Automation of Construction Projects through Application of Artificial Intelligence

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Abstract: Artificial Intelligence (AI) have resulted in evolving the Architecture Construction Engineering (AEC) industry in several ways. In order to improve a number of facets of AEC, AI aids in automated data collecting and data analysis approaches. This paper aims at exploring the possible applications of AI and development of a prototype for application of AI in complex mega construction projects of India. Two sensors are used in this research like motion sensor and Radio Frequency Identification Device (RFID). Within its range of danger zone, the motion sensor will automatically detect any human being or animal. Since the body heat produced by an animal or human being is released as infrared radiation. It has a pyroelectric sensor that can detect motions. It only functions by identifying the infrared signal produced by the heat energy. The findings of this study reveal that RFID can be very widely used in construction safety. Also, RFID deals with location, real-time tracking, and personal warning systems. The developed prototype's findings support the platform's viability for use at actual locations for improved safety management.

Keywords: Artificial Intelligence (AI), Construction projects, Machine Learning (ML), Motion sensor, RFID and Safety.

1. INTRODUCTION

Machines with artificial intelligence can imitate human behavior. Artificial intelligence (AI) is a specialized system that can recognize intelligent entities, create them, and simplify, accelerate, and optimize decision-making [1]. Automation of intelligent behavior that functions like human thought and action is important to AI. In our everyday lives, AI is extremely pervasive and well-integrated [1]. Numerous fields, including computers, cybernetics, scientific theory, psychology, and neurophysiology, have interacted with it. Our time-saving initiatives utilize AI in their usage, research, and design. Collaboration between AI and machines is used to carry out tasks that, when done by humans, would need intelligence [2]. Perhaps we already live in a world where artificial intelligence is a reality. In order to create technological goods and build pertinent ideas, this discipline aims to investigate how to replicate and carry out a number of the intelligent tasks of the human brain. Because technology has an impact on practically every business, the design and construction industries are starting to incorporate all these innovations [2]. Droning over a building site, using a computer game to examine a project before it is finished, or selecting the simplest scenario backed by artificial intelligence projections are all commonplace (AI) [3]. Belief networks, also known as Bayesian networks, are a kind of artificial intelligence (AI) that includes uncertainty via applied mathematics and conditional dependency. Using a combination of simulation and assumption networks, an automated way to developing development operations is detailed [3]. The assumption networks in this application provide diagnostic capabilities to the development operations' performance analysis [3]. The development operations are modelled using computers, and the adjustments to the processes suggested by the assumption network are validated using computer simulation. Sarkar et al. [4] developed a IoT based cloud-enabled platform for managing the assets for metro rail construction project. The primary objectives of this project are to investigate the possible uses of artificial intelligence (AI) in the construction sector and to provide a workable prototype for asset monitoring and safety management in construction sites using motion sensors and RFID. Cheung et al. [5] developed a real-time construction safety monitoring system through integrating the wireless sensor technologies and Building Information Modelling (BIM). Egbu [6] studied the application of Critical Success Factors (CSF) based on knowledge management innovative application of AI in construction industry. Kapliński [7] also developed innovative solutions for application of AI and IoT in construction industry. Patil et al. [8] developed AI tools to monitor the work progress in construction sites. Cao and Zhao [9] applied sensor-based technology to improve the safety monitoring system in construction sites. Zhou et al. [10] also applied AI tools and IoT to automate the construction process for complex project sites. Furthermore, Baduge et al. [11] applied Machine Learning (ML) and Deep Learning (DL) tools for automation of construction projects.

Reviewing the available literature, it has been observed that though many researchers have tried to apply AI in construction projects, but still application of AI, ML and IoT in construction projects is still in nascent stage. Thereby, the present research aims in exploring the possible applications of AI and IoT primarily for monitoring of safety and asset management in construction projects.

2. CASE STUDY AND ANALYSIS

A metro rail project in Gujarat, India, was used as a case study for this research. With a total length of 40 km, this project is made up of 33.5 km of raised space and 6.5 km of subterranean space. In both the north-south and east-west corridors, there are a total of 32 stations. The sensors deployed in the project sites' hazardous locations have been used to identify these areas as hazardous, and the sensor reader subsequently reads the data relevant to the dangers. This information is sent to the indicator through the gateway and then saved in the computer. The project management team, including the safety engineer, safety manager, site engineer, project engineer, and project manager, uses this data to monitor the progress of the project. Fig. 1 illustrates how this procedure works for identification of the hazardous areas and how to store the data read by the sensors in the computers.

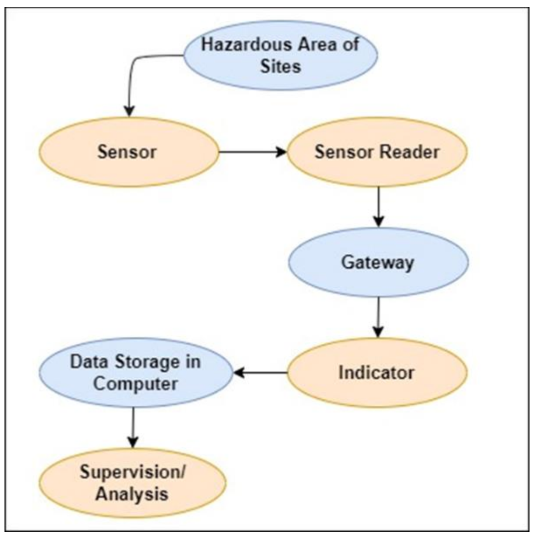

Fig. 1 The methodology for using sensors to identify and store project hazard data

A. Data Acquisition via Inquiry and Experience

Additionally, information was gathered through sharing questionnaire through Google sheets. Out of 150 respondents, roughly 93% believe that AI would improve the state of the construction business, while 7% disagree. Fig. 2 represents the respondent percentages who have responded about the need for application of AI for smart constriction.

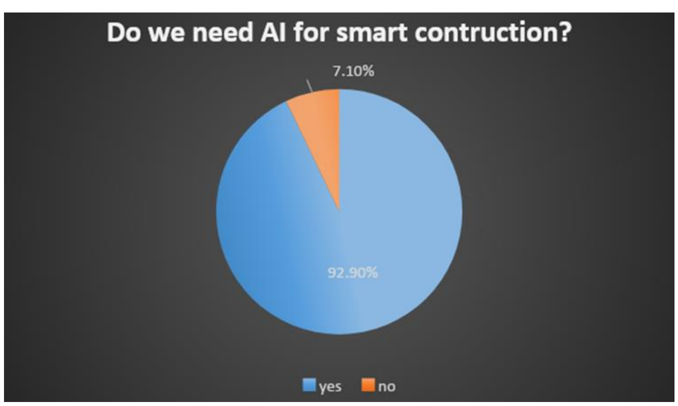

Fig. 2 Details of the percentage respondents who responded about the need for AI for smart construction

Fig. 3 shows the percentage of respondents who expressed interest in the potential for AI to lower construction risk. 57% of respondents agreed that AI would lower risk on the building site. 7% strongly agreed, while 36% were indifferent.

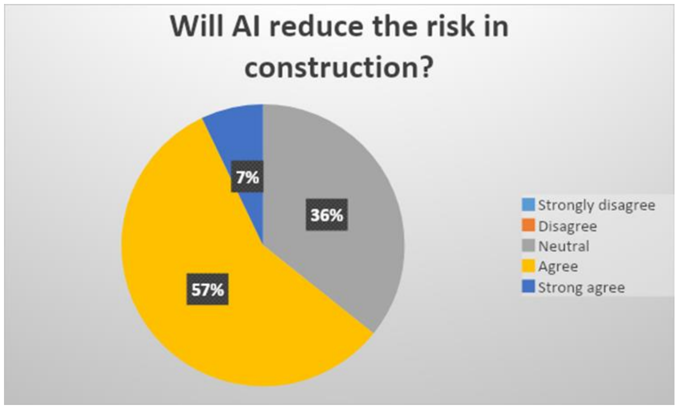

Fig. 3 Details of the percentage respondents who responded about the potentialities for reducing the risk of construction by AI for smart construction

B. Development of the Prototype for Application of AI in Construction Sites of India

Application of AI has been carried out primarily through sensors. It has been observed that passive sensors are more effective than the active sensors for construction sites. The primary reason for using passive sensors is that it does not use additional energy for detection of the human movement in construction sites. The pyroelectric sensors used in this model detects movement when exposed to heat since the human or animal body emits heat in the form of infrared radiation. The term "infrared sensor" refers to the sensor's ability to detect heat energy in the form of infrared radiation. The passive sensors use no energy to carry out its detection functions. It only detects the energy emitted by the other items. The module also includes a Fresnel lens, a specifically made cover that directs infrared signal onto the pyroelectric sensor.

1) Connecting Module to Arduino Board

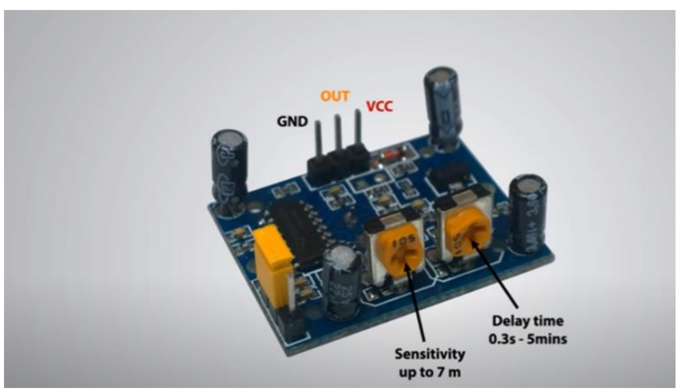

Fig. 4 Details of the Arduino board

For developing the sensor based automated mechanism the Arduino board has a major role to play. The Arduino mother board controls the functioning of the passive sensors which primarily detects the movements of the work person in the construction sites. Fig. 4 represents the details of the Arduino board used for controlling the functioning of the sensors.

When an item is identified, the output provides a high logic level, while ground and VCC are used to power the model (5 to 12 V). It has two potentiometers, one for adjusting the time and the other for controlling the temperature sensor's sensitivity. Upon object detection, the output signal remains high. From 0.3 seconds to 5 minutes, this time may be changed. Three additional pins on the module have jumpers between two of them. The trigger mode is selected via these pins. The output will automatically switch from high to low when the delay period is over and the sensor output is high. Another option is the repeating trigger mode, which maintains a high output level until the detected item is within the sensor's range

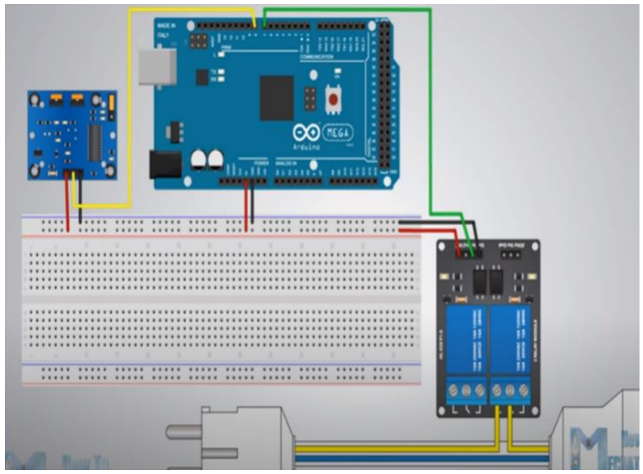

Fig. 5 . Details of the schematic circuit

Fig. 5 represents the details of the schematic circuit which controls the Arduino board with the passive sensor units. When an item enters this circuit's detection range, a high voltage bulb will switch on. The output pin will be attached to PIN 8 in this case on the Arduino board, and when the item is detected, P5N 7 will switch on the relay model and the high voltage bulb.

```
int pirSensor = 8;
int relayInput = 7;

void setup() {
  pinMode(pirSensor, INPUT);
  pinMode(relayInput, OUTPUT);
}

void loop() {
  int sensorValue = digitalRead(pirSensor);

  if (sensorValue == 1) {
    digitalWrite(relayInput, LOW); // The Rel
  }
}
```

Fig. 6 . Arduino code used for AI and ML process

Fig. 6 represents the Arduino code used for the AI and ML process. The relay pin is designated as output in this case, while the PIR sensor pin as input. The sensor is read using the digital read function, and the relay will turn on if the sensor is high or if an item is found. A logic message is sent to activate the relay module since the relay pin operates in the other direction. Fig. 7 represents the indicator module after detection of the object.

Fig. 7 . Details of the indicator module after detection of object

The sensor module takes between 20 and 60 seconds to warm up after being powered in order to work effectively. The relay will turn on the bulb or alert when the item is discovered inside the sensor's detection range. Following the set delay period, the light or alarm will shut off.

A PIR sensor is present on the camera in this prototype model. This camera will automatically turn on if movement of any kind is detected within the PIR sensor's range. The camera will switch off automatically when there is no movement of any personnel in the construction site. Fig. 8 represents the PIR sensor with infrared camera.

Fig. 8 . PIR sensor with camera

RFID: The phrase "radio-frequency identification," or RFID, describes a method of reading digital data from RFID tags or smart labels (explained below) using a reader and radio waves.

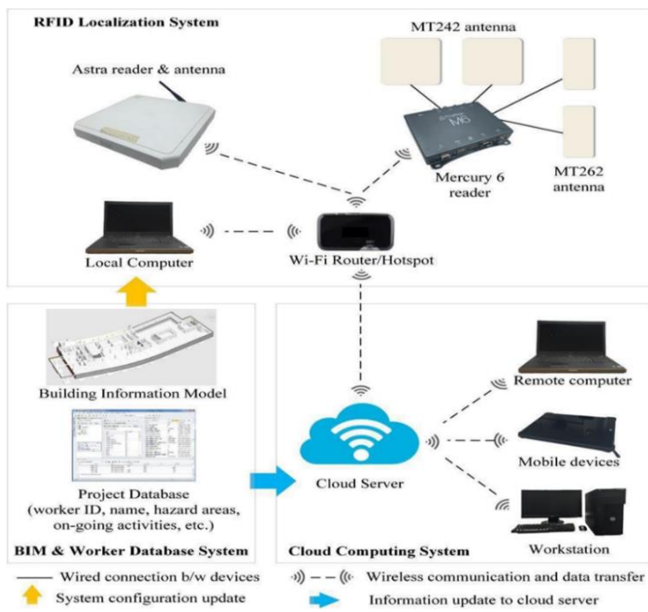

Fig. 8 . Framework of BIM and cloud enabled RFID localization

RFID tags come in three different varieties. RFID tags come in three different forms: semi-passive, passive, and active. The different forms of the tags are presented in Table 1.

TABLE I. Comparative Analysis of Some Major Features Available In the Different Mode of Tags

Features and Tags	Passive tags	Active tags	Semi-passive tags
Power sources inside	Disagree	Agree	Agree
Backscattering the reader's carrier wave to create a signal	Agree	Disagree	Agree
Response	Weaker	Stronger	Stronger
Size	Small	Big	Medium
Costly	Cheap	Costly	Less
Future Shell life	Longer	Shorter	Longer
Range	10 centimeters to several meters	Several hundred meters	Hundreds of meters
Sensors	Disagree	Agree	Agree

2) Active RFID tags are offered in two distinct varieties

a) Transponders:

In a system with an active transponder tag, the reader sends a signal initially (just as in passive systems), and the active transponder responds with a signal containing the necessary data. Transponder tags are very effective since they save battery life when the tag is removed from the reader's line of sight.

b) Beacons:

In a system with an active beacon tag, the tag will not wait for the reader's signal before responding. Rather, in keeping with every 3 to 5 seconds, the tag will "beacon," or broadcast, its distinctive information. EM-18 Reader Module, a low-range serial RFID reader. The information on the RFID tag is read by this module.

3) EM-18 Reader

Fig. 9 depicts an EM18 reader module, one of the several kinds of RFID reader modules. It is used to scan 125 kHz RFID tags. After scanning RFID tags, it sends the specific tag's unique ID serially to the PC or microcontroller using Wieg and format or Universal Asynchronous Receiver-Transmitter (UART) connection on the appropriate pins. The EM18 RFID reader receives information from RFID tags that have a stored ID that is 12 bytes long. There is no need for line-of-sight with the EM18 RFID reader module. Additionally, it only has a few centimeters of identification range.

Fig. 9 . Low Range Serial Reader Module

The following are some of the EM-18 Reader Module's features: The EM-18's working voltage is between 4.5 and 5.5 volts. Its current consumption is 50 milli-amperes, its operating frequency is 125 kHz, its reading range is 10-12 cm, it can run on low power, its operating temperature range is 0 to 80^{o} C, and it has an integrated antenna. It also has a serial RS232/TTL output.

3. RESULT AND DISCUSSION

The prototype that was created above is prepared to work on building sites. Construction site fatalities are increasing yearly. Due to inadequate safety protocols, many employees die on the job. The building project as well as the workers on the sites will benefit when the idea of this prototype is used in such a situation. The worker is encouraged to work freely in the locations that would eventually assist the project's completion by a strong management system of safety. Each worker will also be protected from dangerous environments thanks to an RFID tag, which will also let the site manager find the person who was relocated. The worker will not be able to leave such dangerous areas due to the buzzing or warning system. Thus, it can be concluded that the site will be safer to work on after the created prototype is implemented in the project.

4. CONCLUSION

Utilizing modern technology is increasingly necessary for the construction business to develop. The construction industry will see appropriate and consistent development with the adoption of new technology, just like other industries in our rapidly changing contemporary world. AI has shown to be capable of outperforming traditional approaches. The safety risk and difficulties may simply be resolved with the usage of smart sensors. Construction sites provide difficult management settings with several important challenges in worker safety, production safety, tool tracking, asset management, and monitoring of tools. AI-based sensors, however, have shown to be a blessing for this sector.

When using RFID active tags, it is simple to keep an eye on personnel and physical assets on construction sites. Motion sensors and RFID active tags will ensure the employees' safety by preventing them from entering certain prohibited zones and setting off alarms or turning on the red lights, keeping in mind the risky and dangerous regions found in construction sites.

This research, intends to create a sensor-based platform with the goal of improving site safety. This platform will aid in the safety of the personnel and construction workers, ensuring that the projects are completed without incident. As a result, it will be possible to track and monitor personnel on the job site in real-time and get information about their whereabouts. A motion sensor prototype has also been created as part of this study. The limitation of this study is that unlike the majority of construction businesses, it has not implemented its principles to actual project sites, and its officials are less knowledgeable about the use of these technologies. It is thus quite difficult to persuade construction businesses and their leaders to use this technology.

5. SCOPE FOR FUTURE RESEARCH

The scope of future research lies in developing algorithms for application of AI and ML for each major activity of the construction site. This would be a step forward towards digital transformation and automation of construction projects. Prospects of integrating Building Information Modeling (BIM) and Block chain concept with AI and ML need also to be explored.

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Dr. Debasis Sarkar [B.E. (Civil), M. Tech (Building Science & Construction Management, IIT Delhi), Ph. D. (Project Management), FIE] is presently employed as Associate Professor & former HOD, Dept. of Civil Engineering, School of Technology, Pandit Deendayal Energy University, Gandhinagar. He is Fellow of Institution of Engineers (India), Fellow Member (FM) of Gujarat Institute of Civil Engineers and Architects and Life Member (LM) of Operations Research Society of India (ORSI). Formerly, he was employed as Associate Professor with Dept. of Construction and Project Management, Faculty of Technology, CEPT University, Ahmedabad, India. He has about seven years of industrial experience and over seventeen years of academic experience. Prior to joining academics, he was employed for about two and half years as Senior Engineer and Site in Charge with International Metro Civil Contractors (IMCC JV), Delhi Metro, India. His expertise lies in construction of underground corridor for metro rail operations. He has received Gold Medal from IMCC JV for outstanding performance year 2002. He has also received “Best Paper Award” at 18th International Conference on Civil, Architectural and Constructional Engineering, Amsterdam, Netherlands, August, 2016, NICMAR Journal of Construction Management, 2017, 4th International Conference on Interdisciplinary Research & Practice, AMA, 2017 and 20th International Conference on Civil and Architectural Engineering, Berlin, Germany, 2018. He has received “DISTINGUISHED RESEARCHER AWARD” in field of Engineering (Construction Management) 2023, from Venus International Research Foundation, Chennai, Tamil Nadu, India. Received “BEST INNOVATION AWARD” 2023 from International Science Forum, 2022. Received “BEST RESEARCHER AWARD” 2021 from International Forum for Science, Health and Engineering, SHEN 2021. Received “BEST PAPER AWARD” at 24th International Conference on Innovative Engineering, Technologies & Healthcare, Porto, Portugal, 2021

His areas of research interest include Automation in Construction Projects, Application of AI, ML, IoT and Blockchain in construction projects, Smart Infrastructure and Cities, Project Management, Project Risk Management, Underground Corridor Construction for Metro rail operations and Building Information Modeling (BIM), He has published over sixty five international and national research papers in referred journals. Six PhD students have been awarded their doctoral degrees under his guidance and five students are carrying out their doctoral work under his guidance. He has guided over 90 M. Tech thesis in the area of Construction Management. He is also involved in active consultancy work in the above areas. His international exposure include presenting research papers and chairing sessions in Athens, Greece, Singapore, Bankok, Kualalumpur, Malaysia, Amsterdam, Netherlands, Dubai, Berlin, Germany and Croatia.

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