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O‘ZBEKISTON MILLIY UNIVERSITETI
JIZZAX FILIALI

KOMPYUTER ILMLARI VA MUHANDISLIK TEXNOLOGIYALARI

XALQARO ILMIY-TEXNIK ANJUMAN MATERIALLARI TO‘PLAMI

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O‘ZBEKISTON RESPUBLIKASI OLIY TA’LIM, FAN VA INNOVATSIYALAR VAZIRLIGI

MIRZO ULUG‘BEK NOMIDAGI O‘ZBEKISTON MILLIY UNIVERSITETINING JIZZAX FILIALI

KOMPYUTER ILMLARI VA MUHANDISLIK TEXNOLOGIYALARI

mavzusidagi Xalqaro ilmiy-texnik anjuman materiallari to‘plami

(2025-yil 26-27-sentabr)

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Kompyuter ilmlari va muhandislik texnologiyalari. Xalqaro ilmiy-texnik anjuman materiallari to‘plami – Jizzax: O‘zMU Jizzax filiali, 2025-yil 26-27-sentabr. 355-bet.

Xalqaro miqyosidagi ilmiy-texnik anjuman materiallarida zamonaviy kompyuter ilmlari va muhandislik texnologiyalari sohasidagi innovatsion tadqiqotlar aks etgan.

Globallashuv sharoitida davlatimizni yanada barqaror va jadal sur’atlar bilan rivojlantirish bo‘yicha amalga oshirilayotgan islohotlar samarasini yaxshilash sohasidagi ilmiy-tadqiqot ishlariga alohida e’tibor qaratilgan. Zero iqtisodiyotning, ijtimoiy sohalarni qamrab olgan modernizatsiya jarayonlari, hayotning barcha sohalarini liberallashtirishni talab qilmoqda.

Ushbu ilmiy ma’ruza tezislari to‘plamida mamlakatimiz va xorijlik turli yo‘nalishlarda faoliyat olib borayotgan mutaxassislar, olimlar, professor-o‘qituvchilar, ilmiy tadqiqot institutlari va markazlarining ilmiy xodimlari, tadqiqotchilari, magistr va talabalarning ilmiy-tadqiqot ishlari natijalari mujassamlashgan.

Mazkur to‘plamga kiritilgan ma’ruza tezislarining mazmuni, undagi statistik ma’lumotlar va me’yoriy hujjatlarning to‘g‘riligi hamda tanqidiy fikr-mulohazalar, keltirilgan takliflarga mualliflarning o‘zlari mas’uldirlar.

mexanizmlarini mustahkamlash zarur. Mintaqaviy kooperatsiya va xalqaro qo‘llab-quvvatlash institutsional va moliyaviy to‘siqlarni bartaraf etishda muhim o‘rin egallaydi.

Foydalanilgan adabiyotlar:

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TOWARDS SAFER JOURNEYS IN CULTURAL HERITAGE TOURISM: EXPLORING THE ROLE OF AI IN TOURISM SAFETY IN SAMARKAND AND BUKHARA, UZBEKISTAN

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Abstract: This research explores the integration of Artificial Intelligence (AI) into tourism safety and security in two of Uzbekistan’s most prominent heritage cities, Samarkand and Bukhara. Both cities, located on the historic Silk Road, are UNESCO World Heritage Sites that attract large numbers of international visitors. With rising tourist flows, ensuring visitor safety while preserving cultural assets has become a key priority. The paper examines AI’s role in predictive risk assessment, surveillance enhancement, emergency response, and personalized safety communication in these heritage-rich destinations. By analyzing potential applications such as crowd management at Registan Square in Samarkand, security monitoring at Bukhara’s Ark Fortress, and AI-based health safety during large festivals, the study demonstrates how AI can reinforce tourism resilience. Ethical considerations - including data privacy, surveillance concerns, and cultural preservation - are also discussed. This research contributes to understanding the intersection between advanced technologies and cultural heritage tourism, offering insights for policymakers, destination managers, and technology developers in shaping safer tourism in Uzbekistan.

Keywords: Artificial Intelligence, Tourism Safety, Samarkand, Bukhara, Cultural Heritage, Predictive Analytics, Risk Management, Smart Tourism, Ethical Considerations

1. Introduction

Tourism is one of the fastest-growing industries in Uzbekistan, with Samarkand and Bukhara serving as flagship destinations for cultural heritage. Both cities symbolize the historical grandeur of the Silk Road, featuring landmarks such as Samarkand's Registan Square, Shah-i-Zinda necropolis, and Bibi-Khanym Mosque, as well as Bukhara's Ark Fortress, Poi-Kalyan complex, and Lyabi-Hauz ensemble. Recognized as UNESCO World Heritage Sites, these cities attract millions of visitors annually, significantly contributing to the nation's economic development (UNESCO, 2022).

However, alongside opportunities, increased tourism also brings safety and security challenges. Large gatherings at cultural sites, risks of overcrowding, potential natural hazards, and evolving global health concerns all pose threats to tourists and host communities. Tourism studies emphasize that perceptions of safety strongly influence destination choice and visitor satisfaction (Preko & Gyepi-Garbrah, 2021). For heritage cities, safety issues also risk damaging fragile cultural assets and disrupting the livelihoods of local communities (Çinaj et al., 2022).

Artificial Intelligence (AI) provides new opportunities to strengthen tourism safety and security. From predictive analytics that forecast crowd congestion to AI-enabled surveillance systems that monitor visitor behavior, the technology offers solutions tailored for heritage-rich destinations (García-Madurga, 2023). As Uzbekistan promotes its "Safe Tourism" and "Digital Uzbekistan" strategies, the integration of AI technologies into cultural tourism becomes particularly relevant.

This study explores how AI can be applied to enhance tourism safety in Samarkand and Bukhara. By focusing on predictive risk assessment, enhanced surveillance, emergency response, and ethical challenges, it contributes to the growing body of knowledge at the intersection of cultural heritage management and smart tourism security.

2. AI and Safety–Security Challenges in Heritage Tourism

2.1 Contextual Challenges in Samarkand and Bukhara

Unlike modern entertainment complexes, heritage sites such as Registan or the Ark Fortress were not designed for mass tourism. Narrow passages, fragile monuments, and limited capacity amplify safety concerns during peak tourist seasons. Overcrowding can lead to accidents, cultural asset damage, or even security threats. For example, major festivals such as Navruz attract thousands of visitors to central squares, requiring effective crowd management and real-time safety measures.

Furthermore, both cities face vulnerabilities related to health risks and environmental hazards. Dust storms, seasonal heatwaves, and post-pandemic health anxieties heighten the importance of safety protocols. Traditional methods of safety management—manual supervision and conventional CCTV—are increasingly insufficient to address these evolving risks (Ko & Song, 2021). AI, with its predictive and adaptive capabilities, offers an advanced toolkit for ensuring resilience in heritage tourism.

2.2 AI-Powered Predictive Risk Assessment

AI can harness diverse data sources—tourist entry statistics, environmental sensors, and real-time weather data—to predict risks in heritage destinations. For instance:

- **Crowd prediction at Registan Square**: Machine learning models can analyze ticket sales, mobile network data, and historical visitation trends to forecast crowd surges, enabling authorities to regulate flows and prevent overcrowding.
- **Structural risk assessment**: AI algorithms can monitor vibrations and pressure on fragile monuments such as Bibi-Khanym Mosque, predicting risks of damage caused by excessive visitor load.
- **Health safety monitoring**: During pandemic situations, AI-driven models can track health data and mobility patterns to assess the likelihood of outbreaks at major heritage events (Panah, 2023).

Such predictive systems allow proactive decision-making, enhancing both visitor safety and cultural preservation.

Table 1: Tourism Sites in Samarkand and Bukhara with Safety Challenges

City	Key Site/Attraction	Safety & Security Challenges	Visitor Impact	Heritage Impact
Samarkand	Registan Square	Overcrowding, stampede risks	Reduced visitor satisfaction, stress	Risk of structural strain on monuments
Samarkand	Shah-i-Zinda Necropolis	Narrow passages, crowd bottlenecks	Safety hazards, discomfort	Erosion of fragile tilework
Samarkand	Bibi-Khanym Mosque	Fragile structures, uncontrolled visitor load	Accident risks, falling debris	Accelerated structural damage
Bukhara	Ark Fortress	Security risks, unauthorized access	Visitor injury, theft risks	Potential vandalism
Bukhara	Poi-Kalyan Mosque Complex	Heatwaves, congestion during prayer hours	Health issues, overcrowding	Stress on historic foundations
Bukhara	Lyabi-Hauz Ensemble	Large festivals, water contamination risk	Health hazards, safety concerns	Ecological strain

2.3 Enhancing Security Measures with AI

AI-enabled security systems, including facial recognition, intelligent surveillance, and anomaly detection, can significantly strengthen safety protocols in Samarkand and Bukhara.

- **Facial recognition and access control**: At sensitive sites like the Ark Fortress or Shah-i-Zinda, AI-powered entry systems can authenticate visitors, reducing risks of unauthorized access while streamlining visitor experience.
- **Intelligent surveillance**: AI-enhanced CCTV can detect suspicious behaviors or unattended objects in crowded areas, alerting security teams in real time (Helmy, 2024).
- **Crowd management**: AI systems can monitor visitor density at Registan or Poi-Kalyan Mosque, providing automated alerts to prevent stampedes or congestion-related incidents (Yilmaz, 2024).

These applications reduce human error, enable faster responses, and create safer environments for both tourists and heritage assets.

Table 2: AI technologies and their applications for enhancing safety

AI Technology	Application in Heritage Cities	Example Use in Samarkand & Bukhara	Expected Outcomes
Predictive Analytics	Forecast visitor numbers, detect overcrowding	Predict crowd surges at Registan during Navruz festival	Prevent congestion, safer flows
Facial Recognition	Access control, identity verification	Controlled entry at Ark Fortress & Shah-i-Zinda	Reduced unauthorized access, better security
Intelligent CCTV	Real-time anomaly detection & surveillance	Detect suspicious behavior in Lyabi-Hauz square	Faster threat response, crime prevention
Wearable Sensors	Monitor visitor health metrics (heat, fatigue)	Elderly tourists in Poi-Kalyan Mosque area	Timely health interventions
AI Chatbots/Apps	Multilingual emergency communication	Provide evacuation guidance in Registan & Ark Fortress	Improved visitor trust & safety
Robotics & Drones	Crowd monitoring, monument inspection	Drone-based monitoring of Bibi-Khanym Mosque structure	Protection of fragile heritage assets

3. AI for Improved Emergency Response and Crisis Management

3.1 AI-Powered Communication Tools: AI chatbots and mobile applications can support tourists during emergencies by providing multilingual safety instructions, directions to evacuation points, or immediate health advice. For example, an AI-based app for Samarkand could guide visitors toward safe exits during overcrowding at Registan or provide updates on local safety advisories.

During the COVID-19 pandemic, similar AI-driven chatbots provided travelers with real-time health information and resource availability, reducing strain on

emergency staff (Senthilraja, 2021). For Uzbekistan, deploying such tools would help bridge communication gaps between foreign visitors and local authorities.

3.2 Optimizing Resource Allocation: Machine learning models can predict demand for emergency services in high-traffic periods. For example, AI can forecast the number of ambulances or police officers required during Navruz festivities in Bukhara, ensuring resources are distributed effectively.

Furthermore, AI can integrate data from weather systems and transportation networks, enabling proactive deployment of safety personnel during adverse conditions such as heatwaves or sandstorms.

3.3 Personalized Safety Information: By analyzing traveler profiles and itineraries, AI can provide customized safety recommendations. For instance:

- Advising elderly tourists to avoid crowded hours at Shah-i-Zinda.
- Recommending hydration breaks during summer visits to Poi-Kalyan Mosque.
- Sending multilingual alerts about pickpocket risks or road closures.

Such personalized safety services enhance visitor trust, reduce risks, and improve overall tourist satisfaction.

4. Ethical Considerations and Cultural Preservation

While AI offers numerous benefits, its application in heritage tourism raises ethical and cultural challenges:

- **Data privacy**: Collecting biometric and mobility data may raise concerns among visitors, particularly in contexts where regulations are still evolving.
- **Algorithmic bias**: AI systems trained on limited datasets may misinterpret behaviors of culturally diverse visitors, potentially leading to unfair profiling (Khair, 2020).
- **Cultural authenticity**: Excessive reliance on digital surveillance could diminish the authentic experience of visiting heritage cities, creating perceptions of over-regulation.

Addressing these challenges requires transparent governance, community engagement, and regulatory frameworks that balance safety with privacy and cultural integrity.

5. Discussion

The case of Samarkand and Bukhara demonstrates how AI can be contextualized to heritage tourism. Predictive analytics, surveillance, and crisis management tools can transform how risks are identified and managed in these UNESCO sites. Importantly, AI not only safeguards visitors but also protects the cultural assets themselves by preventing structural damage and overuse.

However, the effectiveness of AI relies on institutional capacity, infrastructure, and public acceptance. Uzbekistan’s digital transformation policies provide a favorable foundation, but investments in training, ethical regulation, and international collaboration will be crucial for sustainable adoption.

6. Future Directions

The integration of AI in Uzbekistan’s heritage tourism can evolve along several dimensions:

- **Smart heritage cities**: Combining AI with Internet of Things (IoT) sensors to monitor visitor flows, air quality, and monument conditions in real time.
- **Blockchain for data security**: Ensuring safe storage and transparency of visitor data collected through AI systems.
- **AI-driven sustainable tourism**: Directing tourists toward less crowded attractions (e.g., smaller madrassas or caravanserais), reducing pressure on Registan and Poi-Kalyan.
- **Cross-cultural adaptation**: Developing AI systems that recognize linguistic and cultural diversity among visitors from Asia, Europe, and beyond.
- **Capacity-building**: Training tourism professionals and local authorities in AI applications to ensure human oversight remains central in decision-making.

7. Conclusion

Samarkand and Bukhara stand as living testimonies of Silk Road history, drawing visitors into Uzbekistan's cultural identity. As tourism grows, ensuring safety becomes inseparable from preserving authenticity and sustainability. Artificial Intelligence provides innovative pathways for proactive risk management, efficient crisis response, and personalized visitor safety. Yet, the responsible adoption of AI must account for ethical, cultural, and regulatory challenges.

This study highlights the transformative potential of AI in enhancing tourism safety in Samarkand and Bukhara while emphasizing the need for balanced approaches that respect both heritage and human rights. By integrating advanced technologies with strong governance, Uzbekistan can pioneer safer, smarter, and more sustainable cultural tourism.

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TELEKOMMUNIKATSIYA TARMOQLARINI RAQAMLASHTIRISHNING IQTISODIY SAMARADORLIGINI BAHOLASH

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Annotatsiya: Maqolada telekommunikatsiya tarmoqlarini raqamlashtirishning asosiy jihatlari va uning aloqa operatorlari faoliyatining iqtisodiy samaradorligiga ta’siri ko‘rib chiqiladi. Raqamli transformatsiyaning nazariy asoslari, samaradorlikni baholash usullari va raqamli texnologiyalarni joriy etishdan olinadigan iqtisodiy samarani hisoblash uchun foydalaniladigan ko‘rsatkichlar tahlil qilingan. Xalqaro va mahalliy tajriba asosida muvaffaqiyatli raqamlashtirish misollari muhokama qilinadi, ijtimoiy-iqtisodiy ta’sirlar va xavflar aniqlanadi. Ushbu maqolada telekommunikatsiya tarmoqlarini raqamlashtirishning iqtisodiy samaradorligini baholashga yondashuvlarni tadqiq etish va uning tarmoqni rivojlantirish uchun strategik ahamiyatini aniqlash masalalari ko‘rib chiqiladi.

Kalit so‘zlar: raqamlashtirish, iqtisodiy samaradorlik, raqamli transformatsiya, telekommunikatsiya, aloqa operatorlari, innovatsiyalar.

XXI asrda telekommunikatsiya sohasining rivojlanishi iqtisodiyot va jamiyatning barcha darajalariga ta’sir ko‘rsatadigan raqamlashtirish jarayonlari bilan chambarchas bog‘liq. Telekommunikatsiya tarmoqlarini raqamlashtirish ma’lumotlarni qayta ishlash, uzatish va saqlashning ilg‘or texnologiyalariga asoslangan “raqamli iqtisodiyot”ni shakllantirishning ajralmas elementiga aylanmoqda. Raqamli yechimlarni joriy etish telekommunikatsiya operatorlariga unumdorlikni oshirish, xarajatlarni kamaytirish, yuqori darajadagi xizmat ko‘rsatish sifatini ta’minlash va yangi daromad manbalarini yaratish imkonini beradi [1-3].