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Artificial Intelligence Techniques Used in Project Management

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Abstract

Artificial intelligence is defined as the ability of a machine to mimic intelligent human behavior and therefore attempts to simulate human cognition capability through symbol manipulation and symbolically structured knowledge bases. Because of many uncertain factors, complicated influence factors in project management, every project has its individual character and generality. Over the last decade, the development and application of artificial intelligence in project management has given good grounds for expecting of achievements, which are mainly used in project evaluation, diagnosis, decision-making and prediction. This paper presents artificial intelligence techniques used in project management. It tries to gather the recent advances and trends on artificial intelligence techniques used in Project Management.

Keywords: *Project management; artificial intelligence; expert systems; fuzzy logic; genetic algorithms; artificial neural network.*

1. Introduction

Artificial intelligence (AI) is essentially defined as the ability of a machine to mimic intelligent human behavior and therefore attempts to simulate human cognition capability through symbol manipulation and symbolically structured knowledge bases. AI was developed based on the interaction of various disciplines namely computer science, information theory, cybernetics, linguistics and neurophysiology [1]. AI have been called "soft computing" by Lotfi Zadeh [2], known father of Fuzzy Logic (FL). In his view, soft computing is an approach that mimics the human mind to reason and learns in an environment of uncertainty and impression. The term cognitive computing is often used interchangeably with AI.

The goal of project management (PM) is to produce a successful product or service. Often this goal is hampered by omissions and commissions from management, project managers, team members and others involved in the projects [3, 4]. PM was influenced by many uncertainties that could not be solved by applying a set of standard procedures but also depends on the knowledge and the experience of practitioners. These are irrational, incomplete and inaccurate and cannot be treated by conventional tools or methods. PM is an incredibly complex field, where no one approach solves all problems. PM involves a multitude of risks and losses, and it is vital to seek some kind of solutions [5]. A research by Liquid Planner presented the finding that managing project costs (49.5%) was the biggest problem faced by manufacturing project managers in 2017. Hitting deadlines (45.8%) and sharing information across teams (43.9%) weren't far behind [6]. According to a study by PMI, for every $1B invested in the US, $122M was wasted due to lacking project planning and performance [7]. Geneca study reveals that up to 75% of business and IT executives anticipate their software projects will fail [8].

Over the last decade, the development and application of AI in PM has given good grounds for expecting of achievements, which are mainly used in project evaluation, diagnosis, decision-making and prediction [9]. Thus, it is aimed that the use of AI in PM for performing management and administration tasks without human influence. One of the biggest challenges in PM is having enough data to know how well projects perform with the desired outcomes, objectives and goals [10]. Using predictive analytics and other aspects of ML, AI can use data that organizations gather about their projects to determine teams' completion rates and determine the likelihood of delivering products on time. This paper presents AI techniques used in PM. It tries to gather the recent advances and trends on AI techniques used in PM.

2. Artificial Intelligence Techniques

The section of this paper outlines some AI techniques that are most applicable to PM management: such as Artificial Neural Networks (ANNs), Fuzzy logics, Expert Systems (ESs), Genetic Algorithm (GA).

2.1. Artificial Neural Networks

An ANN is a type of ML which models itself after the human brain. A "neuron" in an ANN is a mathematical function that collects and classifies information according to a specific architecture. ANNs have

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been central sources of inspiration for a large number of original techniques covering a vast field of applications [11, 12]. An example of an ANNs can be seen from **Figure 1**.

An ANN contains layers of interconnected nodes. Each node is a perceptron and is similar to a multiple linear regression. The perceptron feeds the signal generated by a multiple linear regression into a possibly non-linear activation function. Hidden layers fine-tune the input weightings until the ANN error rate is minimal. As an analysis and solution of complex problems, especially in the non-linear problem, the ANN is an important tool, and the potential of the ANN is increasingly perceived in the scope of PM.

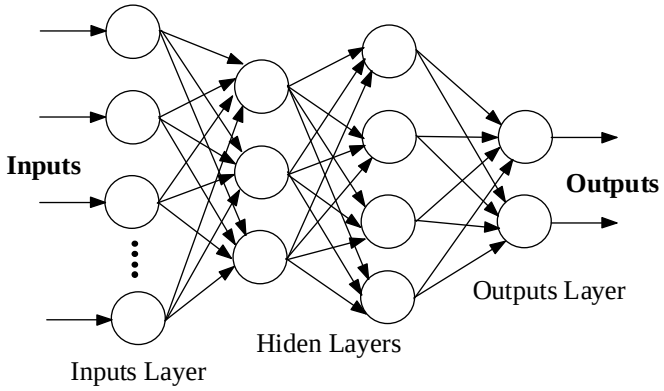

Figure 1. *An example of an ANNs*

2.2. Fuzzy Logic

The idea of FL was first advanced by Lotfi Zadeh in the 1960s. FL is essential to the development of human-like capabilities in software, so the AI system could find a solution in the face of an unfamiliar task. FL can be used to describe how information is processed inside human brains. The approach of FL imitates the way of decision making in humans that involves all intermediate possibilities between digital values YES and NO [13, 14]. An example of a FL can be seen from **Figure 2**.

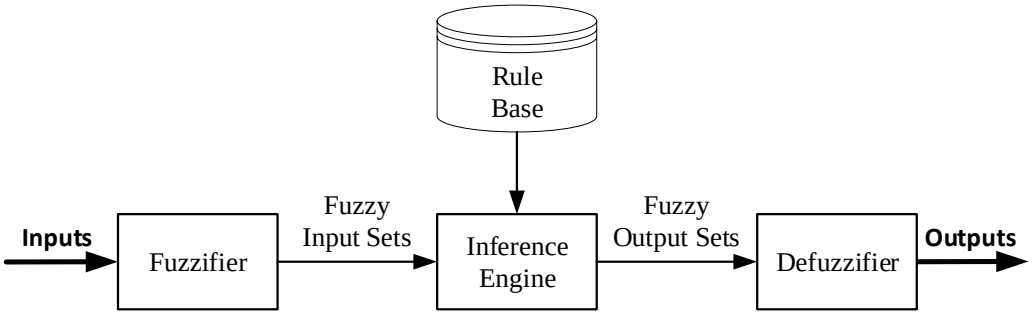

Figure 2. *An example of a FL*

As seen from the **Figure 2**, FL consists of three basic steps;

1. Fuzzification is a process of transforming crisp values into grades of membership for linguistic terms of fuzzy sets. The membership function is used to associate a grade to each linguistic term.

2. Inference engine defines the behavior of a system by using rules on a linguistic level.

3. Defuzzification is the process of producing a quantifiable result in Crisp logic, given fuzzy sets and corresponding membership degrees. It is the process that maps a fuzzy set to a crisp set.

With FL it is possible to simulate the risk and uncertainty that are always associated with projects. The fuzzy model has many advantages for project managers, including speeding up decision-making, effective PM, simulation of potential development projects, and more.

2.3. Expert System

An Expert System (ES) is a computer program that uses AI to simulate the judgment and behavior of a human or organization that has expertise and experience in a particular field. The power of an ES is based on its knowledge base - an organized collection of facts and heuristics about the system domain. An ES is created in a process known as knowledge engineering, where knowledge of the domain is acquired by human experts and other sources of Knowledge Engineers [15, 16]. An example of a ES can be seen from **Figure 3**.

The accumulation of knowledge in knowledge bases from which the inference engine can draw conclusions

is the hallmark of an expert system. The ESs are capable of deriving a solution, predicting results and suggesting alternative options to a problem. ES can be applied areas include, scheduling, planning, risk estimation and classification. ES also help the PM to arrive at quick and proper decisions as well as identify ways to take corrective actions.

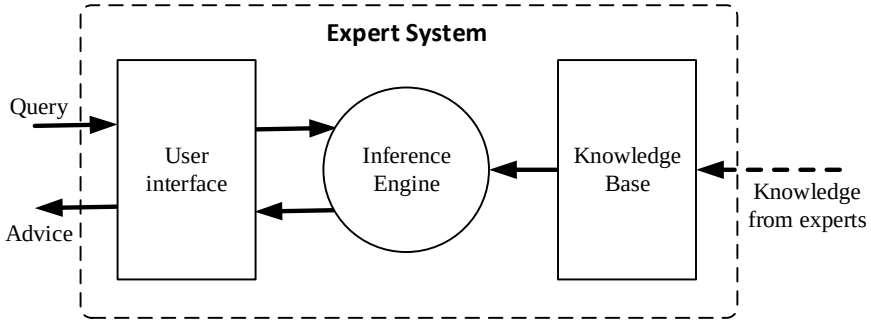

Figure 3. *An example of a ES*

2.4. Genetic Algorithms

A GA is a search heuristic inspired by Charles Darwin's theory of natural evolution. This algorithm reflects the natural selection process of selecting the most suitable individuals for reproduction to produce offspring of the next generation. A GA is a form of AI based on inductive learning technique that was first introduced by Holland (1975). The GA is used to solve both constrained and unconstrained optimization problems. GAs are excellent for searching through large and complex data sets [17, 18]. An example of a GA can be seen from **Figure 4**.

The process starts with a group of people called a population. Each individual is a solution to the problem to be solved. The fitness function determines how fit an individual is. It gives each individual a fitness rating. The probability that an individual will be selected for reproduction is based on their fitness score. The idea of the selection phase is to select the fittest individuals and let them pass on their genes to the next generation. Two pairs of persons are selected based on their fitness scores. Crossover is the most important phase in a GA. For each pair of parents to be mated, a crossing point is randomly selected from the genes. In certain newly formed offspring, some of their genes may be subject to a low probability chance mutation. The algorithm ends when the population has converged. Then it is said that the GA has provided a number of solutions to the problem. With GA it is possible to simulate the risk and uncertainty that are always associated with projects. With the application of GAs, it is possible to solve resource levelling, optimization and management problems. Scheduling and facility layout are also the more established areas for GA applications. It can be used to the adaptive assignment of worker and workload control in PM.

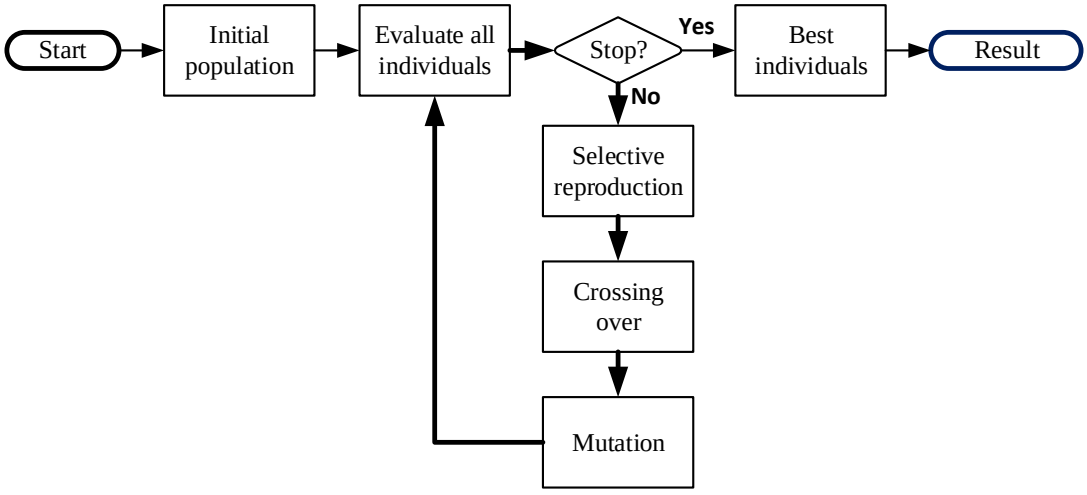

Figure 4. *An example of a GA*

3. Use cases of artificial intelligence in project management

AI can provide a solution to repetitive tasks that burden project managers such as data entry and

management, project plan preparation, and so on. These tasks can be performed automatically. When the majority of the administrative tasks are handed over to AI, the project managers have more time and energy to focus on the actual work. It is possible to make estimations, recommendations and optimizations by using AI. AI can make assumptions about the future development of the project by learning from historical PM data. In addition to automation, one of the key functions of AI in PM is to provide meaningful insights into the project by sorting and aggregating data from a variety of sources. AI is able to find connections in data that would not be visible even to the best trained human eye. AI can also help with complex analysis. It can access much more data than a human manager could do alone. For example, the use of AI can help make value and risk analysis less of a burden and time-consuming task for human operators. There are several areas of PM that AI can potentially provide resolutions:

Risk Estimation and Management: Risk management is the main focus when managing projects. Risk management embodies the identification, analysis, planning, tracking, controlling, and communication of risk. AI allows to retrieve parametric information as needed. For example, historical data such as scheduled start and end dates can be used to predict realistic schedules for future projects. AI can calculate the probability that this will happen in the current project and alert accordingly.

Resource Management: Resource management is an important part of PM. It ensures that the project is executed according to the scope and the overview set in the planning phase. Resource allocation is another important aspect of PM. It involves the determination of resource consumption and the distribution of the money used to achieve the objectives. Assigning the right resources to the right department to make sure they have all the techniques they need to meet the deadline is critical to the health of a project. Predictively allocating these resources can be done using the AI, which monitors resource pools and notifies when teams need attention. AI also offer significant opportunities to improve HR functions, such as self-service transactions, recruiting and talent acquisition, payroll, reporting, access policies and procedures. Appling AI to human resources will speed up processes and create more time for the truly human side of the job.

Cost Management: Accurate cost estimation is critical to budgeting, planning, and tracking a project. AI derive lessons from previous data to get an accurate forecast of project costs. AI can increase the quality of work while reducing the cost of labour.

Time Management: Time management is defined as the process of planning and organizing time to use it most productively. Successful implementation and use of time therefore leads to guaranteed success and the achievement of goals. Project Scheduling is the tool that communicates what tasks are to be done and which organizational resources are assigned to accomplish these tasks in what time frame. AI can create an optimal project schedule. If there is a change in project scope or resource plan, AI can also instantly provide a revised schedule.

4. Conclusion

The development and application of AI in PM has given good grounds for expecting of achievements, which are mainly used in project evaluation, diagnosis, decision-making and prediction. This paper presents AI techniques used in PM. It tries to gather the recent advances on AI techniques used in PM. It is also briefly given information about AI techniques such as ANN, FL, ES, GA and their use in PM.

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