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CLOUD-ENABLED STRUCTURAL ENGINEERING EXPERIMENT DATA TELEPRESENCE AND DATA MANAGEMENT

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Abstract:

Construction sites are dynamic and complicated systems. The movement and interaction of people, goods and energy make construction safety management extremely difficult. Due to the ever-increasing amount of information, traditional construction safety management has operated under difficult circumstances. As an effective way to collect, identify and process information, sensor-based technology is deemed to provide new generation of methods for advancing construction safety management. It makes the real-time construction safety management with high efficiency and accuracy a reality and provides a solid foundation for facilitating its modernization, and informatization. Nowadays, various sensor-based technologies have been adopted for construction safety management, including locating sensor-based technology, vision-based sensing and wireless sensor networks.

Introduction

The development of sensor-based technologies has greatly improved information collection, data transmission and processing, which can serve as the foundation of the modernization of construction safety management. After nearly two decades of development, sensor-based technologies have facilitated the transformation from experimental exploration to practical applications. The applications of sensor-based technology in construction safety management have become the focus of current research. Since the various safety risk factors are endless in many aspects of building construction, construction safety management includes a very broad range of topics. It is hard to give a very clear definition and scope for construction safety management. Some researchers have tried to divide construction safety management into a pre-construction stage and a construction stage.In the former stage, potential safety hazards are usually identified based on experts' or managers' experience and eliminated through necessary preventive actions. In the latter stage, accidents are prevented by monitoring workers, machinery and the whole environment on site. Nevertheless, in the process of exploring more effective safety management methods with enhanced safety concept, it is realized that construction safety management should not be limited to merely the construction phase, but gradually proceed during in the full building life cycle, conducting a comprehensive and thorough safety management. Hence, based on the application range of different kinds of

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sensor-based technologies in the field of construction, this paper divides construction safety management into six aspects in detail, including accident forewarning systems, safety route prediction and planning, hazard identification, etc. The sensor-based technology applied to construction safety management consists of sensor-based location, vision-based sensing, and wireless sensor networks, etc. The combination of multiple sensor-based technologies basically meets the technical requirements in the safety management of construction projects, which will be further discussed in Section 4. Furthermore, the intelligence of sensor-based technology helps construct an interactive management platform, which is the integration of hardware and software for data processing, significantly improving the construction site monitoring capacity and providing guarantees for construction safety. In practice, hardware and software in data processing are the two major factors restricting sensor-based technology. Along with the increasingly in-depth research and advanced experience of utilizing sensor-based technology in some countries and regions, it is not hard to realize that the development of sensor-based technology often falls into the contradiction between the aforementioned restrictive factors. In actual use, managers usually allocate limited resources to only one of the two respects, depending on which one can lead to larger gains. Under the circumstances, stressing the one-sided technical advantages and neglecting its defects inevitably weaken the practical performance of sensor-based technology in construction safety management. How to seek a proper balance between hardware and software in data processing is vital for promoting any sensor-based technology.

Currently, utilizing sensor-based technology to improve construction safety management has been a fast-developing area as well as a great subject of interest within the engineering and academic communities. Nevertheless, there is a lack of a systematic review of sensor-based technology applications for construction safety management. Therefore, this paper aims at contributing to an in-depth investigation and providing a systematic and comprehensive review of previous studies to help researchers and managers acknowledge useful findings and capture future trends. The remainder of the study is structured as follows: in the second section, a two-stage literature selection method was accomplished, identifying relevant papers and compiling a database of the findings. Data analysis was then performed to identify useful research findings. In light of the results from the database, the third section presents an introduction to sensor-based technologies, including sensor-based locating, vision-based sensing, and wireless sensor network. The fourth section carries out a comprehensive and systematic overview of sensor-based technology applications for construction safety management from eight aspects. The fifth section points out the direction for future work, which offers potential opportunities for researchers to conduct more relevant studies and effective measures, in order to ensure a safe construction site. Finally, the conclusions are stated.

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2. Methodology

The paper adopts a methodological approach to conduct a comprehensive review of sensor-based technology applications in construction safety management. It provides a foundation for exploring useful findings and identifying gaps for future research on the basis of previous studies. With the help of scientific selection methods, key papers relevant to the chosen topic were selected and compiled to construct a database. Data analysis was then performed from chronological and thematic perspectives in order to identify useful research findings.

A two-stage literature selection method after Tsai and Wen [2] was applied to collect key relevant papers. The time range was determined to be from 2005 to 2016. The reason is that before 2005, few sensor-based technologies were utilized in construction safety management and their application range was quite restricted. Meanwhile, the level of technology during this period was much too simple, and the content of relevant papers would not play a positive role in improving construction safety management. As for the selection of sensor-based technology, it is conducted in the following steps: (1) based on the review of relevant papers, some sensor-based technologies were preliminarily identified since their utilization was pertinent to improve construction safety management; (2) for those technologies with little literature available (only 1 or 2 references) that only stated their capability of improving construction safety management without verification and test measures (e.g., laser scan and infrared), or those combined with other sensor-based techniques, not playing a central role but only providing supplementary support for construction safety management (e.g., applying Bluetooth to transmit data), should be removed. Thus the sensor-based technology consisted of sensor-based location, vision-based sensing and wireless sensor networks. The preset topic was the application of sensor-based technology in construction safety management. In the first stage of literature selection, theWeb of Science was chosen as the primary literature source and the Engineering Index was selected as a supplement.

A comprehensive literature search within SCI database was implemented using the "Title/Abstract/Keyword" field. The keywords were chosen as 'GPS' OR 'RFID' OR 'WLAN' OR 'ultra-wideband' OR 'Zigbee' OR 'ultrasound' OR 'camera' OR 'sensor' OR 'wireless sensor network' AND 'construction' AND 'management' AND 'safety' OR 'hazard' OR 'incident' OR 'accident'. A total of 156 related papers were found and transferred into the second stage of literature selection, which serves as a refinement. First, 11 papers were removed due to duplication. Considering the publication types, 42 papers belonging to "Patent", "Editorial", "Book", "Letter", "Report" and "Case Report" were then removed. In addition, 19 papers did not match the preset topic, were also removed. For example, exploiting RFID and UWB's data transmission capacity to conduct construction safety management rather than their positioning ability, which is not relevant to the preset topic and thus needs to be removed? A total of 84 papers with specific requirements were acquired from the SCI database.

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After the two-stage literature selection, it was found that there were a few papers retrieved from SCI database on using locating sensors for real-time underground positioning in unstable and unpredictable construction environment such as tunnels and mines. Since this part is one of the important points of Highly Dangerous Operation Management, it is necessary to supplement it through an EI search. The method of selecting papers from EI was the same as SCI search. Nine articles of satisfactory quality were selected. Overall, 93 papers were finally obtained by selection and supplement, which built the desired database.

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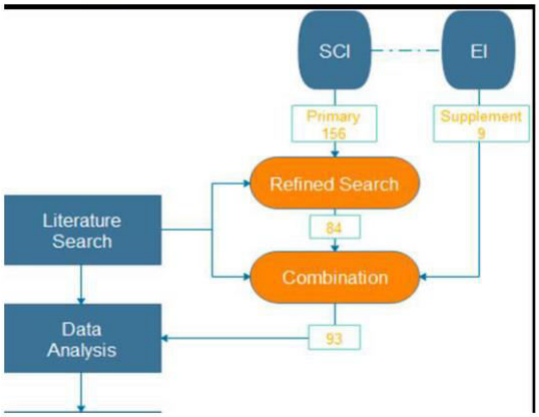

Figure 1. The process of literature database construction.

Results and Discussion

Year Profile of Publications

The annual publication dates of the 93 articles are shown in Figure 2. Before 2009, no more than four publications per year were related to construction safety management based on sensor technology.

A sharply increasing number of related papers have been published since 2009.

Though there are fluctuations in publication quantities, the annual number reaches an average of nine. During the same period of time, the RF locating sensor-based techniques (e.g., RFID, UWB) and the wireless sensor network became well developed and gradually

applied to construction safety management.

The increased publication number indicates that the application of sensor-based technology is getting more and more attention from researchers in construction safety management and has become an important part of construction management practices

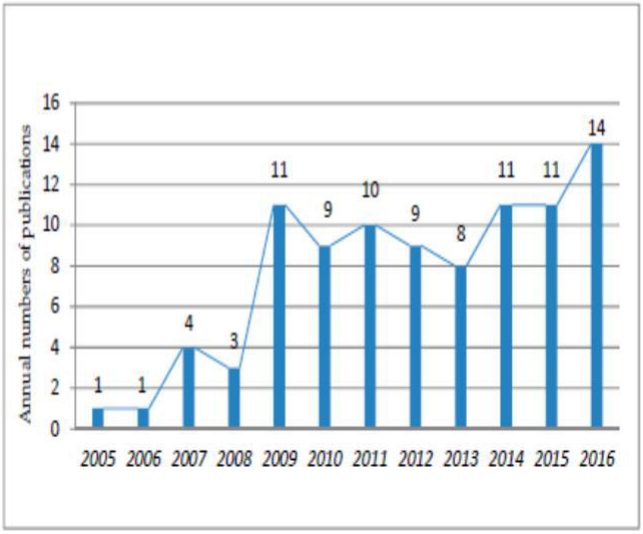

Figure 2. Year profile of publications.

The distribution of sensor-based technology applied in construction safety management is shown as Figure 3. The most widely used technique is RFID, with which 29 studies are conducted.

Wireless sensor networks (WSNs) ranked second (24 times), followed by vision-based sensing (18 times) and UWB (16 times). The least used techniques are WLAN and ultrasound, with four papers each. By percentage, RF locating sensor-based technologies (RFID and UWB) account for 41.28%, followed by sensors and WSN (22.02%) and vision-based sensing (16.51%). Among these three sensor-based technologies, sensors and WSNs are an advanced technology which is in the transitional stage from development to maturity, while RF locating sensor-based technology is the most mature and widespread technique, and it consequently attracts more attention. Though vision-based sensing is a traditional technique, it has the potential to be applied to brand-new fields. The reason is that with the development of machine learning and computer vision in image processing, the information in the images

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or videos, which cannot be identified by professionals, can be read and understood by specific algorithms instead. Compared with the past condition, these applications are brand-new fields and helpful to enhance construction safety management. Therefore, researchers are still devoted to exploiting this technique.

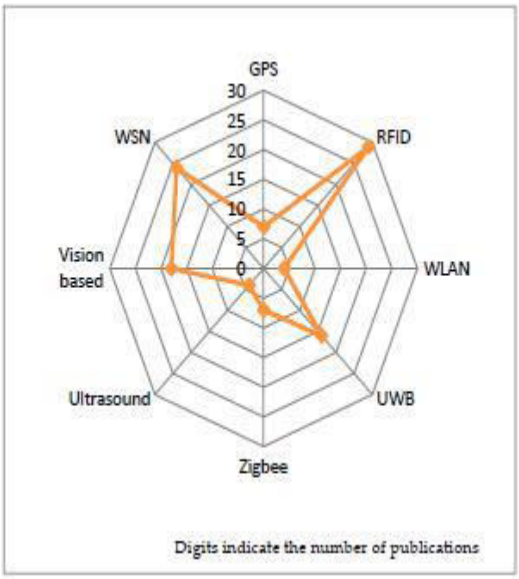

Figure 3. Application trends of sensor-based technology.

Distribution of Research Topics

The research topics are summarized through analysis and classification of 91 papers, including accident forewarning system (AFS), safety route prediction and planning (SRPP), integrated safety management (ISM), structural health monitoring (SHM), safety training and education (ST&E) and highly dangerous operations management (DOM). The distribution of research topics is shown in Figure 4. The most widely studied research topic is AFS with 53 papers involved, accounting for 51% among all research topics. ISM is ranked second with 20 occurrences, accounting for 19%. SHM occupies the third place with 13 referencess, accounting for 13%. In contrast, the three least studied research topics are ST&E, SRPP and DOM, which cumulatively account for 17%.

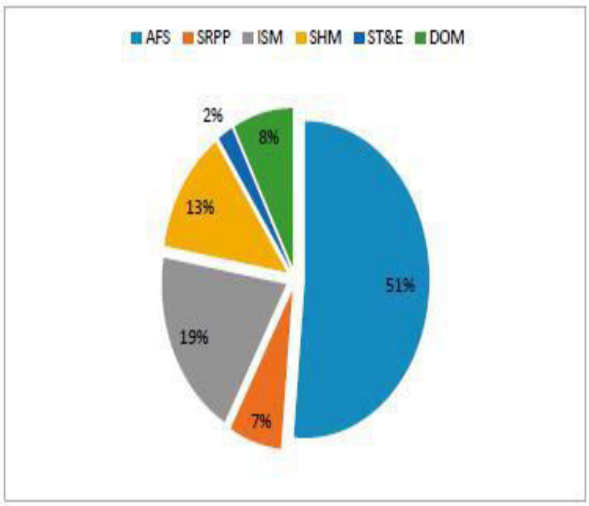

Figure 4. Distribution of research topics.

Conclusions

This paper has provided a comprehensive and systematic review of sensor-based technology applied in construction safety management from 2005 to 2016. In order to give an objective evaluation of the current research status and future trends, a two-stage literature selection method was applied in this research. Taking Web of Science as a primary source and Engineering Index as a supplement, the research identified 93 papers in the preset topics and formed a database. The year profile of publications, application trends of sensor-based technology and distribution of research topics were analyzed statistically. Furthermore, the trends of the research topics and application potential were discussed in the analysis.

Sensor-based technology consists of location sensor-based technology, vision-based sensing and wireless sensor network. The paper summarized the

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positioning accuracy of locating sensor-based technology including GPS, RFID, WLAN, UWB, Zigbee and ultrasound, and gave a brief introduction to vision-based sensing and wireless sensor network. By analyzing the selected 93 papers, research topics were classified as accident

forewarning systems, safety route prediction and planning, integrated safety management, structure health monitoring, safety training and education and highly

dangerous operations management. Meanwhile, the application status of sensor-based technology in the above fields was introduced objectively and systematically. Based on the previous achievements, the paper identified the research gaps, pointed out future research directions and showed the prospects of future development.

In general, single sensor-based technology is not directly applicable in construction safety management. Only the integration of multiple techniques is capable of meeting the ever-increasing requirements. Since the hardware and software are the essential parts of sensor-based technology, a balanced realization will achieve better and faster progress of sensor-based

technology in construction safety management. As an integrated platform of multiple sensor-based technologies, in recent years, the price of smart phones have become attractive because of their substantial popularity and price advantages resulting from large-scale production. In addition, due to the data processing ability and overall performance of smart phones, they have the potential to become an information management platform based on an open source system, which is beneficial in information collection and data processing. Generally, smart phones take both the hardware costs and the software compatibility into consideration and balance their relation in their evolution. Beyond that, compared with other sensor-based technologies, smart phones have some significant advantages, making them an optimal choice for both effective data acquisition solutions and portable data processing platforms.

Considering the environment of construction sites and the information requirements of safety management, in the foreseeable future, smartphones will have an increasing role to play in interactive construction safety management. In conclusion, there is still a long way to go for the development of sensor-based

technology construction safety management from theoretical research to

practical application. Nevertheless, without a doubt, this field of application has great potential and a bright future.

References

1. Guo, H.L.; Yu, Y.T.; Skitmore, M. Visualizationtechnology-based

construction safety management: A review. Automat. Constr. **2017**, 73, 135–144. [CrossRef]

2. Tsai, C.C.; Wen, M.L. Research and trends in science education from 1998 to 2002: A content analysis of publication in

selected journals. Int. J. Sci. Educ. **2005**, 27, 3–14. [CrossRef]

3. Lu, M.; Chen, W.; Shen, X.S. Positioning and tracking construction vehicles in highly dense urban areas and

building construction sites. Automat. Constr. **2007**, 16, 647–656. [CrossRef]

4. Pradhananga, N.; Teizer, J. Automatic spatio-temporal analysis of construction site equipment operations using GPS data.

Automat. Constr. **2013**, 29, 107–122. [CrossRef]

5. Domdouzis, K.; Kumar, B.; Anumba, C. Radio-frequency identification (RFID) applications: A brief introduction. Adv. Eng. Inform. **2007**, 21, 350–355. [CrossRef]

6. Song, J.; Haas, C.T.; Caldas, C.H. Tracking the location of materials on construction job sites. J. Constr. Eng. Manag. **2006**, 132, 911–918. [CrossRef]

7. Gu, Y.Y.; Lo, A.; Niemegeers, I. A survey of indoor positioning systems for wirelesspersonalnetworks.IEEE Commun. Surv. Tut. **2009**, 11, 13–32. [CrossRef]

8. Razavi, S.N.; Moselhi, O. GPS-less indoor construction location sensing. Automat. Constr. **2012**, 28, 128–136. [CrossRef]

9. Montaser, A.; Moselhi, O. RFID indoor location identification for construction projects. Automat. Constr. **2014**, 39, 167–179. [CrossRef]

10. Khoury,H.M.;Kamat,V.R. Evaluation of position tracking technologies for user localization in indoor construction environment. Automat. Constr. **2009**, 18, 444–457. [Cross Ref]