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IoT- Enabled Civil Engineering: A Case Study on Advancements in Civil Engineering

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ABSTRACT

"IOT"- "Internet of Things" is a connecting medium of the upcoming internet, combining existing and fast-evolving networks for improved communication and development. IoT is the branch of Information Technology which creates a connectivity link between Internet and physical Things. In contemporary civil engineering projects, the complexity of construction processes has increased significantly, posing challenges in effective monitoring. vehicles on roads have led to increased damage, primarily attributed to inadequate road monitoring practices. While the integration of IoT may not be applied to the entire construction process of a project. it can serve to streamline complex tasks and effectively monitor the status of various components. This paper addresses the basic notion of Internet of Things, reviews and application and challenges of IoT in the civil engineering construction and maintenance of civil engineering projects. And further more we will also discuss the challenges in application of IOT in civil engineering projects.

Keywords: SHM (structural health monitoring), IOT (internet of things), SHM (structural health monitoring), SO (smart objects), smart home automation.

INTRODUCTION

IOT-internet of things was first introduced in civil engineering in 1960s.With the invention of telegraph and its ability to transmit information by coded signals over the distances, this breakthrough spurred significant interest among leading researchers to investigate methods for integrating computers and computer networks with physical objects. Leveraging this technology, civil engineering projects can be meticulously monitored for progress and potential damages, thereby ensuring safe and efficient project advancement.

The electronics largely comes down to the printed circuit board assembly that we now equip our devices with. These circuit boards actually come with their own antenna which allows to connect with the physical things as for wireless networks, we have 4G, 5G, Bluetooth and Wi-Fi to connect the internet to the physical objects. And now a days android mobiles and computers are very common in every industry we can also connect these physical things to our devices using sensors and other IOT related devices makes the economical and efficient usage of IOT on a daily basis.

When we think of technology advances in civil engineering. It tends to be with regard to equipment, materials, progress and safety and hands on application, and also it might include equipment used in modular construction, or the process of material achievements in a civil engineering project. Now a days due to the advancements in civil engineering structure and rapid growth in construction projects leads to poor monitoring and poor maintenance in the process of construction which may lead to a large scale of economical damage to prevent it effective monitoring should be ensured in the place of construction.to achieve that we can use the information technology which is growing rapidly now a days.by using these information technology and artificial intelligence to monitor the work progress. There are several processes that an engineer has to pass through to finish a construction project different number of possibilities for every process to monitor and help with the construction in a civil engineering project and also IOT is used to monitor the status and life of a construction project to ensure that the project is in a safe condition. There are infinite number of possibilities to use IOT in civil engineering. And also, an IOT concept called SHM (structural health management) is used to report and monitor the condition of a pavement and report any unusual activities on the pavements using sensors and can be reported.

And also, there is a concept called application of IOT in smart homes which there are different IOT parameters to make a normal home into a smart home, smart home means when a home is monitored and controlled by using information, sensors, internet and physical things on a daily basis to ensure the safe and efficient usage of resources and to ensure safe and improve the quality of living in a home is called smart home management.

2.0 Literature Review

2.1. IOT applications in building construction and monitoring

There are different stages in construction of a building. Each stage requires different types of methods and different types of materials to attain its look and structure of the building. Now a days due to rapid growth in population and rapid advancements in infrastructure, the engineer should ensure that he should strictly monitor each step in the construction of a building and ensure that there isn't any lack of material for the construction to ensure that active monitoring of there is no shortage of materials and also few types of sensors can be used to monitor the bending moment or cracks or moisture content to ensure the building safety, these sensors are place on beams to give alerts to the user when there is anything unusual going on in the structure. Even if there are a vast number of structures, we can easily monitor them by placing sensors in them, we can use these sensors from everywhere in the world as long as there Is internet availability. There are different types of sensors based on the application if we want to that the water should not dry during the curing process, we will place water detecting sensors, if we want to monitor the moments in the structure of the beam, we will place a moment detection sensor.

SO's in construction monitoring

These sensors are also named as SO's(smart objects),typically these SO's are connected wireless modality in order to easy monitor the points of structure after an accurate mechanical structural analysis, here the rate of detection and time of detection mainly depends on the SO's and the whole structural health management system depends on SO's sensitivity to detect the problems will be adjusted based on the structure, these SO's are normally connected through internet so that we can manage and monitor the structure from far distances and the collected data can also be stored in cloud storage and can be shared easily using internet

After a short review of IOT paradigm, the paper shows that the building monitoring is very essential to ensure the safety of workers so few researchers reproduced a panel in the lab made by fictile tubules, typically structural element used in Calabria(southern Italy) after the Messina seismic even which cause so many caused so many causalities due to poor management in building construction, these panels are tested in lab under diagonal compression, and tested on a existed old masonry castle in Calabria, subjected to seismic damage and a dynamic identification for existing damage.(Arbaz m kazi)

Through these methods they found out the types and quantities of damage that can occur due to vibrations and through those data we can report about the renovation or we can warn people about approaching structure and taking safety measure or can be used to predict the works which has to be done to ensure the safety or life of the structure.

2.2 IOT applications in pavement construction and monitoring

Pavement is an important part of transportation infrastructure.in order to achieve good maintenance of pavement before the damage and to improve the service quality, it is necessary to develop an intelligent and also a durable pavement managing system. Pavements normally undergoes so many daily basis loads and also occasional heavy load and constant harsh environmental damages like fatigue cracking and pot holes and other failures which leads to shortened life of a pavement than designed. So, in order to maintain the durability and service life of a pavement, effective monitoring system is necessary.

Pavement monitoring mainly includes the structural monitoring and traffic monitoring. For example, the structural information, such as temperature of the pavement, response of pavements under different conditions, layers of roads and load reactions. This kind of structural information is very crucial for effective monitoring of pavements there are different types of sensors based on the different conditions of pavements like piezoelectric sensors, accelerometers, stress strain sensors and optic fiber sensors.

Methods used in pavement monitoring

However, the application of IOT system in in-situ monitoring is very limited due to the vulnerability to be damaged by the harsh weather conditions and constant application of loads on the pavements from vehicles and also due to the vast sizes of roads the wireless sensors which are powered by batteries can be damaged and also the constant moment of vehicles can also interfere with the signals of those sensors. So, to ensure safe monitoring of in-situ pavements, the researchers are focussed on developing the micro electro mechanical system (MEMS) and a separate network for pavement monitoring called wireless sensor network (WSN) for pavement monitoring.

MEMS based sensors are used in developing the self-powered strain sensors to detect the strains generated in the pavements and to monitor the structural health of the pavement. the self-powered sensors can power themselves by using natural resources like sunlight and can detect the damage and load history of that pavement structure. And by combining the MEMS technology with WSN communication we can achieve effective monitoring of pavements wireless sensor network allows us to detect the damages very quickly and can report it at the same time by using the radio frequencies and internet in the real time and it also can save the data in the cloud for further uses. Elsevier (IOT structural health management)

The pavement monitoring systems based on IoT operate through a structured framework comprising six layers: acquisition, energy, preprocessing, processing, and network layers. Initially, the acquisition layer gathers all pertinent information regarding the pavement condition. Subsequently, this data is transmitted through the energy layer to undergo preprocessing, where initial data processing occurs. The processed data is then forwarded to the

processing layer for comprehensive analysis. Following thorough processing, the results are conveyed through the network layer, facilitating discussions and feedback regarding the pavement condition. Any necessary renovation requirements are identified and feedback is provided accordingly.

2.3 IOT applications in home automation

now a days due to rapid growth of population and technology people demands a comfort and safe infrastructure to lead their lives, to achieve such requirements in a home IOT technology can be used. Home automation is constructing automation for domestic uses, this may not make every thing automatic but it can be used to make your home safe and comfy to live in, In sensible homes or smart homes you can control devices like lights, fans, tv etc… a domestic automation can monitor and control your home attributes, there are endless possibilities to use this automaton according to your needs, a domestic automation system usually connects controlled devices to a central hub or a gateway, the programme of the system makes use of both wall-mounted terminals, tablets or desktops or by using an online interface that can even approachable from far distances using internet. The main advantage of home automation is that the system can control a vast number of devices like lights, fans, and thermostats using one device by using other smart technologies, such as voice assistants like AleXa to provide addition functionality and convenience. G Choung, L. Zihao (the research an importance of smart home automation).

3.Challenges in application of IOT in civil engineering

Team Communication

Team communication poses a significant challenge in every facet of IoT deployment. Whether it's a prolonged building project involving collaboration among numerous stakeholders over months or years, or the intricate coordination required for implementing smart city initiatives, effective communication is paramount. In the case of smart cities, the potential for enhancing infrastructure and urban areas is vast but remains largely untapped due to hurdles in technological, financial, and social implementation. This underscores the critical role of team communication, particularly in liaising with higher authorities, coordinating building structures, and strategically situating sensors for optimal functionality.

Task Management

Task management encompasses the comprehensive supervision of tasks throughout their lifecycle within a project or work endeavour. This multifaceted process entails meticulous planning, rigorous testing, diligent tracking, and thorough reporting. Managing construction, development, or projects involving the implementation of internet sensors presents unique challenges that demand careful attention. Automating tasks such as planning, budgeting, reporting, and timely communication of future deadlines to team members is essential, as manual processes are prone to errors and time-consuming. Disjointed teamwork can have detrimental effects, including project delays, errors, or even project failure. Therefore, seamless coordination and effective task management are imperative for project success.

Human Misstep

When managing projects individually, it may not always be feasible to ensure consistent adherence to best practices within your team. Project risks escalate due to challenges in enforcing policies and the unpredictable nature of human behaviour. Even minor errors, such as inaccurately entering budget details into project records, can lead to significant financial losses. This represents a common human error that can occur in any situation. Similarly, incorrectly placing sensors during project implementation can result in erroneous readings and potentially compromised data. Human missteps are inherent in any project or scenario, underscoring the importance of meticulous attention to detail and adherence to established protocols.

Anticipating Points

Effective project management plays a crucial role in identifying potential issues within team communication. In the absence of software tools, communication during project construction can be significantly slower, hindering the team's ability to promptly inform the project manager of potential problems. Cultivating strong teamwork dynamics is advantageous, whether the team comprises primarily internal employees or independent contractors. Without dedicated tools to mitigate the risks of misunderstandings and errors, the likelihood of project failure increases. Ultimately, the success or failure of a project rests upon the capabilities and performance of the staff involved.

Cost & Time Escalation

In construction projects, cost and time overruns are prevalent and directly affect profitability. It is customary to initially estimate the total project cost and duration. Accuracy in estimating these factors is paramount. Delays in project completion inevitably led to increased costs. Therefore, any delay in project timelines directly impacts both the project schedule and budget, potentially resulting in financial losses.

Conclusion

This paper concludes that integration of internet of things (IoT) in civil engineering has opened a new era of innovation and efficiency in project management, construction and infrastructure management and maintenance, as highlighted in this study, IoT offers so many numbers of applications which are ranging from building construction and monitoring of pavements and home automation. By leveraging IoT technologies, civil engineers can enhance safety and efficiency of the work.

However, the adaption of IoT in civil engineering also presents several challenges as mentioned in the paper, to overcome these challenges requires a lot of keen approach, and a good project management capability and by learning the details about IoT. Despite the challenges, the benefits of integration of IOT in civil engineering are undeniable, from real time monitoring of construction progress to predicting the maintenance of infrastructure and pavement managing and also by using home automation we can make our lives smart and comfortable. By using IOT in civil engineering the engineers can pave the way for safer and more sustainable, and efficient building environment for the next generations.

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