JETIR.ORG ISSN: 2349-5162 | ESTD Year : 2014 | Monthly Issue
JOURNAL OF EMERGING TECHNOLOGIES AND INNOVATIVE RESEARCH (JETIR)
An International Scholarly Open Access, Peer-reviewed, Refereed Journal

Use of AI intelligence in the construction waste management domain and handling of smart materials

[1]Shirke Nikita Vijay, [2]R. M. Swamy, [3]Dr.Y.S. Patil, [4]Dr.M.S. Kuttimarks, [5]Lavanya B A
[1] ME Student, SSJCET, Asangaon, Thane, MH, India
[2, 3] Associate Professor, SSJCET, Asangaon, Thane, MH, India
[4] Professor, SSJCET, Asangaon, Thane, MH, India
[5] Assistant Professor, SSJCET, Asangaon, Thane, MH, India

ABSTRACT

This research presents the applications of Artificial Intelligence (AI), Machine Learning (ML), and Deep Learning (DL) in building and construction industry in the facets of architectural design and visualization; material design and optimization; structural design and analysis; offsite manufacturing and automation; construction management, progress monitoring, and safety; smart operation, building management and health monitoring; and durability, life cycle analysis, and circular economy. A unique perspective on applications of AI/DL/ML in these domains for the complete building lifecycle, from conceptual stage, design stage, construction stage, operational and maintenance stage until the end of life. AI is becoming more popular due to the advances in colour cameras and hyperspectral cameras, improvements in the computational capacity to process streaming data with high pixel densities, seamless integration of computer vision with deep learning algorithms and advances in the deep learning algorithms for classification and object detection. Construction can accelerate the digital transformation of the construction industry, and this will generate massive amounts of data that can be used effectively to improve operational efficiency, make informed decisions, drive innovation and growth and enhance sustainability. Most of the applications of AI in the construction domain are still in the research phase with only a few companies offering promising commercial solutions. AI in a human-centric manner will result in environmentally friendly manufacturing and personalized solutions. Intelligent, human- centered design, manufacturing, and maintenance will emerge as AI advances to Construction. Future 3D printing techniques, with more personalized AI integration, will enable a much faster iterative loop of initial production, component testing, and creation of a redesigned object in both prefabricated and onsite construction.

Key Words: - Artificial Intelligence, Computational capacity, Construction, Operational efficiency.

1. INTRODUCTION

Rapid urbanization, population growth, and economic development have increased waste generated worldwide in recent years. According to the latest statistics, 2.01 billion tonnes of municipal solid waste was generated globally in 2016. This figure is expected to increase to 3.4 billion tonnes by 2050 (Kaza et al. 2018). Unfortunately, 33% of solid waste is managed correctly and disposed of in illegal dumpsites or unmonitored landfills (Kaza et al. 2018). Improper waste disposal poses many environmental and health risks, such as groundwater contamination, land degradation, increased cancer incidence, child mortality, and congenital disabilities (Triassi et al. 2015). In the past, waste management practices were more rudimentary, with a small group of individuals collecting garbage from the streets and depositing it in designated areas (Brancoli et al. 2020). Once the trucks were full, the waste was left in these designated areas. However, with the advent of artificial intelligence, the waste management industry is experiencing significant transformation toward achieving sustainability and profitability. Artificial intelligence is a rapidly advancing technology that is gaining popularity in various industries, particularly waste management (Abdallah et al. 2020).

1.1 Challenges in Construction Industry

The construction industry is faced with many challenges that have hindered its growth and led to extremely low productivity levels when compared with other industries such as manufacturing. Sofiat O. Abioye, Lukumon O. Oyedele, *, Lukman Akanbi, Anuoluwapo Ajayi, Juan Manuel Davila Delgado, Muhammad Bilal, Olugbenga O. Akinade, Ashraf Ahmed, the construction industry is one of the least digitized industries in the world and most stakeholders acknowledge the age-long culture of resistance to change. The absence of adequate digital expertise and technology adoption within the construction industry has also been linked to cost inefficiencies, project delays, poor quality performance, uninformed decision-making and poor performance in terms of productivity, health and safety. In recent years, it has become apparent that the construction industry must embrace digitisation and rapidly improve technological capacity especially with challenges of existing labour shortages, COVID-19 pandemic and the need to provide sustainable infrastructures. A foremost digital technology, Artificial intelligence (AI), has helped to achieve significant contributions to the improvement of business operations, service processes and industry productivity in recent years. The subfields of AI such as machine learning, natural language processing, robotics, computer vision, optimisation, automated planning and scheduling, have been applied to tackle complex problems and support decision-making for real-world problems. However, the construction industry is yet to reap any significant benefit from AI despite its existing challenges.

1.2.1 Digitization of Construction Industry

Construction remains one of the least digitized industries in the world and continues to struggle with the beneficial adoption of AI and other digital technologies Zhao et al., 2016. However, it is clear that there exists a lot of grey areas in the research trend of AI applications, future opportunities and barriers to adoption in the construction industry. Robotics has been 3 applied in site monitoring and performance evaluation, offsite assembly, and the management of construction materials, plant and equipment; Kumar et al., 2016; Knowledge-based systems have also been applied for tender evaluation, conflict resolution, risk and waste management, sustainability assessments, etc. (Myllyviita et al., 2017)

1.2.2 Machine Learning Approach

Artificial intelligence (AI) is a region of software engineering that accentuates the making of clever machines that work and respond like people Rahul Hadiya, Hani Upadhyay, Dr. J. R. Pitroda, A portion of the exercises PCs with Artificial intelligence are intended for include Speech recognition, Learning, Planning, Problem solving. Artificial intelligence is a part of software engineering that expects to make wise machines. AI for Better Design of Buildings Through Generative Design Building Information Modelling is a 3D version primarily based procedure that offers design, building and development experts experiences to proficiently design, plan, build and oversee structures and framework. So as to plan and structure the development of a structure, the 3D fashions want to think about the design, building, mechanical, electrical, and plumbing (MEP) plans and the arrangement of exercises of the separate groups. Project Planning In 2018, An AI Start-up propelled with the guarantee that its robots and AI maintain the way to illuminating late and overspending development ventures. In the event that things appear to be off course, the supervisory group can step in to manage little issues before they emerge as massive troubles. Algorithms of the density will use an AI approach known as “reinforcement studying.” Off-site Construction Development organizations are progressively depending on off-site manufacturing plants staffed via self-ruling robots that piece together parts of a structure, which are then sorted out by human specialists on location. Information produced from pictures caught from cell phones, drone recordings, security sensors, building data displaying (BIM) and others have become a pool of data. This presents an open door for development industry experts and clients to investigate and profit by the bits of knowledge created from the information with the assistance of AI and AI 10 frameworks. Using drones to gather accurate survey maps and aerial images of a job site, as well as track progress remotely, saves on a project’s time and cost. Plus, the aerial images can give project managers a different perspective of the project and help spot potential issues that may not have been apparent from the ground. AI for Post-Construction Building supervisors can utilize AI long after the development of a structure is finished. Building data demonstrating, or BIM, stores data about the structure of the structure.

1.2.3 Legal Proceedings by AI

Aditya Joseph, George, A structure plan is approved when it is finished on schedule, under budget, according to specifications, and to the satisfaction of all stakeholders. Functionality, contractor profitability, the lack of lawsuits and legal proceedings, and "fitness for purpose" for occupiers have all been used as indicators of project success. Delays are one of the most serious issues in building projects. Every construction project has delays, and the magnitude of such delays differs greatly between projects. Some works are only a few days behind schedule, while others were pushed back for over a year. Construction activities are generally completed with high costs, prolonged timelines (delays), and quality problems. Delay happens when the contractor, consultant, and client all contribute to the project failing to be finished within the initial, stated, or agreed-upon contract timeframe. Delays create job interruption and loss of productivity, late project completion, higher time-related costs, third party claims, and contract abandonment or cancellation. It is critical that general management monitor project development in order to reduce the potential of delays occurring or identifying them at an early stage. The construction industry is one that has a lot of unpredictability in its day-to-day operations. The construction engineering and management (CEM) industry within the architects, engineering, and construction (AEC) industry is beset with its own serious complications because it encompasses a wide range of construction-related activities and processes, as well as human factors and interactions. In the Indian construction sector, Muneeswaran et al. Although subjective data is inadequate for generalization of results, it has the potential to speed the usage and acceptance of ml algorithms to solve building difficulties. In view of the foregoing, the goal of

this study is to develop a machine learning algorithm to help in the evaluation of delayed risk in tall construction works. The research is based on objective data gathered from experts working on high building projects in Gulf Co - operation Council (GCC) countries. To continue, the research identifies delayed project risks from the existing literature, and then used questionnaire surveys to evaluate the identified delayed risks in two zones: probability and impact.

1.2.4 Artificial Intelligence (ANN) in Construction Industry

Artificial Neural Networks (ANNs) are data structures meant to imitate the behaviour of biological neural networks (Pitts et.al 1943). ANNs are seen as adaptive systems composed of connected "neurons" structured in a multi-layered network. It can gather, represent, and simulate complex nonlinear relationships between inputs and outputs by doing numerous concurrent calculations. An input layer, an output layer, and hidden layers comprise the layers. The learning method is based on altering the numerical values associated with the connecting edges among different artificial neurons on a regular basis (Sethi et al. 2017). Mohammed E. Haque, Vikram Karandikar, ANN and GA- concepts and definition Neural computing is a relatively new field of artificial intelligence (AI), which tries to mimic the structure and operation of biological neural systems, such as the human brain, by creating an Artificial Neural Network (ANN) on a computer. An ANN is a modelling technique that is useful to address problems where solutions are not clearly formulated or to validate the results obtained through other modelling techniques. GA usually begins with a random solution and keeps revising it until an optimal solution is found. The good solutions reproduce to form new and hopefully better solutions in the population, while the bad solutions are removed. A genetic search progress through a population of points on the contrary to the single point of focus of most search algorithms. It employs a population of strings initialized at

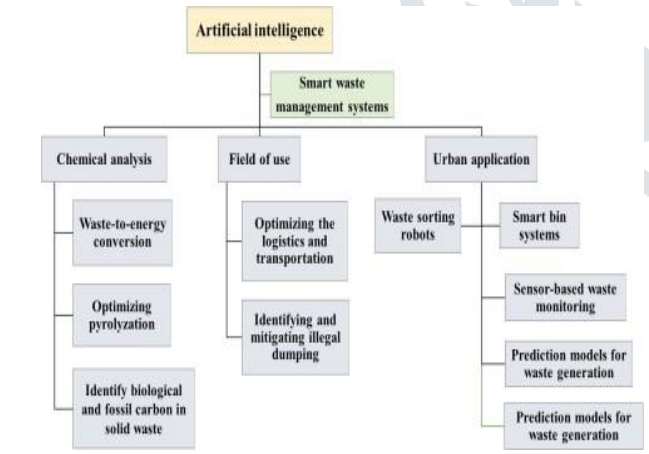


Figure 1.1: *Application of artificial intelligence in waste management.*

random, which evolve to the next generation by genetic operators – selection, crossover, and mutation. The fitness function evaluates the quality of solutions coded by strings. Selection permits strings with higher fitness to emerge with higher probability in the next generation. Starting from a randomly chosen crossover point, crossover combines two parents by exchanging parts of their strings to develop new solutions inheriting desirable qualities from both parents. Mutation flips single bits in a string, which prevents the GA from premature convergence, by exploiting new regions in the search space. GA tends to take advantage of the fittest solutions by giving them greater weight, and concentrating the search in the regions, which lead to fitter structures, and hence better solutions of the problem.

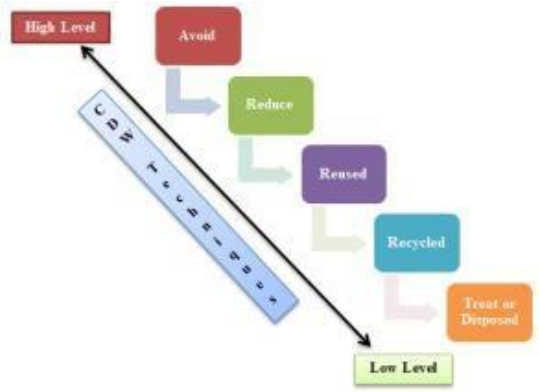


Figure: 1.2 *Waste Management Hierarchy*

1.2.5 Machine Learning

In computing, ML represents a paradigm shift. Traditionally, a programmer would write computer code that established the rules for processing data inputs and producing an output. In ML, the computer is given input data as well as the expected answers, and the ML agent must then generate the rules. These rules can then be used on new data to generate unique results. Rather than being explicitly programmed, an ML system is trained. There are generally three types of ML: i) supervised learning, ii) unsupervised learning, and iii) reinforcement learning (RL). The main early algorithms used in supervised learning are Logistic Regression (Cox, 1959), Perceptron (Rosenblatt, 1958), and kNN (Nearest Neighbour)

(Cover and Hart, 1967). While the Perceptron algorithm undoubtedly laid the groundwork for ML algorithms, they were fragmented and unstructured prior to the publication of the Decision Tree algorithm (Xu et al., 2021). Support Vector Machine (SVM), AdaBoost, and Random Forest (RF) are the most widely used supervised learning algorithms in the construction industry (Xu et al., 2021).

1.2.6 Computer based Intelligence

Computer based intelligence can be utilized to screen creating issues and even offers answers for forestall issues. Specialists can wear computer generated reality goggles and send smaller than usual robots into structures underneath development. Rather, it will change plans of action in the development business, decrease costly blunders, lessen worksite wounds, and make building activities more effective. Pioneers at development organizations ought to organize venture dependent on zones where AI can have the maximum effect on their organization's interesting wishes. Early movers will set the bearing of the business and advantage in the fast and long haul. Machine learning is a form of AI that can perform a specific task without being explicitly programmed, instead relying on patterns and inferences. Large data sets are collected quickly and cleansed in a structured sequence of steps using networks to determine relevancy and improve accuracy with each data point, providing additional layers of intelligence (see prior address example for a form of machine learning). The machine operates

on diversified learning patterns (supervised, unsupervised or reinforcement) to accomplish a desired task most efficiently. Machine learning platforms have become foundational to real time predictive analytics that allow users to better mitigate risks and monitor controls.

2. LITERATURE REVIEW

The important problems in the construction industry is materials and construction waste management. In every construction project and the magnitude of these waste varies considerably from project to project. So, it is essential to define the actual causes of material handling and waste management in any construction project. This chapter discusses about the literatures under the following heads: Conventional works, types of artificial intelligence, causes of AI, resource reduction GDP, alternative work output as a replacement for construction project, data analysis and inference from literature survey.

2.2 Linear programming models

Babu and Suresh [G. Babu, N. Suresh] proposed a new technique to study the trade-off between time, cost and quality by using three interrelated linear programming models. Their approach is based on the linear relationship between project completion time, project cost and quality measure. Khang and Myint [D.B. Khang, Y.M. Myint] applied the time-cost-quality trade-off for construction project of cement factory. El-Rayes and Kandil [K. El-Rayes, A. Kandil] designed modified GA model, which transforms the traditional two-dimensional time cost trade-off analysis to an advanced three-dimensional time-cost-quality trade-off analysis, this model was developed as a multi-objective genetic algorithm to provide the capability of quantifying and considering quality in construction optimization. Rahimi and Iranmanesh, M. Rahimi, H. Iranmanesh] proposed a new Multi Objective Particle Swarm Optimization for a discrete project time, cost and quality trade-off problems. Developed multi-objective for finding the Pareto optimal front of project time, cost and quality, whose activities belong to a ‘‘start to finish’’ activity relationship network (CPM) and they can be done in different possible modes which are non-continuous or discrete, and each mode has a different cost, time and quality. [Abd El Razek et al.] presented the development of a multi-objective optimization model in order to search optimal resource utilization plans that minimize construction time and cost while maximizing its quality for construction projects with repetitive activities, then developed multi objective optimization software for repetitive construction projects which is named Automatic Multi-objective Typical Construction Resource Optimization System, ‘‘AMTCROS’’. Developed the utilized steps to determine the best combination of minimum project financing.

2.2.1 Data exchange process

Chien Ho Ko et al. (2003) reviewed by way of using Fuzzy logic (FL), neural networks (NNs), and genetic algorithms (GAs) they broaden an Evolutionary Fuzzy Neural Inference Model (EFNIM). Integrating those 3 strategies, the EFNIM uses GAs to simultaneously search for the fittest membership functions (MFs) with the minimum fuzzy neural network (FNN) shape and choicest parameters of FNN. Tom Andersen et al. (1996) carried out research based on AI in construction and focused on expert systems lab. He observed that ESL (Expert Systems Lab requires) the strong technical computer support that was not present then. The ESL was neglected, and the reason was its narrow prototypes. For every project evaluation was generally done using ESL in five different stages. But harmony between IT (Information Technology) system and this process wasn’t up to the mark. Data and information exchange process among the different firms was major obstacle with available computer and IT technology at that time. Access of the project data was very difficult for employees working on same projects in different firms. Furthermore, this study proposes an object-oriented (OO) device improvement method to integrate the EFNIM with OO pc approach to expand an unfolding Fuzzy Neural Inference System (OO-EFNIS) for solving production control troubles. Simulations are performed to exhibit the application capacity of the EFNIS. This framework may be utilized as diverse canny choice help device for decision making to clear up manifold creation management issues. The benefits of making use of the machine are collected from the programs of different issues, which are inherently protean. However, a key advantage is that customers can follow this system without area and AI expertise to clear up ill-based, complex, unsure, incomplete statistics, and nonlinear problems in production management.

2.2.2 Material Testing in infrastructure construction

Mohamed A. Sachin (2014) Geotechnical engineering (GE) deals with substances (e.g., Soil and rock) and modelling the conduct of such materials in GE applications is complex. Artificial intelligence (AI) is turning into extra popular and particularly amenable to modelling the complex conduct of most GE packages because it has tested advanced predictive capacity as compared to traditional strategies. This paper presents different selected AI techniques and their programs in pile foundations, and gives the salient functions related to the modelling improvement of these AI techniques. It also reviews the power and barriers of the chosen AI techniques as compared to different available modelling approaches. It became obtrusive from the evaluation provided in this paper that AI strategies had been applied efficaciously to conduct of pile foundations consisting of bearing capacity prediction, settlement estimation, and modelling of load- settlement response. Based on this it can be concluded that AI strategies carry out higher than, or at least as accurate as, the maximum traditional strategies. Akshata Patil et al. (2017) observed that while stimulating the complex nature of the problems many mathematical models fail. This led to implementation of AI in the field of construction and civil engineering. Development of the robotic and automated system is possible with AI. The smart building and green building concepts are possible with this AI based systems. In this smart system, optimization of smart building materials is possible with specific chemical and mechanical properties. Artificial neural network system plays vital role in decision making and planning phases. Other applications of the AI are design of bridges using GIS (Geographic information system) pavement maintenance schedules, seismic activity prediction and tidal forecasting.

2.3 Artificial Neural Networks

George F. Bigham et al. (2019) defined the approaches in which AI can assist within the goal of creating construction web sites safe. Currently, undertaking safety and threat evaluation in the construction industry is accomplished by using professionals and There is a loss of a 21 systematic technique and methods to check the reliability of these selections. Through the aspect of

AI, we can automate the method and create an environment where capacity risks are identified before they occur with a hyperlink to the OSHA (Occupational Safety and Health Administration) standards for endorsed mitigation techniques. Automation of the danger identity manner will keep vast time and personnel price to assist small firms. Long time period objectives of the thought include definitive data showing the effectiveness, time and price comparison of automatic vs guide danger identity. Construction industry, taken into consideration to be the most coincidence prone enterprise, ought to grow to be one of the most secure if those tasks use of AI are advanced and applied. Bob Prieto et al (2019) focussed on how any project execution done by using the AI, machine learning and language processing. Business management, sales, data, finance, human resources, operations, engineering designs, supply chains, logistics, construction can be easily performed proficiently using AI techniques. Adoption of the AI system consists of several barriers like lack of compassion, lack of assets and lack of preparedness. Some serious threats to the system are related to cyber security, data scrapping and hacking of the system. Mohsen Hatami et al. (2019) offers an in-intensity assessment of AI techniques and how the generation can be petitioned to computerized construction fabricating cycle. The paper evaluations synthetic neural networks (ANNs) (e.g., Deep studying and transfer learning). The goal of the paper is to assist become aware of the route for future studies and development in this discipline. Industries wherein smart fabricating and synthetic intelligence strategies had been efficaciously carried out, the development industry can benefit from those advances throughout the globe consisting of all elements of venture designing, observation, manage, as well as protection analysis. Benefiting from AI that we can observe other industrial processes which include making use of predictive AI solutions for lowering R&D (Research and development) cost, on-line optimization for higher tracking and control, supervised studying for modularization and prefabrication in creation, robotic togetherness for modular or prefabrication production, and device learning strategies for picture reputation for hazard and protection supervision. Marte H. Schia et al (2019) reviewed how Artificial Intelligence can be implemented in construction industry and presented a single case study. Research indicated that technology, process and culture have equal importance to make this technology use successful with a time.

2.4 Artificial Linguistic Internet Computer Entity

The study showed some results that are derived by using two different techniques in construction named Implementation of ALICE (Artificial Linguistic Internet Computer Entity) and implementation of Touch plan. These techniques are respectively called digitization and digital transformation. This technology improves the workflow and work tasks of the construction projects. The rust between human and AI is the main asset of the project. Fig. 1 and 2 shows Implementation of Touch plan and ALICE respectively. Box colours indicate how much the implementation of given aspect reached. Darker the background higher the efficiency of implementation. Touch plan is the digital version of physical boards and sticky notes, a collaborative web-based tool for construction projects. Where in ALICE by analysis and optimization tools based on AI, schedule of the project is provided as an output. Henrietta Bakers et al. (2020) in this paper considerably improves on, and finishes to validate, a method proposed in previous studies wherein protection results had been expected from attributes with 22 machine learning. As per the original observe, we use Natural Language Processing (NLP) to separate fundamental qualities from raw material and machine studying fashions are trained to predict safety effects. The outcomes expected right here are injury severity, damage kind, frame part impacted, and incident kind. Now results are highly predictive, confirming the validity of the unique method. Other upgrades delivered by using the current have a look at consist of the usage of (1) a mile's larger dataset presenting more than 90,000 reports, (2) two new models, XGBoost and linear SVM (Support Vector Machines), (3) version stacking, (4) a greater sincere experimental setup with greater suitable performance metrics, and (5) an evaluation of according to-class characteristic significance scores. Finally, the harm severity outcome is properly predicted, which became no longer the case within the authentic have a look at. [6] Zaher Mundher Yaseen et al. (2020) developed a hybrid artificial intelligence model named integrative Random Forest classifier having Genetic Algorithm optimization (RF-GA) for delay problem prediction. Collection of data of various projects in Iraq were carried out. Data of about 40 projects collected which were related to delay levels of the project. Advantages/disadvantages of Artificial Intelligence: a) Fear among workers - there is a circulating perception amongst a few personnel concerning AI programs that it may also lessen jobs through changing human resources, therefore an improved implementation of information technology via personnel is necessary; b) Cultural resistance - A few socially based methodologies are found as snags for embracing new noteworthy innovations to modern upgrades, in this way, it is fundamental for individuals to know about this reality that AI exist in our life and its application must be organized for improving mechanical undertakings; c) Security - this undertaking has end up a fundamental trouble from an IT point of view and the security business in the long run address the one-of-a-kind prerequisites of IoT, comprehensive of AI. This paper summarizes the usage of clever optimization systems in civil engineering and the researchers performed within the subject. The construction industries are on the verge of digitalization, which is disrupting traditional processes and also holds many opportunities in store. Artificial intelligence is expected to increase efficiency throughout the entire value chain – from the production of building materials to the design, planning and construction phase itself, and facility management as well. As the construction industry continues to move toward increased automation to increase safety and on-site productivity, AI and machine learning applications will help get the job done on time and on budget.

2.5 Machine learning-based assessment models:

The main reason of this article is to assist members of the construction project team in understanding the elements that must be regularly checked in order to finish the work on time and on budget. As a result, the study's goal was to create a neural network model (ANN) model that could predict the performance of construction works based on the different speculation specified ADITYA JOSEPH, DR. K J GEORGE. Despite the frequency of delay studies, productive research to advance tools and capacity to address the fundamental problem is lacking. As this give idea of outlines the improvement of a machine learning algorithms for finding the risk of delay in high rise building. 36 delay risk variables were initially discovered in existing literature and then converted into questionnaires to examine the likelihood and consequences of the risk factors. A data collection for machine learning applications was created

using 48 usable replies gathered from subject matter experts. The approaches of K- 24 Nearest Neighbors (KNN), Neural Networks (ANN), Support Vector Machines (SVM), and Ensemble were investigated. The most important independent factors, according to feature subset selection, were "slowness in decision making," "delay in sub-contractors' work," "architects'/structural engineers' late issuing of instruction," and "waiting for approval of drawings and material supply." The model for finding the risk of delay was find out by ANN, and it was then finished with a classification accuracy of 93.75 percent. After the final model created in this study might help construction companies manage project risk on high rise building. The building business is undergoing a technological transformation that will increase productivity. Project delays and abandonment, which have become a threat in tall construction projects, are a serious under-productivity concern. Numerous research on the causes of building delays have previously been conducted; however, the present difficulty is establishing prescriptive methods to address the issue.

2.6 Digitization of development

Digital technology is causing significant shifts in the construction industry. This industry is crucial on a regional, national, and global scale and contributes the most to India's economy, second only to agriculture Dilshad Khan. The design, designing, and development industry is at present encountering different innovative and modern changes and difficulties, including the rising utilization of data innovation and supportable practices. The Internet of Things) Information and Communication Technologies, Big Data, Automation, Standardization, Disruption, Flexibility, Blockchain, and Supply Chain are just some of the most recent trends and tools. The Internet of Things, artificial intelligence, and cloud computing all hold particular promise e for the creation of a construction management environment that is integrated and collaborative. This insightful article presents a careful assessment of existing writing in regard to the execution of man-made reasoning in the administration of development projects. The construction industry's productivity can be greatly enhanced by implementing these new technologies. Likewise, this article is a continuation of our prior correspondence that addresses the "ongoing perspectives of digitization of development, the executives, development venture and development industry, and the development business." This research 24 will contribute to a better understanding of the transformation and pave the way for additional research in this field because the development of this technology is still in its infancy 2.6.1 Artificial intelligence in construction management Artificial intelligence (AI) applications have gained a broad interest in civil/construction/ architectural engineering problems. Its applications are very extensive and interdisciplinary. A comprehensive review" (2020): This study reviews the applications of AI in construction management, including project planning, risk management, and resource optimization. The study highlights the potential of AI to improve efficiency and productivity in construction projects. "A review of the applications of artificial intelligence in construction safety management" (2019): This study reviews the applications of AI in construction safety management, including hazard detection, worker behaviour monitoring, and safety performance prediction. The study concludes that AI can improve safety outcomes on construction sites by identifying and mitigating potential hazards. "Building performance simulation using artificial intelligence: A review" (2018): This study reviews the applications of AI in building performance simulation, including energy consumption modelling, indoor air quality prediction, and thermal comfort assessment. The study concludes that AI can improve the accuracy and efficiency of building performance simulation, enabling architects and engineers to design more sustainable and efficient buildings. "Autonomous construction equipment and its impact on productivity and safety" (2021): This study explores the impact of autonomous construction equipment, including robots and drones, on productivity and safety in the construction industry.

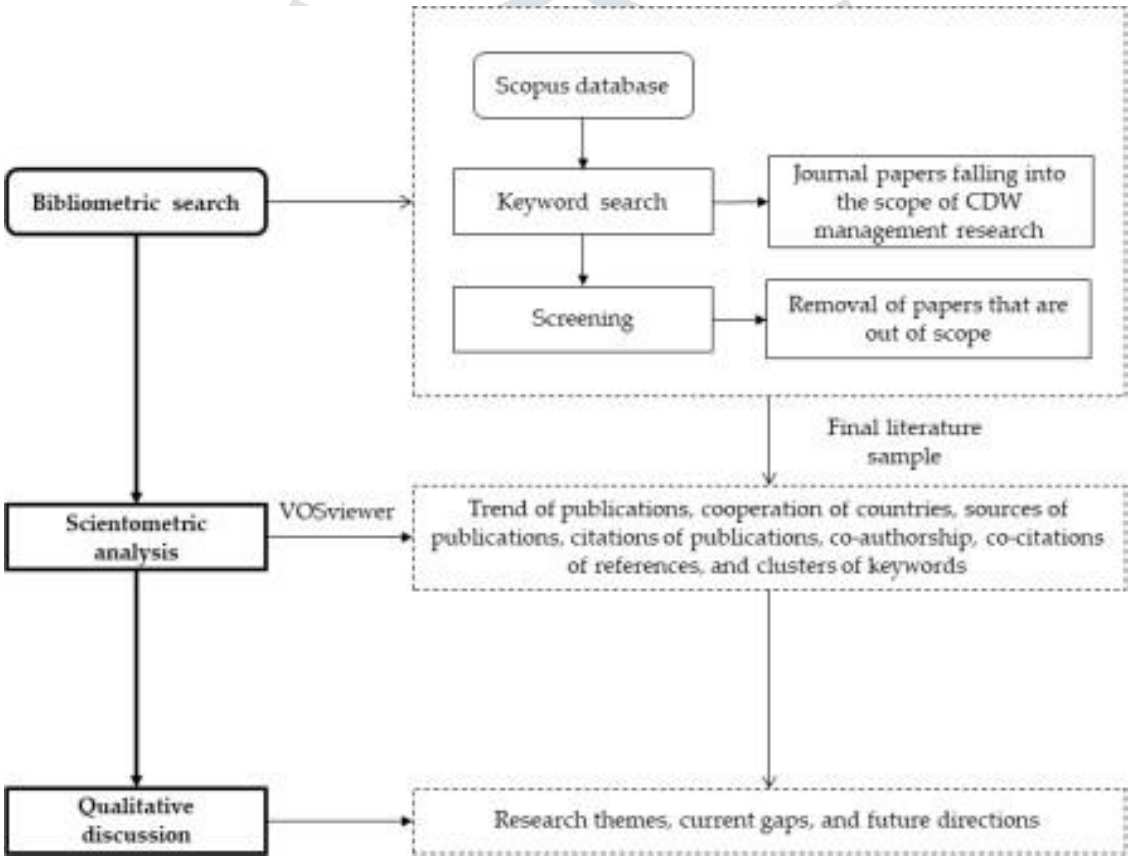
2.7 ANN and GA

The graduate students civil/construction/architectural students should especially be encouraged to learn various applications of computing techniques including artificial neural network (ANN), genetic algorithm (GA), etc. Presently, there are no courses on AI applications for the undergraduate and graduate students at the Construction Science Department of Texas A&M University. Under “Directed Studies” (3 Credits), the first author has been teaching applications of AI to interested graduate students. Some interested students do their graduate projects and thesis in AI applications. This paper highlights various applications of AI through an example and referring other research papers. As an example of a graduate project, this paper demonstrated an ANN and GA based knowledge model regarding comfort and safety issues in a large residential multistorey flat housing complex. Through post occupancy of building evaluation, the builders/designers able to assess what elements exceed customers’ expectations and are important in repeating in future projects, as well as the elements that fall short of expectations and may require modification for the next projects. During this process, designers are challenged with soft data, which are linguistic qualitative in nature, and needed to interpret and integrate into their design decision making processes. This paper demonstrated an Artificial Neural Network (ANN), and Genetic Algorithm (GA) based knowledge model of customer’s preferences regarding comfort and safety issues in a large residential multi-story flat housing scheme. The data in the form of a structured questionnaire regarding comfort and safety issues was collected. A five-point scale was used to depict the range of importance from least to most for each issue. A General Regression Neural Networks (GRNN) model was trained and evaluated in order to determine the best representative response for each question. The questionnaire dealing with various issues related to the safety and comfort were grouped into various grouping for GA optimization and created various scenarios to improve safety and comfort for the studied housing complex one of which was discussed in this paper. It was observed that ANN and GA have exceptional ability to process the qualitative data, analyse, interpret and finally integrate it into a sound knowledge model for architectural design.

3. CONCLUSION

AI is necessary to study how AI directly interacts with individuals and how different AI technologies can positively or negatively impact individuals or companies in the construction industry. In this direction, it is explored that there AI, which has not received much attention from research community. A variety of artificial intelligence technologies will be utilized in order to train appropriate models in order to successfully manage the rapid development of data generation in CPM. It is projected that artificial intelligence would be able to deliver on promises about prediction, optimization, and decision making, which will enable the traditional construction industry to catch up with the rapid speed of automation and digitization.

APPENDIX



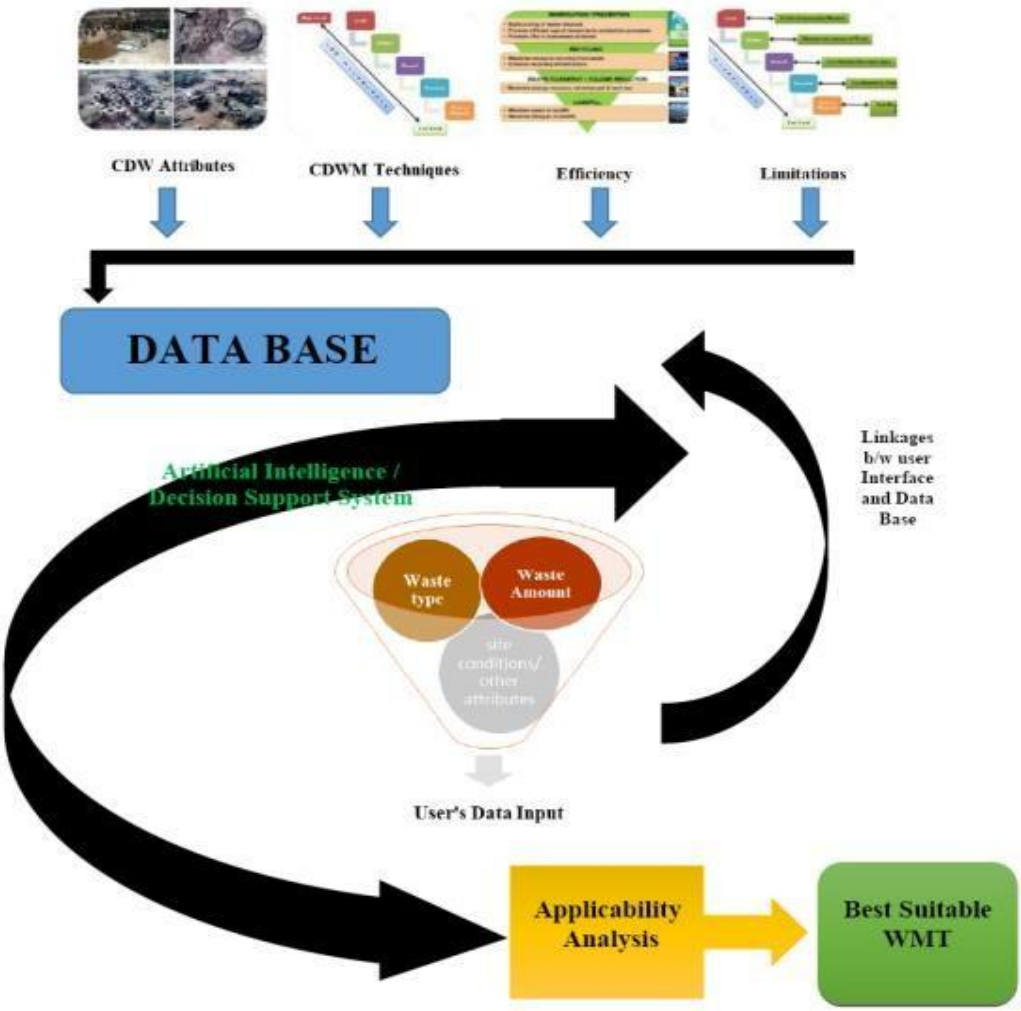


Figure 1.2: *Artificial intelligence Decision Support system.*

Aknowledgement

The authors would like to express their gratitude to all the faculty members from civil engineering department who have helped their research work in timely completion and valuable suggestions during the technical discussions.

REFERENCES

[1] Aggarwal S, Jindal A, Chaudhary R, Dua A, Aujla G S and Kumar N 2018 Energy Chain: Enabling energy trading for smart homes using blockchains in smart grid ecosystem Proceedings of the 1st ACM MobiHoc Workshop on Networking and Cybersecurity for Smart Cities, Smart Cities Security 2018

[2] Aldwairi T, Perera D and Novotny M A 2018 An evaluation of the performance of Restricted Boltzmann Machines as a model for anomaly network intrusion detection compute. Networks 144 111–9

[3] Aristodemou L and Tietze F 2018 The state-of-the-art on Intellectual Property Analytics (IPA): A literature review on artificial intelligence, machine learning and deep learning methods for analysing intellectual property (IP) data World Pat. Inf. 55 37–51

[4] Chang P D and Chow D S 2018 Reply Am. J. Neuroradiol. 39 E128

[5] Clavero, J., Applications for Artificial Intelligence in Construction Management,2018

[6] Collins J, Howe K and Nachman B 2018 Anomaly Detection for Resonant New Physics with Machine Learning Phys. Rev. Lett. 121

[7] de Lange T, Halvorsen P and Riegler M 2018 Methodology to develop machine learning algorithms to improve performance in gastrointestinal endoscopy World J. Gastroenterol. 24 5057–62

[8] Dong Y, Zha Q, Zhang H, Kou G, Fujita H, Chiclana F and Herrera-Viedma E 2018 Consensus reaching in social network

group decision making: Research paradigms and challenges Knowledge-Based Syst. 162 3–13

[9] Giuffrida M V, Doerner P and Tsaftaris S A 2018 Pheno-Deep Counter: a unified and versatile deep learning architecture for leaf counting Plant J. 96 880–90

[10] Green C P, Engkvist O and Pairaudeau G 2018 The convergence of artificial intelligence and chemistry for improved drug discovery Future Med. Chem. 10 2573– 6

[11] https://towardsdatascience.com/concrete-compressive-strengthprediction-usingmachine-learning-4a531b3c43f3.

[12] Kearney V, Chan J W, Valdes G, Solberg T D and Yom S S 2018 The application of artificial intelligence in the IMRT planning process for head and neck cancer Oral Oncol. 87 111–6

[13] Love-Koh J, Peel A, Rejon-Parrilla J C, Ennis K, Lovett R, Manca A, Chalkidou A, Wood H and Taylor M 2018 The Future of Precision Medicine: Potential Impacts for Health Technology Assessment Pharmaco economics 36 1439–51

[14] Mittal M, Verma A, Kaur I, Kaur B, Sharma M, Goyal L M, Roy S and Kim T-H 2019 An efficient edge detection approach to provide better edge connectivity for image analysis IEEE Access 7 33240–55

[15] Mohsen Hatami, Ian Flood, Bryan Franz, Xun Zhang, State-of-the-Art Review on the Applicability of AI Methods to Automated Construction Manufacturing, Computing in Civil Engineering 2019 51

[16] Neidhardt J and Werthner H 2018 IT and tourism: still a hot topic, but do not forget IT Inf. Technol. Tour. 20

[17] Patil, Ar & Mahajan, Ar. Gayatri. “Applications of Artificial Intelligence in Construction Management” International Journal of Research in Engineering, IT & Social Sciences (IJREISS), March 2019.

[18] Peña J M 2018 Reasoning with alternative acyclic directed mixed graphs Behaviour metrika 45 389–422

[19] Sarowa S, Singh H, Agrawal S and Sohi B S 2018 Design of a novel hybrid inter carrier interference mitigation technique through wavelet implication in an OFDM system Digit. Commune. Networks 4 258–63

[20] Seyedzadeh S, Rahimian F P, Glesk I and Roper M 2018 Machine learning for estimation of building energy consumption and performance: a review Vis. Eng. 6

[21] Singh H and Kumar R 2013 Measuring the utilization index of advanced manufacturing technologies: A case study IFAC Proceedings Volumes (IFAC-Papers Online) vol 46 (Saint Petersburg: IFAC Secretariat) pp 899–904

[22] Strąk Ł, Skinderowicz R and Boryczka U 2018 Adjustability of a discrete particle swarm optimization for the dynamic TSP Soft Compute. 22 7633–48

[23] Tsakalakis G and Koutsakis P 2018 Improved user similarity computation for finding friends in your location Human-centric Compute. Inf. Sci. 8

[24] Udias A, Pastori M, Dondeynaz C, Carmona Moreno C, Ali A, Cattaneo L and Cano J 2018 A decision support tool to enhance agricultural growth in the Mékrou river basin (West Africa) Compute. Electron. Agric. 154 467–81

[25] van Gent P, Melman T, Farah H, van Nes N and van Arem B 2018 Multi-Level Driver Workload Prediction using Machine Learning and Off-the-Shelf Sensors Transp. Res. Rec. 2672 141–52

[26] Zhang X, Chen X, Wang J, Zhan Z and Li J 2018 Verifiable privacy-preserving single layer perceptron training scheme in cloud computing Soft Compute 2020, 8, 122908–122922.