tradition and innovation. Thus, "digital piety" becomes part of the broader digital culture, reflecting profound changes in the ways faith and spiritual practice are perceived in the 21st century.

Keywords
digital religion; COVID-19; digital culture; virtual space; Uzbekistan

Changes in Self-Esteem and Personal Responsibility in the Use of Artificial Intelligence

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In the context of the rapid integration of artificial intelligence (AI) technologies into various aspects of human life, significant psychological changes are being observed, affecting personality structure, self-esteem, and levels of personal responsibility. This article aims to examine the mechanisms through which interaction with AI systems influences the formation and dynamics of self-esteem, as well as the awareness of personal responsibility in decision-making.

One of the key issues in contemporary psychological research is the transformation of self-esteem and personal responsibility in the context of active AI use. Self-esteem is a fundamental personal construct that determines an individual's attitude toward themselves, their abilities, and their achievements. Responsibility, in turn, serves as the psychological core of volitional regulation of behavior, reflecting an individual's readiness to recognize the consequences of their own actions and to bear accountability for them. Both constructs – self-esteem and responsibility – form the foundation of personal autonomy, without which the full development of the individual is impossible.

The influence of artificial intelligence on the psychological structure of personality cannot be regarded as direct or one-dimensional. It is multidimensional in nature, affecting cognitive processes, motivational orientations, the emotional sphere, and the individual's value system. Interaction with AI triggers complex mechanisms of psychological regulation which, under certain conditions, lead to changes in self-esteem and a weakening of personal responsibility.

Young professionals, students, and creative individuals – whose self-realization is closely tied to feelings of uniqueness and originality – are particularly vulnerable. Confrontation with "perfect" machine productivity can evoke frustration, lower self-esteem, and trigger compensatory behaviors – such as passive content consumption or the demonstrative use of AI without reflection.

Keywords
artificial intelligence; self-esteem; personal responsibility; self-control; agency; digital dependency; psychological adaptation

The Role of IT Technologies in Promoting Tourist Routes and Restaurant Services: The Case of Samarkand

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Uzbekistan is a country of ancient civilisation and rich culture. No other republic in Central Asia possesses as many monuments of history and ancient culture as Uzbekistan. The land of our Republic is a unique and priceless archive that preserves historical and archaeological monuments from various epochs – from the early stages of human development to the rise of great ancient states.

Modern development of tourism and the restaurant industry is impossible without the active implementation of information technologies. In the context of the digitalisation of the economy, IT technologies have become a key tool for promoting tourist routes, attracting visitors and improving the quality of services. Samarkand, as one of the largest tourist centres in Uzbekistan, serves as a vivid example of how modern digital solutions can contribute to the growth of the tourism infrastructure and restaurant sector.

The use of IT technologies in promoting tourist routes includes the creation of interactive websites and mobile applications, where tourists can explore attractions, tour routes, maps and reviews in advance. In Samarkand, virtual tours, online guides and QR codes placed near historical monuments are actively being introduced, making visits to the city more convenient and informative. Social networks and digital marketing play a significant role in shaping the city's image as a tourist destination, helping to attract both foreign and local travellers.

Samarkand's restaurant industry also actively utilises IT tools. Online table reservations, electronic menus, delivery systems through mobile apps and promotion via social media help restaurants attract new customers and improve service quality. Geolocation services and user reviews on platforms such as Google Maps, TripAdvisor and Telegram channels foster a competitive environment and encourage higher service standards.

Thus, IT technologies not only contribute to the effective promotion of Samarkand's tourism and restaurant services but also create new opportunities for integrating these industries. Digital transformation makes the city more open, convenient and attractive to visitors, strengthening its position as a cultural and gastronomic centre of the region.

Keywords
Uzbekistan; Samarkand; tourism; information technologies; restaurant industry; digitalisation; central Asia; cultural centre

Information Technologies as a Factor in the Personal Development of Female University Students in Uzbekistan

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Information technologies (IT) are among the key factors influencing educational outcomes and personal development in the context of digital transformation. In Uzbekistan, between 2020 and 2025, IT has been actively integrated into higher education, with efforts focused on increasing women's participation in the digital economy. Bridging the gender gap is recognised as a means of improving socio-economic status. Uzbekistan is working to ensure equal opportunities for students of both genders, as access to digital literacy and the ability to utilise IT are considered critical aspects of contemporary personal competencies. This study analyses how IT has influenced the personal development of female students in Uzbek universities from 2020 to 2025, based on statistical data and recent research, and discusses initiatives aimed at strengthening women's roles in the digital sphere.

International studies consistently indicate that IT benefits both education and personal development. Integrating digital technologies into education provides access to high-quality resources for acquiring 21st-century skills, such as critical thinking and communication in a global environment. Digital literacy is essential for addressing inequality; in 2020, basic awareness of digital technologies in Uzbekistan was low – 15 per cent – aiming for over 70 per cent by 2030. Globally, however, the gender digital divide persists: women lag behind men in IT skills by approximately 20–25 per cent, primarily due to lower participation in technical fields and limited access to technology in certain regions.

National research and official statistics show that Uzbekistan has made significant progress in educational equity. In recent years, the number of women pursuing higher education has grown rapidly, accounting for nearly 51 percent of university students in 2024. Nevertheless, women remain underrepresented in engineering and technical fields, comprising only about one-quarter of students in these programmes, which indicates gender segregation in education, with women predominantly in humanities and educational fields.

A key factor highlighted in research is the impact of education and computer access on bridging the gender gap. Internal statistics indicate a significant increase in digital skills among women with higher education. For instance, graduates are far more likely to possess advanced IT skills and achieve higher educational outcomes than non-graduates. Social barriers – such as early marriage and stereotypes – reduce women's likelihood of continuing to enhance their digital skills post-graduation. Consequently, the literature emphasises the need for a comprehensive approach that addresses both technical and socio-cultural aspects to fully leverage IT for women's development.

Keywords
Information Technology; Digital literacy; women university students; personal development; higher education in Uzbekistan; gender gap; gender equality; ICT education

Information Technology as a Means of Developing Reflective Culture

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This article explores the role of information technology in developing the reflective culture of counselling psychologists. It examines the potential of digital tools – such as online journals, supervision groups, and simulation platforms – for fostering professional self-awareness and metacognition. Empirical examples from practice are provided. The article concludes that IT can act as an active driver of professional growth and contribute to improvements in the quality of psychological services.

The development of reflective culture in counseling psychologists has become a crucial direction in professional education and practice. In the context of digital transformation, information technologies open new opportunities for the formation of stable reflective skills, self-understanding, and professional growth. The effectiveness of electronic tools such as online diaries, supervision platforms, digital simulators, and analytical tools is confirmed by both empirical observations and theoretical models.

Reflection, as a dynamic process of making sense of one's own actions, emotional reactions, and motivations, serves as the basis for ethically and scientifically grounded decisions in the counselor's work. An information environment properly integrated into professional training contributes not only to the realization of internal potential but also to the formation of a responsible attitude toward clients, society, and the profession as a whole. Thus, information technologies act not merely as auxiliary tools but as an active component in the formation of reflective culture, playing a key role in the training of the modern psychologist.

Keywords
reflection; counselling psychologist; information technology; professional development; digital environment; online supervision; metacognition

Multimedia Education for the Mental Well-being of Girls and Young Women

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In a rapidly transforming global society, the intersection of mental health, education, and technology has become a crucial domain for social innovation. The psychological well-being of girls and young women is both a public health concern and a human rights issue. According to the World Health Organization, one in seven adolescents aged 10–19 experiences a mental disorder, most often anxiety or depression. Social inequalities, cultural stigma, and limited access to reliable psychological education amplify these challenges. Addressing these multidimensional factors requires culturally sensitive, interdisciplinary approaches that integrate awareness of mental health, identity formation, and digital literacy.

The Lancet Psychiatry Commission on youth mental health underscores the importance of community-based prevention and educational initiatives that empower young people as active participants, not passive recipients. Empowerment in this context extends beyond individual self-efficacy – it involves collective agency, cultural participation, and social recognition. Programs that invite girls and young women to co-create content, moderate discussions, or mentor their peers strengthen both personal resilience and communal solidarity.

When digital educational tools affirm cultural heritage – through local narratives, traditional metaphors, and native languages – they reinforce dignity and self-worth. Recent empirical studies support this approach. From a technological standpoint, multimedia education serves not only as a tool for dissemination but also as a transformative framework for inclusivity and cultural preservation. Technology, therefore, should not be seen as a disruptor of tradition but rather as a bridge between heritage and progress – a medium that preserves cultural continuity while fostering cognitive and emotional innovation.

Cultural adaptation plays a crucial methodological role in ensuring that digital and educational interventions are authentic and relevant. Culturally attuned multimedia learning acts as both pedagogy and therapy – a form of "digital storytelling for healing" that restores continuity between collective identity and personal experience. When young people see their culture mirrored in the tools they use to learn and grow, technology becomes not an external influence but a culturally grounded extension of selfhood and belonging.

Culturally grounded psychological education, supported by digital technologies, has the potential to transform individual and collective well-being. It empowers girls and young women to become confident, compassionate, and informed members of society. By merging scientific understanding with cultural wisdom, we create a foundation for sustainable mental health that reflects the richness of human identity in a globalised world.

Keywords
Multimedia education; Mental well-being; Psychological empowerment; Cultural adaptation; Digital literacy; Digital storytelling; Gender-sensitive education

From the Ancient Silk Road to the Digital Era: Artificial Intelligence and Regional Integration in Central Asia

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The transformation from the historic Silk Road to today's Digital Silk Road marks not only a technological shift but also a civilisational transition. Internet connectivity in Central Asia has grown rapidly, reflecting the region's strong move towards digital integration. The digital economy now plays a significant role in countries like Kazakhstan and Uzbekistan.

Within this transformation, Artificial Intelligence serves as a key driver: UNESCO's AI Readiness Index shows consistent progress across the region. Together with projects such as Digital CASA, which expands fibre networks across Central Asia, these developments illustrate how the region is reviving the Silk Road's legacy in digital form.

Keywords
Artificial Intelligence; Digital Silk Road; Central Asia; Digital Transformation; Regional Integration; Smart Governance

Modern Trends and Prospects for the Development of the Tourism Industry in the Republic of Uzbekistan

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This article analyses the current state and prospects for the development of Uzbekistan's tourism market. It provides an overview of the existing tourism infrastructure and the dynamics of tourist flow growth, and identifies the main achievements and current challenges in this field. Special attention is given to the state and prospects for the development of transport, tourism, and service infrastructure, as well as to the enhancement of traditional and the introduction of innovative forms of tourism in Uzbekistan.

Uzbekistan pays special attention to implementing targeted programs and projects aimed at improving the quality of services for foreign tourists and developing modern tourism infrastructure. Priority areas include the modernization of transport logistics, development of rail and air communication, renewal of the tourist transport fleet, and improvement of the public transportation system through multilingual navigation. Additionally, particular attention is given to creating new tourist routes, diversifying types of tourism (industrial, geological, scientific, medical, agrotourism, etc.), constructing modern accommodation facilities, and ensuring tourist safety.

The development of international tourism in Uzbekistan represents the result of a centuries-long evolution – from historical caravan routes to a high-tech tourism industry capable of meeting the needs of the modern traveler. Owing to its rich cultural heritage, ongoing reforms, and the active implementation of innovative technologies, the country continues to strengthen its position as an attractive tourist destination in the global market. Modern digital solutions contribute to improving the accessibility of tourism services, enhancing infrastructure, and diversifying tourism products, which in turn promotes sustainable socio-economic growth, the development of international cooperation, and the strengthening of intercultural dialogue.

Keywords
Republic of Uzbekistan; modern tourism; cultural heritage; tourism infrastructure

Interactive Online Platform for Learning Art History: Digital Education of Artists and Artworks

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The advancement of information technologies provides new opportunities for the study and popularisation of art history. This paper presents the concept of an interactive online platform designed to teach users about artists, their works, and the historical context of visual art. The platform integrates digital archives, multimedia resources, and artificial intelligence-based tools to deliver personalised educational experiences. Users can explore artists' biographies, detailed analyses of paintings and sculptures, and virtual exhibitions enriched with 3D visualisations and interactive timelines. Artificial intelligence assists in recommending relevant artworks, identifying stylistic patterns, and offering adaptive learning pathways based on the user's knowledge level. Moreover, the platform incorporates accessibility features, allowing people with visual or hearing impairments to engage with art through audio descriptions, text captions, and tactile feedback. This approach not only enhances art education but also promotes inclusivity and global access to cultural heritage. The study emphasises that digital educational platforms can complement traditional teaching methods by providing flexible, immersive, and interactive experiences, ultimately fostering a deeper understanding and appreciation of the visual arts.

Keywords
art history; digital education; online platform; interactive learning; artificial intelligence; 3D visualisation; accessibility

Inclusive Education in Uzbekistan's Higher Education System

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Inclusion in higher education enables all students to have equal opportunities for success, regardless of their origin, demographic characteristics or current circumstances. In Uzbekistan's higher education system, inclusion is regarded as an important initiative that has a strong impact on the academic, scientific and cultural life of universities, as well as on enhancing their institutional reputation at local, national and international levels. The introduction of inclusive principles in higher education helps to attract talented individuals, create an inclusive culture for all, promote well-being, stimulate development, diversify communities and perspectives, create opportunities for students and staff as well as strengthen cooperation between higher education institutions and other partners, organisations and institutions.

Currently, alongside inclusive education, integrated education has also been introduced in Uzbekistan. As a result, children with special needs have started studying in general education schools. The education of a child with disabilities, whether in specialised or general education institutions, is carried out based on the conclusion of local psychological, medical and pedagogical diagnostic commissions, taking into account the type and degree of disability (mild or severe). In Uzbekistan, specialists working in the field of special education, in collaboration with international organisations such as UNESCO and UNICEF, are gradually implementing an inclusive education system.

Ensuring the priority of inclusion, along with providing student support services and accessible campus design, helps universities combat discrimination and remove barriers to comfort, accessibility and participation for students. In this context, consulting with students and staff is of great importance, as it allows universities to anticipate and address the needs of students from various social backgrounds and living conditions. This ensures that all students can fully participate in the educational, cultural and social life of the university and realise their full potential.

Keywords
inclusive culture; child with disabilities; social life; potential; diagnostic commission

Developing Parallel Corpora for Low-Resource Languages: a Methodology for Kyrgyz–Kazakh Data Creation

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This paper addresses the pressing challenge of data scarcity in low-resource languages, focusing on a practical methodology for building parallel corpora for the Kyrgyz–Kazakh language pair. The lack of extensive, high-quality bilingual datasets remains a critical bottleneck in developing neural machine translation (NMT) systems for such languages. To address this issue, the study proposes and evaluates a structured approach to generating parallel data using artificial intelligence tools. The methodology includes selecting an optimal AI-based translation system based on accessibility (free availability), translation accuracy, and processing efficiency. Using a test dataset of 1,000 sentences, the most effective system was identified and subsequently employed to construct a large-scale Kyrgyz–Kazakh parallel corpus. A manual error analysis revealed that approximately 0.5% of the translations contained inaccuracies, highlighting the need for additional post-editing and refinement. The findings contribute to the broader development of linguistic resources for low-resource language pairs and provide practical insights into the effective application of modern AI systems for parallel data creation.

Keywords
low-resource languages; Kyrgyz; Kazakh; parallel corpus; neural machine translation; AI-assisted translation; bilingual datasets; data creation methodology; post-editing; language resources

A Unified Comparative Framework for Video Dictionaries, Notation-to-Animation, Writing-to-Animation, and the Keypoint Approach of SignBridge

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This article proposes a unified comparative framework for three sign language visualisation paradigms: (P1) notation → animation (HamNoSys → SiGML → JASigning), (P2) writing → animation (SignWriting → SWML → tuniSigner), and (P3) the keypoint approach (AI-based pose extraction/generation). The comparison uses four criteria: (1) pipeline architecture and automation, (2) data and annotation, including the existence of video+gloss pairs, (3) portability to new domains and languages, and (4) integration and accessibility, such as API, web embedding, and offline mode. We show that P1 delivers the highest linguistic precision and transparent formalisation. P2 provides high iconicity and strong user community engagement. P3 offers scalable automation and flexible movement synthesis, especially when using corpora. Based on this analysis, we present a component taxonomy, a set of metrics, and a reproducible evaluation protocol. We position SignBridge as a 'bridge' between symbolic and AI approaches. In this system, input glosses and/or SW notations are converted into a unified representation (JSON) and then into VMD/VRM format for a web avatar in real time, with offline support. A pilot study demonstrates gesture comprehensibility and tempo comparable to those of existing methods, but with lower computational requirements. The main areas for improvement are smoothing inter-gesture transitions and refining finger configurations. This framework can guide the selection of architectures for education, government services, and media, and help plan the expansion of corpora and annotations for underserved sign languages.

Keywords
sign languages; HamNoSys, SiGML; SignWriting; SWML; avatar; keywords; glosses; multilingual translation; real-time; accessibility

Speech Generation Models for the Kazakh Language

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The Kazakh language faces a shortage of high-quality audio data for speech recognition and translation. Key challenges include the limited availability of annotated datasets, insufficient speaker diversity, and limited coverage of speech styles. The study identified optimal speech synthesis models for the Kazakh language based on a comprehensive evaluation using a wide range of quality metrics. The Meta MMS, KazakhTTS2, ElevenLabs, and OpenAI TTS models were studied. The use of such models allows for expanding the available audio data for training other systems, creating a variety of voice assistants and applications, accelerating the development of speech technologies for the Kazakh language, and significantly reducing the cost of professional voice-over production. Experiments have shown that some models generate speech that is close to natural intonation, pronunciation, and prosody. Using such models enables expanding audio data for system training, developing voice applications, and reducing voice-over costs. Based on a comprehensive assessment of quality metrics for Kazakh speech synthesis, the OpenAI TTS model was selected for its optimal balance between spectral accuracy and audio quality, with the following results: MCD (117), PESQ (1.12), DNSMOS (7.03), and STOI (0.14). This study makes a significant contribution to the development of speech technologies for low-resource languages by providing experiments for speech generation using TTS models with a focus on Turkic languages. It is planned to collect parallel audio data for Turkic language groups for communication among them. The research was funded by the grant “Research on the Automatic Generation of Parallel Speech Corpora of Turkic Languages and Their Use for Neural Models” (IRN AP23488624) from the Ministry of Science and Higher Education of the Republic of Kazakhstan.

Keywords
speech generation models; Kazakh language; Meta MMS; KazakhTTS2; ElevenLabs; OpenAI TTS

The Role of Artificial Language and Communication in Social Networks of the Information Society

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This article explores the role of artificial language and communication within the context of the modern information society. It emphasises the growing influence of computational linguistics and social networks in shaping human interaction, communication and cultural development. The study argues that artificial linguistic systems have become not only tools for information exchange but also active forces in redefining social structures and cultural identity in the digital age.

Social networks play a special role in the processes of interaction through information technologies in social life. In particular, it has been repeatedly emphasised that "in the implementation of the agenda for the 21st century, ensuring their continuity is directly related, first of all, to the harmonious course of social processes in different regions, the mutual coordination of various parties, the solidarity of representatives of social strata in society, and the strength of the level of interdependence of states, organisations and individuals". The success of social networks lies in their ability to allow users to create virtual lives, present themselves as they wish, and maintain continuous virtual contact.

The convergence of human and machine communication creates a new linguistic ecology characterised by immediacy, interactivity, and multidimensionality. This transformation, while enhancing intercultural dialogue and knowledge dissemination, also necessitates ethical reflection and cultural responsibility.

Hence, the sustainable development of the information society depends on achieving a dialectical synthesis between technological rationality and humanistic values. Only through this balance can artificial communication serve as a catalyst for intellectual progress, intercultural solidarity, and the continued evolution of human civilisation in the digital age.

Keywords
artificial language; computational linguistics; information society; social networks; communication; globalisation; digital culture

Development of a Speech-to-Sign Language Translation System to Support People with Hearing and Speech Impairments

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This research aims to design and develop an innovative real-time translation module that converts spoken language into Kazakh-Russian Sign Language (KRSL) using advanced neural network architectures and machine learning methods. As speech remains a primary mode of human communication, automatic speech-to-sign translation holds great potential for fostering inclusivity and improving communication between hearing individuals and people with hearing or speech impairments. However, existing systems often fail to account for the grammatical, semantic, and spatial characteristics of sign languages, which reduces the accuracy and naturalness of the synthesis. The proposed system integrates Automatic Speech Recognition (ASR) and Text-to-Sign (T2S) modules, utilising Transformer and Conformer architectures for high-accuracy processing of multilingual Kazakh and Russian data. The research involves the creation and annotation of a multimodal corpus comprising parallel speech, text, and sign data, alongside the development of a hybrid neural model that captures grammatical, semantic, and spatial features of KRSL. Emphasis is placed on real-time optimisation and linguistic adaptation to KRSL's unique structure. The outcomes contribute to the advancement of inclusive technologies in Kazakhstan, enabling instant speech-to-sign communication and supporting individuals with disabilities. Furthermore, the proposed methods can be extended to related sign languages within the Commonwealth of Independent States (CIS) and other regions where Kazakh communities are present, promoting cross-linguistic research collaboration and accessibility innovation worldwide.

Keywords
speech recognition; sign language; Transformer; Conformer; inclusive technologies; machine learning

A Stable Model of Steganography in Digital Communication Systems

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The advent of modern digital communication systems has led to the widespread use of steganography for covert information transmission, thereby ensuring confidentiality and resistance to interception. The primary focus of research is on increasing secrecy and resilience. The basis of traditional methods is the modification of low-level characteristics of multimedia signals. For example, the embedding of message bits into the least significant bits (LSB), frequency coefficients (DCT, DWT), or image feature vectors. Despite their simplicity, such approaches are susceptible to distortion during compression and filtering. In an effort to enhance resilience and secrecy, there is ongoing development of information-theoretical and learnable models. Information-theoretical approaches (Cachin, Mittelholzer) utilise relative entropy between the cover and stegotext distributions to quantify the probability of detecting a hidden message. This paper proposes a pioneering adaptive information-theoretical steganography model (AITSM) that enhances the secrecy and resilience of steganographic algorithms in digital communication systems. The model integrates a probabilistic characterisation of the distributions of cover and stegotext with trainable embedding and extraction functions based on deep neural networks. Optimization is implemented as a sender-detector-receiver game problem. The proposed model has been demonstrated to apply to images, audio, and video signals.

Keywords
stegonagraphy model; stealth; stability

Impact of Intellectual Property Protection Measures on the Reception of the Game

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The rapid development of digital technologies and the global nature of the computer games market create a situation where protecting intellectual property becomes one of the key challenges for the modern creative industry. How it is implemented directly affects the relationship between creators and the gaming community, and consequently, the reception and popularity of games. New security and licensing mechanisms raise both legitimate expectations from producers and concerns from consumers, making this an important area of research at the intersection of law, technology, and digital culture.

As part of the study, a survey was conducted among people of various ages and educational backgrounds, including representatives of IT professions and those outside the industry, to determine how technical knowledge and professional standing influence opinions on intellectual property protection solutions in games. The survey revealed that most participants recognise the importance of protecting intellectual property but react negatively to extreme technical measures. Restrictions imposed by DRM security measures, time-limited licences, or the requirement of constant internet connectivity are widely seen as intrusive, regardless of respondents' age, education, or profession.

The analysis suggests that the core issue is not the protection of intellectual property itself but how it is implemented. Creators who successfully protect their rights without restricting players' freedom tend to build closer relations with their audience and foster a positive brand image.

Keywords
intelectual property; game development; optimisation; video game industry; digital distribution; player experience

Analysis of Phishing Detection Possibilities in Text Messages

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The rapidly increasing number of attacks with phishing usage makes it necessary to effectively detect malicious messages. The aim of this work is to examine the possibility of detecting phishing in text messages using multiple parallel feature classifications and a fuzzy risk assessment system. The research involves identifying and evaluating key characteristics of potentially dangerous messages, such as time pressure, requests for data, suspicious links, threats, or references to negative consequences. Each of these features is independently assessed by various methods, including large language models accessible via APIs, traditional machine learning algorithms based on established frameworks, and a simple rule-based system relying on specific language patterns. These methods determine the presence level of each feature, creating a multidimensional security profile of the analysed content. The study was conducted using available datasets of phishing and safe messages obtained from the internet, which were processed for feature extraction and evaluation from a classification perspective. The results from each method are combined by a fuzzy classifier, enabling the final risk level to be expressed as a percentage, considering both the number of criteria met and their strength. This methodology facilitates comparison of different approaches, analysis of feature importance, and evaluation of phishing detection effectiveness in real-world conditions. The findings serve as a foundation for developing a test application that allows users to gauge the danger level of a message through fuzzy analysis of multiple parallel classifications.

Keywords
phishing detection; fuzzy classifier; machine learning; language models; text security; risk assessment; feature-based classification

The Phenomenon of Digital Anonymity and the Manifestation of the Shadow in Online Space in the Context of C. G. Jung's Analytical Psychology

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The modern era of digital technologies has transformed not only the forms of communication but also the psychological mechanisms of self-expression. Today, social networks, forums, and online platforms have become spaces where an individual can exist in multiple forms – from real to anonymous. Anonymity, in turn, has become a unique phenomenon that reveals the deeper layers of the human psyche. In conditions of reduced external control and fear of judgement, individuals begin to manifest aspects of themselves that are usually hidden in everyday social interactions.

From the perspective of C. G. Jung's analytical psychology, this hidden space of the personality can be considered a manifestation of the Shadow – the part of the psyche containing suppressed, repressed, or unaccepted traits of the self.

Digital spaces hold potential for psychological growth and self-awareness. Increasingly, people recognise how their online behaviour affects both their own emotional state and that of others. A new cultural trend – digital mindfulness – emerges, emphasising attentive and responsible use of digital tools. By realising that aggression or anxiety may be amplified online, individuals can consciously work with their Shadow.

New forms of psychological support in digital spaces also emerge. Anonymous online platforms, support forums, and psychotherapy chatbots serve as "containers" for Shadow expression, allowing individuals to safely release emotions, reduce anxiety, and feel heard without fear of judgement.

Thus, the phenomenon of digital anonymity provides researchers with a unique opportunity to study the deep mechanisms of the modern human psyche. The digital environment offers freedom of self-expression and a space where unconscious aspects of personality – particularly Jung's Shadow – manifest openly. Digital spaces act as mirrors of the psyche, reflecting internal conflicts, repressed emotions, and unconscious impulses.

However, such manifestations require psychological awareness. Without recognising the source of emotions, online anonymity becomes a form of unconscious discharge, where aggression and projections are expressed outwardly without internal processing. This not only intensifies internal dissonance but also harms others, reducing empathy and the quality of digital communication.

Future prospects lie not in rejecting digital technologies but in fostering digital mindfulness – the ability to understand and regulate online behaviour. Developing a culture of conscious communication, self-awareness, and digital ethics can transform the online space from a source of internal conflict into a space for self-understanding and integration.

Keywords
digital anonymity; online identity; Jungian psychology; Shadow; Persona; self-expression; cyberpsychology; digital self; online behaviour; deindividuation; psychological projection; digital mindfulness

Manual and Automated Testing: A Comparative Evaluation of Efficiency and Defect Detection

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This study presents a comparative analysis of the effectiveness of manual and automated testing using the MrBuggy4 application. The main objective of the experiment was to evaluate the differences between these two testing approaches in terms of test preparation and execution time, as well as the effectiveness of error detection categorized by error type. The study was conducted in two stages: the first stage included functional and integration tests, while the second stage involved retesting.

The results of the experiment showed that manual testing allowed for faster preparation and better detection of complex defects related to the user interface and certain integration tests. In contrast, automated testing demonstrated significantly higher performance in repeatable execution, result stability, and functional tests. Although the initial setup time for automation was longer, the cumulative testing time decreased in subsequent cycles, confirming its long-term cost-effectiveness.

The findings indicate that the implementation of automated testing is particularly beneficial – and sometimes necessary – in projects with a large number of repetitive scenarios and frequent software changes, whereas manual testing remains essential during the exploratory phase and when testing new functionalities.

Keywords
Manual testing, automated testing, error detection effectiveness, test execution time, software testing comparison, MrBuggy4

Comparative Analysis of Software Security Mechanisms in Salesforce and Microsoft Dynamics 365

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Salesforce and Microsoft Dynamics 365 are two leading CRM systems used for managing customer relationships. These systems handle both processing and storing confidential user and financial data, making it essential that they have robust security mechanisms to ensure data confidentiality, integrity, and accountability. This work focuses on a comparative analysis of such mechanisms in both systems to determine which is more secure and reliable. To achieve this, corresponding mechanisms for each solution were analysed. The scope of the research included comparing authentication methods (SSO, OAuth/SAML integrations, MFA), access control (object-, field-, and record-level security), as well as data integrity and confidentiality. Additionally, data encryption at rest and in transit was verified (Azure SQL Transparent Data Encryption in Microsoft Dynamics 365 and Salesforce Shield Platform Encryption), data leakage protection was assessed (e.g., whether exports via API or Excel are permitted and to whom), and API security tests were conducted to evaluate how each system handles this critical aspect (including checks on authorization, CORS implementation, API key governance, and rate limiting). Further investigations included password policy enforcement and the review of security controls such as auditing and event logging. The final phase of the research involved validating configuration-level safeguards to determine sandbox isolation from the production environment.

Keywords
CRM; security mechanisms; comparative analysis; data confidentiality; data integrity; access control; audit logging

A Review of Computational Models of Vowel Harmony in the Kazakh Language

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This paper provides a comprehensive review of vowel harmony (VH) in the Kazakh language from a computational linguistics perspective. As an agglutinative member of the Turkic language family, Kazakh exhibits a highly developed morphological structure and a complex phonological system. Among its key features, vowel harmony – where suffix vowels change between back and front depending on the root vowel – is one of the core phonetic laws that ensures naturalness and phonological coherence. However, building computational models that accurately capture and automate this phenomenon remains a significant challenge. The two main types of harmony – palatal (back-front) and labial (rounding) – interact in complex ways, and the gradient (non-binary) nature of labial harmony poses difficulties for traditional rule-based and finite-state models. This review discusses modern statistical and cognitive-phonological approaches, particularly the Maximum Entropy Harmonic Grammar (MaxEnt HG) and Dispersion Theory, which can effectively capture probabilistic and gradient aspects of vowel harmony. Furthermore, it explores the potential of neural and hybrid modelling frameworks to capture the phonological patterns of Kazakh with greater empirical precision. Such approaches may contribute to improving phonologically aware NLP systems for morphologically rich and low-resource languages like Kazakh.

Keywords
computational models; vowel harmony (VH); Kazakh language; Turkic language family; natural language processing; Maximum Entropy Harmonic Grammar; phonology

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