ROLES OF ARTIFICIAL INTELLIGENCE AND ROBOTICS IN CIVIL ENGINEERING

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Abstract- The growth of the construction industry is severely limited by the myriad challenges it faces such as cost and time overruns, health and safety, productivity and labor shortages. Also, construction industry is one of the least digitized industries in the world, which has made it difficult for it to tackle the problems it currently faces. An advanced digital technology, Artificial Intelligence (AI), is currently revolutionizing industries such as manufacturing, retail, and telecommunications. The subfields of AI such as machine learning, knowledge-based systems, computer vision, robotics, and optimization have successfully been applied in other industries to achieve increased profitability, efficiency, safety, and security. While acknowledging the benefits of AI applications, numerous challenges which are relevant to AI still exist in the construction industry. This study aims to unravel AI applications, examine AI techniques being used and identify opportunities and challenges for AI applications in the construction industry. A robot is a reprogrammable, multifunctional manipulator designed to move materials, parts, tools, or specialized devices through variable programmed motions for the performance of a variety of tasks. It is an autonomous machine that is capable of mobility, dealing with large forces, harsh environment and is equipped with some cognitive skills. Robotics is the science of designing, building, and using robots. It is the physical extension of computer technology. The greatest incentive for robotization on construction sites is in the cost of labor, of meeting environmental, safety and health regulations and avoidance of disruptive effects of strikes. These machines perform high-volume, simple and repetitive tasks most economically. The robot requirements for construction tasks and its applications are in inspection, maintenance, spraying, cleaning, welding, tunneling, demolition, site clearance, underwater work and nuclear plant construction.

CHAPTER I
INTRODUCTION
1.0 INTRODUCTION.
In the current situation, there is a tremendous rise in the living standards and economic level of the population leading to a gradual increase in competition between industries. The construction industry is key to India’s economic development and its status affects the national overall economy. With individuals pursuing an improved quality of life, there is a rise in the rewards of natural civil engineering construction technology. The framework of the civil engineering projects is far more complicated owing to the field’s diversity. According to the current construction situation, there are still many unresolved issues in the construction technology of civil engineering. (Hai-chao, L. 2021)[1]. Hence forth, reasonable solutions should be crafted to counter the problems and propagate rapid development of the field’s construction technology. Effective construction technology does not only create high levels for the industry but also accrue economic benefits which allow quality improvement at a reduced cost. Extensive technological innovation research should be conducted with the full participation of relevant professional staff. Higher-performance construction technologies will create more entrepreneurship opportunities in the industry. To guarantee quality post incorporation of innovative technology, personnel should be educated and trained on their respective application.

A broad extension of entrepreneurship knowledge in the Civil Engineering sector can allow bunch of business. Civil Engineers can drive their own business as entrepreneurs. However, a good start is often not a guarantee to a happy future in this field. According to Oswald (2015)[2], risk of breakdown in future, additional competition in marketplace and asymmetrical working timetable are top three obstacles seen in any start-up business curriculum. So, besides of proper planning, scheduling of work is also a very essential aspect to get success in this field. For successful entrepreneurship in civil engineering, an individual should have a good grasp of engineering principles coupled with problem-solving skills and aptitude to embrace innovative technologies. Innovative entrepreneurship is the key driver in today’s engineering world, and the push for sustainable products, services and technologies is needed now more than ever. Science, Technology, Engineering and Math (STEM) skills are an absolute necessity to running a successful business in Civil Engineering.

There is a strong connection between Technological development, Innovations and entrepreneurship. It is noteworthy that, entrepreneurship forms the sub structure upon which science and technology are built. As we understand it, technopreneurship is, by a large part, still entrepreneurship. The difference is that technopreneurship is either involved in delivering an innovative hi-tech product or makes use of hi-tech in an innovative way to deliver its product to the consumer or both (Fowosire & Idris, 2017)[3]. The latest technologies and advancements in the building construction industry such as Artificial Intelligence and robotics are the recent outstanding forms of technopreneurship. However, the construction business is way behind in adopting robotics, automation and digital technologies as it is one of the least automated industries of all. This is despite the industry being labor-intensive. Implementation of such technologies facilitates accuracy and quicker construction, saving time, money and other resources.
1.1 ARTIFICIAL INTELLIGENCE

Artificial Intelligence (AI) is a specialized system that can recognize intelligent entities, make decision-making easier, faster, and more efficient. Artificial intelligence is concerned with the robotization of intelligent behavior that thinks and acts the same way people do. As a result, artificial intelligence is a discipline of science concerned with the study, design, and implementation of time-saving technologies. AI is concerned with machines that carry out tasks. Artificial Intelligence is mostly used in civil engineering applications like construction management, building materials, hydraulic optimization, geotechnical and transportation engineering, and is also useful in developing robots and automated systems.

AI models in civil engineering can be used for accurate, cheaper, and less disruptive construction projects. In modern structures, artificial intelligence is being utilized to plan the routing of electrical and plumbing systems. Artificial intelligence (AI) is being used to track real-time interactions between personnel, machinery, and items on the job site and supervisors for potential safety hazards, construction errors, and productivity concerns (Samui, & Kothari, 2012)[4]. Simulated intelligence makes it simpler for those who engage with the development business by making it more sensible. It gives more open doors in a structural design by making it appealing field of work.

Practicing civil engineers, contractors, and service providers have all been using AI to solve wide range of problems. For instance, Artificial Intelligence in Civil Engineering has become more sophisticated, with efficiencies feeding directly into construction processes. AI is also applied in the initial stages of many projects in design optimization, risk control, and improving productivity. It is imperative to realize construction companies that have already started implementing AI practices are 50% more profitable, (Lu, Chen, & Zheng, 2012)[5]. More importantly, Artificial Intelligence as a whole has a range of functions in civil engineering. In an age where machines can think rather than just do, engineers can make better judgments while discharging their services more effectively.

1.2 ROBOTICS

Computer technology is already assisting the construction industry in many areas, notably in computer aided design, knowledge-based design, communication, scheduling, and financial control. Robotics is the only area of this technology that has not significantly penetrated the industry, because of high level of investment required. However, introduction of robots in construction industry to avoid ever-rising accidents in hazardous operations is justifiable. It is reasonable to expect financial benefits from machine capable of working in foul weather, darkness and hazardous areas without problems of motivation and administration. The introduction of robotic technology into the construction industry is slow because of slow mobility and lack of manipulation tools (Kumar, etl., 2016)[6]. Technical problems associated with the application of robotics are being solved and the comprehensive range of mobility, vision, and manipulation tools maybe expected by the end of twentieth century.

The principal advantage of robots lies in the remote operations which are tele operations by human is a principle likely to be adopted for the construction sites where the plant in dangerous situations maybe controlled by an operator situated safely away from the hazard. Laser and fiber optic technologies are a paramount importance in the teleoperations and to assist the microcomputer for the data transmission. Tele robotics is such a technology which is a mixture of two technologies where a computer is programmed and constrained to carry out certain simple repetitive tasks, leaving the operator to attend to the main control. The computer aids are becoming more and more sophisticated, including models of the physical task and advisory aids based on the expert system.

1.2.1 Critical characteristics required for construction robots

a. Sensing and Control - The biggest problem in development of robots for construction lies in the sensing and control, particularly in location and navigation. For control, the mobile robot constantly needs position and heading information. Obstacle avoidance and object location will be possible with the use of video and image recognition techniques. Present robots for construction, use preloaded guidance tracks. Obstacle avoidance by use of touch sensors and ultrasonic is in use on several prototypes.

b. Mobility and Manipulation - Equipment mobility on construction sites depends on several factors such as varying surface materials, type of tasks/jobs to be carried out and type of working space. Rail-mounted robots have sufficient mobility for many finishing operations and wall inspection tasks. Manipulative tasks will be divided among various robots classified by their load carrying capacity, length of arm and type of grip.

c. Human and Task Factors - Human factors are especially important in tele operation. Automation decreases manual workloads, but increases cognitive and mental work. The man–machine interface is very in control and display of machine. Safety is the primary reason for developing construction robots to work in harsh environments, high and deep places, boiler-seas, and in radiation zones. In these applications, the robots could work alone or a tele robot could work remotely with its operator in a place of safety. For safety reasons, either man or machine must have overall control. To avoid the delay problems in difficult tasks and feedback of manipulation to the operator, it is relevant to consider the current state of telecontrol.

d. Expert System and Task Flexibility - Robots alone will bring little benefit to the construction industry. Only with total organization of the construction process will real progress be made. For civil engineering applications, expert systems, CAD/CAM and database technology are very important in robotics for task flexibility. A computerized work-control system for robotic work will be essential for their optimal use; this would have to include site organization and sophisticated handling of materials from factory to robot.
1.3 OBJECTIVES
The specific objectives for the PCL are the following.
1. To incorporate technology in improving the quality of building designs through automation of construction processes.
2. To employ Artificial intelligence in the risk identification and mitigation strategies. Robotics to be used where working conditions are not suitable for people.
3. To minimize cost and time overruns in construction projects.
4. To increase precision in construction

CHAPTER 2
APPLICATION
2.1 APPLICATION IN ARTIFICIAL INTELLIGENCE AND ROBOTICS
Each and every civil engineering project is associated with risks and uncertainties. This can include the risks regarding task force allocation, milestone achievement, project costing and overall construction management (Siau, & Wang, 2018)[7]. Machine learning which is a branch of Artificial Intelligence (AI) is widely used in the domain of civil engineering. Current applications of artificial intelligence and robotics in civil engineering include the following.

2.1.1 Visualization with drones
The quadcopter distinguishes itself by being the optimal choice of the construction industry (DeYoung, 2018)[7]. The drone’s domination is due to its pricing, simplicity, maneuverability, and flight times around 30 minutes (DeYoung, 2018)[7]. Drones have already made an impressive contribution to construction, and their influence is set to grow in the coming year. Small, camera-mounted flying drones can reduce the costs of processes that used to be extraordinarily expensive.
2.1.2 Artificial Intelligence-based soil profiling
Ensuring soil strength, as well as preliminary construction cost and duration prediction, is a very crucial in any construction project, (Sharma et. Al., 2021)[9]. Similarly, building strong structures is very important in geotechnical engineering to ensure the bearing capability of structures against external forces. Hence, in this first-of-its-kind state-of-the-art review, the capability of various artificial intelligence (AI) based models toward accurate prediction and estimation of preliminary construction cost, duration, and shear strength is explored. Similarly, soil moisture is an integral quantity parameter in hydrology and geotechnical practices. Satellite remote sensing has been widely applied to estimate surface soil moisture. The AI technology of learning from an existing knowledgebase is used to automate various civil- and geotechnical-related applications, such as the estimation of compressive strength of concrete, shear strength of soil, project pre-cost and duration, structural health monitoring, crack detection and pothole detection. Machine calculation of parameters allows not only lowering the cost and time required but also enhancing the accuracy in their calculation by eliminating any type of human error.

2.1.3 Steel Beam Positioning Manipulator
Steel Beam erection work is one of the most dangerous tasks on the construction to be robotized. Steel Beam positioning manipulator lifts two or three steel beams and sets them in the correct position by teleportation. While setting beams, the manipulator grasps the top of the columns and there is no need to be lifted by a tower crane. This means that the tower crane can be used for the other jobs while the manipulator is working. It weighs a total of 1,900 kg with a hanging load capacity of 2,100 kg and one degree of freedom, (Jung, et al., 2009)[10]. So, we will developing SM15-01 Steel Section Manipulator Specifically developed for handling and installing OLE masts this powerful manipulator will handle, erect and precisely position any steel section post or mast from 200mm to 650mm.

2.1.4 Fire Proofing Spray Robot (SSR-3)
Robot system used in building construction sites can efficiently reduce construction time and increase safety by replacing human in dangerous operations. Construction robots are defined as field robots and while operating in dynamic environment. Rock wool spray work for fireproofing steel structural members is a hazardous construction job. The SSR-3 was developed to provide a safer work environment for spray workers. While spraying, the SSR-3 moves parallel to a steel beam at a constant distance measured with a pair of ultrasonic sensors.

![Figure 2: Steel Beam Manipulator](image1)

![Figure 3: Interior Finish Spray Robot](image2)
2.1.5 Attention-guided analysis of infrastructure damage with semi-supervised deep learning.

In the field of civil infrastructures physical inspection is needed to ensure safety. However, it is difficult to inspect some structures by human beings. In such cases computer vision and machine learning based software techniques are used to detect damage in place of manual observations. In recent years, a novel method to improve the accuracy of the damage quantification (detection + segmentation) using attention guided technique has been developed. In the proposed method a fast object detection model is used (Abioye, et al., 2021)[11]. It is a Single Shot Detector (SSD) method, trained on VGG-16 base classifier architecture. This model performs a real-time crack and spall detection along with inspectors’ verification. The detected region is used for further analysis. This initial region of interest selection reduces the computational cost, required amount of training data. The proposed attention-guided infrastructure damage analysis technique provides 30% more precision with a very minor amount of decrease in computational speed.

2.1.6 Predicting maximum dry density and optimum moisture content in concrete using RBF neural networks

The proposed novel approach for the prediction of maximum dry density (MDD) and optimum moisture content (OMC) of soil-stabilizer mix uses radial basis function (RBF) neural networks. RBF neural network is utilized to construct comprehensive and accurate models to be able to relate the MDD and OMC of stabilized soil to the properties of natural soil such as particle size distribution, plasticity, linear shrinkage and the type and quantity of stabilizing additives. Two separate sets of RBF prediction models, one for the MDD and the other for the OMC, have been developed. A parametric study conducted using the results obtained from the proposed models to evaluate the sensitivity of MDD and OMC due to variation of the influencing parameters. The accuracy of the proposed models is satisfactory when compared with that of the experimental results. The results of RBF models are further more accurate as compared with those of the existing models.

CHAPTER 3 METHODOLOGY

Figure 4: Methodology for Design, Development and Marketing
3.2 PROCEDURE
Examination into details will be conducted based on the methodology;

a. **Cloud-Based Application**: The following considerations will be taken into account as we construct the oriented language-based program application for the cloud storage.

i. The data of total work done per day
ii. The total cost of the material and other things also
iii. The risk management data synchronization
iv. The structure and construction detail.

b. **Modelling**: In software based on Artificial intelligence only we will be developing the model visually and the main purposes is to do designing without any error. The synchronization data will help us into remove the redolence error and with that we will be designing efficient model.

c. We will be combing the BIM (BUILDING INFORMATION MODELLING) and program based on Artificial intelligence. Most usually the AI software we will use **Augmented reality** (AR) is a digital layer of information that enhances a view of the real world.

i. Automatic measurements: By measuring a physical space in real time, AR technology can help construction workers accurately follow building plans.
ii. Visualize modifications: By layering potential project modifications directly onto the job site, contractors can visualize potential changes before committing to them.
iii. Provide safety information: By recognizing hazards in the environment, augmented reality devices can display real-time safety information to workers.

d. **Construction Wearables**

i. **Smart boots**: Powered by walking, smart boots can detect workers at risk of a collision with nearby construction vehicles equipped with sensors.
ii. **Smart hard hat**: By sensing brainwaves, smart hard hats can detect “microsleeps,” which put workers at risk of injury.
iii. **Power gloves**: When worn on a worker’s hands, power gloves increase dexterity and strength, helping reduce overuse injuries.

a. These construction wearables will be monitored by AI software programs.

3.3 RESOURCES AND SCHEDULES
AI is a game changer in terms of construction scheduling. Traditionally, only one or two schedules were created for large projects. Even this was a challenge, because developing schedules is time-consuming. By using AI, hundreds or even thousands of fully resource-loaded schedules can be developed within hours, along with a clear cost and time impact of each iteration. AI can manipulate the massive number of parameters involved in a project that impact construction, including labor, equipment and material availability or construction methods. This rapid data manipulation can only happen with parametric software. Robots are primed to revolutionize the construction industry. Construction is one of the least digitized, least automated industries in the world, positioning robots as an attractive solution for construction companies.

CHAPTER 4
RESULTS AND DISCUSSION
4.1 RESULTS OF AI AND ROBOTICS IN CONSTRUCTION

4.1.1 Results of AI in construction

1. **Preventing Cost Overruns** - Cost overruns are almost expected for construction projects, and the bigger the project, the bigger the overruns are likely to be. By using AI in conjunction with Big Data analytics, you can generate reports for past projects, pinpoint where the overruns were and predict better budgets for future ones. You can also use AI to streamline your supply chain and avoid costly delays with the same method. For instance, if your building calls for a solar panel system, your AI can predict the best time to order and install the system based on projected delays in previous steps.

2. **Improving Worksite Safety** - Not only can Artificial Intelligence gather data from the sensors in your equipment, it can also manage the flow of people and materials around the site. This reduces accidents by ensuring faulty equipment is identified before failure, that equipment like cranes are not blocking access to critical areas and much more. Your AI can be integrated with security cameras to monitor for unsafe actions or events and use facial recognition technology to warn affected workers. By using the Internet of Things, your AI can even use RFID chips in building and safety equipment to track site traffic in real-time and redirect it to avoid collisions or delays.

3. **Helping Design Better Buildings** - More design firms are integrating AI with their Building Information Modeling software to provide 3D walkthroughs of their projects and predict potential problems faster than ever. These models can automatically update as each team makes changes to the electrical, plumbing or structure of the building and run predictive analytics on the data to help smoothly integrate key features. 3D modeling is already used to let architects, contractors, and designers tour the space at various stages of the design process, and Artificial Intelligence units can analyze this data and generate reports on the function of the building while the design team focuses on other tasks.
4. ** Supervising Project Planning** - Not only can Artificial intelligence help design better buildings and prevent cost overruns, but it can also help with other aspects of project planning, such as scheduling and materials sourcing, and train better managers by analyzing past data. Your AI will look at how factors such as the weather and politics have affected your projects in the past to predict the best times to order materials and from whom to get them. The algorithms used in this process learn from past errors to make better choices in the future, all at learning speeds that only a computer can accomplish. You can even find software companies with machine learning data sets designed for planning construction projects, so you do not have to source the information yourself.

5. **Making Job Sites More Productive** - Self-driving equipment can reduce the need for workers to perform some repetitive tasks, freeing them up for more detailed and hands-on processes and making jobsites more productive. Some tasks being developed include excavation and sitework, pouring concrete and even welding, giving you the opportunity to focus on more things at once. Your AI project manager can keep track of these equipment pieces and tasks through your integrated security system and you can monitor progress and updates through your mobile device.

### 4.1.2 Results of Robotics in Construction

1. **Easier Demolition** - Breaking down walls and crushing bricks/concrete is no easy task. Without robotics, the demolition process would drag on far longer than necessary due to limited human strength. With robotics, buildings can be demolished and disposed of in one day, saving time and money.

2. **Higher Quality** - With automation comes higher quality. Unfortunately, humans are prone to error, and this reflects in our work. No matter how often we double check for flaws, there is still a high chance that we will miss something. With robotics, the construction industry and its customers can rest easy knowing robotic machines are ensuring the quality of their product. Automation gets the job done better, faster, and more efficiently.

3. **Total Automation** - Once the construction industry embraces robotics, everyday processes will eventually become completely automated. This means everything from manufacturing to dispensing! More automation means less human error and lots of financial savings.

4. **Job Changes** - Robotics will perform certain tasks that construction workers used to perform. This is one huge reason for why the construction industry has been slow to adopt new technology. Workers have done things the same way for a long time and are hesitant to change and possible job losses. While robotics will not get rid of all jobs completely, it will drastically change what workers will be doing day-to-day and, in some cases, will replace the need for human workers.

### CHAPTER 5

**MARKET REVIEW**

#### 5.1 REVIEW

Markets expects the global Artificial Intelligence (AI) in construction market to grow from USD 407.2 Million in 2018 to USD 1,831.0 Million by 2023, at a Compound Annual Growth Rate (CAGR) of 35.1% during the forecast period. The rising demand for AI-based solutions and platforms, the need for more safety measures at construction sites, and the capabilities of AI solutions and services to reduce the production costs are expected to drive the growth of the AI construction market. AI in construction solutions plays a vital role in the efficient and effective functioning of construction businesses using Natural Language Processing (NLP); and machine learning and deep learning technologies. AI-based solutions are required to revolutionize the way the construction industry functions. These solutions also help the construction industry familiarize itself with advanced technologies and assist professionals in saving their time in the process of decision-making.

The construction robotics market size was valued at $2,450.7 million in 2019, and is expected to reach $7,880.3 million by 2027, registering a CAGR of 23.3% from 2020 to 2027. Construction robotics refers to construction operations that are automatically carried out by using automated construction equipment or construction robots. It is used in applications such as building and demolishing of residential, commercial, and industrial infrastructures. Construction robotics has reduced or completely removed human intervention from construction activities. Construction robots are used in activities such as demolition of structures as well as 3D printing of walls & structures. In addition, construction robots can be used for material handling activities such as placing bricks to build wall and transportation of building material vertically or horizontally on construction site. Further, automatic drones are used for surveillance of construction sites that are not easily accessible or need to be remotely monitored.

#### 5.1.1 Novelty

The adoption of robotics is yet to reach the tipping point in construction industry. This translates to a dire need of automation in our industry in terms of demolitions, 3D printing, Brick laying and other functions. Despite there being advanced knowledge on AI and Robotics, adoption in the construction field is limited for factors related to lack of specialization and the costs related to adoption. The cost of robots as per the Construction Robots company ranges between $75000 to $150,000 which is exorbitant. The adoption of robotics in construction is on the rise with an estimated growth of 95% in the next five years. The leading in adoption is North America and Europe, followed by Pacific Asia with a very promising growth rate. However, South America and Sub-Saharan Africa still depict low levels of adaptability. Moreover, the incorporation of AI is on the high-rise with an inclination on safety in sites. Clearly, both AI and Robotics in the construction Industry are under development and with a promising future. The analyzed benefits range from reduced costs of construction to speed and quality delivery of projects.

#### 5.1.2 Feasibility for Business

The construction industry is a labor-intensive industry. The construction business is way behind in adopting robotics, automation and digital technologies as it is one of the least automated industries of all. The latest technologies and advancements in the building construction industry such as Artificial Intelligence and robotics are currently the talk of the town. Implementation of such
technologies facilitates accuracy and quicker construction, saving time, money and other resources. With a fast-paced construction process, the incorporation of robotics technology in construction facilitates construction professionals with quality-assured outcomes and reduced human errors.

5.1.3 Expected Demand
The value of the global construction robot market was clocked at US$ 91.2 Million in 2021. The market is likely to expand at a CAGR of 15.3% during the forecast period, from 2022 to 2031. The global market is anticipated to attain value of US$ 359.6 Million by 2031. In terms of use of robotics in construction industry, the sector is falling behind and the sector heavily relies on human labour. The global deployment of sophisticated construction robotics is now being driven by the demand for more economical and environmentally responsible homes with reduced environmental effects. Few construction companies now use automation, suggesting that there is a tremendous opportunity for service providers and construction robotics companies alike to revolutionize the manufacture of building materials to the design, planning, and construction phases themselves, as well as facility management.

5.1.4 Regulatory Aspects
The prospect of a highly automated construction industry is a medium-term future prospect. Hence it is imperative to proactively understand the regulatory gaps, to support policy interventions to mitigate potential risks. Regulation of futuristic technologies like AI and robotics is challenging in sectors where there is a lack of adequate tacit and applied knowledge. AI regulation is complicated by the massiveness of the construction industry, characterized by a broad spectrum of actors and activities. We propose a framework to understand the AI and robotics inclusion in the construction industry and identification of risks and regulatory gaps by considering the diverse stakeholders and their risk perception.

5.1.5 Risk identified and management
1. **Ownership** - It is crucial to establish at an early stage who will own the data, know-how or other intellectual property derived from the new technology, and who will take responsibility for it. In cases of partnership between clients and software development companies or start-ups in the race to harness the benefits of AI, disputes tend to rise over the ownership of commercially valuable technologies. This is in particular to where a party has contributed significant sums to the cost of the project, only to find that they do not have appropriate rights in the end product.

2. **Data protection** - In order to adapt, machine learning requires large datasets to analyze and train upon. Some implementation models allow users to effectively "rent" a dataset upon which to train their own systems. Other users prefer to insource their systems, or use AI as a service. In any event, care must be taken before collecting, sharing and processing personal data. Failure to comply with data protection legislation could lead to criminal prosecution and significant fines. Use of AI in facial recognition, sensors or other methods of monitoring individuals on a construction site, for example, could lead to issues in processing data under GDPR. Developing practical policies for managing data and dealing with subject access requests will minimize risk.

3. **Cybersecurity** - The risk of a cyber-attack is evident, given the significant amount of personal data that can be collected and processed within a construction project, as well as the payments being made in connection with the project and the potential for ransomware to disrupt time-sensitive actions. Supply chains play a vital part in the security, or vulnerability, of the end system. Ensure appropriate due diligence has been carried out on suppliers and that contracts contain adequate cyber-security protections and audit rights. It is advisable to put in place a response policy and ensure all relevant individuals are aware of the steps that need to be taken.

4. **Licensing** - Checks should be carried out to ensure that rights of use can be assigned or sub-licensed to sub-contractors, to allow collaboration across design and build.

5. **Liability** - Collaboration through AI systems can also lead to difficulties in establishing who has responsibility for issues. For example, who has a duty to warn where multiple parties have inputted to the design? Risk must be identified, with appropriate insurance and contractual liability flow-downs to ensure that the costs associated with any liabilities do not impact on the viability of the project. Changes to the regulatory framework should also be closely monitored, as legislators approach liability issues in relation to AI.

5.2 INTER/TRANS-DISCIPLINARITY
Robotics is a multidisciplinary area that combines electrical engineering, mechanical engineering and computer science. This area includes embedded programming, control systems, automated decision making, and power electronics. Moreover, Artificial intelligence is a science and technology based on disciplines such as Computer Science, Biology, Psychology, Linguistics, Mathematics, and Engineering.
CHAPTER 6
CONCLUSION AND DISCUSSION

Robotics is the area of computer technology which is now penetrating the construction industry. Robotization of construction sites is very important to replace men for hazardous operations in foul weather, darkness, deep waters, high radiation zones, hazardous areas and at high elevations. It is also useful from the point of view of avoidance of disruptive effects of strikes, problems of motivation and administration, safety and health regulations, shortage of skilled labors and to carry out repetitive, dirty and dangerous works and completion of projects or tasks with quality control, within the specified time and economy. Though this technology is assisting the construction industry in developed and developing countries, considerable research is required for sensing and control, human factors, task flexibility and the software support to integrate robots into an overall computer-aided design and data-based construction management. Robot requirements for construction tasks and various applications of robots in construction industry depending upon the nature of work to be performed.

The use of artificial intelligence will undoubtedly make life easier for humans in the future and may even encourage humans to expand their skill sets. The work for the constructors and architects is getting much simpler due to AI techniques. Artificial intelligence has been effectively applied in developed countries to a variety of civil engineering applications, including prediction and risk management. Artificial Intelligence used in Civil engineering is important in the construction, maintenance, and management of several components of civil infrastructure.

Robotics is the area of computer technology which is now penetrating the construction industry. Robotization of construction sites is very important to replace men for hazardous operations in foul weather, darkness, deep waters, high radiation zones, hazardous areas and at high elevations. It is also useful from the point of view of avoidance of disruptive effects of strikes, problems of motivation and administration, safety and health regulations, shortage of skilled labors and to carry out repetitive, dirty and dangerous works and completion of projects or tasks with quality control, within the specified time and economy. Though this technology is assisting the construction industry in developed countries, considerable research is required for sensing and control, human factors, task flexibility and the software support to integrate robots into an overall computer-aided design and data-based construction management. Robot requirements for construction tasks and various applications of robots in construction industry depending upon the nature of work to be performed are presented in this paper.

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**APPENDICES STUDENT INFORMATION**

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