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Artificial Intelligence as a Tool in Civil Engineering – A Review

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Abstract: *The field of artificial intelligence, or AI, attempts to understand intelligent entities as well as construct them to make the operation reasonably simple and easy, correct and precise. Artificial neural networks are typical example of a modern interdisciplinary subject. Sophisticated modeling technique that can be used for solving many complex problems serves as an analytical tool for qualified prognoses of the results. Using the concept of the artificial neural networks and the results of the performed numerical analyses make the field of Civil Engineering more accurate, precise and efficient especially in the fields of smart materials and many more.*

Keywords: *Artificial Intelligence, Artificial Neural Network, Smart Materials, EHS and GIS*

I. Introduction

Artificial intelligence (AI) is a specialized system to understand intelligent entities, construct them and make the process of decision making simple, quick and efficient. Artificial intelligence is concerned with the automation of intelligent behavior that think and act like humans. Artificial intelligence is an extremely broad and deeply embedded in our daily lives [1]. It is based on interaction of several kinds of disciplines, such as computer science, cybernetics, information theory, psychology and neurophysiology. Hence Artificial intelligence is a branch of science, involved in the research, design and application of time efficient projects. AI deals with machines that perform functions, which require intelligence when performed by people. Artificial intelligence is a concept already embedded in our day to day lives e.g. in speech recognition, computer's Reasoning, computer vision, EHS compliance, Neural Network in construction and management etc [2].

In the field of civil engineering it covers a vast area for human benefits especially in engineering design construction management and program decision-making and can solve complex problems to the level of experts by imitating the experts. The traditional methods for design, modeling, optimizing complex structure systems and manual observation of activities are difficult, time-consuming and prone to error, so, AI helps in automated data collection and data analysis techniques to improve several aspects of construction engineering and management for productivity assessment, safety management, idle time reduction, prediction, risk analysis, decision-making and optimizing construction costs [3].

Artificial neural networks are typical example of a modern interdisciplinary subject that helps solving various different engineering problems which could not be solved by the traditional modelling and statistical methods. Neural networks are capable of collecting, memorizing, analysing and processing large number of data gained from some experiments or numerical analyses [4]. ANN is efficient tool for engineering design, pavement maintenance, structural damage assessment, risk analysis, HPC strength prediction, optimization, construction of robot fleet management, planning, classification and selection and estimation of construction projects [5].

II. Development of Artificial Intelligence

The term Artificial Intelligence was coined by John McCarthy attempts to describe the process of human thinking as a mechanical manipulation of symbols was started in 1940s. The main constituents of soft computing are neural networks, evolutionary algorithms, probability reasoning and fuzzy-logic. The potential applications of Artificial Neural Networks in the field of Civil engineering includes the use of ANNs in designing, planning, construction, and management of infrastructures such as highways, bridges, airports, railroads, buildings, dams, and utilities [6]. ANNs have been applied to predict tender bids, construction cost, construction budget performance. AI has role in project cash flow, maintenance construction demand and labour productivity. The genetic algorithms particularly employed in the field of structural optimization and in the allocation of resources for building problems. The optimization of road infrastructure and water channel nets, for the analysis and planning of long suspension bridges and to define better load scenarios and structural performances, genetic algorithms can be employed. The fuzzy logic finds remarkable applications [7] in the

field of civil engineering such as the demand of analysis in presence of uncertainties like control techniques, structural reliability and handling uncertainty in materials.

ANN's has used to conduct crane type and model selection, the model was developed and tested for cost estimating for RCC structures and employed a framework which employs Neural Networks to plan the work breakdown structure of projects. The application of ANN's to forecast actual cost of project, building of two credible models linking pre-projects planning and project success by employing Neural Network has gaining acceptability [8].

III. Applications of Artificial Intelligence in the civil engineering

Artificial Intelligence methods have been extensively used in the fields of civil engineering applications e.g. construction management, building materials, hydraulic optimization, geotechnical and transportation engineering and newly added EHS. Over the past 20 years, in the civil engineering field, development and application of the expert system have made a lot of achievements, mainly used in project evaluation, diagnosis, decision-making and prediction, building design and optimization, the project management construction technology , road and bridge health detection and some special field, and so forth.

Among AI based computational techniques, adaptive neuro-fuzzy inference systems were particularly suitable for modelling complex systems with known input-output data sets especially to study the behaviour of cement-based materials undergoing single, dual, or multiple damage factors. The model allows construction planners to generate and evaluate optimal/near-optimal construction scheduling plans that minimize both project time and cost.

AI also helps in development of robots and automated systems. Even the role of artificial intelligence is also reported in the case of smart materials. The smart system refers to a device which can sense changes in its environment and can make an optimal response by changing its material properties, geometry, mechanical or electromagnetic response. Both the sensor and the actuator functions with their appropriate feedback must be properly integrated [9] [10] [11].

3.1 Role of smart materials:

Structural Health Monitoring - Embedding sensors within structures to monitor stress and damage can reduce maintenance costs and increase the lifespan. This is already being used in over forty bridges worldwide.

Self-Repair materials - it involves embedding thin tubes containing uncured resin into materials. When damage occurs, these tubes break, exposing the resin which fills any damage and sets. Self-repair could be important in inaccessible environments such as underwater or in space.

Structural Engineering - In the field of structural engineering, they are used to evaluate durability. Not only the smart materials or structures are restricted to sensing but also they adapt to their surrounding environment such as the ability to move, vibrate and demonstrate various other responses as well as for monitoring the integrity of bridges, dams, offshore oil-drilling towers where fiber-optic sensors embedded in the structures are utilized to identify the trouble areas.

Waste management - Manual disassembly of the waste is a challenging, expensive and time consuming task but the use of smart materials could help to automate the process. Even it shows a role in food waste management.

Concrete mix design – Concrete mix design is difficult and sensitive. The concrete mix design is based on the principles of workability of fresh concrete, desired strength and durability of hardened concrete which in turn is governed by water-cement ratio law. The strength of the concrete is determined by the characteristics of the mortar, coarse aggregate, and the interface. For the same quality mortar, different types of coarse aggregate with different shape, texture, mineralogy, and strength may result in different concrete strengths.

Estimation: artificial neural networks (ANNs) are most suited for developing decision aids with analogy-based problem-solving capabilities in the estimation.

3.2 Role of Artificial Neural Networks (ANNs):

Neuro-modex -Neural Network System for Modular Construction Decision Making:

This model helps to make a decision whether to use a conventional "stick-built" method or to use some degree of modularization in a particular project. This decision is based on several decision attributes which are divided into following five categories: project location, environmental and organizational, labor-related, project characteristics, and project risks. The neural network is trained using cases collected from several engineering and construction firms and owner firms of industrial process plants.

Initial Design Process using Artificial Neural Networks:

The preliminary design model is of vital importance in the synthesis of a finally acceptable solution. The network predicts a good initial design (i.e. tensile reinforcement required, depth of beam, width, cost per meter,

and the moment capacity) for a given set of input parameters (i.e., span, dead load, live load, concrete grade, and steel type) and make the project efficient in the initial phases.

Planning of Construction Projects:

AI has its application to generate plans in all the stages of the project, descriptions of actions along with their preconditions and effects, and selection of new actions to be inserted into a project plan.

Construction Robot Fleet Management System Prototype:

The application of robotic equipment to the execution of construction tasks is gaining attention among researchers and practitioners around the world. A number of working prototype systems has been developed by construction companies or system manufacturers and implemented on construction job sites for the efficient management of time and cost. Japan has developed their own fleet of construction robots for future construction sites.

Bridge Planning Using GIS and Expert System Approach:

In the planning process of a new road network, possible locations of bridges and tunnels should be considered. The selection of the best alignment imposes the need to investigate the effect of the location of each bridge on the bridge type that fits this location. This task has not been done so far because of the large volume of data needed and the complicated interaction between many factors but GIS is a tool which can be incorporated for the effective data collection so that in near future, it can be practiced.

Artificial Neural Network Approach for Pavement Maintenance:

The major objective is to assist decision makers in selecting an appropriate maintenance and repair action for a defected pavement. This is typically performed through collecting condition data, analyzing and selecting appropriate maintenance and repair actions.

ANN for EHS - For EHS, there are multiple areas where AI can contribute. Imagine a robot carrying out tasks in construction – near misses and accidents would potentially be zero because of the lack of human errors (dropping something, deciding to answer the phone at the wrong time, coffee breaks). But there is a need for both innovation and governance going forward for the effective OSHA.

Tidal Forecasting- Tidal level record is an important factor in determining constructions or activity in maritime areas. Kalman (1960) proposed the Kalman filtering method to calculate the harmonic parameters instead of the least squares analysis. Mizumura (1984) also proved that the harmonic parameters using the Kalman filtering method could be easily determined from only a small amount of historical tidal records and can be used for tide level forecasting.

Earthquake-Induced Liquefaction- During the occurrence of earthquakes, numerous civil structures, such as buildings, highway embankments and retaining structures have been damaged or completely destroyed. The damage of civil structures occurs in two modes; the first mode is that of structural failure and the second mode is that of foundation failure, caused by liquefaction. Therefore, estimation of the earthquake-induced liquefaction potential is essential for the civil engineers in the design procedure. Artificial intelligence immensely helps in the design of structures to safeguard against the earthquakes.

IV. Conclusion

In many situations of civil engineering, various problems are encountered that are very complex and not well understood. Most of the mathematical models fail to simulate the complex behavior of these problems. Artificial Intelligence has been successfully applied to many civil engineering areas like prediction, risk analysis, decision-making, resources optimization, classification, and selection etc. The artificial intelligence in civil engineering is playing a major role in constructing, maintaining and managing different aspects of civil engineering problems. Be it in the field of waste management, database, or construction. AI has shown its potency to perform better than the conventional methods. Thus AI has a number of significant benefits that make them a powerful and practical tool for solving many problems in the field of civil engineering and are expected to be applicable in near future by using sophisticated instruments based on the algorithms and database to reduce the efforts and cost of construction and management.

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