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Editorial

Special Issue on BIM and Its Integration with Emerging Technologies

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1. Introduction

Building information modeling (BIM) has quickly gained attention in the construction industry due to its promising benefits and has become a key technology affecting all phases of construction projects (i.e., design, construction, and operation). BIM also offers great potential for significantly enhancing project performances through its integration with other emerging technologies, such as virtual reality (VR) for improved design inspection, laser scanning for capturing as-built conditions, unmanned aerial vehicles (UAVs) for automated progress monitoring, design for manufacture and assembly (DFMA) for improved productivity, and the Internet of Things (IoT) for post-occupancy evaluation. However, BIM and its integration remain challenging due to data exchange and interoperability issues, such as insufficient data capturing, object recognition, and processing. Hence, this Special Issue of *Applied Sciences* aimed to address the practical and theoretical problems associated with BIM practice and their solutions to effectively use and integrate BIM.

2. BIM and Its Integration with Emerging Technologies

This Special Issue was introduced to collect the latest research on relevant topics and to address challenging issues with BIM and its integration with emerging technologies. In total, 31 papers were published in this issue on various topics. Five papers focused on the implementation of emerging technologies, such as additive manufacturing (i.e., 3D printing), laser scanning, and Long Range (LoRa) networking protocol, with BIM [1]. For example, Forcael et al. [2] formalized effective communication protocols between BIM-designed elements and their additive concrete manufacturing with the help of an articulated robotic arm. Kang et al. [3] proposed a rule-based mapping method between point cloud data from laser scanning and BIM for pipelines. In addition, five papers supported the implementation of various machine learning algorithms with BIM. For instance, Zhu and Wang [4] developed an intelligent prediction method of structural construction safety based on a backpropagation (BP) neural network while considering structural design parameters and mechanical parameters. Kim and Lee [5] also formalized an approach for identifying and appending interior design style information stochastically, with reference images and a deep-learning model. Furthermore, Hou et al. [6] proposed a vision-based framework for pavement-marking detection and condition assessment for proper maintenance strategies on roadway markings.

Three papers focused on applying VR and augmented reality (AR) with BIM for design review and collaboration. Specifically, Keung et al. [7] presented a system framework that integrates multiuser VR (MUVR) applications into omnidirectional treadmills for architectural design review and collaboration. Jin et al. [8] introduced a new form of AR called spatial augmented reality (SAR) to display graphics on physical objects for augmenting real-world objects. Lee et al. [9] investigated how the AR system affects architectural design review based on the users' perspectives. Moreover, two papers support the integration of BIM with geographic information systems (GIS). Adouane et al. [10]

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addressed the issue of offering a consistent 3D visual rendering of subsurface objects. To this end, they proposed a methodology to obtain missing spatial and geometrical data through field or empirical means. Ma [11] integrated historical building models and 3D-GIS attribute data to develop a model that provides virtual reality simulation function and environmental interaction experience.

Three papers discussed how BIM can be integrated with the implementation of new types of construction materials and construction methods. For example, Pavón et al. [12] formalized the object information of origami-based architecture materials required to form a dynamic shell that prevents or allows the perpendicular incidence of the sun into the infrastructure. Furthermore, four papers extended the information included in BIM for integrated project management. In particular, Seo and Lee [13] formalized BIM prototype libraries based on the standards of railway infrastructure in South Korea. Chen et al. [14] developed a BIM platform for the manufacture of steel structures to manage and visualize manufacturing progress in a steel structure factory. Pavón et al. [15] designed a BIM-based management system for the facility management of university buildings that provides real-time information synchronized with spreadsheets and a 3D model. Cho et al. [16] employed big data technology to propose a data-processing algorithm for integrated cost–schedule data management. In addition, four papers supported automated processes for various decisions on construction projects. For instance, Choi et al. [17] developed and applied BIM-based quality control requirements to improve the architectural design quality. Kim et al. [18] validated the effectiveness of the automatic generation of program-created 2D drawings (e.g., detailed plan, elevation, cross-section, and structural drawings) required for the IFC-based licensing process.

Three papers focused on the enhanced and collaborative implementation of BIM for various stakeholders. Par and Ock [19] investigated the desirable nature of an owner-oriented BIM guide, suggested the structure of the guide, and identified the major advisory contents to be included in the guide for public owners. Additionally, Jo and Choi [20] created a systematic standard for BIM so that one item of information can be used in various ways while enabling everyone to share and use it together. Lee and Yu [21] conducted a longitudinal study on a construction organization's BIM acceptance models. Two papers discussed BIM education for enhanced BIM diffusion. Specifically, Jin et al. [22] verified the effectiveness of the construction education theory in BIM and integrated project delivery (IPD) collaboration. Besné et al. [23] analyzed which methods are being used by higher education institutions around the world to integrate BIM implementation in the architecture, engineering, and construction (AEC) industry.

New technologies are rapidly emerging, and some of them will be suitable for integrating with BIM to enhance decision making in the construction industry. Thus, further research will be required to overcome the challenges of integrating these technologies with BIM in the future.

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References

1. Kim, K.; Li, S.; Heydariaan, M.; Smaoui, N.; Gnawali, O.; Suh, W.; Suh, M.J.; Kim, J.I. Feasibility of LoRa for Smart Home Indoor Localization. *Appl. Sci.* **2021**, *11*, 415. [CrossRef]
2. Forcael, E.; Pérez, J.; Vásquez, Á.; García-Alvarado, R.; Orozco, F.; Sepúlveda, J. Development of Communication Protocols between BIM Elements and 3D Concrete Printing. *Appl. Sci.* **2021**, *11*, 7226. [CrossRef]
3. Kang, T.; Patil, S.; Kang, K.; Koo, D.; Kim, J. Rule-Based Scan-to-BIM Mapping Pipeline in the Plumbing System. *Appl. Sci.* **2020**, *10*, 7422. [CrossRef]
4. Zhu, H.; Wang, Y. Intelligent Prediction of Prestressed Steel Structure Construction Safety Based on BP Neural Network. *Appl. Sci.* **2022**, *12*, 1442. [CrossRef]

5. Kim, J.; Lee, J.-K. Stochastic Detection of Interior Design Styles Using a Deep-Learning Model for Reference Images. *Appl. Sci.* **2020**, *10*, 7299. [CrossRef]
6. Xu, S.; Wang, J.; Wu, P.; Shou, W.; Wang, X.; Chen, M. Vision-Based Pavement Marking Detection and Condition Assessment—A Case Study. *Appl. Sci.* **2021**, *11*, 3152. [CrossRef]
7. Keung, C.; Kim, J.; Ong, Q. Developing a BIM-Based MUVR Treadmill System for Architectural Design Review and Collaboration. *Appl. Sci.* **2021**, *11*, 6881. [CrossRef]
8. Jin, Y.; Seo, J.; Lee, J.G.; Ahn, S.; Han, S. BIM-Based Spatial Augmented Reality (SAR) for Architectural Design Collaboration: A Proof of Concept. *Appl. Sci.* **2020**, *10*, 5915. [CrossRef]
9. Lee, J.G.; Seo, J.; Abbas, A.; Choi, M. End-Users' Augmented Reality Utilization for Architectural Design Review. *Appl. Sci.* **2020**, *10*, 5363. [CrossRef]
10. Adouane, K.; Boujon, F.; Domer, B. Digital Modelling of Underground Volumes, Including the Visualization of Confidence Levels for the Positioning of Subsurface Objects. *Appl. Sci.* **2021**, *11*, 3483. [CrossRef]
11. Ma, Y.-P. Extending 3D-GIS District Models and BIM-Based Building Models into Computer Gaming Environment for Better Workflow of Cultural Heritage Conservation. *Appl. Sci.* **2021**, *11*, 2101. [CrossRef]
12. Pavón, R.M.; Bazán, Á.M.; Cepa, J.J.; Arcos Álvarez, A.A.; Trigueros, J.M.A.; Alberti, M.G.; Tellaeche, J.R. New Use of BIM-Origami-Based Techniques for Energy Optimisation of Buildings. *Appl. Sci.* **2022**, *12*, 1496. [CrossRef]
13. Seo, M.B.; Lee, D. Development of Railway Infrastructure BIM Prototype Libraries. *Appl. Sci.* **2020**, *10*, 8118. [CrossRef]
14. Chen, S.; Wu, J.; Shi, J. A BIM Platform for the Manufacture of Prefabricated Steel Structure. *Appl. Sci.* **2020**, *10*, 8038. [CrossRef]
15. Pavón, R.M.; Arcos Alvarez, A.A.; Alberti, M.G. BIM-Based Educational and Facility Management of Large University Venues. *Appl. Sci.* **2020**, *10*, 7976. [CrossRef]
16. Cho, D.; Lee, M.; Shin, J. Development of Cost and Schedule Data Integration Algorithm Based on Big Data Technology. *Appl. Sci.* **2020**, *10*, 8917. [CrossRef]
17. Choi, J.; Lee, S.; Kim, I. Development of Quality Control Requirements for Improving the Quality of Architectural Design Based on BIM. *Appl. Sci.* **2020**, *10*, 7074. [CrossRef]
18. Kim, I.; Lee, Y.; Han, C.-H.; Kim, G.; Choi, J. Validation of Support for Creation of License Drawings Using Application for openBIM-Based Automatic Generation of 2D Drawings. *Appl. Sci.* **2020**, *10*, 6470. [CrossRef]
19. Park, K.-J.; Ock, J.-H. Structuring a BIM Service Scoping, Tendering, Executing, and Wrapping-Up (STEW) Guide for Public Owners. *Appl. Sci.* **2022**, *12*, 3275. [CrossRef]
20. Jo, C.; Choi, J. BIM Information Standard Framework for Model Integration and Utilization Based on openBIM. *Appl. Sci.* **2021**, *11*, 9926. [CrossRef]
21. Lee, S.; Yu, J. Longitudinal Study on Construction Organization's BIM Acceptance. *Appl. Sci.* **2020**, *10*, 5358. [CrossRef]
22. Jin, J.; Hwang, K.-E.; Kim, I. A Study on the Constructivism Learning Method for BIM/IPD Collaboration Education. *Appl. Sci.* **2020**, *10*, 5169. [CrossRef]
23. Besné, A.; Pérez, M.Á.; Necchi, S.; Peña, E.; Fonseca, D.; Navarro, I.; Redondo, E. A Systematic Review of Current Strategies and Methods for BIM Implementation in the Academic Field. *Appl. Sci.* **2021**, *11*, 5530. [CrossRef]