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*Editorial*

# Smart Tech 4.0 in the Built Environment: Applications of Disruptive Digital Technologies in Smart Cities, Construction, and Real Estate

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Since the beginning of industrialization, there have been several paradigm shifts initiated through technological revolutions, inventions, and leaps. These were later named the industrial revolutions. Accordingly, the first industrial revolution focused on mechanization, followed by advancements in electrical energy and its usage (second industrial revolution) and digitalization (third industrial revolution) [1]. The fourth industrial revolution (Industry 4.0) is based on digital transformation and aims to revolutionize industries' manufacturing, distribution, and process improvement [2]. Recently, the focus is shifting to Industry 5.0, which aims to complement the existing "Industry 4.0" approach. It puts research and innovation at the service of the transition to a more human-centric, sustainable, and resilient industry. However, there are fields such as the built environment that are lagging behind the technology curve and are yet to materialize the true potential of Industry 4.0.

The traditional built environment needs to transform into a smart built environment. Accordingly, it needs a technological transformation aligned with the Industry 4.0 requirements. Disruptive digital technologies must be adopted in the built environment and its associated fields such as construction, cities, real estate, architecture, and urban planning to achieve this goal of technological transformation. Accordingly, in line with the United Nations sustainable development goals, integrated smart cities, construction, and real estate goals can be achieved to promote sustainability in the built environment. Such technologies in line with Industry 4.0 requirements (hereby referred to as the Smart Tech 4.0) have been proposed in various built environment fields. To date, more than 20 such technologies have been identified. Some examples include, but are not limited to: Unmanned Aerial Vehicles (UAVs), Artificial Intelligence (AI), Big Data, Internet of Things (IoT), Clouds, 3D Scanning, Laser Scanning, 3D Printing, Wearable Technologies, Wireless Technologies, Virtual Reality (VR), Augmented Reality (AR), Mixed Reality (XR), Robotics, Blockchains, Software as a Service (SaaS), Digital Twins, Building Information Modeling (BIM), Machine Learning (ML), Ubiquitous Computing, Mobile Computing, Renewable Energy, Autonomous Vehicles, and 5G Communications [3]. Though the huge potential for the adoption and applications of such technologies exist in the built environment, the research around the adoption and implementation of these smart technologies is currently limited. To address this gap, this Special Issue (SI) sought contributions from academic researchers and industry professionals, including construction managers, city and urban planners, project managers, civil engineers, IT managers, real estate and property managers, web developers, software developers, architects, governance management specialists, data scientists, computer systems analysts, and others, to submit their scholarly works.

The scholarly contributions in this Special Issue present some important technologies, aspects, and applications of Smart Tech 4.0 in the built environment. In the papers submitted to this SI, researchers have developed a wide range of novel ideas, frameworks, approaches, models, and prototypes that provide valuable resources, guidelines, implications, and adoption approaches for built-environment practitioners, managers, policy, and decisionmakers. Overall, this Special Issue compiles diverse but relevant thought-provoking ideas of Smart Tech 4.0 applications in the built environment. The details of the papers published in this SI are as follows:

The only review paper published in this SI by Gao et al. [4] presented a state-of-the-art review of the applications of wearable devices in construction safety. The authors conducted an extensive bibliometric analysis of the 169 articles published on the topic between 2005 and 2021 using CiteSpace® software. The authors identified 10 research clusters as extremely important for developing construction safety wearables and recommended developing a dynamic platform to integrate such technologies in the future.

Among the technical articles, Munawar et al. [5] investigated infrastructural damage and corrosion in civil engineering structures using UAVs. The authors applied ML to 600 images collected from two case study projects in Victoria, Australia. The authors developed a modified convolutional neural network (CNN)-based architecture utilizing 16 convolution layers and a cycle generative adversarial network (CycleGAN) and achieved more than 98% accuracy in identifying damaged components of the case study projects.

Olowa et al. [6] presented the idea of a web platform, "BIM-enabled Learning Environment (BLE)," to facilitate BIM-enabled education and training. The authors used the Adaptive Structuration Theory (AST) perspective to interpret their findings and suggested integrating information technology applications, including virtual learning environments, collaboration platforms, and BIM applications, to enable BLE.

Baraibar et al. [7] investigated the challenges of implementing BIM for executing underground works. Using an example of the Arnotegi tunnels of the Bilbao Metropolitan Southern Bypass, the authors developed a contractual framework to enable collaboration among stakeholders using BIM. The framework also encouraged advanced uses for integrating the information in the common data environment. Overall, the approach enables improvements in quality decisions and presents the information in an easily interpretable and transparent manner to enhance participants' perceptions.

Pérez et al. [8] optimized fieldwork for digitalizing urban settings using examples of two university campuses in northern Spain. The authors designed solutions generated through 3D models using the Design Science Research (DSR) approach. The authors used LiDAR ALS point clouds to digitalize the case studies and leveraged additional TLS capture techniques using UAV-assisted photogrammetric techniques. The results showed potential for reduction of working time on sites.

Ramos-Hurtado et al. [9] proposed deploying an AR tool for construction safety inspections. The authors analyzed building projects' traditional safety inspection processes and associated key performance indicators (KPIs). Accordingly, the authors proposed an AR-based digitalized collective protective equipment (CPE) inspection process followed by methodological recommendation and evaluation of applications.

Aslam et al. [10] identified and ranked landfill sites for municipal solid waste (MSW) using an integrated remote sensing and GIS approach. The authors used a case study of Fasiablabd Pakistan and developed a framework for identifying, ranking, and selecting MSW disposal sites in nine municipalities of the case study. The authors used multiple datasets, including normalized difference vegetation, water, and built-up areas indices (NDVI, NDWI, and NDBI) and some physical factors, including roads, water bodies, and the population.

Jahan et al. [11] addressed the integration complexity related to profitability-influencing risk factors (PIRFs) for construction projects using a system dynamics (SD) approach. Using the systems thinking (ST)-based approach to developing the causal loop diagram (CLD), the authors quantified the PIRFs. Field surveys and expert opinions were utilized in the process, and recommendations were presented for field professionals to identify PIRFs, diagnose issues and integrate the impacts of such factors on decision making.

Rajput et al. [12] investigated the impacts of political, social safety, legal risks, and the host country's attitude towards foreigners on project performance using a case study of China Pakistan Economic Corridor (CPEC). A Likert scale was used in the quantitative analyses of data collected through questionnaire surveys that were empirically investigated using partial least square structural equation modeling (PLS-SEM). The authors reported a negative relationship between political, social safety, and legal risks on the project performance. The social risks are increased if there is a negative attitude towards foreigners.

Amin et al. [13] examined the key factors for adopting collaborative technologies and the barriers to information management in construction supply chains of developing countries using an SD approach. The authors identified 60 factors and highlighted three main barriers, including top management support, complexity, and trust and cooperation, which impede the adoption of collaborative technologies in construction supply chains.

Jo and Lee [14] focused on the analytical methods for characterizing smart cities' ecological and industrial perspectives. The authors developed a smart SPIN (Spectrum, Penetration, Impact, and Network) model and analyzed the Korean smart city industry's ecology. The results highlighted the interactions of the Korean industrial ecosystem of smart cities with existing industries and uplifting its intelligence and smartness levels.

Shahzad et al. [15] examined the plastic deformation and seismic structural response of a mega-sub controlled structural system (MSCSS). The authors used nonlinear finite elements and dynamic analyses to examine the structural behavior using the MSCSS configuration that improved the mean equivalent plastic strain of columns and beams by 51% and 80% and reduced in maximum equivalent plastic strain by 44%. In addition, using varying configurations, the authors achieved a maximum coefficient of variation (COV) of 16% and 32% in the acceleration and displacement responses.

Ghufran et al. [16] determined the enablers of the circular economy (CE) in the construction industry for its sustainable development. The authors identified 10 key enablers of the CE in the construction industry, established the casualty among the factors using interviews, developed a CLD, and simulated it using SD. The authors concluded that policy support and organizational incentives for adopting the CE are critical for its implementation to achieve sustainable development in the construction industry.

Gharaibeh et al. [17] explored the barriers affecting BIM implementation in the Swedish construction industry. The authors extracted 34 barriers through an extensive literature review followed by barriers to BIM implementation in the wood construction industry in Sweden. The authors developed a conceptual framework and recommended solutions to overcome the identified barriers.

Calvetti et al. [18] deployed a laboratory circuit-based simulation to enhance electronic process monitoring (EPM) of construction tasks. The simulation was based on 10 common construction activities that involved wearable devices and used ML (accuracy between 92 and 96%) and multivariate statistical analysis (47–76%). The results showed accurate detection of hand motions in manual methods using wearables. More analysis points were recommended for free hand movements, walks, and operation activities.

The final paper in this SI is that of Huang et al. [19]. The authors presented a multi-criteria digital evaluation approach to facilitate accessible journeys and move towards inclusive walkable communities in smart cities. The authors introduced a proximity modeling web application subjected to two case studies. The application simulates pedestrian catchments for user-specified destinations and is based on the crowd-sourced road network and open topographic data. The model considers urban topography, travel speed, time, and visualization modes to accommodate various simulation needs for different urban scenarios, thus promising applications for urban planners, designers, managers, and health planners.

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