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"Artificial Intelligence in Building Construction"

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ABSTRACT: Artificial intelligence is the ability of computer systems to perform tasks which otherwise need human brain. Those tasks include visual perception, decision-making, speech recognition and translation between languages. Large amount computing resources is required to traditionally design and optimize complex civil structure in traditional method. This can be effectively eased by using intelligent systems. Safety can be defined as absence of danger or eliminating the situations that could be fatal. As construction industries working environment is very complex and thousands of workers are being injured or killed in accidents every year, so safety needed to be taken into consideration. There is a high need of monitoring the workers and warn the construction workers at the site. The process of safety should start from planning stage itself.

I. INTRODUCTION

Workplace safety and technology are thoroughly intertwined. From Excel spreadsheets to full-blown EHS software, most EHS professionals now use technology to save time AND effort while ensuring workplace safety. However, a new form of technology has entered the world of EHS. Today, Artificial Intelligence (AI) is undeniably a big part of our lives. Whether it is the virtual assistant on your phone, or the smart speaker in your home, AI has been increasingly normalized in past years. Applications of AI in Workplace Safety Thanks to computing power, a full office working day in 1970 can now be completed in 1.5 hours. Amazing, right? In fact, in 1930 the economist John Maynard Keynes predicted that automation and technology advancements would eventually leave us with a 15-hour work week. We're not quite at that stage yet. However, the value AI brings to each industry is enormous. Here are some of its applications in workplace health and safety. One major benefit of AI is its inability to get stressed, tired or unwell. In other words, AI safety can scale down human factors in the workplace. Human factors play a huge role in workplace safety, with fatigue and stress readily contributing to accidents. PPE detection: In 2018, AI-SAFE (Automated Intelligent System for Assuring Safe Working Environments) launched which cleverly detects if employees are wearing the correct PPE for each working area. Normally, PPE checks are conducted by a staff member, with potential for human error. Drones for difficult tasks: Another application of AI is to undertake dangerous tasks, so humans don't have to. Although strictly speaking drones themselves are not AI, they arequickly incorporating it. This allows them to make decisions and operate autonomously. For example, drone use is rising intheconstructionindustry. In fact, between 2017 and 2018, the number of drones deployed to construction sites grew by 239%.Furthermore, one survey found over 50% of construction sites using drones reported an improvement in safety. Construction site drones can gather and analyze data otherwise overlooked by humans. For example, one Dallas construction site has used drones to inspect roofs since 2014.

II. LITERATURE REVIEW

1. Hong ling Guo et al. (2018) studied the real time unsafe behavior of the workers at the site. For the same he studied the dynamics motion of the workers. The study is done with the help of video clips from the site. The video clips are being cut into small clips and then the dynamic motion of each worker is being compared with the predefined unsafe parameters.
2. Kwang-Pyo LEE, Hyun-Soo LEE (2012) they give an idea about finding the real time safety issues in the construction site. Here they predefined the unsafe areas and receivers are kept at that area and that will intimate the

workers with the help of an alarm that they are entering into an unsafe region.

3.Shuang Dong et at (2017) provides an effective approach to an automatically identify,issue timely warnings and capture worker responses. The warning and response data were then analysed to assess individual safety performance and locations over time for effectives safety behavior.

4. Eadie R (2013), Stowe et. (2014) BIM can enable site safety management system in construction industry. BIM when combined with RFID can help in finding the blind spots while using multiple cranes. The use of BIM with cloud computingtechniques has been suggested for maintaining construction health and safetypurpose.

III. SCOPE OF THE PROJECT

1) Artificial intelligence has made an impact in almost every industrial sector, and civil engineering is now joining the bandwagon as well. According to a report by McKinsey, the civil construction sector has a net worth of more than $10 trillion a year, and while it has one of the largest consumer bases, until recently, the industry had been relatively under digitized. This is because civil engineering is one of the few fields in which basic practices of bricklaying and pouring concrete have remained the same over the century.

2) However, the construction sector is set to undergo yet another industrial revolution, one powered by technology, particularly artificial intelligence. When one mentions artificial intelligence in civil engineering, a picture of robots driving trucks and laying bricks comes to mind. On the contrary, these techniques have more sophisticated applications in construction management, design optimization, risk control, and quality control.

3) Therefore, it would make sense for civil engineers to enroll in artificial intelligence courses, as it would provide significant value-adds to their career. Not only is AI making construction operations more manageable, but it is also set to make the construction business more lucrative. In the same report, McKinsey states that construction companies that have been incorporating AI techniques are 50% more likely to generate profits than those who don't.AI has a whole gamut of operations in civil engineering that would enhance the processes and transform the way builders and engineers work.

4) This research focuses only on activities carried out in the phases of the project development process that precedes construction and is limited to qualitative assessment.

5) Reduces the cost of the project.

6) Increases the overall quality of the project.

IV. CASE STUDY

METHODOLOGY

4.1 DATA COLLECTION :

4.1.1 MONITORING ACTIVITIES OF CONSTRUCTION SITES USING ARTIFICIAL INTELLIGENCE :

Construction sites are a massive jigsaw of people and parts that must be pieced together at the right time. With larger projects, delays become more expensive. McKinsey projects that on-site mismanagement costs theconstruction industry $1.6 trillion a year. But you might usually only have five managers overseeing construction of a building with 1,500 rooms, foresees Founder and CEO of British- Israeli startup Buildots Roy Danon. "There's no way an individual can control that much of detail."

Mr. Danon thinks that artificial intelligence (AI) can help developing an image recognition system, which monitors every detail of an ongoing construction project. It also flags up delays or errors automatically. Along with Buildots, the two biggest building firms in Europe, including UK construction giant Wates is using this system in large residential builds. Construction is significantly a kind of manufacturing. If high-tech factories adopt AI to manage their processes, it the high time for construction sites to start using it.

Artificial intelligence (AI) has started to change various aspects of construction, ranging from design to self-driving diggers. Some companies even offer a kind of overall AI site inspector, which matches images taken on-site against a digital plan of the building. Buildots is now making that process easier and feasible than ever by using video footage from GoPro cameras ascended on the hard hats of workers.

When managers visit the site once or twice a week, the camera on their head captures video footages of the entire project and then uploads it to image recognition software. It compares the status of many thousands of objects such as electrical sockets, and bathroom fittings on-site with a digital replica of the building.

Artificial intelligence also uses the video feed to find out where the camera in the building within a few centimetres so that it can spot the

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exact location of the objects in each frame. Mr. Danonclaims that the system can track the status of approximately 150,000 items several times a week. AI can identify which of three or four states it is in for each object, from not yet begun to fully deploy.

Sophie Morris, a civil engineer at Buildots, says, "Site inspections are slow and tedious." Buildots developed AI to get rid of many repetitive tasks and allows people to focus on making important decisions. "That's the job people want to do where one doesn't have to go and check whether the walls have been painted or someone's drilled too many holes in the ceiling," says Morris.

Another advantage is the way the tech works in the background. It records data without the requirement to walk the site with spreadsheets or schedules, explains Operations Director of Wates, Glen Roberts, whose firm is now planning to roll out the Buildots system at other locations.

The complete status of the project and its digital plan has a big difference. It has been found after comparing it several times a week during the COVID-19 pandemic. Although construction sites were shut down in the wake of the coronavirus outbreak, the essential on-site workers, managers on various Buildots projects kept tabs on progress remotely.

Artificial intelligence will not replace these essential workers anytime soon. Humans are still creating buildings, not AI. "At the end of the day, this is an extensive labor-driven industry, and this fact won't change," foresees Morris.

Fig. No.1. Construction Site Supervision By AI

3.1.2 A SMART HARD HAT : SAFETY TOOL (PPE)

Fig. No.2 Smart Hard Hat

A smart hard hat is personal protective equipment (PPE) designed to enhance worker performance and safety in construction and related industries through embedded technology.

A smart hard hat is a rigid protective helmet with embedded sensors. The hat provides workers in construction and related industries with additional safety controls made possible through technology. Smart hard hats and other smart personal protective equipment (PPE) equipment use an array of sensors to track and monitor conditions and employee actions.If the smart hat is connected to the internet, data may be sent through a wireless local area network to a gateway, from which it can be distributed to managers and archived if necessary. Aggregated data from multiple employees can be used to discern and predict trends and guide future practices. Some smart hard hats include augmented reality technologies that allow the user to access their own bio data statistics, read email, search for information or study blueprints and other images. AR in these helmets is typically provided through a transparent visor or mask.

Personal safety monitoring can be enhanced through smartphone-connected wearables or wearables with embedded cellular connectivity, creating a promising market. Through these devices, an SOS alert can be sent in a timely and discreet manner to deter crimes or minimize personal injuries.

3.1.3 SENSOR BASED TECHNOLOGY :

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1. GPS :

GPS, namely the global positioning system, consists of satellites, ground control stations and use receivers. Owing to its capacity of providing 3D coordinates including points, lines and planes in afast, accurate and efficient way under all-weather circumstances, it has been widely utilized in different fields, e.g., geodesy, photogrammetry, marine surveying and mapping. GPS has also been promoted greatly in construction safety management in the last few decades. Besides its uses in engineering surveys and monitoring the deformation in buildings or building components, it has been developed in safety monitoring of building construction, including machinery equipment and construction materials. GPS is suitable for tracking objects in outdoor environments, however, it does not work well indoors with obstacles such as basements, tunnels, culverts, etc. The accuracy and efficiency decrease evidently once the signals are blocked in such conditions. Lu et al.pointed out that the average error in tracking a concrete mixer truck, in a large dense urban area in Hong Kong, was less than 10 m using a combination with GPS, dead reckoning vehicle navigation and Bluetooth beacons. Pradhananga and Teizer reported an average error of 1.1 m when locating equipment with GPS in an open area, but it increased to 2.15 m and 4.16 m in the presence of nearby obstacles.

2. RFID :

RFID is short for radio frequency identification, which identifies a specific target through radio signals. It can read and write corresponding data without mechanical or optical contact with the identification system. RFID consists of tags, readers and antennas. Since it is able to locate single or multiple targets precisely in static or dynamic indoor environment, RFID has been widely used in construction safety management, such as AD, HI, ISM and AFS. Song et al. found that the average error of 2D positioning with RFID was 3.7 m, which was similar to Gu's report]. The experiments conducted by Razavi and Moselhi showed the average positioning error was about 1.3 m in indoor environments. In practice, the accuracy of RFID can be further improved by promoting relevant algorithms or adopting different locating methods.

3. WLAN :

Wireless local area network (WLAN) is a data transition system using RF technology. WLANs can access the network in any location within the coverage area of wireless signals and calculate the target's position from the strength of the detected signal. The positioning system based on WLAN requires deployment of wireless signal transmitters, and the target must be in the signal coverage area, thus limiting its usability in the dynamic and complicated construction site. In practice, the obstacles may hinder or even reflect the electromagnetic signals, affecting the WLAN's positioning accuracy, and restrict the development of WLAN in construction site. Khoury and Kamat tested the accuracy of WLAN positioning system in the laboratory, showing an average error of 2 m. Taneja et al.reported that the positioning error ranged from 1.5 m to 4.57 m with a credibility level of 95% for static targets and about 7.62 m for dynamic ones with a credibility level of 95%.

4. UWB :

Ultra-wideband (UWB) is a wireless positioning technique newly-developed in recent years. It has a good application potential in the field of wireless indoor positioning. UWB takes advantage of ultra-wideband signals that are suitable for high-speed and short-range wireless transition due to their wide spectrum range. Compared to other narrow-band transition systems, it is less susceptible to multipath interference, thus it has the capability of real-time tracking for multiple targets with high sampling speed, high accuracy and low energy consumption [13]. Sensors 2017, 17, 1841 7 of 24 UWB has been well accepted by scholars and construction managers and gradually popularized in related experiments and practices. So far, it has been utilized in fields including AP, SD, HI and ST&E. In general, the average positioning error is about 0.5 m [14] and the accuracy can reach the centimeter level in indoor environment. Maalek and Sadeghpour [15] reported that the 2D positioning accuracy was 20 cm and 40 cm for 3D positioning in open area with 70% credibility level for both. In contrast, Cheng et al. [16] reported the UWB was much less accurate in a large area (65,000 m2) affected by the frequency of positioning labels. A set of tests showed the positioning accuracy of UWB was 1.26 m with 1-Hz label and 1.63 m with 60-Hz label. In addition, the obstacles in work environment and metal interference will have a significantly negative impact on UWB's positioning accuracy.

5. ZIGBEE :

Zigbee is a two-way wireless communication technique with the characteristics of short distance, low complexity, low energy consumption, low transition speed and low costs. It is mainly used for data transition among various electronic devices. Zigbee is widely favored by the researchers in China and in recent years is becoming a hot technique for conducting DOM in locations such as tunnels, roadways and underground mines. On the other hand, scholars from other countries have explored its application potential by combining it with other positioning techniques such as RFID and WSN rather than the use of Zigbee alone in AP, AFS, etc. Meng et al. reported an average error of 0.76 m when acquiring personnel position data in coal mines. Shen et al. designed an automated tunnel-boring-machine positioning system based on Zigbee and tested its performance. The test was conducted by the designed system and a specialist surveyor independently. The differences between the two surveying were less than 2 mm, verifying the accuracy of the designed system.

6. ULTRASOUND :

An ultrasound positioning system uses sound speed and transfer time to calculate the distance between the measured point and a fixed point, and identify the target with triangle location method. The accuracy can usually reach centimeter level and the technology is mature and low cost. However, ultrasound positioning systems have some limitations. For example, the quick attenuation of ultrasound in air restricts its transition distance; it cannot penetrate obstacles such as walls and can be easily distorted by the reflected signals caused by metal objects. Cricket is a mature ultrasound positioning system. It requires the targets to carry signal receivers and the signal transmitters mounted on walls or ceilings. In order to deal with the insufficient number of signal transmitters, the system applies RF as a backup method to provide positioning data. Tests showed the positioning error was 10 cm and the orientation accuracy was 3 degrees. Skibniewski and Jang employed a combination of ultrasound and RF to track the construction material in a construction site, achieving an accuracy of less than 0.2 m with 80% credibility level ranging from 1 m to 15 m under line-of-sight conditions. Another set of experiments showed that the average positioning accuracy was 0.97 m.

7. VISION BASED SENSING :

Vision-based sensing uses imaging sensors to collect photos or videos. The collected data is then analyzed with specific algorithms to perceive and understand the surrounding environment. In vision-based sensing, the target does not need to carry any device. The technique itself can meet the positioning requirements in a relatively large area. However, the vision-based sensing is also vulnerable to the impact of surrounding environment, such as lighting condition and background color. In practical use in most countries around the world, including China, the application of vision-based sensing is limited to the elementary level, namely setting up video surveillance systems to transmit images or videos of various construction scenes to a surveillance center. Professionals are hired to identify useful information from images or videos and make decisions. This level is far from Sensors 2017, 17, 1841 8 of 24 intelligent due to the low degree of information utilization and low accuracy of identification, leading large amount of information being unused or even ignored directly. To resolve the dilemma in practical application, foreign research has focused on the development of algorithms to replace manual supervision so as to read and understand the useful information from images quickly and accurately. Though under some circumstances, the actual effect of some algorithms is not as satisfactory as desirable, e.g., the machine learning in image processing is not as accurate as human interpretation, the unceasingly improving algorithms and advances in technology will eventually overcome the current obstacles. Since there is a huge amount of information in images or videos neglected by humans but that can be read and understood by algorithms, it provides a foundation for the application of vision-based sensing in construction safety management, such as AP, SD, HI, ISM, etc.

8. WIRELESS SENSOR NETWORK :

The sensors applied in construction safety management mainly include temperature sensors, displacement sensors, light sensors, optical fiber sensors and pressure sensors. They play an indispensable role in real-time monitoring of structures or structural components. Sensors usually acquire information and store data in a passive manner and cannot read and understand the collected information proactively. In practice, wireless sensor networks are a proper way to turn passivity into initiative, and have thus become one of the research hotspots in sensor applications.

3.1.4 SENSORS :

1. TEMPERATURE SENSORS :

The main applications of temperature sensor include shrinkage crack monitoring for mass concrete construction, concrete curing, assisted management for winter construction and freezing method construction and temperature monitoring of structural components for improving the installation accuracy.

2. Displacement sensors :

The main applications of displacement sensors include building inclination monitoring building subsidence monitoring, geological prediction and geological hazard pre-warning.

3. Light sensors :

Light sensors are mainly used for nondestructive examination of structural components, including concrete constructions, pile foundations, welding seams in steel structures, etc.

4. Optical fiber sensors :

Optical fiber sensors are widely applied in long-term monitoring for structural safety. They are usually integrated into a WSN so as to turn the whole monitored object into a sensing structure. These sensors can be used for monitoring strains, deformations and cracks of structures, and safety evaluation for mass concrete constructions. For example, the optical fiber sensors have been used in the health monitoring and safety assessment of the Three Gorges Dam and some bridges in China.

5. Pressure sensors :

Pressure sensors are useful in structural load measurement. They have been used for monitoring roads, bridges and buildings, especially in pre-stressed engineering, testing end bearing capacity of pile foundations.

6. Wireless Sensor Network :

A wireless sensor network (WSN) is a set of spatially distributed sensors to monitor physical or environmental conditions and to cooperatively pass the data via a network to a main location. A WSN Sensors 2017, 17, 1841 9 of 24 is usually composed of a central processor, communication module and sensor nodes with internal or external power supplies. With the help of a WSN, the system acquires local information as a whole and transits collected information to the terminal server automatically to process the collected data. In this way, the key environmental information is collected passively, but being transited and processed actively. Owing to the application of WSN in remote monitoring of engineering structures, pressure sensors installed on vehicles can transmit real-time information of cargo-handling to the terminal server; temperature sensors embedded in construction materials can detect temperature changes to avoid the dangers of extremely high or low temperatures; displacement sensors and pressure sensors embedded in concrete structures are able to collect real-time information including stresses and strains, thus achieving long-time monitoring.

V. CONCLUSION

AI has a number of significant benefits that make them a powerful and Practical tool for solving many problems in the field of building construction and are expected to be applicable in near future by using sophisticated instruments based on the algorithms and database to reduce the efforts of safety alerts for labour's..AI can give construction managers the ability to protect their workers like never before, and ensure the sites are as safe as possible.

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