Journal of Research Administration
Society of Research Administrators International

APPLICATIONS OF ARTIFICIAL INTELLIGENCE IN STRUCTURAL ENGINEERING: REVIEW

Tarun Gehlot[1], Harshveer Singh Kachhwaha[2]
[1]Assistant Professor (Civil Engineering), Agriculture University Jodhpur
[2]Project Consultant, NS Enterprise Jodhpur

Abstract: The area of computer science known as artificial intelligence (AI) focuses on creating software and hardware with intelligence akin to that of humans. The most promising route to better practises in civil engineering turns out to be artificial intelligence. When testing is not feasible, artificial intelligence (AI) can be effectively applied as a game-changing tool in the field of structural engineering to establish engineering design parameters. AI will never be able to completely replace human involvement, not even in the near future, given its great range of flexibility. This is because AI will never be able to account for the logic that is unique to humans. Instead, its main purpose is to act as a touchstone for structural engineers, enabling them to increase their productivity. The sophisticated and profound learning algorithms seen in contemporary AI systems offer engineers well-defined platforms and merit investment. Massive computational resources are needed for the modelling and optimisation of complicated structural systems using traditional approaches; nevertheless, artificial intelligence-based technologies can frequently offer useful substitutes for effectively resolving civil engineering issues. This paper provides an overview of current ideas and practises that are being explored in the direction of artificial intelligence applications in civil engineering, such as fuzzy systems, neural networks, and evolutionary computation.

Key Words: structural engineering, artificial intelligence, machine learning, pattern recognition, deep learning, structural maintenance

1. INTRODUCTION

AI is defined as "the branch of science and engineering concerned with the creation of artefacts that exhibit intelligent behaviour, as well as the computational understanding of what is commonly called intelligent behaviour." At a 1956 meeting held at Dartmouth College, the word "AI" was first used. Through the use of symbol manipulation and symbolically structured knowledge bases, this computational approach aims to replicate human cognition in order to address engineering issues that are difficult to solve using traditional methods. AI and machine intelligence are synonymous terms. AI is the ability of a machine to think and act like a person, whereas machine intelligence is the ability of machines to think and act like humans. to imitate human cognitive processes in order to carry out tasks intelligently. The incubation period (prior to 1956), the formation period (1956–1970), the dark period (1966–1974), the knowledge application period (1970–1988), and the integrated development period (1986–present) are the five phases that comprise the evolution of AI approaches.

2. PROGRESS OF ARTIFICIAL INTELLIGENCE

The first person to use the term artificial intelligence was John McCarthy. He explained it as the way symbols mechanically controlled the human thought process. 4. Machine intelligence comes in two flavours: methods of hard computing and ways of soft computing. Numerical analysis, crisp systems, and binary logic are the foundations of hard computing. This can yield exact answers and necessitates a precisely specified analytical model. In contrast to hard computing, soft computing supports parallel computations, can handle ambiguous and noisy input, and integrates stochastic information. Neural networks, fuzzy logic, evolutionary algorithms, and probability reasoning are the basic building blocks of soft computing.Artificial Neural Networks are being used in the field of Civil Engineering to predict construction tender bids, construction cost, and construction budget performance, as well as to design, plan, build, and manage infrastructure such as highways, bridges, airports, railroads, buildings, and dams. Artificial intelligence also affects worker productivity, maintenance and construction demand, and project cash flow.

Adaptive neuro-fuzzy inference systems are artificial intelligence (AI) based computational tools that are well-suited for modelling complex systems with input-output data sets that are known, particularly when examining the behaviour of cement-based materials subjected to single, dual, or multiple damage causes. Building schedules that minimise project time and cost can be created and evaluated by construction planners using the model.

A branch of artificial intelligence called machine learning creates models to identify patterns and make predictions based on characteristics that have been identified through training data.8. One tool that focuses on learning the features and representations of the data is deep learning. Differentiating AI from data science and big data is also essential.9. Data mining is a transdisciplinary field that looks for undiscovered features in an area with less understanding in order to uncover important trends and insights in a data set. Large or complicated data sets that are challenging to depict with traditional data processing methods are referred to as "big data" [Fig 1].

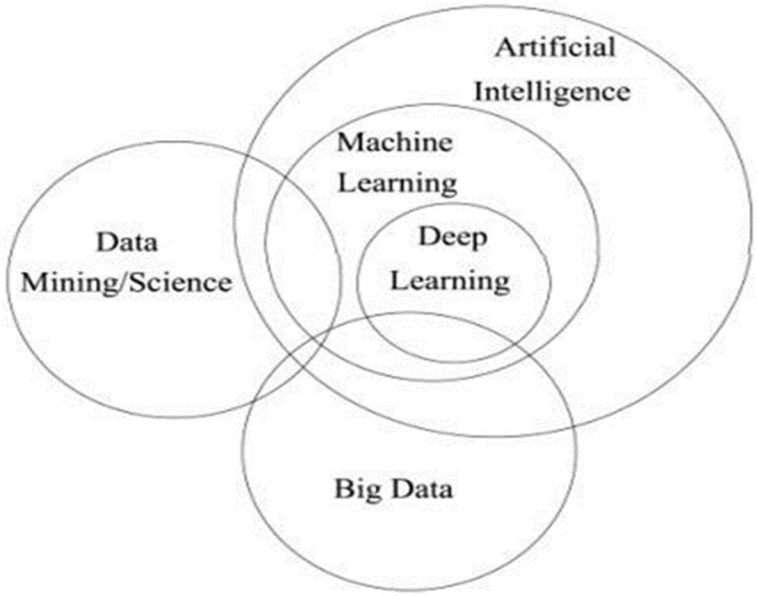

Figure 1 illustrates different intelligent techniques and their correlation.

2.1 Structural System Identification

Structural System Identification (SSI) allows constructing a mathematical model of a structural system from a set of input-output measurements generated by dynamic time series signals. In a study by Jiang et al. a fuzzy stochastic neural network model for nonparametric identification of civil structures using the nonlinear autoregressive moving average with exogenous inputs model through the combination of two computational intelligence techniques, i.e., fuzzy logic and neural networks. The proposed model was validated using a 1:20 scaled model of a 38-storey concrete building and a benchmark 4-story 2 x 2 bay 3D steel frames.13 Amezquita Sanchez et al introduced a new method to find the modal parameters of large structures using adroit integration of multiple signal classification and this method was applied to a 123-story super high-rise building structure, the Lotte World Tower, which is the tallest building in Korea to calculate the natural frequencies and damping ratios of the structure. He also concluded that this approach could identify the natural frequencies and damping ratios of large civil structures with high accuracy.

2.2 Structural Health Monitoring (SHM)

Structural Health Monitoring (SHM) is one of the subject of intensive research in structural engineering. It can be divided into two categories of image-based SHM employing the computer vision technology and vibration signal-based SHM based on the signals obtained during dynamic events. The vibration signal-based SHM involves two general approaches: parametric system identification (modal parameters identification) and non-parametric system identification

Deep learning algorithms such as Convolutional Neural Networks (CNNs) have been employed for automatic feature extraction in SHM. In these methods, feature extraction and classification steps are performed in a single step to avoid the exhaustive tests between features and classifiers [Fig 2].

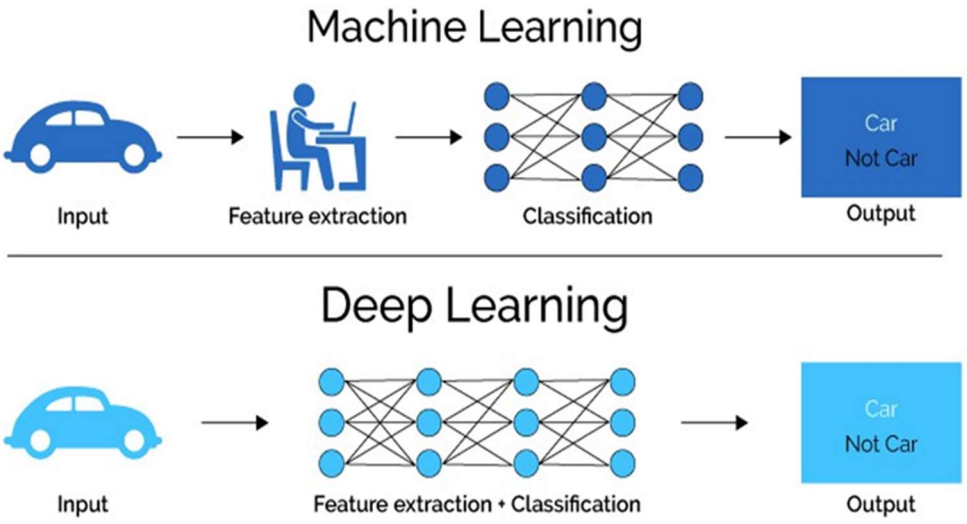

Figure 2 shows machine learning and deep learning

The effective training of supervised ML approaches requires a large set of data from healthy and damaged structures. To overcome this limitation, unsupervised ML-based methods have been proposed recently because they do not require labelling the training data from different damage scenarios.16 In a study by Ibrahim et al, a comparison of the classification performance of three

machine learning algorithms, SVM, K-Nearest Neighbor (KNN), and CNN, for evaluating the health condition of two simulated four- and eight story building structures subjected to earthquakes. They reported that CNN outperformed SVM and KNN in terms of accuracy for damage detection.

3. ARTIFICIAL INTELLIGENCE AS A IMPLEMENT FOR MODELING

An artificial neural network imitates the brain's neural cells. Despite being a greatly reduced representation of the human brain, they can offer fresh perspectives on how to approach addressing tasks that arise naturally. ANN can generalise a job when given unseen data and can learn from experience without needing to know anything about it beforehand.Twenty

"A massively parallel distributed processor made up of simple processing units, which has a natural propensity for storing experimental knowledge and making it available for use" is the definition of an artificial neural network.The processing units in neural networks are known as "neurons," and each connection has a "weight" parameter that indicates how important the connection is between the neurons.22, The knowledge of brain networks is stored in these synaptic weights. Error back-propagation is a learning algorithm that updates synaptic weights continuously.

Because it can learn to determine complex, nonlinear, and unknown relationships between dependent and independent variables, ANN also serves as a universal function approximator.22 Thus, it can be applied to a wide range of issues and phenomena in the field of civil engineering.24-The ANN has some drawbacks in addition to its tremendous benefits. They are inappropriate for long-term forecasting and ineffectual in choosing starting weights.

4. NEURAL DYNAMIC CLASSIFICATION ALGORITHM

Neural Dynamic Classification (NDC) is a new supervised classification algorithm which was developed with a goal of uncovering the most effective feature spaces and finding the optimum number of features required for accurate classification. This is capable of solving highly complicated classification of problems by employing a new feature space with large margins between clusters and close proximity of the transformation functions. NDC was successfully employed for the development of an earthquake warning system and also for detection of damages in high- rise building structures.

5 FUTURE TRENDS

In civil engineering field, in the present situation, the research and development of artificial intelligence is only just starting, so far failing to play its proper role. The combination including Artificial intelligence technology and object-oriented and the Internet is the artificial intelligence technology the general trend of development. Artificial intelligence is in its development for civil engineering in the following aspects.

- Fuzzy processing, integrated intelligent technology, intelligent emotion technology in the civil engineering. To deepen the understanding of the problems of uncertainty and to seek reasoning mechanism is the primary task.
- To develop practical artificial intelligence technology, only to be developed in the field of artificial intelligence technology, and the knowledge to have a thorough grasp.

- According to application requirements of civil engineering practical engineering, the research and development of artificial intelligence technology in civil engineering field were carried out continually. Many questions in civil engineering field need to used artificial intelligence technology. Due to the characteristics of civil engineering field, artificial intelligence technology was used in many areas for civil engineering field, such as civil building engineering, bridge engineering etc.
- Hybrid intelligence system and a large civil expert system research.
- With the development of artificial intelligence technology, some early artificial intelligence technology need enhance and improve for knowledge, reasoning mechanism and man-machine interface optimization, and so forth.
- To some related problems, many single function of artificial intelligent system integration can carry out, integrated as a comprehensive system of artificial intelligence, and expand the artificial intelligence system to solve the question ability.
- Artificial intelligence technology was used in the actual application, only in the practical application of artificial intelligence technology, to test the reliability and give full play to the role of the artificial intelligence technology and to make artificial intelligence technology to get evolution and commercialize. In the commercialization of artificial intelligence technology, there are many successful examples abroad, for enterprise and socially brought considerable benefit.

5. CONCLUSION

This paper summarizes and introduces the intelligent technologies in civil engineering with recent research results and applications presented. All aspects of applications of the artificial intelligence technology in civil engineering were analyzed. On the basis of the above research results, prospects of the artificial intelligence technology in structural engineering field application and development trend were represented. Artificial intelligence can help inexperienced users solve engineering problems, can also help experienced users to improve the work efficiency, and also in the team through the artificial intelligence technology to share the experience of each member. Artificial intelligence technology will change with each passing day, as the computer is applied more and more popularly, and in civil engineering field will have a broad prospect. ANN's ability to derive enormous historical data can be coupled with the large data handling capability of the modern computers. ANN can model any functional relationship with reasonable accuracy. Machine Learning algorithms and their application in the field of Civil and Structural engineering are worth exploring. Material model based on ANN helps in explaining and deriving complex, unknown and non-linear functional relationships. This helps to simplify decision making, saves tim and helps to reasonably obtain results with accuracy.

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