Advanced Interdisciplinary Approach in Construction Industry: Internet of Things (IOT)

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Abstract. Promoting construction, enhancing safety and multiple functions of IoT. Since the beginning of Fourth Industrial Revolution, digitalization becomes a fundamental function of all the construction project and bring all the project to a brand new practical and efficient world. IoT (Internet of Things), which refers to a large network of connected sensors and devices capable of autonomously exchanging and analysing data in real-time, belongs to a major facilitator of this function. To have an idea of the importance of this technology in the construction field, one must think about it as an instrument to decrease labour cost, reduce project repair time, and save material cost by automating and networking process. Among these could be automated assessment of a construction site to alert about hazards that might affect workers' lives. IoT alarms and delivered insights reduce risks and keep the working place of the construction workers safe. Overall, it is claimed in the paper that IoT has a significant number of applications in the construction sector- starting from the project management to the quality testing of work. These are just some of the applications of IoT and as the field evolves, more benefits and value-added services would be seen arising. In this regard, IoT will also have a key role in communication and coordination between many stakeholders involved, hence creating collaboration and cooperation for a healthy conductive environment with openness among all. Its integration with latest technologies like digitization of data, data analytics, AI, facilitate predictive maintenance decisions and end up making less mistakes. Although there is a huge potential for IoT to develop in the construction industry, so far, it is not utilised in a large scale. There are some limitations to be reduced like the cybersecurity, interoperability, and workforce readiness among others that need to be addressed or enhanced in due time. Industry participants must join hands to overcome these issues. It would be an understatement to say that IoT has the ability to completely revolutionize the construction industry. In article it

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illustrates how the Internet of Things is transforming the building sector and offers guidance on how interested parties can take advantage of this technology to raise project sustainability, output, and safety. By adopting innovation and digitization, those involved in the construction industry can take advantage of new moves for efficacy and efficiency in systems performance.

Keyword-: Internet of Things, Predictive Maintenance, Connectivity, Automation, Workforce Readiness, Sustainability, Quality Control, Stakeholders, Safety Enhancement

1 Introduction

Building technology is the area in which technology is making notable and substantial progress due to its rapid growth and development. Technology has the potential to revolutionize many aspects of our lives [1]. In the last few years, this industry has undergone tremendous change. Although major reforms have not been implemented globally, where they have been implemented, they are having a remarkable effect. Following the advent of the Industrial Revolution (IR) 4.0, digitalization in the construction sector has streamlined the processes involved in building and maintaining infrastructure. Digitalization is used in all stages of a construction project, not just the execution stage, which gives the construction parties even more convenience [2]. The construction industry, which requires a lot of labour, energy, and materials, is one sector where IoT is starting to be applied extensively. Along with the high degree of complexity of the entire construction project, another significant factor is the long service life of the built structures. From a variety of angles, the Internet of Things therefore has a great deal of potential for application in the building industry [3]. Automation of potential danger detection and safety inspection on construction sites is possible with IoT. Additionally, for construction projects to fully benefit from the use of digital technologies, all devices must be connected in order for data experts and researchers and to transfer and analyze all data. Though, like other emerging technologies, IoT is not yet regarded as a common practical technology in every construction site, it is a workable approach for supporting such data transmission among equipments [4].

2 IOT in Construction Industry

The Internet of Things, or IoT, is a technology that was created by humans and is envisioned by advanced virtual objects that are able to understand everything and allow the devices in their immediate environment to interact with one another automatically without human intervention. IoT, to put it more simply, is a channel of sensors, appliances, and other devices that can actually communicate with one another to exchange information about changes to their immediate surroundings and current physical state [5]. Accessibility and connectivity are added, and the new innovation and technology also lowers labour costs, gets rid of human error, and improves efficiency levels ultimately. To modernize society and raise standards of living, it is anticipated that IoT will sense, understand, and measure the environment around it [6]. On the Internet of Things, there are numerous uses, features, and opportunities. There's a rapid uptake of this technology. Virtually every aspect of life and a broad spectrum of industries use the Internet of Things. The widespread presence of the Internet of Things (IoT) in our daily lives will enable people and devices to establish connections at anytime, anyplace, and with any and all objects [7]. In addition to causing too much energy consumption and environmental emissions, the construction industry's labour-intensive methods are the cause of the sluggish growth of the industrial transformation. These

sophisticated mechanisms are the result of working in this complex field. Even though the sector has a lot of potential, digitization, new building methods, and innovations are the only ways to improve project management, suitability, efficiency, safety, and production efficiency [8]. The Internet of Things' architecture is designed to give every object the ability to identify itself, sense its surroundings, connect to other objects, and process data. This allows objects to share and exchange information with one another and create sophisticated services through the Internet. As a result, the interconnection will indeed enable intelligent autonomy, vibrant context-aware judgment capabilities, and a deeper understanding of the various systems. These features open the door to realizing the objectives of integrated ambient intelligence in industrial automation, which include establishing a worldwide network that enables ubiquitous computing and device context awareness [9]. Fig 1 shows the uses of the IOT in construction.

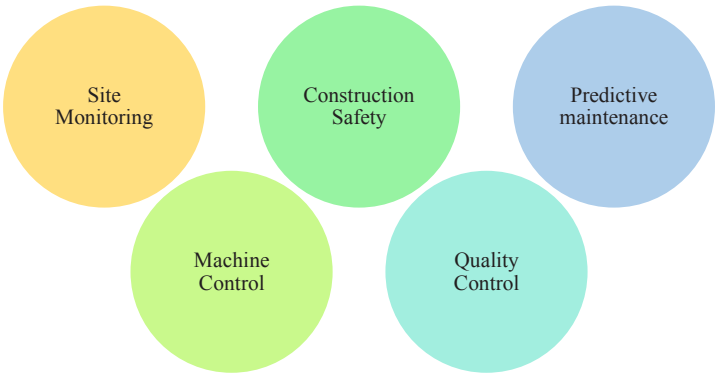

Fig 1: IOT in Construction Industry

3 The Importance of IOT in Construction

The construction industry has demonstrated a dynamic evolution in response to the challenges posed by modern infrastructure development in recent times. In order to address these issues, effective management of time, money, and quality is just as important as safety on the building site. In many industries, safety is crucial, and the construction industry is no exception [10]. In order to help construction sector policymakers avoid interactions with associated problems challenges and to provide education-based initiatives to educate professionals practitioners on the relevance and usefulness and of using IOT in the sector, this paper represents a good understanding of IOT in the and their potential challenges [11]. The application of IoT for all industries is important to enhance the quality of industrial processes. Inefficiencies, breakdowns, and squandering of resources, along with COVID-19, are the reasons for the delay in the delivery processes, services, and the production of quality products within the allocated budget. Most of these challenges can be addressed by deploying IoT to secure the quality of the production process and reduce production costs [6]. Restrictive and administrative hierarchies that are opposed to change and evolvement have historically ruled the construction sector. This presents a major obstacle to the steady and gradual adoption of IoT methods and procedures. The only way to change things is to persuade key decision-makers of the many advantages of IoT, particularly in the financial domain, so that changes are made from the executive level, becoming more efficient and integrated, instead of from the ground up [12]. The ability of the protection device to be

activated instantly in the case of emergency is one of the main features. When an abnormal or unusual condition is detected, the IoT devices will promptly alert, offer additional, and request assistance. With the help of the Internet of Things, the safety administration can monitor the entire site's condition and respond to threats instantly. For the purpose of checking construction site safety, a variety of sensing technologies and systems are currently in use. Sensors have been used by numerous researchers in proximity detection, environmental sensing, physiological monitoring, and location tracking [13]. Fig 2 demonstrates some of the important factors of IOT in construction sector.

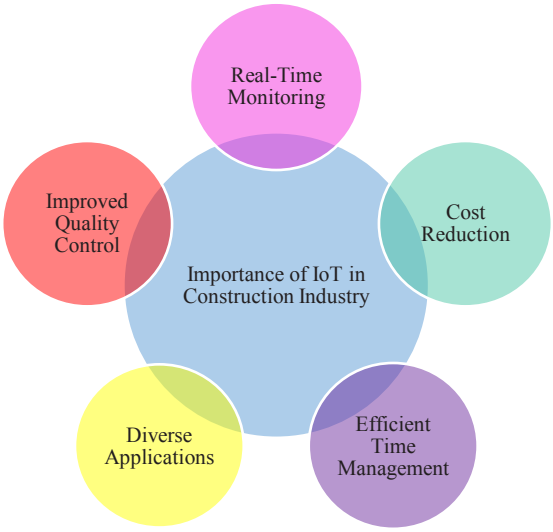

Fig 2: Important Factors of IOT in Construction Industry

4 IOT Techniques in Construction

The idea of discussing these techniques is to motivate researchers to use them with an IoT-enabled UAV to have better update from the site in less time.

4.1 Simultaneous Localisation and Mapping (SLAM)

Simultaneous Localization and Mapping (SLAM) represents a pivotal technology in autonomous robotics, revolutionizing the capability of robots to navigate and map complex environments in real-time without prior knowledge. SLAM algorithms, camera, and active sensors integrated together has the advantage of letting robots build spatial maps while localizing themselves [14]. Laser scanners that are known as Light Detection and Ranging (LiDAR) on the other hand can be used in SLAM applications to provide accurate distance measurements by emitting laser pulses and detecting reflections afterwards. LiDAR sensors have been found useful in high resolution mapping of both indoor and outdoor environments with very high accuracy levels [15]. Furthermore, global positioning satellite (GPS) receivers provide essential components for obtaining absolute geospatial positioning data especially in outdoor settings [16]. On the contrary, thermal sensors are very important, especially in situations where visibility is limited or lighting is inadequate. Thermal sensors work in partnership with other sensor modalities to provide a comprehensive understanding of the environment by identifying heat signatures [17]. Acclaimed for its adaptability, SLAM

technology finds application in numerous domains, including automation, robotics, augmented reality, and autonomous vehicles. In robotics domain particularly SLAM is a base for mobile robots which are able to move independently within changing environments with exceptional autonomy and productivity. These robots keep changing their mind maps using SLAM algorithms that simply make them to adapt changes in the environment, thereby enhancing spatial awareness and operation capability [18]. On the contrary, self-driving cars depend on SLAM to know their exact position and create a map of their environment especially in urban areas full of obstacles. By making use of SLAM technology, self-driving cars can have accurate perception and interpretation of surrounding environment which is imperative for well-informed navigation among the numerous complexities found in urban landscapes [19-22]. Autonomous vehicles may thus integrate SLAM into their navigation systems in order to guarantee safe as well as efficient transportation thus laying a foundation for common autonomous mobility solutions as shown in Table 1.

Table 1: Simultaneous Localisation and Mapping

Application	Description	Study
SLAM Algorithms	Real-time localization and mapping technology enabling robots to navigate and map complex environments without prior knowledge	[23]
Camera and Active Sensors	Integration of sensors capturing visual and environmental data to aid SLAM algorithms in localization and mapping	[24]
Laser Scanners (LiDAR)	Instruments providing precise distance measurements and enabling high-resolution mapping of indoor and outdoor environments	[25]
Global Positioning Satellite (GPS) Receivers	Devices furnishing absolute geospatial positioning data, particularly beneficial in outdoor settings	[26]
Thermal Sensors	Sensors detecting heat signatures, enhancing environment perception, especially in low-visibility conditions	[27]
Applications in Robotics	Empowering mobile robots with autonomy and efficiency in dynamic environments, enhancing spatial awareness	[28]
Applications in Autonomous Vehicles	Providing precise localization and mapping for navigating complex urban environments, facilitating informed navigational decisions	[29]

4.2 Radio-Frequency Identification (RFID)

In the construction industry, RFID (Radio Frequency Identification) technology has emerged as an innovative tool capable of enhancing efficiency, productivity, and safety. RFID is a wireless way to identify and track objects or assets by using radio frequency electromagnetic fields so that one can be aware of their presence in real-time and can also manage them for different stages of construction projects [30-34]. One main use of RFID in building sector is the tracking and management of resources. This allows construction firms to follow closely the whereabouts, condition and usage trends for their equipment, tools as well as materials [35]. This ensures better inventory control, minimizes incidences of theft or loss while enabling just-in-time delivery of supplies at the construction site; hence optimizing resource utilization and cutting project slippages [36]. Worker's safety at work place as well as site security has been enhanced through application of RFID technology. Using RFID enabled access control systems, construction companies can limit access into hazardous areas only to authorized persons with related competence [37-39]. Also in-site movement monitoring can be done by tagging individual employee's PPEs with RFIDs or imbedding RFIDs into workers' clothing within a jobsite, assisting or enabling timely response in the event of accidents or emergencies [40].

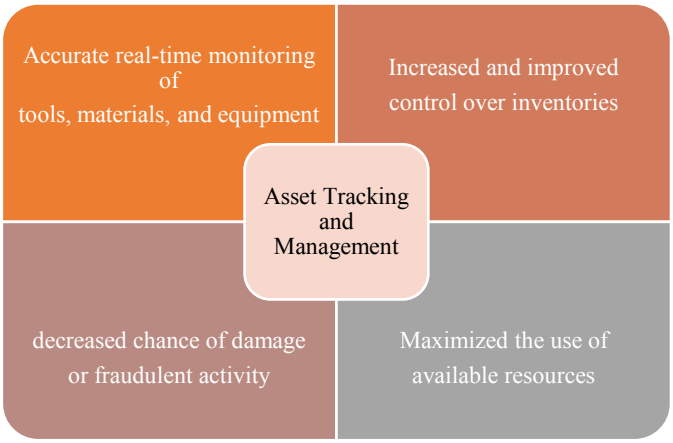

Fig. 3. Asset Tracking and Management in Construction Industry

The supply chains become more visible and logistical problems are better managed when RFID is used in this sector. For the benefit of these advantages, construction companies can use RFID tags that are integrated and embedded in their materials and components [41]. They can monitor every item more easily as it travels from manufacturers to construction locations, which enhances delivery coordination and reduces the possibility of shortages, delays, and material runs [42-46]. Additionally, RFID can be combined with other technologies like Building Information Modelling (BIM) and Construction Management Software (CMS), which facilitate stakeholder coordination and decision-making processes by automatically collecting data and updating information about the project and more precise details about it [47]. There is an added advantage to using tags enhanced by radio frequency identification technology (RFID) in building construction-related activities. These enhance maintenance while also aiding in the management of construction assets over their whole life cycle [48]. For example, construction companies can monitor the usage records of their machinery tools and equipment by using such tags. This allows for optimal asset practice, which increases lifespan without increasing maintenance costs, and it also allows preplanned servicing [49]. Additionally, this technology has enabled facilities departments within companies to move

away from outdated approaches that relied on reactive emergency response measures because electronic sensors fitted with RFID among others could be installed at strategic locations for instance within a plant pipeline network [50]. RFID technology has completely changed the sustainable construction industry in several ways, from supply chain optimization and worker safety to asset tracking and stock inventory management. Construction companies can improve project outcomes and quality satisfaction to stakeholder, by utilizing RFID technology to increase efficiency, productivity, and safety throughout all stages of the project. Fig 3 illustrates the point on asset tracking and management on sites.

5 Conclusion

This is an important milestone in the ongoing digitization of the industry, as IoT is being applied in construction. As is evident throughout this paper, there are several advantages of using IoT such as improving safety and efficiency, better project management and sustainability. Construction stakeholders could utilize these interconnected networks of sensors and devices in order to streamline processes, optimize resource allocation, or proactively manage risks before they occur.

- IoT has improved security by augmenting real-time monitoring and detection of possible dangers at construction sites. As per the established security standards, the workplace is guaranteed to be safe for workers through automatic identification and notification of any potential threats found on the assumptions, which can be resolved immediately with the use of specific devices and detectors.
- The Internet of Things (IoT) is one tool that can help to develop or encourage this kind of exposure or visibility and cooperation among stakeholders in construction projects. Real-time data exchange, or continuous information and communication exchange, makes this possible by allowing managers, builders, and designers to more effectively plan and coordinate their actions and activities, thus helping in decisions and project outcomes.
- It can be found from the study that due to IOT and its ability to automatically connect the entire building's operating procedure, productivity has increased and improved. Also if completion dates could be precisely forecasted instead of relying on maintenance or quality assurance, projects could be finished faster and for a lower price.
- Internet of Things (IoT) utilization in the construction sector, comes with some disadvantages despite its bright future. Several factors, including high rates, data security concerns, incompatibility, unpredictable reliability, and connectivity, could be addressed to ensure universal access to this technology. But with combined efforts and technological advancement, these challenges can be met, and the building industry will be able to keep coming back to increased productivity, sustainability, and innovation.

The growing adoption of IoT signals new ideas for the construction process based on intelligence that result in digitalization or changes to the traditional construction sector. As a result, the application of Internet of Things (IoT) technologies to the solutions for emerging or expanding engineering problems generates effectiveness that includes both safety and efficiency, which redefines future methods for carrying out various building tasks and projects duties.

References

1. Mijwil, Maad M., Kamal Kant Hiran, Ruchi Doshi, and Omega John Unogwu. "Advancing Construction with IoT and RFID Technology in Civil Engineering: A

Technology Review." Al-Salam Journal for Engineering and Technology 2, 02 (2023): 54-62.
2. Musarat, Muhammad Ali, Alishba Sadiq, Wesam Salah Alaloul, and Mohamed Mubarak Abdul Wahab. "A systematic review on enhancement in quality of life through digitalization in the construction industry." Sustainability 15, 1 (2022): 202.
3. Shvets, Yulia, and Tomáš Hanák. "Use of the internet of things in the construction industry and facility management: usage examples overview." Procedia Computer Science 219 (2023): 1670-1677.
4. Telagam, N., Kandasamy, N., & Nanjundan, M. (2017). Smart sensor network based high quality air pollution monitoring system using labview. International Journal of Online Engineering (iJOE), 13(08), 79-87.
5. Chaudhury, S., Krishna, A. N., Gupta, S., Sankaran, K. S., Khan, S., Sau, K., ... & Sammy, F. (2022). Effective image processing and segmentation-based machine learning techniques for diagnosis of breast cancer. Computational and Mathematical Methods in Medicine, 2022.
6. Ramu, G. (2018). A secure cloud framework to share EHRs using modified CP-ABE and the attribute bloom filter. Education and Information Technologies, 23(5), 2213-2233.
7. Tabatabaee, Sanaz, Saeed Reza Mohandes, Rana Rabnawaz Ahmed, Amir Mahdiyar, Mehrdad Arashpour, Tarek Zayed, and Syuhaida Ismail. "Investigating the barriers to applying the internet-of-things-based technologies to construction site safety management." International journal of environmental research and public health 19, 2 (2022): 868.
8. Maru, Rupamkumar V., Jayeshkumar R. Pitroda, and Amitkumar D. Raval. "Feasibility study of Internet of Things (IoT) in construction industry." (2020): 447-452.
9. Malagavelli, V., Angadi, S., Prasad, J. S. R., & Joshi, S. (2018). Influence of metakaolin in concrete as partial replacement of cement. Int J Civil Eng Technol, 9(7), 105-111.
10. Bhukya, L., Kedika, N. R., & Salkuti, S. R. (2022). Enhanced maximum power point techniques for solar photovoltaic system under uniform insolation and partial shading conditions: a review. Algorithms, 15(10), 365.
11. Vijayakumar, Y., Nagaraju, P., Yaragani, V., Parne, S. R., Awwad, N. S., & Reddy, M. R. (2020). Nanostructured Al and Fe co-doped ZnO thin films for enhanced ammonia detection. Physica B: Condensed Matter, 581, 411976.
12. Khurshid, Kiran, Aamar Danish, Muhammad Usama Salim, Muhammed Bayram, Togay Ozbakkaloglu, and Mohammad Ali Mosaberpanah. "An in-depth survey demystifying the Internet of Things (IoT) in the construction industry: Unfolding new dimensions." Sustainability 15, 2 (2023): 1275.
13. Maqbool, Rashid, Mohammed Rayan Saiba, and Saleha Ashfaq. "Emerging industry 4.0 and Internet of Things (IoT) technologies in the Ghanaian construction industry: sustainability, implementation challenges, and benefits." Environmental Science and Pollution Research 30, 13 (2023): 37076-37091.
14. Yogananda, H. S., Basavaraj, R. B., Darshan, G. P., Prasad, B. D., Naik, R., Sharma, S. C., & Nagabhushana, H. (2018). New design of highly sensitive and selective MoO3: Eu3+ micro-rods: Probing of latent fingerprints visualization and anti-counterfeiting applications. Journal of colloid and interface science, 528, 443-456.
15. Suganthi, S. T., Vinayagam, A., Veerasamy, V., Deepa, A., Abouhawwash, M., & Thirumeni, M. (2021). Detection and classification of multiple power quality disturbances in Microgrid network using probabilistic based intelligent classifier. Sustainable Energy Technologies and Assessments, 47, 101470.
16. Srivastava, Amit, Sajjaf Jawaid, Rajesh Singh, Anita Gehlot, Shaik Vaseem Akram, Neeraj Priyadarshi, and Baseem Khan. "Imperative role of technology intervention and

implementation for automation in the construction industry." Advances in Civil Engineering 2022 (2022).
17. Jia, Mengda, Ali Komeily, Yueren Wang, and Ravi S. Srinivasan. "Adopting Internet of Things for the development of smart buildings: A review of enabling technologies and applications." Automation in Construction 101 (2019): 111-126.
18. Awasthi, A., Saxena, K. K., & Arun, V. (2021). Sustainable and smart metal forming manufacturing process. Materials Today: Proceedings, 44, 2069-2079.
19. Waqar, Ahsan, Muhammad Basit Khan, Nasir Shafiq, Krzysztof Skrzypkowski, Krzysztof Zagórski, and Anna Zagórska. "Assessment of challenges to the adoption of IOT for the safety management of small construction projects in Malaysia: structural equation modeling approach." Applied Sciences 13, 5 (2023): 3340.
20. Gamil, Yaser, Majid A. Abdullah, Ismail Abd Rahman, and Muhammad Mujtaba Asad. "Internet of things in construction industry revolution 4.0: Recent trends and challenges in the Malaysian context." Journal of Engineering, Design and Technology 18, 5 (2020): 1091-1102.
21. Cheruvu, A., Radhakrishna, V., & Rajasekhar, N. (2017, May). Using normal distribution to retrieve temporal associations by Euclidean distance. In 2017 International Conference on Engineering & MIS (ICEMIS) (pp. 1-3). IEEE.
22. Kumar, K. U., Babu, P., Basavapoornima, C., Praveena, R., Rani, D. S., & Jayasankar, C. K. (2022). Spectroscopic properties of Nd3+-doped boro-bismuth glasses for laser applications. Physica B: Condensed Matter, 646, 414327.
23. Kalyani, G., Janakiramaiah, B., Karuna, A., & Prasad, L. N. (2023). Diabetic retinopathy detection and classification using capsule networks. Complex & Intelligent Systems, 9(3), 2651-2664.
24. Ghosh, Arka, M. Reza Hosseini, D. J. Edwards, Mohamad Kassem, and Monica Mateo-Garcia. "Use cases for Internet of Things (IoT) in the construction sector: Lessons from leading industries." International Council for Research and Innovation in Building and Construction (2019).
25. Das, Karan, and Abhijit Rastogi. "Role of IoT & Big Data in Construction Industry." Research & Reviews: Journal of Architectural Designing 4, 3 (2023).
26. Jayabal, R., Subramani, S., Dillikannan, D., Devarajan, Y., Thangavelu, L., Nedunchezhiyan, M., ... & De Poures, M. V. (2022). Multi-objective optimization of performance and emission characteristics of a CRDI diesel engine fueled with sapota methyl ester/diesel blends. Energy, 250, 123709.
27. Raghu, M. S., Kumar, C. P., Prashanth, M. K., Kumar, K. Y., Prathibha, B. S., Kanthimathi, G., ... & Osman, S. M. (2021). Novel 1, 3, 5-triazine-based pyrazole derivatives as potential antitumor agents and EFGR kinase inhibitors: Synthesis, cytotoxicity, DNA binding, molecular docking and DFT studies. New Journal of Chemistry, 45(31), 13909-13924.
28. Awasthi, A., Saxena, K. K., & Arun, V. (2020). Sustainability and survivability in manufacturing sector. In Modern Manufacturing Processes (pp. 205-219). Woodhead Publishing.
29. Vandana, C. P., & Chikkamannur, A. A. (2021). Feature selection: An empirical study. International Journal of Engineering Trends and Technology, 69(2), 165-170.
30. Prakash, S., Somiya, G., Elavarasan, N., Subashini, K., Kanaga, S., Dhandapani, R., ... & Sujatha, V. (2021). Synthesis and characterization of novel bioactive azo compounds fused with benzothiazole and their versatile biological applications. Journal of Molecular Structure, 1224, 129016.
31. Awasthi, A., Saxena, K. K., & Dwivedi, R. K. (2021). An investigation on classification and characterization of bio materials and additive manufacturing techniques for bioimplants. Materials Today: Proceedings, 44, 2061-2068.

32. C. Cadena et al., "Past, present, and future of simultaneous localization and mapping: Towards the robust-perception age," arXiv preprint arXiv: 1606.05830, 2016.
33. J. Wang et al., "A Review on Simultaneous Localization and Mapping for Mobile Robots with Light Detection and Ranging Sensors," Sensors, 21, 21, (2021): 7396.
34. G. Wang et al., "Indoor Localization of a Mobile Robot using GPS," Procedia Computer Science, 138, (2018): 588-593.
35. S. He, "A Survey of Visual SLAM: Advances and Challenges," IEEE Transactions on Intelligent Transportation Systems, 23, 2, (2022): 707-723.
36. S. L. Bowman et al., "Autonomous Vehicle Localization and Mapping using LIDAR and GPS," Procedia Computer Science, 89, (2016): 11-20.
37. M. Bloesch et al., "Iterated Extended Kalman Filter Based Visual-Inertial Odometry and Mapping for Quadrotors," Proceedings of Robotics: Science and Systems, (2017).
38. Li, H., M. S. Maginnis, and S. Wilkinson. "Utilizing RFID Technology in Construction Projects: An Exploratory Study." Journal of Construction Engineering and Management 143, 8 (2017): 04017052.
39. Zhang, X., and Y. Tan. "RFID Technology Applications in Construction Industry: A Literature Review." Advanced Engineering Informatics 42 (2019): 100962.
40. Ram, J. P., Pillai, D. S., Ghias, A. M., & Rajasekar, N. (2020). Performance enhancement of solar PV systems applying P&O assisted Flower Pollination Algorithm (FPA). Solar Energy, 199, 214-229.
41. Kumar, K. Y., Saini, H., Pandiarajan, D., Prashanth, M. K., Parashuram, L., & Raghu, M. S. (2020). Controllable synthesis of TiO2 chemically bonded graphene for photocatalytic hydrogen evolution and dye degradation. Catalysis Today, 340, 170-177.
42. Awasthi, A., Rao, U. S., Saxena, K. K., & Dwivedi, R. K. (2022). Impact of equal channel angular pressing on aluminium alloys: An overview. Materials Today: Proceedings, 57, 908-912.
43. Kashiwagi, D., J. Kashiwagi, and K. T. Sullivan. "Cost, Time, and Quality Tradeoff Analysis for Integrating RFID Technology into Construction Projects." Automation in Construction 87 (2018): 246-258.
44. Chien, S. W., H. Y. Chen, and S. C. Chen. "Integration of BIM and RFID for Real-time Equipment Management in Building Construction." Automation in Construction 72 (2016): 133-144.
45. Kim, K., and Y. K. Cho. "A Framework for an RFID-based Automated Construction Equipment Management System." Automation in Construction 74 (2017): 54-69.
46. Chou, J. S., and Y. Chang. "Integration of RFID and Wireless Sensor Networks for Construction Asset Management: An Application for Tower Crane Fleet." Automation in Construction 70 (2016): 96-110.
47. Tarawneh, M., A. Abdallah, and A. Althayabeh. "RFID-based Asset Management System for Construction Projects." Procedia Computer Science 192 (2021): 335-342.
48. Padmaja, B., Prasad, V. R., & Sunitha, K. V. N. (2018). A machine learning approach for stress detection using a wireless physical activity tracker. International Journal of Machine Learning and Computing, 8(1), 33-38.
49. Parashuram, L., Sreenivasa, S., Akshatha, S., & Udayakumar, V. (2019). A non-enzymatic electrochemical sensor based on ZrO2: Cu (I) nanosphere modified carbon paste electrode for electro-catalytic oxidative detection of glucose in raw Citrus aurantium var. sinensis. Food chemistry, 300, 125178.
50. Sridhara, V., Gowrishankar, B. S., Snehalatha, & Satapathy, L. N. (2009). Nanofluids—a new promising fluid for cooling. Transactions of the Indian Ceramic Society, 68(1), 1-17.