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“WOMEN IN INNOVATION AND SCIENCE” XALQARO ILMIY-AMALIY KONFERENSIYA VA FORUMI ILMIY ISHLARI TO‘PLAMI

Toshkent davlat transport universitetida 2026-yil 27-mart kuni “Women in Innovation and Science” xalqaro forumi ilmiy ishlari to‘plami chop etildi.

Mazkur nufuzli tadbirlar O‘zbekiston Respublikasi Oliy ta’lim, fan va innovatsiyalar vazirligi hamda Transport vazirligi hamkorligida tashkil etilib, mamlakatimizda ilm-fan, innovatsiyalar va zamonaviy texnologiyalarni rivojlantirish, shuningdek xalqaro ilmiy hamkorlikni yanada kengaytirishga qaratilgan muhim platforma hisoblanadi.

Konferensiya ochilish marosimida davlat organlari, xalqaro tashkilotlar va yetakchi oliy ta’lim muassasalari vakillari ishtirok etdi. Jumladan, Toshkent davlat transport universiteti rektori G‘ulomov Abdulaziz Abdullayevich, O‘zbekiston Respublikasi Transport vazirligi vakili Ulmasova Lobarkhon Adilovna, Osiyo taraqqiyot banki eksperti Claire Charamnac, Istanbul Aydin universiteti vasiylik kengashi raisi Mustafa Aydin, Belarus davlat transport universiteti rektori Kazakov Nikolay Nikolayevich hamda Qirg‘iziston Respublikasi Transport vazirligi vakili Dinara Moldokalieva ishtirok etdilar.

Konferensiya ilmiy dasturi doirasida plenar va panel sessiyalar, shuningdek ilmiy ma’ruzalar taqdimoti o‘tkazilib, ularda sun’iy intellekt va raqamli texnologiyalarni iqtisodiyot va ta’limga joriy etish, transport va aviatsiya sohasida innovatsion yechimlar, sanoat va IT sohasida texnologiya transferi, shuningdek ta’limda raqamli platformalar va intellektual tizimlar kabi dolzarb masalalar yoritildi.

2026-yil 27-mart kuni o‘tkazilgan “Women in Innovation and Science” xalqaro forumi ayollar yetakchiligi, innovatsiyalar va STEM sohalariga bag‘ishlangan bo‘lib, mamlakatimizda ayollarning ilm-fan va texnologiya sohalaridagi ishtirokini kengaytirish, ularning yetakchilik salohiyatini rivojlantirish hamda xalqaro hamkorlikni mustahkamlashga qaratilgan strategik maydon sifatida tashkil etildi.

Forum doirasida ayollar yetakchiligini rivojlantirish va rag‘batlantirish, xalqaro tajriba almashinuvi va ilmiy tarmoqlarni kengaytirish, yosh tadqiqotchi ayollar va PhD talabalarni qo‘llab-quvvatlash hamda innovatsion ekotizimlarda gender tenglikni ta’minlash kabi ustuvor vazifalar amalga oshirildi. Shuningdek, forumda ayollar yetakchiligi va STEM, gender tenglik va ilm-fan institutsional rivoji, ayollar tadbirkorligi va innovatsion startaplar, innovatsiya ekotizimlari va xalqaro hamkorlik, yosh ayol tadqiqotchilarni rivojlantirish, mentorlik va akademik tarmoqlar yo‘nalishlarida tematik sessiyalar tashkil etildi.

Forumda davlat organlari, xalqaro tashkilotlar, yetakchi oliy ta’lim muassasalari va ilmiy markazlar vakillari, jumladan “OLIMA” uyushmasi raisi Murtazayeva Raxbar Hamidovna, “Sharq ayoli” xalqaro ayollar jamoat fondi raisi Tursunbayeva Saodat Gafurovna, Osiyo taraqqiyot banki eksperti Claire Charamnac, O‘zbekiston Respublikasi Transport vazirligi vakili Ulmasova Lobarkhon Adilovna, Toshkent davlat transport universiteti rektori G‘ulomov Abdulaziz Abdullayevich, Qirg‘iziston Respublikasi Transport vazirligi vakili Dinara Moldokalieva hamda Indoneziyadan universitet dekani Yoga Prihatin ishtirok etdilar.

Shuningdek, forumda Yevropa va Osiyo davlatlaridan yetakchi olimlar, ekspertlar va yosh tadqiqotchilar keng qatnashdi.

Forum dasturiga ochilish marosimi, panel muhokamalar, ilmiy chiqishlar hamda professional rivojlanish bo‘yicha workshoplar kiritilgan bo‘lib, ular doirasida gender tenglik, ayollar karyerasini rivojlantirish, ilmiy tadqiqotlar va innovatsion boshqaruv bo‘yicha amaliy seminarlar tashkil etildi.

Mazkur tadbirlar Osiyo taraqqiyot banki (ADB), “OLIMA” — O‘zbekiston xotin-qizlar olimlari uyushmasi, “Sharq ayoli” xalqaro ayollar jamoat fondi, Germaniya xalqaro hamkorlik jamiyati (GIZ), shuningdek Rossiya, Turkiya, Indoneziya va Qirg‘iziston oliy ta’lim muassasalari hamda Belarus Milliy fanlar akademiyasi ilmiy institutlari hamkorligida o‘tkazildi.

Mazkur xalqaro ilmiy-amaliy konferensiya va forumning ahamiyati shundaki, ular xalqaro ilmiy hamkorlikni mustahkamlash, innovatsion ishlanmalarni amaliyotga joriy etish, raqamli va barqaror rivojlanishni ta’minlash, shuningdek ayollarning ilm-fan va innovatsiya sohalaridagi rolini kuchaytirishga xizmat qiladi. Shu bilan birga, mazkur tadbirlar yosh olimlar va tadqiqotchilarni qo‘llab-quvvatlash, ilmiy tajriba almashish hamda global ilmiy makonga integratsiyalashuvni jadallashtirishda muhim ahamiyat kasb etadi.

Mazkur xalqaro ilmiy-amaliy konferensiya va forumning maqsadi zamonaviy ilmiy tadqiqot yo‘nalishlarini muhokama qilish, innovatsion yondashuvlar va ilg‘or texnologiyalar bo‘yicha ilmiy natijalar almashuvini ta’minlash, shuningdek xalqaro ilmiy hamkorlikni rivojlantirishdan iboratdir.

Tadbirda O‘zbekiston Respublikasi hamda xorijiy mamlakatlarning oliy ta’lim muassasalari va ilmiy-tadqiqot institutlari olimlari, shuningdek amaliyotda muhim natijalarga ega bo‘lgan mutaxassislar o‘z ilmiy ishlari bilan ishtirok etdilar.

Ushbu ilmiy to‘plamda muhandislik, transport, raqamlashtirish, sun’iy intellekt, innovatsion boshqaruv, gender tenglik va barqaror rivojlanish sohalarida faoliyat yuritayotgan yetakchi olimlar, professor-o‘qituvchilar va tadqiqotchilarning ilmiy ishlari jamlangan. To‘plamda dolzarb ilmiy muammolar, zamonaviy yechimlar, nazariy va amaliy tadqiqot natijalari yoritilib, ushbu yo‘nalishlarning bugungi holati va istiqboldagi rivojlanish tendensiyalari aks ettirilgan.

Mazkur nashr mamlakatimizda ilm-fan va innovatsion rivojlanishni ta’minlash, xalqaro ilmiy aloqalarni mustahkamlash hamda yosh olimlar va tadqiqotchilarni qo‘llab-quvvatlash yo‘lidagi muhim qadamlardan biri sifatida e’tirof etiladi.

Shuningdek, mazkur ilmiy to‘plamda keltirilgan natijalar kelgusida ilmiy tadqiqotlar samaradorligini oshirish, amaliyotga yo‘naltirilgan innovatsion yechimlarni keng joriy etish hamda sohalararo integratsiyani chuqurlashtirish uchun muhim ilmiy asos bo‘lib xizmat qiladi. To‘plam materiallari nafaqat ilmiy jamoatchilik, balki ishlab chiqarish sohasi mutaxassislari, doktorantlar va talabalar uchun ham foydali manba hisoblanadi.

Mazkur nashrda yoritilgan ilmiy g‘oyalar va ilg‘or yondashuvlar asosida yangi ilmiy izlanishlar olib borilishi, xalqaro ilmiy aloqalarning yanada rivojlanishi hamda innovatsion rivojlanish strategiyalarining takomillashishiga xizmat qilishi kutilmoqda.

Application of digital twin technology for monitoring residential buildings

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Abstract: The rapid digitalization of the construction industry has led to the development of advanced technologies for monitoring and managing the condition of buildings and infrastructure. One of the most promising approaches is Digital Twin technology, which creates a dynamic digital representation of a physical object by integrating digital models with real-time monitoring data. This study investigates the application of Digital Twin technology for monitoring residential buildings in Uzbekistan, a region characterized by high seismic activity. The proposed framework integrates Building Information Modeling (BIM), sensor-based Structural Health Monitoring (SHM), and cloud-based data analytics to provide continuous assessment of structural performance. The methodology includes the development of a detailed BIM model of the building, the installation of a network of structural and environmental sensors, and the integration of collected data into a digital twin platform for real-time analysis and visualization. The system enables monitoring of vibration characteristics, deformation, and environmental effects on structural elements. The results demonstrate that the integration of digital models, sensor networks, and artificial intelligence technologies allows early detection of structural anomalies, supports predictive maintenance strategies, and improves the reliability and safety of residential buildings. The proposed approach can serve as a technological basis for developing digital seismic passports of buildings and implementing smart infrastructure monitoring systems in Uzbekistan and other seismically active regions.

Keywords: digital twin, structural health monitoring, BIM, seismic monitoring, residential buildings, sensor networks, predictive maintenance, smart infrastructure

1. Introduction

One of the most promising directions in the digitalization of the construction industry is **Digital Twin technology**. A digital twin represents a highly accurate virtual counterpart of a physical object that is created based on digital models and continuously updated using data obtained from sensor-based monitoring systems [1]. Unlike traditional **Building Information Modeling (BIM)** models, a digital twin functions as a dynamic system that ensures synchronization between the physical object and its virtual representation in real time [3]. In civil engineering, digital twin technology is actively applied to address problems related to **structural health monitoring and assessment of the technical condition of building structures**. The integration of sensors measuring acceleration, deformation, temperature, and vibration with digital building models enables continuous analysis of the dynamic behavior of structures and prediction of potential structural damage [2]. These technologies are particularly important in **seismically active regions**, where rapid evaluation of structural performance under dynamic loading is required. Structural health monitoring systems integrated with digital twins allow the analysis of dynamic characteristics such as **natural frequencies, mode shapes, and damping ratios**, which may indicate changes in structural stiffness and possible damage [4]. Recent studies show that the integration of digital twins with sensor-based monitoring systems can significantly improve structural condition assessment and enable **predictive maintenance strategies** [1]. Such systems allow early detection of structural defects, reduction of maintenance costs, and improvement of the reliability of building structures.

Literature Review

Digital Twin Technology in Civil Engineering

The concept of **Digital Twin (DT)** has emerged as a transformative approach in civil engineering, allowing the creation of high-fidelity digital replicas of physical structures. Unlike traditional BIM models, a digital twin operates dynamically, continuously integrating real-time sensor data to represent the current state of a structure and predict its behavior under operational or environmental loads (Fuller & Fan, 2020) [6].

Digital twin systems facilitate continuous structural monitoring by integrating networks of accelerometers, strain gauges, temperature, and vibration sensors with analytical models. Such integration allows early detection of deviations from expected performance, identification of structural damage, and implementation of predictive maintenance strategies [7].Recent studies demonstrate that combining laser scanning technology with DT frameworks significantly improves the accuracy of as-built models and structural deformation monitoring. For example, Yashinsky et al. (2014) utilized laser scanning for post-earthquake bridge inspections, highlighting its effectiveness in detecting subtle geometric changes and structural anomalies [8]. Similarly, Takhirov & Kayen (2021) compared point clouds generated by terrestrial laser scanning and photogrammetric methods, showing that DT models based on laser scanning provide higher fidelity for structural analysis [9].

Structural Health Monitoring (SHM) for Seismic Regions

Structural Health Monitoring (SHM) is a key application of digital twins, particularly in seismically active regions. SHM systems record structural vibrations, natural frequencies, mode shapes, and damping ratios, enabling early detection of stiffness reductions and potential damage [10].The integration of DT and SHM allows continuous

evaluation of structural integrity under dynamic loads. For instance, studies on reinforced concrete and steel bridges show that DT-based SHM can predict post-earthquake performance, optimize maintenance schedules, and extend the service life of infrastructure (Takhirov et al., 2021) [11]. Furthermore, real-time monitoring enables engineers to respond promptly to critical changes in building performance, ensuring occupant safety in high-risk seismic zones (Takhirov, 2021) [12].

Regional Research in Central Asia

Research on Structural Health Monitoring (SHM) and Digital Twin technologies in Central Asia is becoming increasingly important due to the region's high seismic activity and rapid urban development. In Uzbekistan, several studies have focused on the application of advanced monitoring technologies for infrastructure safety. For instance, Takhirov et al. (2020–2025) applied terrestrial laser scanning and vibration sensors for bridge monitoring in Tashkent, demonstrating that point cloud data can effectively detect geometric imperfections and support the creation of digital twins for predictive maintenance [9]. Similarly, Rashidov et al. (2020) presented a comprehensive program for the structural assessment of bridges, emphasizing the importance of integrating SHM systems to improve seismic risk mitigation strategies [10]. In Kazakhstan, research has explored the use of modern sensor technologies and data analysis methods for structural monitoring. Yusupov and Suleimenov (2022) implemented wireless sensor networks and inertial measurement units (IMUs) to monitor building vibrations under seismic loads, integrating the collected data into predictive maintenance models [11]. Furthermore, Akhmetov et al. (2023) applied statistical and machine learning algorithms to analyze the dynamic responses of buildings in Almaty, demonstrating the potential for automated SHM systems within digital twin frameworks [12]. Studies in Kyrgyzstan and Tajikistan have also contributed to this field. Ismanova (2021) investigated the seismic response of residential buildings using modal frequency analysis, which aligns with SHM methodologies used in digital twin modeling [13]. In addition, Yusufova (2023) examined vibration-based monitoring techniques for residential buildings, highlighting their importance for early warning systems and damage detection in seismically active regions [14].

2. Materials and methods

The proposed Digital Twin system for residential buildings consists of three interrelated components: a digital building model based on Building Information Modeling (BIM), a structural monitoring sensor network, and a data analytics platform that enables real-time analysis and predictive diagnostics. The integration of these components allows the creation of a dynamic digital representation of the physical building, which continuously updates based on real operational data and supports informed decision-making for maintenance and safety management.

Digital Building Model

The digital representation of the building is developed using BIM software such as **Autodesk Revit**. The BIM model contains comprehensive and structured information about the building and serves as the foundational layer for the Digital Twin system. It includes detailed data on structural geometry, such as columns, beams, slabs, and shear walls, which define the load-bearing framework of the structure. In addition, the model incorporates information on material properties, including strength characteristics, density, elasticity, and durability parameters of construction materials. The BIM environment also stores architectural information, such as floor plans, spatial configuration, façade systems, and internal layout of residential units. Furthermore, engineering systems—including Mechanical, Electrical, and Plumbing (MEP) components—are integrated into the model. This includes ventilation systems, electrical networks, water supply pipelines, and heating infrastructure. By combining these datasets, the BIM model provides a comprehensive digital representation of the building that supports structural analysis, maintenance planning, and integration with monitoring technologies. Within the Digital Twin framework, the BIM model acts as a reference model that is continuously updated based on sensor data obtained from the physical structure.

Sensor Monitoring Network

To monitor the structural performance of the building in real time, a network of embedded and surface-mounted sensors is installed in critical structural elements. These sensors collect continuous data on the physical state and dynamic behavior of the building. The monitoring system may include accelerometers to measure structural vibrations and dynamic responses, strain gauges to detect deformation in structural members, displacement sensors to monitor movement or settlement, and environmental sensors to record temperature and humidity conditions that may influence material behavior. The placement of sensors is determined based on structural analysis and critical load-bearing zones of the building, such as foundations, columns, shear walls, and floor slabs. During seismic events or dynamic loads, the sensors capture vibration characteristics, including frequency, amplitude, and acceleration responses. This information allows engineers to evaluate structural performance and detect early signs of damage or structural degradation.

Sensor data are transmitted in real time to cloud-based data processing systems using Internet of Things (IoT) communication protocols. Through wireless communication technologies, the collected data are continuously synchronized with the Digital Twin platform. The integration of real-time monitoring data with the digital model enables the visualization of structural behavior, automatic detection of anomalies, and the development of predictive maintenance strategies aimed at improving the safety and resilience of residential buildings, particularly in seismically active regions.

3. Results and Discussion

The figure illustrates the integrated system for monitoring, diagnosing, and analyzing transport infrastructure, buildings, and engineering structures using mobile laboratories, 3D scanning technologies, artificial intelligence, and digital twin modeling. At the first stage, field data are collected using a mobile laboratory equipped with modern measurement instruments, including drones, 3D scanners, and cameras. These tools are used to perform instrumental inspections and 3D scanning of buildings,

structures, and transport infrastructure, allowing researchers to obtain accurate geometric and structural data. The collected information is then transferred to the scientific and practical laboratory at the university, where it is processed in a modern simulation laboratory equipped with high-performance computers and specialized software. At this stage, computational analysis and structural modeling are performed. The processed data are further analyzed in the Artificial Intelligence Laboratory (AI Lab). Using artificial intelligence algorithms, the system creates a digital twin of the building or structure, which represents a virtual model that reproduces the real object's physical and structural characteristics. Based on the digital twin, advanced simulations and analytical calculations are carried out to assess the condition and behavior of structures under different loads, including seismic impacts. As a result, the system provides several important outputs:

• Non-destructive diagnostics of buildings and structures using artificial intelligence technologies

• Creation of digital seismic passports for buildings and transport infrastructure

• Development of seismic-resistant structural solutions to improve safety and reliability

Thus, the presented scheme demonstrates a closed technological cycle that integrates field measurements, digital modeling, artificial intelligence, and engineering analysis to support modern infrastructure monitoring and structural safety assessment.

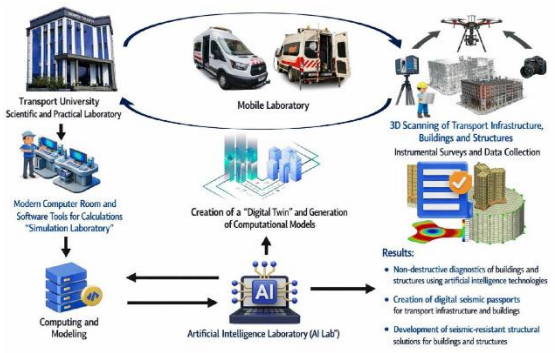

Fig. 1. Transport infrastructure, buildings and structures "Digital twin" scheme of simulation modeling of seismic effects

4. Conclusion

This study presented the concept and methodological framework of a Digital Twin–based monitoring system for residential buildings in Uzbekistan, integrating Building Information Modeling (BIM), sensor-based Structural Health Monitoring (SHM), and advanced data analytics technologies. The proposed approach demonstrates how digital models, real-time sensor data, and analytical platforms can be combined to create a dynamic representation of a building that continuously reflects its physical condition.

The results indicate that the integration of BIM models with sensor monitoring networks enables continuous observation of structural behavior, including vibration characteristics, deformation patterns, and environmental influences. Such integration improves the ability to detect structural anomalies at an early stage and provides a reliable basis for assessing the technical condition of buildings, particularly in seismically active regions. The use of cloud-based data transmission and Internet of Things (IoT) technologies ensures real-time synchronization between the physical structure and its digital counterpart. The analytical platform of the Digital Twin system further enhances monitoring capabilities by applying signal processing, modal analysis, and machine learning algorithms to interpret structural data and identify abnormal patterns. This enables predictive maintenance strategies and supports informed decision-making regarding building safety, maintenance planning, and lifecycle management.

T he developed monitoring scheme also demonstrates the effectiveness of integrating field inspection technologies, such as mobile laboratories, 3D scanning, and drone-based data collection, with artificial intelligence and digital modeling tools. This integrated workflow allows the creation of digital seismic passports for buildings and infrastructure, supports non-destructive structural diagnostics, and provides a basis for the development of improved seismic-resistant design solutions.

Overall, the proposed Digital Twin framework offers a promising approach for improving the monitoring, safety, and resilience of residential buildings in Uzbekistan. The implementation of such systems can contribute to the development of smart infrastructure management practices and enhance the reliability of buildings exposed to seismic hazards. Future research should focus on the practical implementation of pilot Digital Twin systems, expansion of sensor networks, and the development of advanced AI-based algorithms for automated structural damage detection and risk assessment.

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