Automation and Robotics in Construction and Civil Engineering

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1 Introduction

The construction industry plays a significant influential role in national and global economies. The industry makes up 10 % of GDP in developed countries, and more than 25 % in developing countries. However, the degree of automation in construction is far less than in other industries, such as manufacturing. This results in both poor productivity and risky working conditions. Automation and robotics applications are opportunities to solve such issues in construction industry. Due to the rapid development of computer hardware and software in the past few decades, major improvements

can be found in robotic control, sensing, vision, localisation, mapping, and planning modules.

The research in this special issue is expected to give the readers a look into how innovate management strategies are influencing state-of-the-art building and infrastructure construction, and helping inspire industry or research to integrate automation and robotic technologies into their own practices

This special issue specifically focuses on research and case studies that demonstrate how automation and robotics technologies and tools can be applied in the construction of buildings and infrastructure. The submitted papers identify one or multiple problems where the use of automation, robotic technologies, or advanced management techniques can be applied to provide innovative solutions. This publication contains a plethora of new studies and research that aspire to mark critical milestones in the industry.

After rigorous blind reviews by the construction management experts and scientific committee, eighteen papers are included in this special issue; and these papers can be organized into the following four categories:

2 Automation and Robotics in Surveying Processes

In current construction practices, the use of surveying processes is an essential procedure that can be performed with automation and robotics technologies if

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the appropriate tools can be integrated. Various regular surveying processes, such as point layout and soil deformation monitoring, can benefit from innovative hardware development, like robotics total stations and laser scanning, which speed up the checking processes of the accuracy and quality of construction. In this special issue, the research topics cover civil excavation, tunnelling engineering and infrastructure monitoring.

Zhao et al. [1] have identified the deformation characteristics of buildings that are located in concave or convex positions of the excavation, which help predict and prevent possible influences with surrounding buildings among similar excavation cases. In considering a safe, efficient, and inexpensive method to extract spatial data of infrastructures, Dai and Zhu [2] have utilised a collecting of photographs from the infrastructure in question, and developed an approach to automate the object vertices and edges marking processes. The improved process is essential to reducing the efforts of converting image data into a 3D geometric model, which represents a big step toward a fully automation of as-built information reconstruction processes. The tunnel boring machine (TBM) is cutting edge construction equipment for rapidly excavation and is far safer comparing to conventional tunnelling methods. Mao et al. [3] utilised a robotic total station and innovative computing algorithms to monitor the alignment status of the TBM machine, which avoids the problems with accuracy and tedious calibration processes on using the conventional laser station.

3 Automation in Construction Quality Control

Wang et al. [5] proposed an integrated system encapsulating Building Information Modelling (BIM) and Light Detection and Ranging (LiDAR) for on-site information collection and construction quality control. It can help quality managers quickly and accurately identify and manage defects; an improvement to time-consuming inspections that had to be performed at specific positions. By proposing a situation awareness environment in the construction site, Chi et al. [6] conducted several case studies to identify the potential usage of laser scanned as-built model in quality assurance processes of Liquid and Gas (LNG) plant construction. Other tracking technologies, such as RFID, GPS and so on, can also be used to rapidly

discover uncertainties during construction, and help the manager to make better re-planning decisions as early as possible. The communications among such environment can be built online with the utilisation of cloud services. The research done by Cheng et al. [18] introduced a Construction Quality Supervision Collaboration System (CQSCS), which is developed with integration of SaaS private cloud to strengthen construction quality supervision and management.

4 Risk and Safety Analysis and Education in Construction

Zhong and Li [7] explored an opportunity for combining process and risk management by introducing an ontological and semantic approach. The risk-oriented ontology model has been proposed, and a case study on bored pile retaining wall system has been considered. Other than safety protections and risk identification in practice, safety education in promoting a safe and healthful working environment is necessary as well. Le et al. [10] utilised virtual reality technologies to create a virtual environment which allows cooperative distributed safety learning, hazard inspection, safety cognition, and active game-based learning. An evaluation has shown that such an education platform can increase the learning effectiveness. Zhang et al. [16] targeted the effects of metro tunnelling with respect to surface road operation and proposed a guideline for dynamic safety analysis over time. It can be used as a decision tool for safety assurance in a dynamic construction environment.

5 Innovation Management in Sustainable Construction

Fu et al. [4] identified a relationship between low carbon and the adoption of lean construction process. By going through a case study and utilising Life Cycle Assessment (LCA), the lean construction process has been proved to reduce carbon emissions when compared to the original processes. Besides sustainability analysis at construction stage, it is also important to aware of the energy consumption for indoor healthy space design. Kim et al. [12] utilised Mobile Augmented Reality (MAR) technologies, which derived from computer vision theorem,

to simulate energy consumption awareness in a building environment. They also identified key factors of energy evaluations for developing health smart home services.

6 Interface Management and Data Exchange in Construction

Wang et al. [8] studied a method for structural model transformation, and identified the representations and features between architectural and structural models. In response, an IFC-based software has been developed, and the test results show that data exchanging between the building information models for different disciplines can be achieved. Luo and Gong [14] utilised BIM to facilitate code checking and risk identification before the construction of deep foundation projects. A case study is provided to prove that BIM-based code processes increased the efficiency and precision of the code compliance checking and risk identification. Other than data exchanging issues in current construction processes, various interfaces among different disciplines also created a big gap for communication and cooperation. Ju and Ding [15] targeted on these issues and came up with a Web-based Integrated Interface Management System (WIIMS) for reducing interface conflicts and reworks. Some researchers like Yu et al. [17] developed an automatic approach on section map recognition for construction risk identification. Two typical legends on the section map of a metro project are recognised by their developed algorithm, which would help further improve risk evaluations.

7 New Scheme, Component and Tool in Construction

With the development trend of automation and robotics technologies in construction and civil engineering, new schemes, components, and tools are expected to be invented for ease of the integration and the maximum benefits. Xiong and Li [9] studied and proposed a modified internal model control scheme for the drive part of the robotics system, which is usually treated as rigid bodies. An experiment was conducted to verify the effectiveness of the proposed control scheme. Lee et al. [11] developed

a domain-specific computer programming language for dealing with building information models in the early design phases. The design concept of the language focuses on building objects and their associated properties and relationship, which provides effectiveness and ease of use without precise knowledge of the conventional languages that are used in BIM software development. In light of this development by Lee et al. [13], a new column-beam structure called Green Frame (GF) was developed to further enhance the constructability, economy, and environmental friendliness of construction. The dynamic erection system of the developed structure was established in this study in response to the changes of on-site production and erection condition.

The special issue presents novelty, emerging, high-quality research concepts, and results on the state-of-the-art construction and civil engineering advancement. All the proposed methods, models, technologies, and applications can potentially contribute to the current construction paradigm, or inspire further research with integration of automation and robotics technologies. We look forward the better life that advanced integrations between the automation and construction industries will bring us in the near future.

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