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IoT in Civil Engineering

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Abstract: *The Internet of Things (IoT) has had profound impacts in almost all sectors, even in construction civil engineering. The installation of IoT devices enhances project potential by allowing real-time monitoring, automation, and data-based decision-making. The goals of efficiency, safety, and sustainability are also improved. The paper aimed to analyze the current state of IoT implementation in civil engineering such as structural health, construction management, or smart buildings. Moreover, we also evaluate some of the barriers and constraints of the more expanded use of IoT in civil engineering and recommendations for further development of the research.*

Keywords: Internet of Things.

I. INTRODUCTION

One of the sectors that tackles the design, building and maintenance of civil structures, bridges, roads, amongst others is civil engineering. The growth in size and difficulties of projects in civil engineering means that new ways of accomplishing these works, which are more effective, secure, and sustainable, need to be derived. There's emerging technological advancement that addresses such issues, which is the IoT. Accordingly, there is a complexity that teachers of the discipline of civil engineering are even beginning to grapple with.

A smart building or an intelligent building is any structure that includes Internet-based automation in order to control various building systems such as HVAC (Heating ventilation Air conditioning), lighting, security, energy optimization etc. This can be accomplished by means of sensors, actuators and microchips which can gather information that is further transformed into action in context to the functional needs of the building. This type of infrastructure helps its users enhance asset reliability and performance in terms of energy efficiency, space optimization, air regulation and the overall footprint of buildings [1-4]. Buildings such as smart office buildings, smart home, health care facilities, hospitals, smart transportation facilities, smart educational facilities, smart parking garages, sports stadiums etc. are some of the examples of smart infrastructure.

To begin with the global tendencies towards the automation of processes, surveillance, building management systems, construction of smart cities and Internet of Things that will most likely be encountered in the future professionally. However, the lack of collaboration that exists in civil engineering education when it comes to embedding the use of devices, IoT, software and other tools that are the key enablers of this change.

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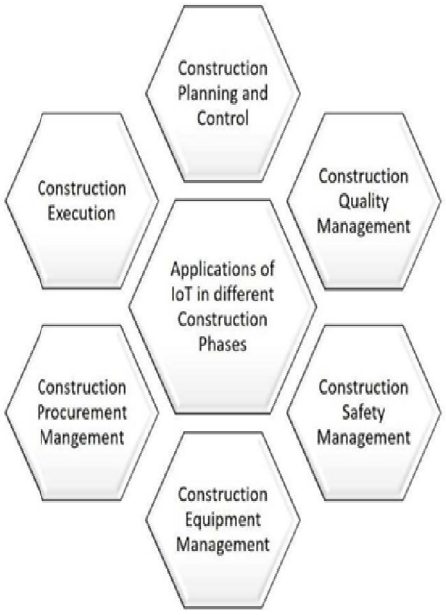

Figure 1. IoT applications in Construction phases of a project

Applications Of IOT

IoT consists of enhancing the internet connectivity In the interest of various well known devices like work of art sites, computers, cells and tablets, or in the case of many dumb or non IoT directed actual devices and normal devices. Such devices when embedded with technology can communicate and collaborate over the internet, and that they are able to some extent be monitored and managed. IoT devices may be interfaced for the purpose of depicting and regulating the systems of mechanics, electricity, and even the digital systems integrated in various forms of structures e.g. public and private, industrial, institutional, or residential in home automation and building automation systems. In this particular context, the special positioning of IoT in Civil engineering programs is highlighted.

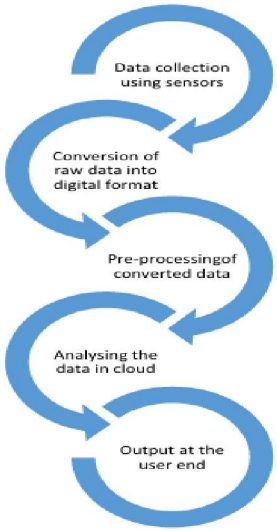

Figure 1: Stages in the IoT technology

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II. LITERATURE REVIEW

Internet of Things Applications within civil engineering domain can be analyzed along three parameters or within three spheres of knowledge:

- **Structural Health Monitoring (SHM):** With the use of IoT devices, a structure's status can be remotely monitored so that the likelihood of any infrastructure being reached can be managed in advance.
- **Construction Management:** The Internet of Things can facilitate the management of construction sites by monitoring equipment, materials, and human resources at a given time.
- **Smart Infrastructure:** The Internet of Things can help develop smart infrastructure like smart transportation systems and smart buildings.

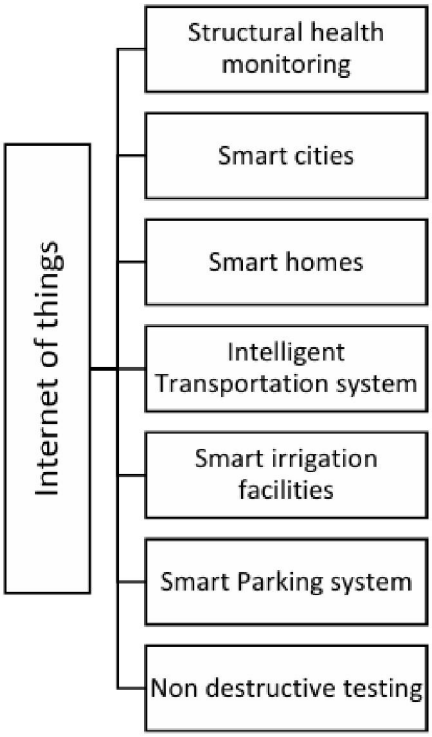

Figure 2: Applications of internet of things in civil engineering

Pros and Cons of IoT:

Lately, these IoT devices have proven to be very effective in enhancing our living standards and making day-to-day activities simple as IoT devices and appliances are interconnected to work together. With the use of IoT devices Stress and daily physical work-load can be reduced while remaining productive, The combination of physical and intellectual tasks can be further cut down where a human being is expected to work with these devices. Just like every other advancements in technology such as web-based applications and companies, IoT has its own advantages and disadvantages. They are:

Pros:

Automation: Furthermore, productivity can be complemented with automation, thereby minimizing production Akshat and increasing profit margins for industries. The accuracy level in automation will also help to improve the standardization and quality of the goods and services produced.

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- **Efficiency:** Utilization of IoT enabled devices, minimization of human involvement and escalation of machine to machine relations, resulting to a lot free time resources. In addition to that, the M2M interaction enhances overall transparency of the process.
- **Economy**: Smart devices may be costly at first, but it has been proven to be economical and a cost cutter in the long run.
- **Faster Communication:** M2M interaction has simplified all the activities and enables the user to manage all of the activities effortlessly. Talking of smart home devices, Amazon echo dot, Google home, and Apple Siri talk have simplified even daily chores.
- **Data accessibility**: With the IOT, data is readily available after it has been collected in the appropriate time which assists later on in the decision making.

Cons:

- **Security concerns:** The usage of smart devices requires internet connectivity huge data transfer to the cloud. The storage and availability of such huge amount of data on the remote servers has its own drawbacks where unauthorized users and hackers always pose a threat.
- **Lag in real time data acquisition:** The smart devices need better internet connectivity to perform tasks. Fluctuations in the connectivity and speed of the internet will result in time lag and obtaining real time data becomes difficult in such cases.
- **Availability of networks and services:** The network connectivity and services which are required for these smart devices cannot be ascertained round the clock due to a number of reasons such as device on the move, weather issues etc.
- **Storage and processing of data:** The IoT requires a number of interconnected devices to work efficiently which means collection of huge data. It becomes difficult sometimes for transferring, storage and processing of this data. Moreover, it becomes time taking for processing such huge data leading to delays in action.
- **Accuracy:** The time lag and improper network and connectivity issues will result in inaccurate data.
- **Compatibility:** Since the IoT is still in its 2.0 stage, not all companies have developed solutions that will work properly on equipment designed by other manufacturers.

Challenges and Limitations

Despite the fact that IoT is capable of revolutionizing civil engineering, quite a number of challenges and limitations must be considered:

1. **Data Management**: The IoT essentially leads to an explosion of data which needs to be effectively managed and interpreted.
2. **Security**: The majority of the IoT devices pose a risk of being hacked which leads to loss of data integrity and security.
3. **Standardization**: Standardization of IoT devices and even protocols is paramount otherwise, these will constrain the interoperability and scalability aspect.
4. **Cost**: IoT deployment has an economic risk because it requires substantial investment in technological supplies, software, and human resource.

Future Research Directions

In order to leverage the full capabilities of IoT in civil engineering areas, much more tailored research should concentrate on the following aspects:

1. **Advanced IoT Sensors**: Concentrating on improving how accurate, reliable, and durable these sensors are.
2. **Fusion of IoT with other Technologies**: Infusing other technologies such as AI, blockchain and robotics into IoT.

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3. **Security and standardization of IoT devices**: Robust security measures to counter threats and standardization to avoid risks of compatibility and interoperability.
4. **Investigating Expense-Lowering Mechanisms**: - This strategy was adapted from Economical strategies for implementing the internet of things in civil engineering undertaking.

III. METHODOLOGY

The authors conducted a systematic literature review and bibliometric analysis to identify the current trends and gaps in the application of IoT, BIM, and digital twins in construction.

IV. CONCLUSION

The paper concludes that the integration of IoT, BIM, and digital twins has the potential to transform the construction industry by improving efficiency, productivity, and safety. However, further research is needed to address the challenges and limitations of IoT adoption in construction. Proponents of the internet of things believe its application in civil engineering practices will greatly enhance operational performance, safety and practices that are environmentally friendly.

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