Mutah University
College of Graduate Studies

Applying of Artificial Intelligence to Reduce Cost and Time in Construction Projects

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الْآرَاء الْوَارِدَةِ فِي الرِّسَالَةِ الجَامِعِيَّة لَا تُعَبِّر
بِالضَّرُورَة عَنْ وَجْهِهِ نَظَرِ جَامِعَةٌ مَوْتِه

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DEDICATION

I am dedicating this thesis to my dearest possessions, my beloved parents, who supported me in my academic career and inspired me to love challenges and hard work, be optimistic, and enjoy every moment I spend in my life.

To my role model in life my sisters Ayat and Asia to those who taught me persistence, confidence and determination to reach the highest levels.

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Table of Contents

List of Tables

List of Figures

List of Appendices

List of Abbreviations

α	Alpha
AI	Artificial Intelligence
AGI	Artificial General Intelligence
ANN	Artificial Neural Networks
ANI	Artificial Narrow Intelligence
ASI	Artificial Super Intelligence
EA	Evolutionary Algorithm
EFA	Exploratory Factor Analysis
FIPA	Foundation for Intelligent Physical Agents
GRNN	Generalized Regression Neural Network
Ho	Null Hypothesis
KMO	Kaiser-Mayer-Olkin
ML	Machine Learning
MLP	Multilayer Perceptron
NN	Neural Networks
PRISMA	Preferred Reporting Items for Systematic Reviews and Meta-Analyses
R	Root
R^2	Root-Squared
Sig.	Significant Value
SPSS	Statistical Package for Social Sciences
Std. Deviation	Standard Deviation
SVM	Support Vector Machines

Abstract

Applying of Artificial Intelligence to Reduce Cost and Time in Construction Projects

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Mutah University, 2022

During the practicing construction industry process, there are two important pillars, which are time schedule and cost. Utilizing artificial intelligence methods and applications has become important with the advent of the fourth industrial revolution we are currently experiencing. This study aimed to prevent cost overruns and time delays in construction projects. It can be achieved by knowing the effect of using artificial intelligence in its dimensions (neural networks, genetic algorithms, expert systems, and intelligent agent) on the construction project schedule along with the cost of construction projects This study was conducted on engineering's offices, contractor companies, and consultant companies working in the construction sector in Aqaba. A questionnaire has been used to be the tool of the study.

The results showed that using artificial intelligence with dimensions, such as neural networks, genetic algorithms, expert systems, and intelligent agent, will lead to a reduction in the cost and time in construction projects. The most influential factor based on artificial intelligence to overcome time and cost overrun in construction projects is the intelligent agent.

The study recommends the necessity of training engineers working in the field of construction projects to use and benefit from the applications of artificial intelligence and highlights the need for decision-makers in the field of construction projects to pay attention to the applications of artificial intelligence and work on adopting these techniques in all activities.

Key words: artificial intelligence, cost, time, construction projects.

الملخص

تطبيق الذكاء الاصطناعي لخفض التكلفة والوقت في المشاريع الانشائية

الاء هارون النعيمات

جامعة مؤتة، 2022

أثناء ممارسة عملية صناعة البناء، هناك ركيزتان هامتان، هما الجدول الزمني والتكلفة.

أصبح استخدام طرق وتطبيقات الذكاء الاصطناعي أمرا" مهما" مع ظهور الثورة الصناعية الرابعة، التي نشهدها حاليا".وتهدف هذه الدراسة الى منع تجاوز التكاليف وتأخير الوقت في المشاريع الانشائية. يمكن تحقيقه من خلال معرفة تأثير استخدام الذكاء الاصطناعي في أبعاده (الشبكات العصبية، الخوارزميات الجينية، الأنظمة الخبيرة، الوكيل الذكي) على جدول المشروع الانشائي الى جانب تكلفة المشاريع الانشائية.

أجريت هذه الدراسة على المكاتب الهندسية وشركات المقاولين والشركات الاستشارية العاملة في قطاع البناء في العقبة،وقد استخدم الاستبيان ليكون أداة الدراسة.

أظهرت النتائج أن استخدام الذكاء الاصطناعي بأبعاده (الشبكات العصبية، الخوارزميات الجينية، الأنظمة الخبيرة،الوكيل الذكي) سيؤدي الى تقليل التكلفة والوقت في المشاريع الانشائية، والأكثر تأثيرا" بناء" على الذكاء الاصطناعي لخفض التكلفة والوقت هو الوكيل الذكي.

أوصت الدراسة بضرورة تدريب المهندسين العاملين في مجال المشاريع الانشائية على استخدام تطبيقات الذكاء الاصطناعي والاستفادة منها،وضرورة اهتمام صانعي القرار في مجال المشاريع الانشائية بتطبيقات الذكاء الاصطناعي والعمل على اعتماد هذه التقنيات في جميع الأنشطة.

الكلمات المفتاحية: الذكاء الاصطناعي،التكفة،الوقت،المشاريع الانشائية.

Chapter One
Introduction

1.1 **Background**

The construction sector is facing obstacles, as out of every ten projects, nine projects exceed the cost allocated to them (Flyvbjerg, 2002), this comes from a poor estimation of the budget allocated to the projects to complete the project from its implementation to its suspension. Sometimes it is suspended before implementation, resulting in the conversion of all the investments paid into losses (Cheng et al., 2009a).

The project is described as having exceeded the budget and the costs allocated to it in the event that the project's actual cost is greater than 110% of the estimated cost allocated to it (Brookes, 2015). In another definition, it could be estimated by dividing the change in the contract amount by the original contract amount (Jackson, 2002), (Merrow, 2011).

According to a previous study conducted by the researcher (Bekr, 2018), it was found that the construction sector in the State of Jordan faces a great challenge in adhering to the project schedule plan while ensuring high quality and being within the budget. Factors related to this include frequent design changes, additional work at the owner's request, and design errors. However, the most important reasons are the delay in the schedule and the inadequate scheduling of planning, as every day of the delay entails an increase in expenses.

Technology has been advanced dramatically since the industrial revolution, and many arduous physical labors have been replaced by technology, greatly benefiting humanity (Philippe et al., 2004).

Artificial intelligence (AI) is a technical advancement that has been used to replace human labor in a variety of sectors.

Once upon a time, artificial intelligence (AI) was only a notion found in science fiction and arguments concerning the impact of technology on the modern world. However, this technology has become an integral part of our daily lives (Chris ,1994).

With the start of the Fourth Industrial Revolution, which we are currently accompanying, it was necessary to take advantage of the techniques and applications of artificial intelligence, as they are widely spread and have shown their effectiveness in every aspect of our current life. The term "artificial intelligence" has evolved over the years and can be considered as a field of computer science in which computer devices and systems have the ability to think and adapt in a human-like manner of thinking and adaptation, such as learning, self-correction and inference processes, as it facilitates the use of computer technologies in a more effective way by improving programming (Kok et al., 2010).

In a study conducted by (Akmam et al.,2018), he stated that the construction sector faces challenges characterized by the adoption of digital

technologies, smart machines, smart materials, and sensors, which will enable productivity, reduce project delays, cost overruns, and enhance safety and quality.

In a study conducted by (Samarah & Bekr, 2016) the researchers in the Kingdome of Jordan related to the causes of delays in construction projects and found 22 major important factors that contribute directly to the delay of the project, and the most important of these reasons related to the contractor's inadequate management and supervision with a rank of 68.45; the second was the client's changes to the design with a rank of 64.99; the third was inadequate planning and control by the contractor with a rank of 64.67; and the sixth major reason was the consultant's errors in design and contract documents with a rank of 59.63.

The issue of cost overrun and delay in projects is a global issue not just on the scale of the Kingdome of Jordan, so it is imperative to make use of all that is currently available, in terms of data and technology, in which we seek to find ways to reduce costs in projects and limit their overrun and commit to delivering projects on time.

The main applications of artificial intelligence in building and construction have been classified by the researcher (Bharadwaj, 2018) as (a) planning and design, (b) safety, (c) autonomous equipment, and (d) monitoring and maintenance. In this study, we will investigate the effectiveness of artificial intelligence in preventing overrun costs of construction projects, in addition to trying to control the project schedule and deliver the project on time.

1.2 Research Problem

Through my work as a site engineer, I have noticed issues with cost and time in construction projects. On the other hand, utilizing artificial intelligence methods and applications became essential with the advent of the fourth industrial revolution. This study aimed to prevent cost overruns and time delays in construction projects by utilizing AI.

The problem with the study lies in the following question:

What is the impact of the application of artificial intelligence in reducing costs and time in construction projects?

Through a study conducted by (Al-Tawal et al., 2020), an attempt was made to theoretically apply artificial intelligence in the Hashemite kingdom of Jordan in the construction sector, demonstrating the effectiveness of the artificial neural network in reaching the best pricing for construction costs and controlling them. The motivation behind this study was the need for further study on the application of artificial intelligence to be used in the initial stages of design to control it in reducing the excesses of additional costs of the project and to deliver the project on schedule while finding solutions that contribute to maintaining

costs and schedule and provide many options for the owner and the contractor according to the budget and according to the time they have to implement the project.

This study continues the (Al-Tawal et al., 2020) study by adding a dimension (time).

1.3 Elements of The Study Problem (Research Questions)

To guide this research and achieve the main mentioned goals, it is important to set these questions which have to be answered during and after the research in the following main question:

Is there an effect of applying artificial intelligence in its dimensions (neural networks, genetic algorithms, expert systems, intelligent agent) to reduce cost and time in construction projects?

From the main question, the following sub-questions emerge:

1. Is there any effect of neural networks in reducing cost and time in construction projects?
2. Is there any effect of genetic algorithms in reducing cost and time in construction projects?
3. Is there any effect on expert systems in reducing the cost and time of construction projects?
4. Is there any effect of the intelligent agent in reducing the cost and time of construction projects?
5. What is the most influential dimension of artificial intelligence to reduce cost and time in construction projects?

1.4 Research Objectives

The main aim of this research is to prevent cost overruns in construction projects and to deliver the project on time. Based on this aim, applying artificial intelligence will derive the objectives:

1. To know the effect of using Neural Networks on the construction project schedule and the cost of construction projects.
2. To know how Genetic Algorithms, impact the construction project schedule and the cost of construction projects
3. To know the effect of using Expert Systems on the construction project schedule and the cost of construction projects
4. To know how Intelligent Agent, impact the construction project schedule and the cost of construction.
5. To determine a useful tool based on artificial intelligence to overcome time and cost overruns in construction.

1.5 Study Model

In light of the researcher's review of previous references and studies on the subject and problem of the study, the researcher developed a study model as shown in figure (1.1), which reflects the impact of artificial intelligence in its dimensions on the cost and time of construction projects.

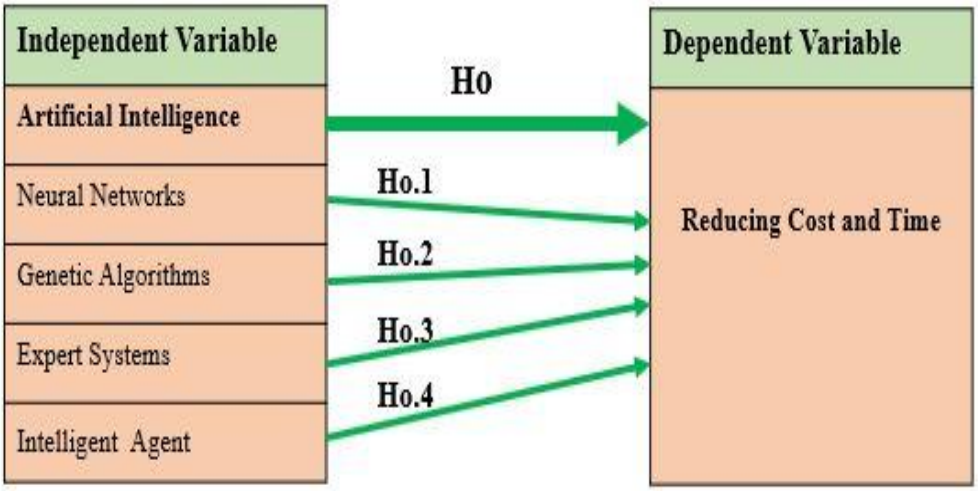

Fig (1.1)
Study model

1.6 Thesis Hypotheses

In light of the problem and model of the study, the hypotheses were formulated as follows:

The main hypothesis (H0) There is no statistically significant effect at the level of significance ($\alpha \leq 0.05$) of Artificial Intelligence in its dimensions (neural networks, genetic algorithms, expert systems, intelligent agent) to reduce cost and time in construction projects, and stems from this hypothesis a set of hypotheses:

1.6.1 The first sub hypothesis ($H_0.1$) There is no statistically significant effect at level of significance ($\alpha \leq 0.05$) of Neural Networks in reducing cost and time in construction projects.

1.6.2 The second hypothesis ($H_0.2$) There is no statistically significant effect at level of significance ($\alpha \leq 0.05$) of Genetic Algorithms in reducing cost and time in construction projects.

1.6.3 The third sub hypothesis ($H_0.3$) There is no statistically significant effect at level of significance ($\alpha \leq 0.05$) of Expert Systems in reducing cost and time in construction projects.

1.6.4 The fourth sub hypothesis (H_0.4) There is no statistically significant effect at level of significance ($\alpha \leq 0.05$) of Intelligent Agent in reducing cost and time in construction projects.

If the study proves the opposite of these hypotheses, the following alternative hypotheses will be accepted:

(H1) There is statistically significant effect at level of significance ($\alpha \leq 0.05$) of artificial intelligence in its dimensions (neural networks, genetic algorithms, expert systems, intelligent agent) to reduce cost and time in construction projects.

1.6.5 H_1.1: There is statistically significant effect at level of significance ($\alpha \leq 0.05$) of Neural Networks in reducing cost and time in construction projects.

1.6.6 H_1.2: There is statistically significant effect at level of significance ($\alpha \leq 0.05$) of Genetic Algorithms in reducing cost and time in construction projects.

1.6.7 H_1.3: There is statistically significant effect at level of significance ($\alpha \leq 0.05$) of Expert Systems in reducing cost and time in construction projects.

1.6.8 H_1.4: There is statistically significant effect at level of significance ($\alpha \leq 0.05$) of intelligent agent in reducing cost and time in construction projects.

1.7 Importance of study

The importance of this research is to demonstrate how the enrollment of artificial intelligence in construction work would effectively prevent cost overruns and how to engage this tool nicely in the future. We are interested in knowing the role of using artificial intelligence, including the application of artificial neural networks, in preventing cost overruns in construction projects and seeking to reduce them.

The contribution of this research is to find a way to prevent cost overruns in construction projects in Aqaba City and to control the schedule time of the project and its delivery on time. This study would help to find a solution to prevent cost overruns in construction projects through the use of artificial intelligence in construction projects and to predict cost overruns through several factors.

The importance of the study is evident in two aspects:

Theoretical importance: This study is important because of the limited studies at the local and global levels, as evidenced by the scarcity of scientific references, studies, and books in this field. Starting towards other studies in this field, this study will enrich the theoretical literature and

libraries with the topics of artificial intelligence, cost, and time. It will be directed at researchers in the future.

Practical importance (applied): This study dealt with a central topic, which is artificial intelligence, as it is linked in all areas of our lives. The researcher dealt with the topics of cost and time in the construction projects and how to use the capabilities of artificial intelligence to deliver the project on time within the budget. The results and recommendations of this study will guide decision-makers in Aqaba City (contractors' companies, consultants, and owners) in making their future decisions.

1.8 Procedural Definitions

For the purposes of completing the study, the following procedural definitions for all variables and their dimensions were determined:

The first axis: Artificial Intelligence: It is a set of steps that strive for the happiness and well-being of man, fulfill his purpose and help us accomplish tasks in construction projects. It will be measured through the paragraphs of the questionnaire.

1. Neural Networks: A set of models that are used to process and analyze data used in the implementation of construction projects It was measured through the questionnaire paragraphs of the number (1-to-7).
2. Genetic Algorithms: The set of steps by which computer-based software is provided, and the necessary data is provided and used in construction projects, was measured through the questionnaire paragraphs of the number (8-to-12).
3. Expert Systems: A huge and massive set of data that is used to make decisions in construction projects was measured through the questionnaire paragraphs of the number (13-to-18).
4. Intelligent Agent: It is the component responsible for making improvements in construction projects based on the stored database of previous projects. It was measured through the questionnaire paragraphs of numbers (19-to-25).

The Second axis: Reducing cost and time in construction projects.

Cost overruns and delays in project completion time: are the failure to comply with the allocations necessary for the implementation of the project and the failure to take the schedule into consideration. It was measured through the questionnaire paragraphs (26-to-43).

1.9 Limitations

The limitations of the study are the following:

1. Geographical boundaries: The study was limited to the construction projects in the city of Aqaba.
2. Time limits: the study was during the academic year 2021-2022.
3. Human boundaries: the study included only engineers working in

first, second, and third-degree contracting companies, as well as consultants and engineering offices, as well as the owners of construction projects in the city of Aqaba.

4. Practical boundaries: in this study, the variables related to the principles of artificial intelligence and their impact on cost and time in construction projects in the city of Aqaba were measured.

1.10 Thesis layout

This study consists of the following chapters:

Chapter One: Introduction: in this chapter, the background of the problem is presented as well as the discussion of the chosen topic. Following that is the

The research question, the objectives, the study model, the hypotheses, the procedural definitions, the significance of the study, and the limitations

Chapter Two: Theoretical Framework and Literature Review, this chapter generally reviews the information included, with the main goal of providing an overview of the study (research) in relation to the study's main headlines. Previous studies have included using artificial intelligence with cost and time in construction projects. The theoretical framework reviews artificial neural networks, genetic algorithms, expert systems, intelligent agents, cost, and time.

Chapter Three: Research Design and Methodology In this chapter, we will discuss sample and data collection procedures, operational measures of variables used in the study, as well as the statistical tests used to evaluate the hypothesis. Discuss the validity and reliability of the questionnaire and review the demographic characteristics of the study participants.

Chapter Four: Analysis of Results, Conclusions, and Recommendations, in this chapter, we will present the descriptive statistics results and hypothesis testing, including the normality test and multicollinearity test. With the hypothesis test results, this chapter also presents a conclusion, recommendations, and suggestions for future works.

Chapter Two
Theoretical Framework and Literature Review

2.1 Introduction

The construction sector is one of the most important pillars of a country's economy; therefore, it should be given top priority. Given the large amount of money being pumped into this sector, it was necessary to investigate the factors that have the greatest impact on the time and cost of implementing construction projects. As a matter of fact, 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 (Abioye et al., 2021).

The lack of digitization and the overly manual nature of the industry make the management of projects more complex and unnecessarily tedious (Bello et al., 2021). 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 (Nikas et al., 2007). Recently, it has become apparent that the construction industry must embrace digitization and rapidly improve technological capacity, especially with the challenges of existing labour shortages, the COVID-19 pandemic and the need to provide sustainable infrastructures (Abioye et al., 2021).

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 (Yao et al., 2017). The adoption of AI techniques has helped to enhance automation and provide better competitive advantages as compared to conventional approaches (Chien et al., 2020). The subfields of AI including machine learning, natural language processing, robotics, computer vision, optimization, automated planning and scheduling (Mhlanga, 2021), have been applied to tackle complex problems and support decision-making for real-world problems. For instance, in the manufacturing industry, the advent of the fourth industrial revolution is geared towards automation, data-driven technologies and the application of advanced AI techniques (Yao et al., 2017). It is evident that this revolution has led to significant process improvements, cost-efficiency, and reduced production times.
The following sections discuss the dimensions of the study.

2.2 Artificial Intelligence

The idea of developing machines exhibiting intelligence like humans can be traced back to several fields, which include philosophy, fiction, imagination, computer science, electronics and engineering inventions (B.

Buchanan,2005). Alan Turing's test for intelligence was a turning point in the field of AI as the test exceeds the traditional theological positions and mathematical conclusions about the possibility of intelligent machines. Sixty years later, intelligent machines are outperforming humans in so many domains, such as learning (Brynjolfsson, et al., 2018) by leveraging rapid advances in other technologies such as big data and computer processing power The definition of AI as given by Ref. (E. Rich, K. Knight) states that "AI is the study of how to make machines do things that, at the moment, people do better." This definition perfectly captures the concept of AI.

In recent decades, artificial intelligence (AI) and robots have advanced dramatically in the last two decades. Future progress is projected to be even more remarkable with many analysts predicting that these technologies will change the way people operate all around the world (Manyika et al., 2017). In the late 1980s, industrial robots were introduced, which automated many of the remaining labor-intensive production operations, such as machining, welding, painting, palletizing, assembling, material handling and quality control (Acemoglu & Restrepo, 2018), (Graetz & Michaels, 2015). Automation isn't just limited to industry and agriculture.

A variety of white-collar tasks in retail, wholesale and business services have already been mechanized by computer software. Using software and AI-powered technologies information can now be retrieved, logistics can be coordinated, inventories can be handled, taxes can be prepared, financial services can be provided, complex documents can be translated, business reports can be written, legal briefs can be prepared, and diseases can be diagnosed (Erik & Andrew, 2013).

Artificial neural networks and deep learning are currently at the heart of the majority of AI applications that we are familiar with. They're at the heart of Facebook's image recognition algorithms, as well as the speech recognition algorithms that power smart speakers and self-driving cars (Silver et al., 2016). In "Letting the Computers Take Over: Using AI to Solve Marketing Problems," Overgoor, Chica, Rand, and Weishampel present a six-step paradigm for how AI may help marketers make better decisions. These include the characteristics of artificial intelligence in thinking, perceiving and imagining; knowledge acquisition and application; learning or understanding from experience; dealing with incomplete and ambiguous information; displaying creativity; handling complex cases; and supporting administrative decisions (Overgoor et al., 2019).

Artificial intelligence is divided into three levels: the first one is Artificial Narrow Intelligence (ANI), which is capable of completing a decade in a single sphere. For example, artificial intelligence can beat the world chess champion in chess, but that's all it can accomplish. Secondly,

Artificial General Intellect (AGI) is an artificial intelligence that achieves and surpasses human intelligence, i.e., it can reason, plan, solve problems, think abstractly, comprehend complicated ideas, learn quickly and learn from experience in almost every field, including scientific inventiveness, general knowledge, and social skills. Thirdly, Artificial Super Intelligence (ASI) is far smarter than the best human brain (O. Strelkova & O. Pasichnyk, 2014).

Nobody knows whether AI will allow us to improve our own intelligence, as Google's Raymond Kurzweil believes, or whether it will eventually lead to World War III. However, everyone agrees that it will result in unique ethical, legal, and philosophical challenges that will need to be addressed (Kaplan & Haenlein, 2019).

The Trolley Problem, a thought experiment in which an imaginary individual must choose between an action that leads to the death of many and an action that leads to the death of a few, has occupied ethics for decades (Jarvis et al., 2016). These challenges will become genuine choices that machines and by extension their human programmers will have to make in a world of self-driving cars (Awad et al., 2018).

The areas of application of artificial intelligence are many, including libraries and information centers. Specialists benefit from this technology and produce many systems for preservation, retrieval, and indexing. It was artificial intelligence applied in computer games, such as chess, by expert systems, where these systems are based on collecting information from specialists and putting it in a form where a computer can apply that information to similar problems (Saud,2020). Artificial intelligence has intervened even in the medical field where it has revolutionized the field of health care through its ability to think and learn by inference from arithmetic operations and enables it to make decisions (Johnson et al., 2021).

In the field of construction, artificial intelligence has had an impact on decision-making and improved the project management methodology in terms of monitoring the construction process step-by-step based on rules, artificial neural networks, genetic algorithms, and input data (Klashanov, 2016). One of its applications in the field of construction is the safety management of construction projects by enriching it with big data in the fields of construction, safety management, and analyzing the literature (Yi & Wu, 2020).

It is mainly used in structural maintenance, management, and design improvement through engineering simulation and forecasting programs based on large amounts of historical data (Huang et al., 2019).

Artificial intelligence has contributed to the smart environmental construction that depends on the environmental systems of consumers and knowledge. Its objectives are to improve reliability and raise the level of

quality between the parties, consumers and service providers (Gec et al., 2022).

2.3 Artificial Neural Networks

The idea of artificial neural networks was inspired by early brain models of sensory processing. It was discovered in the 1960s that networks of these model neurons exhibit feature comparable to those in the brain, as they can recognize complex patterns and continue to function even if some of the neurons are destroyed. Rosenblatt demonstrated that simple networks of model neurons known as "perceptrons" could learn from examples (Krogh, 2008). However, Minsky and Papert showed that simple perceptrons could solve only the very limited class of linearly separable problems, so the activity in the field diminished. Nonetheless, the error back-ropagation method two, which can make decently complex networks of basic neurons learn from examples, demonstrated that these systems could solve problems that were not easily distinguishable (Minskey & Papert,1969).

In 1943, McCulloch and Pitts proposed a model of a neuron as a switch that takes input from other neurons and is either activated or inactive based on the overall weighted input. The strength of a synapse—the neural synapses between nerve cells—is determined by the weight by which an input from another cell is multiplied. These weights can be both negative (inhibitory) and good (energizing) (Krogh, 2008).

One of the best-known applications of artificial neural networks on a large scale is NET Talk, a network for automatic text reading (Sejnowski & Rosenberg, 1987).

2.3.1 Architectures of Neural Networks

The nodes, which are known as processing elements, each of which has its own input, which it uses to receive communications from other nodes and/or the environment, and its own output, which it uses to communicate with other nodes and/or the environment. Finally, each node has a f through n function. It does this by converting its own global input into output (Grossi, 2011).

There are three types of neuron layers in the basic architecture: input, hidden, and output layers. The signal flow in feed-forward networks is from input to output units, purely in a forward-looking manner. There is, however, no feedback (Walczak & Steven, 2018). Figure (2.1) below shows the architecture of the neural network.

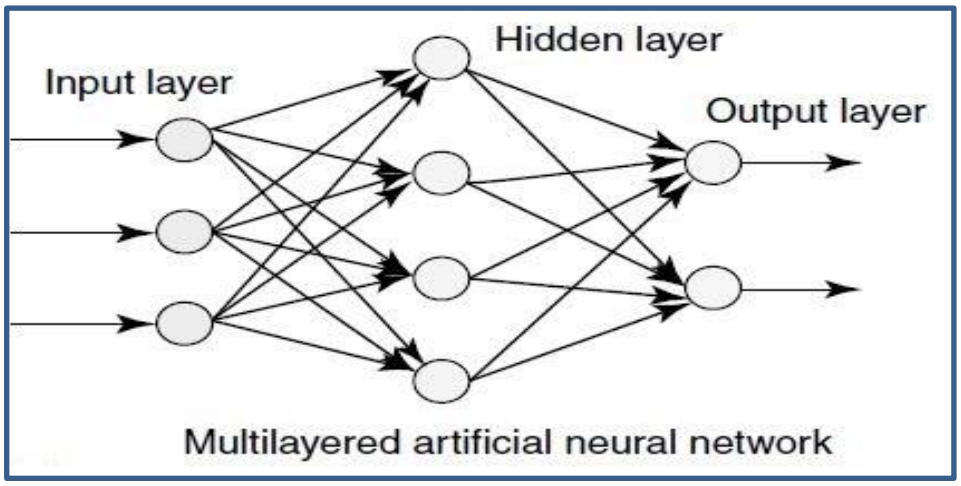

Fig (2.1)
Architecture of Multilayered artificial neural network, (Walczak & Steven,2018)

The above figure shows a typical artificial neural network with three layers, an input layer, a hidden layer, and an output layer. The number of inputs utilized by the network determines the size of the input layer, while the size of the hidden layer is freely selected. Typically, an activation function is installed in the hidden layer (and occasionally the output layer) to indicate if a node is "active" in response to an input.

2.3.2 Learning of Neural Network

Artificial neural networks have the potential to learn from their surroundings, which is one of their major advantages.

Learning from the environment is effective in applications when the environment's complexity (data or job) makes other types of solutions hard to apply. Learning the combination of a complex model with a basic task leads to memorization rather than learning. There are a variety of learning algorithms available, each with its own set of tradeoffs, and practically all of them are applicable to any form of artificial neural network model. Choosing the best learning algorithm for a specific task necessitates a great deal of trial and error on a specific issue and data set. When the artificial neural network model and learning algorithm are suitably picked (Grossi, 2011), we get a robust instrument for tackling an issue. Supervised learning, unsupervised learning, and reinforcement learning are the three major learning paradigms.

They can usually be used by any form of artificial neural network architecture. There are numerous training algorithms for each learning paradigm. Artificial neural networks have the potential to learn from their surroundings, which is one of their advantages. Learning from the environment is effective in applications when the environment's complexity (data or job) makes other types of solutions hard to apply. As a result,

artificial neural networks may be applied to a wide range of activities, including classification, function approximation, data processing, filtering, clustering, compression, robotics, regulations, and decision-making (Kenji, 2011). The utilization of ANNs doesn't need a particular foundation. It is a well-disposed innovation, simple to utilize and permits the displaying system with a predetermined number of analyses and expenses. It also makes a suggestion of the best mix of elements conceivable to achieve the best outcome (Gago et al., 2011).

2.4 Genetic Algorithms

A genetic algorithm is a search strategy for finding perfect or approximate answers to optimization and search issues in computers. Global search heuristics are a type of evolutionary algorithm (EA) that employs evolutionary biology processes such as inheritance, mutation, choice and crossover (Kumar et al., 2020).

The genetic algorithm is a population genetics-based adaptive heuristic search tool. John Holland introduced genetic algorithms in the early 1970s (Fuzzy and Neural Approaches in Engineering Lefteri H. Tsoukalas Robert E. Uhrig, 1997).

John defined genetic algorithms as heuristic learning models derived from natural evolution and selective breeding principles (Grefenstette, 2014).

Another definition by (Bhosale et al., 2017) The genetic algorithm is an optimization method based on natural selection, which is the mechanism that drives biological evolution.

In fields as diverse as biology, engineering, computer science, social science and genetic algorithms have been employed to identify optimal solutions to challenging issues (Kumar et al., 2020). Algorithms are used in various fields of engineering, politics, economics and management to solve complex life problems (Kumar et al., 2014).

Methodology of genetic algorithm (Kumar et al., 2020)

1. Initialization.
2. Selection.
3. Reproduction.
4. Termination.

Since the 1980s, genetic algorithms have found a wide range of applications (Goldberg, 1989), although there have been many applications of genetic algorithms in the domains of function optimization, parameter tuning, scheduling and other complex problems (Mitchell, 1998). Some traditional machine learning issues, such as idea recognition from examples, establishing weights for neural nets and generating rules for sequencing decision problems, were taken into account using genetic algorithms.

The following section shows the applications of Genetic Algorithms.

2.4.1 Genetic algorithm applications

After reviewing the literature reviews of genetic algorithms, the following some of applications:

1. Takai and Yasuda applied a genetic algorithm to the sensor path planning of mobile robots in an uncontrolled environment real time (Yasuda & Takai, 2001).
2. In the field of operations management, the genetic algorithm was applied to solve dynamic scheduling problems by suggesting a coordination mechanism by the genetic algorithm and using a set of fixed schedules (Madureira et al., 2002), to inventory control, using genetic algorithm they used the area stock model to figure out the number and area of stockrooms, different plan requirements have been included in the goal elements of genetic algorithm and its variations for tackling stock control issues (Hiassat et al., 2017).
3. In the field of multimedia, such as image processing, genetic algorithms have been applied by Yang and Gong (Gec et al., 2022).
4. Optimization problems in civil engineering, such as:
    1. bridge water network design (Savic & Walters, 1997),
    2. geometric tunnel design (Eid, 2015b), and structural optimization (Eid, 2015a).
    3. time-cost-quality trade-off software in a multi-objective GAs model, they used the Line of Balance and the Critical Path Method, presented by (Abd El Razek et al., 2010).
    4. method for assessing the likelihood of a project meeting its Quality-Cost-Time goal in the face of uncertainty proposed by (Saputra & Latiffianti, 2015).
    5. developed a model for repeatable construction projects, including highways, housing developments and high-rise buildings, which is based on a dynamic programming formulation that identifies the best crew formation and interruption choice for each project activity, resulting in the shortest project duration, scheduling method, and an intermission algorithm, by (T. For et al., 2001).

According to (Devikamalam & H, 2013), some of the top issues in project management are project complexity, allocation of resources, and leveling. The genetic algorithm (optimization technique) can be used to optimize the scheduling of building project operations in order to reduce the total cost while meeting resource restrictions and prove the ability of the genetic algorithm solution.

2.5 Expert System

It is a program that simulates a human decision-making capacity in order to solve complicated problems using reasoning knowledge. Newell, Shaw, and Simon created the General Problem Solver in 1959 (Michie,1969). They discovered that while people are solving problems, they engage in three types of mental activity:

1. putting together a basic plan.
2. solving the problem according to plan, using recollection of the axiom, theorem, and problem-solving plan.
3. The method and objective of the problem-solving process are continually examined and updated during implementation.

It is defined by (Naser & A.Ola, 2019) as an intelligent computer program that uses heuristics and knowledge to solve problems that are difficult enough to require a highly experienced human to solve.

Expert System Applications:

1. System development, Dendral by Stanford University (Mars, 1966).
2. System MIT created the MACSYMA system (Petrick et al.,1971).
3. Smart, knowledge-based expert systems can be used to monitor construction projects, including time and cost control, inventory control, and procurement (Reinschmidt, 1989).

The expert system consists of the following basic structure: (Tan, 2017)

1. base of knowledge.
2. working memory.
3. machine of reasoning.
4. An interaction interface between a computer screen and a human through an interpreter.

The expert system is divided into four categories: (Tan, 2017)

1. expert system with rules, examples of applications include planning, teaching, sensor control and production planning (Liao, 2005).
2. expert system using fuzzy logic, which was suggested by Lotfi Zadeh,who was an instructor at the University of California (Wedding, 1997). Examples of applications include the ability to predict, such as the prediction of forecasting energy loads! Water supply forecasting, online scheduling, medical diagnosis, and a manufacturing information network are all examples of applications (Liao, 2005).
3. expert system with a framework for using it for teaching is shown in the following figure (2.2) below, (Krishnamoorthy & Rajeev ,2018).

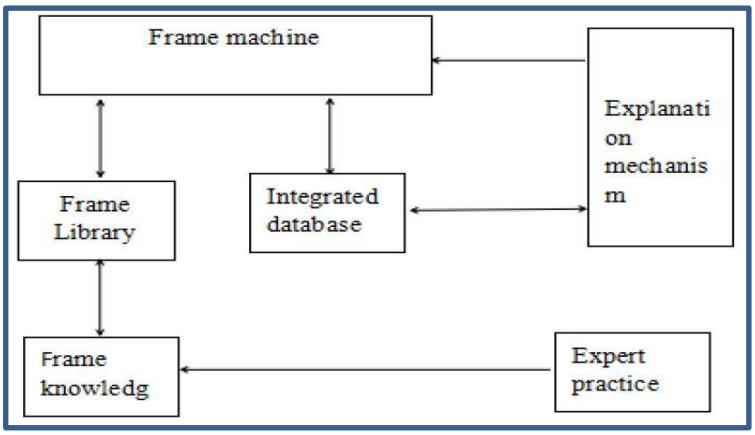

Fig (2.2)
Expert system based on framework (Krishnamoorthy & Rajeev ,2018)

The figure above shows how expert systems for teaching start from the expert practice, then frame knowledge, frame a library, frame a machine, and finally frame an integrated database for explanation mechanisms. The lines connecting the shapes represent data flow.

4. The neural network based expert system, Examples of applications include process control, decision making, (Liao, 2005), and robotics, as shown in the following figure (2.3) (Krishnamoorthy & Rajeev ,2018).

Fig (2.3)
Expert system with artificial intelligence (Krishnamoorthy & Rajeev ,2018)

The figure above shows screen that improve the ability of artificial intelligence by using a robot control with screen like a human.

2.6 Intelligent Agent

A smart agent is a piece of software located in an environment and has the following characteristics:(Padgham & Winikoff, 2004)

1. autonomous, independent of external control.
2. flexible: capable of achieving goals in a variety of ways.
3. interacts with a number of other agents on a social level.
4. reactive: responds to changes in its environment.
5. proactive: persistent in pursuing goals.
6. situated: occurs in a specific setting.
7. robust, resilient, recovers after failure.

The figure below shows the concept of building agents (Padgham & Winikoff, 2004).

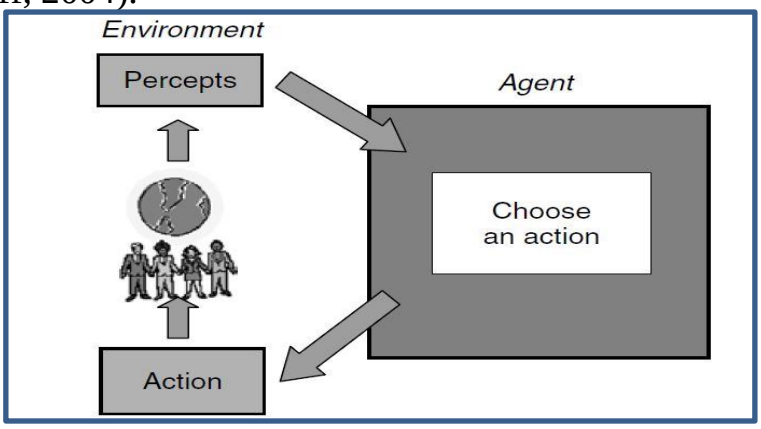

Fig (2.4)
Concept for building agents (Padgham & Winikoff, 2004)

The figure above shows the concept for building agents, it is a cycle start from choose an action.

Intelligent agents provide new levels of abstraction, decomposition and organization that align with our natural worldview. Agent-oriented programming is sometimes regarded as the inevitable successor to object-oriented programming (For N, 2001), Thus, we must look at agents as having mental attitudes such as goals, beliefs and intentions. The researcher (Dennett, 1989) has a startling logical justification: as a system is becoming more complex, it may be anticipated more consistently by abstracting away from how it achieves its objectives and instead reasoning about what its aims and beliefs are.

AI's job is to create the agent program, which is a function that enacts the agent mappings starting from percepts to actions (Dibley et al., 2011). The agent architecture is a popular framework for creating multi-agent systems that includes FIPA communications, agent hosting, lifecycle control and some other infrastructure services like agent placement (Bellifemine, 2001).

2.6.1 The Intelligent Agent Technologies

The characteristics of intelligent agent technologies include autonomy, intelligence, interaction and mobility allowing for much faster information transmission than is humanly conceivable, resulting in a shift in firm market orientation (Köhler et al., 2011).

According to a study by the researchers (Kumar et al., 2014), the employment of intelligent agent applications in the field of markets necessitates a dynamic survey of the environment and economic factors such as competitors and clients.

2.7 Cost Overruns

Cost overrun is a major problem in project development that characterizes the construction sector (Issn, 2010). A cost overrun is defined as exceeding the budget. This includes an unexpected extra cost that occurred due to a miscalculation of the budget for projects (Al-Hazim et al., 2017). The project is described as having exceeded the budget and the costs allocated to it in the event that the project's actual cost is greater than 110% of the estimated cost allocated to it (Brookes, 2015). In another definition, it could be estimated by dividing the change in the contract amount by the original contract amount (Jackson, 2002), (Merrow, 2011). Projects need to manage costs in the first stage to finish the project within the required cost, time and quality. This is considered the largest factor affecting the success of projects in all developing and developed countries (Albtoush et al., 2020). Cost management is one of the important factors that determine the successful completion of the project within a limited period of time with reasonable profits, as it works to maintain the contract amount by monitoring the amounts spent and helps in taking the right decision at the right time (Albtoush et al., 2020).

The construction project consists of two distinct phases (Sweis, 2013):

1. The pre-implementation stage: is the time between the project's initial planning stage and contract signing.
2. Implementation stage: during which the contractor completes the construction process in accordance with the contract.

Re-executing the job as a result of mistakes and non-compliance with specifications is a significant contributor to cost overruns because it is evident in bills of quantities and charges (Dehghan & Ruwanpura, 2011).

The problems facing construction projects were classified as being consultant-related, owner-related, or contractor-related. The contractor is usually seen as the first cause of failure in projects, while the contractor looks at the employer as the main cause of failure. However, in the end, all good or bad decisions pour into the project (Falqi, 2004).

The most important obstacles to construction projects (classified by the owner and by the contractor) (Falqi, 2004).

Table (2.1)

The most important reasons and obstacles that construction projects face from the owner's perspective

The table was prepared by the researcher with the help of a study (Falqi, 2004).

Owner	
1.design hurdles	10.Solvency
2.Natural phenomena	11.resource shortage
3. Occupational Safety and Health	12.the approval of the authorities
4.Contractor Efficiency	13.inflation
5.different scope of work	14.Compatibility with change
6.the quality	15.Legislation changes
7.Site conditions	16.low productivity
8.Inappropriate equipment	17.Disputes
9.Site access facilities	18.Payment delays

In the above table, the study (Falqi, 2004) explains the most important reasons and obstacles that are facing construction projects from the point of view of the owner, which are 18 reasons.

On top of that falls at the first-place design hurdles, followed by natural phenomena and problems of occupational safety and health.

At the bottom of the list are these reasons: low productivity, conflicts, and late payments.

Table (2.2)

The most important reasons and obstacles that face construction projects from the point of view of the contractor

The table was prepared by the researcher with the help of a study (Falqi,2004)

Contractor	
1.design hurdles	10. the approval of the authorities
2.Site conditions	11.website accessibility
3. different scope of work	12. low productivity
4. Compatibility with change	13. resource shortage
5. Occupational Safety and Health	14. inflation
6. Natural phenomena	15.Legislation changes
7. Solvency	16. Disputes
8.Quality	17.payment delays
9.Site access facilities	

In the above table, the study by (Falqi,2004) explains the most important reasons and obstacles that are facing construction projects from the point of view of the contractor, which includes 17 reasons. On top of which falls in the first-place design hurdles followed by site conditions and different scope of work and at the bottom of the list are Legislation changes and disputes and payments delays. We note from Table Number

(2.1) and Table Number (2.2) that the owner and contractor agree on the main cause and main obstacle in construction projects, which is the design difficulties, as it is ranked first for both.

Whatever the cause, project stumbling is a phenomenon that affects projects everywhere, and one of the most significant difficulties of stumbling is the delay in the deadline for project delivery and cost overrun (Kululanga & Price, 2005).

Inadequate monitoring leads to errors in the update during implementation and thus leads to another problem represented by (extension of the contractual completion period and cost overrun) (Latif et al., 2019).

A study by (Sweis ,2013) shows cost overruns, representing the percentage of each worker to the overall total, and shows that the first factor behind the high cost of public construction is the government delay of 32%. (Essentially a slow decision by the owner), followed by severe weather conditions of 23% and 18% to change the design. These three factors account for 73% of excess costs, as shown in the following figure (2.6).

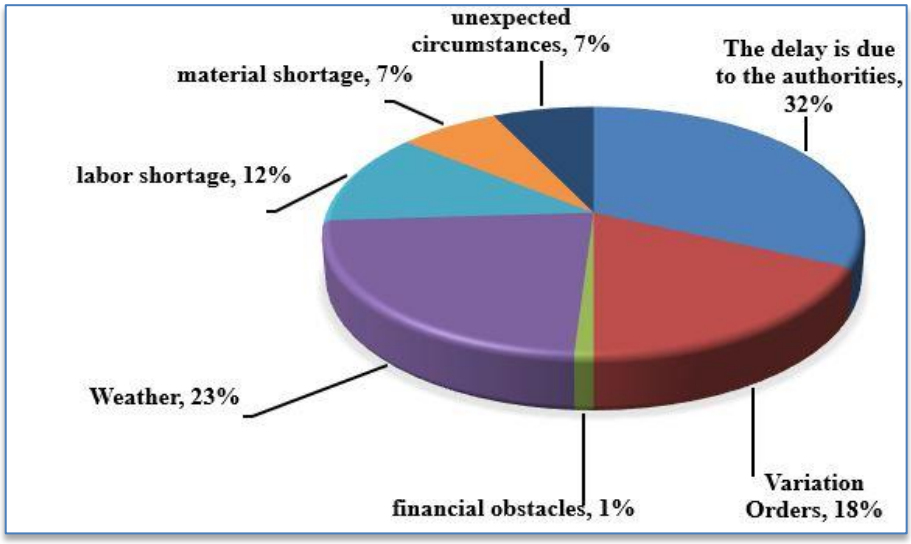

Fig (2.6)

Cost overruns, which represent the proportion of each worker to the overall total. The figure was created by the researcher with the assistance of a (Sweis ,2013) study.

In the above figure, the study conducted by (Sweis,2013), which shows the percentage of each worker who contributes to the failure of construction projects, and the highest percentage with a figure of 32%, which is due to the delay caused by the authorities, followed in the second place by the weather by 23%, and in the third place , change orders by 18 %, located in the fourth rank, a shortage of labor by 12%, and in the fifth rank, a shortage of materials and exceptional circumstances by 7%, and in the last rank comes financial obstacles by 1%.

2.7.1 Reasons for Cost Overrun

Materials price fluctuations, a lack of experience in contract work, insufficient time, and incomplete drawings are all major causes of cost overruns in construction projects.

Greater effort should be exerted in the study phase of any project, and a keenness to prepare good planning, logical scheduling, and real cost evaluation, to reduce the risks of delay and cost overrun in the implementation of the project (Al-Hazim et al., 2017).

Changes in one project affect other unrelated projects by linking resources committed elsewhere, affecting the nature of the relationship between project parties negatively (Khalifa & Mahamid, 2019), and summarizing (Keane et al., 2010), To table (2.3) the effects of modifications and changes on projects.

Table (2.3)

impact of modifications and changes in construction projects

The table was prepared by the researcher with the help of a study (Keane et al., 2010)

Cost implications	Effects related to quality	Organization related effects	Other effects
1. Increase in public expenditures.	1. Late payments.	1. Damage to the company's reputation.	1.Delayed progress and slow completion
2. Additional payments to the contractor.	2. Rework and demolition.	2. Bad professional relationships.	
3. Rework and demolition.	3. Logistics delay.	3. Unstable environment.	
	4. Delayed purchases.	4. Disputes.	
	5. Delaying the agenda.		

The above table shows the impact of modifications and changes on construction projects. The most important implications are related to cost, as it leads to re-work demolition and additional payments to the contractor; additionally, it leads to an increase in public spending. followed in second place by the effects related to the quality of projects and the consequent effects of delaying the agenda, delaying purchases, delaying transport and supply, returning work, and logistics delays. Among the other effects are the delayed progress and slow completion.

It was found that the most important factor that increases the cost of construction projects in Jordan is (change orders) (Sweis,2013).

The changed orders in the projects affect the nature of the relationship between the project parties negatively (khalifa& mahamid,2019), which are issued to cover differences in scope of work, quantities of materials, and design errors, often having a clear impact on the quality, time, and cost of projects. Variation orders are defined as any work added to the asset or deleted from the contract that changes the amount of the original contract or its completion date, resulting in additional cost, additional time, or both (Desai et al., 2015). Not to mention that it is an integral part of construction projects that a project is rarely complete without change orders (Alaryan et al., 2014).

These include design errors; quantity errors for the project; poor coordination; financial difficulties; and a change in the surrounding working conditions (Khalifa & Mahamid,2019). Quantity errors were found to be the main cause of project change requests, and therefore, quantity errors can be classified as another major cause of changes requested by the engineer (Halwatura & Ranasinghe, 2013).

A study conducted in Jordan about the reasons for the excess of time and cost in infrastructure projects concluded 20 factors with variation orders ranked thirdly. (Al-Hazim et al., 2017). Therefore, the owner is considered primarily responsible for the variation orders, and hence, the first step to reducing variation orders in construction projects starts with the owner. Several recommendations for minimizing variation orders in the construction industry are reported by various studies. For example, the provision of appropriate full design site requirements would help to minimize the degree of variance in the construction industry (Jraisat et al., 2016). Adequate contract preparation and interpretation by the parties involved prior to the start of construction work (Nasser, 2013). The study showed that variation orders are one of the most important dimensions of cost overruns, as the construction sector is characterized by a lot of change and modification for various reasons, and therefore, one of the most important difficulties facing the sector is maintaining the project's planned cost and the balance between its expenses. The problem of cost overrun starts from the planning and study stage because it is linked to the nature of the project and the nature of the materials used in the project, through the development of the scenarios and requirements required by the project taking into account the materials and modern construction methods used to make all parties fully aware of all the merits of the project and thus build a meta-analysis closer to the accuracy of the project cost, represented by direct and indirect costs. Cost estimation is defined as a forecast of the budget that must be allocated to complete the project, including all wages for the resources needed to carry out the project.

2.8 Time

Delays in projects are one of the most common problems that cause many negative effects for the project and the parties involved, and they are also one of the costliest problems (G. Sweis, 2008). These delays occur frequently during the life of the project, resulting in disputes and lawsuits (Marzouk & El-Rasas, 2014). A delay is defined as the act or event that prolongs the time required to perform or complete the work, and the delay is manifested as additional working days, or the time exceeded either after the completion date specified in the contract, or after the date agreed upon by the two parties to deliver a project (Assaf et al., 1995). It is also defined as the difference between the actual achievement date and the estimated achievement (Faridi et al., 2007). According to a study conducted by the researcher (Bekr, 2018), it was found that the construction sector in Jordan faces a great challenge in adhering to the project schedule plan while ensuring high quality and within the available costs of the project. The researchers (Tarawneh et al., 2020; Sweis, 2013) summarized the most important reasons that led to exceeding the specified period of completion from several previous studies in the Middle East region, as shown in Table (2.4).

Table (2.4)

The most important reasons that led to exceeding the time limit for completion (Tarawneh et al.,2020; Sweis, 2013)

Country	Reasons that lead to exceeding the time limit for completion
Jordan	1. Poor level of design. 2. the weather. 3.Late deliveries. 4.change commands. 5.unforeseen circumstances
United Emirates	1. Delay in preparing designs and obtaining approvals. 2. Bad planning. 3. Delayed decision making. 4. Labor shortage. 5. Poor management. 6. Poor productivity.
Lebanon	1. Financial problems. 2.Contractual problems. 3. administrative problems.
AL-Kuwait	1.Payments. 2.The inexperience of the employer. 3.Variation Orders

AL-Saudia	1. Slow preparation and approval of working drawings. 2. Delays in payments. 3. Constant changes in design. 4. Labor shortage. 5. Inefficiency. 6. Referral system at the lowest prices. 7. Variation orders. 8. Poor management and funding difficulties.

The above table summarizes the most important reasons that led to exceeding the deadline for completion in the Middle East whereas in Jordan, the main reason was a lack of design quality; and in the UAE, the main reason was a delay in preparing designs and obtaining approvals. The main reason in Lebanon is financial matters, while in Kuwait the main reason was payments.

In Saudi Arabia, the main reason is the slow preparation and approval of working drawings. Saudi Arabia and Kuwait share the change orders among the reasons contributing to the delay in the project. The United Emirates and Saudi Arabia agree for two reasons. The first is the lack of labor. The other is poor management.

The researchers concluded (Marzouk & El-Rasas, 2014) that the reasons for the delay change according to the source, and they are summarized in the table (2.5).

Table (2.5)

Reasons for delay in construction projects by owner, contractor, consultant

The table was prepared by the researcher with the help of a study (Marzouk & El-Rasas, 2014)

Owner	Contractor	Consultant
1. Slow decision-making. 2. Delay in issuing approvals. 3. Late payments. 4. Type of bid and method of assignment. 5. Ineffective penalties. 6. Suspension of work. 7. Delay in preparing the site. 8. Change orders. 9. Unreasonable execution time. 10. Employer Intervention.	1. Financial difficulties. 2. Preparing an illogical schedule. 3. Delay in preparing the site. 4. Weak site management. 5. Rework due to errors. 6. Delay in issuing executive drawings.	1. Inefficiency of the competent team. 2. Errors and inconsistencies in the documents. 3. Lack of clarity in details and specifications. 4. Delay in approving plans and materials. 5. Quality Assurance

Table (2.6)
Reasons for delay in construction projects by Labor and machinery, Materials, Factors related to the project itself
The table was prepared by the researcher with the help of a study (Marzouk & El-Rasas, 2014)

Labor and machinery	Materials	Factors related to the project itself
1. Labor shortage. 2. Inefficiency. 3.Weak mechanisms used.	1. Lack of materials in the local market. 2. Delay in delivering materials to the site	1. The nature of the soil. 2.Traffic and control. 3.Unavailability of services. 4. Accidents. 5. Problems with the local environment.

The above tables (2.5 and 2.6) summarize the most important reasons for delaying projects in terms of sources and reasons related to the owner with ten reasons. In the first place, is the slowness in making decisions.

Reasons that are related to the contractor include, in the first-place financial difficulties. Among the reasons related to the consultant are five reasons, the first of which is the inefficiency of the competent team. Among the reasons for the delay in the project and its source of employment are three reasons, the first of which is the labor shortage. Among the reasons related to the materials are lack of materials in the local market and delays in delivering materials to the site. One of the reasons for delaying a project is the project itself, such as the natural soil.

The most important economic sector in Jordan is the construction sector. Exceeding time and cost are two of the most serious problems that the sector suffers from (Samarah & Bekr, 2016). The irregularity of financial payments is the most important cause of delays in Jordan. The second reason is change orders, and the third reason is poor management and planning. It is necessary to work early to identify the main delays and work to develop appropriate solutions (Odeh & Battaineh, 2002).

Because the consequences of delays on project performance may be cumbersome (Aibinu & Jagboro, 2002).
Among the most important consequences of the delay are: 1. Time overrun 2. Cost overruns 3. Arbitration 4. Litigation 5. Work Stoppage.

2.9 Literature Review:

The researcher found through the search for previous studies related to the subject of artificial intelligence and its use in construction projects, and this part of the study contains a group of studies related to the problem of the current study. The studies on the subject of the topic (Applying of

Artificial Intelligence to Reduce Cost and Time) were divided into three groups by the researcher:

A. Previous studies connected with artificial intelligence.
B. Previous studies connected with cost and time.
C. Previous studies connected with cost and time by using artificial intelligence.

A. Previous Studies Connected with Artificial Intelligence:

(Regona, Yigitcanlar and Xia, 2022); "Opportunities and Adoption Challenges of AI in the Construction Industry: A PRISMA Review" which intended to grant a precise full array of artificial intelligence technologies and identify the key challenges in their applications and key possibilities these technologies will convey to the construction industry.

This study using the PRISMA protocol conducted a systematic review of the literature on artificial intelligence in construction Industry. The researchers came to the following conclusion: Leverage use of artificial intelligence in the construction industry throughout the project lifecycle and that there is still a missing data link between technology and humans, despite the availability of possibilities to spread artificial intelligence applications; therefore, it is necessary to give more effort to use digital solutions. For example, using smart wearable technologies and sensors. The view of the researchers is that the integration of artificial intelligence applications with current technologies is the future of the construction industry.

(Egwim et al., 2021); conducted a study with the title of "Applied artificial intelligence for predicting construction projects delay"which aims to demonstrate that sophisticated models of artificial intelligence that are capable of predicting project delays. This study was conducted in Nigeria. The researchers followed the method of data collection literature review (identified the factors causes delay in construction projects) and questionnaire. The researcher found 24 factors like (contract management, material procurement, project schedule, late delivery of materials) the researcher used all of these factors to build machine learning method to develop predictive models such as (decision tree, multinomial naive bayes, random forest). combining these predictive models to develop a multilayer high preferment ensemble.

After analyzing the data, the researcher employed a statistical procedure and found the potential usefulness of using ensemble machine learning to enhance the quality of choices and risk management by bringing together stakeholders in the construction industry. The researchers reached the following results: as efforts to improve construction project time efficiency, which is a major performance indicator of successful projects, that (Ensemble Machine Learning Algorithms) EMLA can improve the prediction capacity of a single algorithm when it comes to anticipating

construction project delays, as the proposed modern technique it is expected that it may be used to reduce delays in any construction project in the sector. The researchers reached the following recommendations: future studies should focus on improving the algorithms through parameter optimization or feature engineering, other strategies employed in the formation of ensemble models should be considered to anticipate the delay of construction projects.

(Cheng & Darsa, 2021); conducted a study with the title "Construction Schedule Risk Assessment and Management Strategy for Foreign General Contractors Working in the Ethiopian Construction Industry"the goal of this research is to create a project time-delay forecasting model using artificial neural networks and the garson algorithm, the country in which the study was conducted is Ethiopia. The researcher followed the method of data collection for 94 construction projects in Ethiopia based on delayed schedules in these projects, literature survey (based on historical data records, survey) identifying 26 factors causing delay in construction projects then they analyzed it using questionnaire survey (identified 41 factors causes delay in construction projects). There are 22 factors the researchers used to build Artificial Neural Networks (ANN) trained, tested and validated with the top three ranked factors by ANN were (change orders, corruption/bribery, delay in payment).

The researchers reached to the following results: that Construction Schedule Risk Assessment Model (CSRAM), will provide an objective and systematic strategy for identifying the main causes of schedule delays and thus offers management solutions along with suggestions to reduce schedule delays, in addition to saving Important schedule control reference for Foreign General Contractors (FGCs) planning to be entered or already engaged in construction business in Ethiopia.

The study demonstrated the ability of artificial neural networks to predict the delay of future construction projects, which is a useful technique for managing and controlling the schedule of future construction projects.

(Kyivska and Tsiutsiura, 2021); conducted a study with the title "Implementation of Artificial Intelligence in The Construction Industry and Analysis of Existing Technologies "which aims to use artificial intelligence to apply an approach that links information technology and artificial intelligence in the construction industry, which was conducted in Oslo and Norway. The researchers used interviews and document studies. The sample included a seven-year construction project and they compared the traditional method with the approach used in this study and had the following results:

The increase in the volume of data and the increase of machine learning algorithms leads to prediction of work in construction projects, based on real time and past activities resulting in improved construction processes, better decision-making and helps reduce risks.

(Varouqa, 2021); The researcher conducted a study with the title" Using Artificial Intelligence and computation Enhanced apply in neural network" which aims to reduce cost and time in prefabricated construction by focusing on artificial neural network technolog. The study was applied to prefabricated projects small and medium residential, commercial, and institutional building.

The researcher followed used to conduct training exercises for the models and conduct examinations for each project separately.

The sample size were seven prefabrication projects. After analyzing the data, the researcher reached the following results:

The time and cost performance of projects were predicted using the artificial neural network. After training the models and reaching the optimal model using the help of technology by GUI, participation and consultation with professionals working on prefabricated structures is recommended by the researchers.

(Huang, Li and Fu, 2019); the researchers conducted a study with the title" Review on Application of Artificial Intelligence in Civil Engineering "this study aims to review the development and application of intelligent algorithms for artificial neural networks in civil engineering. The researchers collected data from literature review and summarized previous studies. The researchers reached the following results:

Artificial intelligence has been used and developed in civil engineering over time. For decades, artificial intelligence algorithms and neural networks have been employed in civil engineering and are now widely used in structural design, construction engineering, optimization, structural state evaluation and health monitoring, Bridge engineering, geotechnical engineering, highway engineering. Big data and deep learning technologies have been successfully implemented in different parts of civil engineering in recent years, with big data technologies leading the way in structural maintenance. The structural health monitoring based on computer vision has substantially improved due to the rapid development of computer vision based on deep learning. On the other hand, deep learning has achieved little success in other areas of civil engineering. Deep learning has become an efficient tool in the era of big data since it can completely tap into the rich information contained in big data.

B. Previous Studies Connected with Cost and Time:

(Jaiswal et al., 2021); The researchers conducted a study with the title" Time delay and cost escalation in construction works "this study aims to demonstrate and quantify the consequences of delays in building

projects, such as time and cost overruns. It was conducted in India. The researchers used questionnaire and previous studies methodology to collect data. The researchers found 50 causes contribute to delays in Indian construction projects. The first reason was (Material related delays), the second reason was (Labor related delays), the third reason was (Equipment related delays).

The researchers reached the following recommendations: that contractor should boost worker productivity as much as feasible and to motivate it and should be able to manage financial and cash flow issues. Also, to corporate subcontractors to work together effectively.

Owners must take care before granting the contract to the lowest bidder and to check for resources and capabilities.

Regarding consultants they should not be late in evaluating and approving the documentation and drawings that have been provided.

(Tarawneh et al.,2020); The researchers conducted a study with the title" Time and Cost Overruns in Jordanian Building Construction Projects "this study aimed to determine the primary elements that affect cost overruns and time delays in Jordanian building projects.

The researchers used the questionnaire which was written by selecting 12 experts from all companies. The questionnaire was distributed to 150 participants.

The research sample included workers in the relevant parties of the consultants, contractors and owners. The researchers reached the following results:

contractors confirm with Clients that financial and competency concerns significantly affect time delay and cost overruns.

Clients and consultants concede that design concerns also have a big bang.

The consultants point of view is that there are factors that contribute and greatly affect the overrun of cost and time due to workmanship problems. The researchers concluded that in Jordan the most crucial challenges for projects and construction parties are time delays and cost overruns. Time delays and cost overruns will have a significant impact on clients, consultants, contractors, teams of man crafts, subcontractors and labors.

The researchers reached the following recommendations:

Contractors must consider the amount of work that must be completed as well as their financial situation. Contractors must carefully examine the terms of each contract independently in order to complete them on time and within the budget. The clients should consider financial concerns while obtaining funds for projects, strive to allow a suitable amount of time for construction, inform contractors of any unfeasible conditions.

consultants should take care of specifications and penalties for more control on construction contracting. Additionally, they should give the right price and time for contracting within the minimum and maximum limits according to the market status and competency.

(Herrera et al., 2020); The researchers conducted a study with the title" Cost Overrun Causative Factors in Road Infrastructure Projects: A Frequency and Importance Analysis "this study aims to review the previous literature to find out the most important factors and reasons that lead to cost overruns in road infrastructure projects.

The researcher reviews 45 projects that cost overrun factors in road construction in various regions such as Asia, Africa, America, Oceania and Europe.

The researcher reached the following results:

The consultants ranked Late decision making firstly as the cause of cost overrun. While by contract the poor contract, management was the first cause. According to contractor it was (delays of activities). Contractual relationships revealed Poor coordination among stakeholders is the primary cause of cost overrun.

Other causes include design changes, shortage of equipment, financial difficulties of contractor, payment delays to contractor, shortage of materials, slow permits by local authorities.

After comparing all the factors that related to cost overruns.

The top seven ranked factors were failures in design, price variations of materials, inadequate project planning, project scope change, design changes, unrealistic contract duration and Inadequate bidding method. The researchers recommended that cost overruns in road projects be mitigated from the beginning.

(Roumeissa, 2019); The researchers conducted a study with the title" Impact of Delay on Cost Overrun in Construction Projects in Algeria "this study aims to determine the effect of schedule delays on cost overruns. The researcher collected data from previous eleven projects in Constantine city in Algeria. The researcher classified the projects into two categories; the first were economic infrastructures and administrative buildings the second category was education sector. After data collection from these projects, the researcher used the coefficient of correlation and simple linear regression method reaching to the following results:

The data revealed that cost and time overrun have a close relationship and that delay has a favorable impact on cost overrun. The developed model is appropriate for cost overrun prediction, and practitioners in construction projects and can be utilized as a predictive measure to reduce potential cost overrun

(Akhund et al., 2018); The conducted a study with the title" Contributing Factors of Time Overrun in Public Sector Construction

Projects “this study aims to identify and classify time overrun reasons in Pakistani public-sector projects. The researchers used a questionnaire distributed to various construction industry professionals and the researchers reached the following results:

That the financial issues faced by constructors are a crucial element in time overruns and scheduling. Inadequate planning was ranked as the second most common cause of time overruns by the stakeholders. The client's financial troubles were the third most significant factor affecting the expected completion time of the construction project and client decision-making delays were ranked fourth contributing to time overrun. By identification of factors that contribute to the overrun of time, stakeholders will be able to prepare properly based on the identified factors to avoid the issue of time overrun.

(Bekr, 2018); The researcher conducted a study with the title” Study and Assessment of Causes and Effects of Delay in Large Public Construction Projects in Jordan “this study aimed to determine the major reasons of delays in big public projects in Jordan, as well as the impact of these delays on project completion.

The researcher used interviews, site visits, comprehensive related studies and questionnaire. The questionnaire is divided into three sections, the first was to find out about the characteristics of the people who took part in the poll and to find out what they thought about the degree of delay that already exists in the sector.

The second section had 55 causes of delay which were divided into four groups with the third section focused on the impact of delays on the completion of large-scale public projects.

146 engineers representing various companies involved in the construction process responded.

The investigation's findings according to the study indicated that almost 95% of projects are late, with more than half of those being delayed by 10% to 30%.

The researcher concluded that the contractor's management and supervision is the first factor while the constant change of customers on the design is the second factor.

The third major cause of delay for large-scale public construction projects in Jordan is cash flow challenges encountered by contractors.

(Rezaei & Jalal, 2018); The researchers conducted a study with the title” Investigating the causes of delay and cost-overrun in construction industry “this study aimed to determine the major causes and factors of delay and cost overrun in projects. It was conducted in the north of the State of Iraq.

The methodology used by the researcher is to collect data from previous projects, the research tool included a questionnaire.

The researchers reached the following results:

That 61 factors involved in causing delay in projects and 42 factors to cost overrun.

The three causes of delay in projects were safety precautions, the same contractor has a large number of subcontracts and low labor predictivity.

The major three causes to cost overrun were unavailability of labor skills, unacceptable contractor policies and dominance of the construction industry by foreign companies and assistance.

The researchers recommended supply of specialized security teams, rigorous adherence to the rules, customized trainings and workshops, consideration of worker motives to boost productivity and motivating locally held construction.

C. Previous Studies Connected with Cost and Time By using Artificial intelligence:

(Arba, 2021); conducted a study with the title "Future Directions of Cost and Productivity Estimating using Artificial Intelligence (AI)"-which it aimed to develop a model for estimating the cost of engineering services using an artificial neural network approach.

Based on the data of previous projects, the researchers reached the following results:

Self-learning and deep learning algorithms open new horizons and applications that we can use in statistical models, as they show the effectiveness of analytical and statistical methods in cost estimation, in addition to their wonderful contribution to the modeling of artificial neural networks as they gave better, accurate and faster results which lead to better decision-making.

(Yaseen et al., 2020); the researcher conducted a study with the title "Prediction of Risk Delay in Construction Projects Using a Hybrid Artificial Intelligence Model", it aimed to the development of integrated hybrid and classified artificial intelligence models random forest(RF) and improved genetic algorithm (RF-GA) to predict the delay problem of the project.

This study was conducted in Diyala city in Iraq and the research tool divided by two steps; first collecting the sources that effect delay in projects from literature review, second collecting data through historical records of the delay level. The research sample included the 3000 an expert in construction projects to answer the questionnaire.

After data analysis, the researchers reached the sources affecting the project delay and used them to develop the model by training the model based on data of the previous construction projects and validate it by using statistical performance measure indices the Random Forest-Genetic Algorithm (RF-GA) hybrid model was created to address the complex and

dynamic character of the environment, evaluation of the Random Forest-Genetic Algorithm; (RF-GA) model using performance indicators based on data from the construction industry, in comparison to the traditional Random Forest (RF) model, the researchers discovered that RF-GA detects more accurately, the ability to deal with non-linear data in the construction sector is demonstrated by radio frequency performance, which demonstrates the genetic algorithm's ability to tackle problems with multiple solutions

(Al-Tawal et al., 2020); the researcher conducted a study with the title " A model utilizing the artificial neural network in cost estimation of construction projects in Jordan" which aims to verify the effectiveness of artificial neural networks in overcoming cost estimation problems in the early stages of the building design process. The researcher used the data collection method for the historical records of 104 construction projects held in Jordan to find out the most important factors that affect the cost of construction projects in Jordan. The researcher used a questionnaire and interviews with experts specialized in the field of cost estimation.

The research sample is from cost engineers and contracting companies of first- and second-degree classification.

After analyzing the results of the questionnaire and the expert interviews, the researcher reached to identify 53 factors that affect the cost of building and these factors were adopted to develop three models of artificial neural networks depending on the number of design factors used. The first model used all the influencing factors, the second model used 41 influential factors and the third model used of 27 factors.

The results of the research after conducting several tests of the models to ensure their validity like statistical performances measures such as (mean absolute error), (mean absolute percentage error).

The values show that there are no significant differences between the estimated cost and the actual budget value.

The researchers recommended utilizing a cost evaluation system to estimate costs and target projects with similar cost criteria as well as gathering more data for new projects that will enhance the developed model.

(Galli, 2020); the researcher conducted a study with the title" Application of Multiple Regression and Artificial Neural Networks as Tools for Estimating Duration and Life Cycle Cost of Projects "which it aimed to compare the accuracy of artificial neural network models and multiple regression as well as forecasting the project duration and cost by applying simulations in the building models to investigate concepts and statistical tools that can be integrated in the second phase of the project life cycle: the planning stage.

The researchers followed the method of data collection from literature review and the classified studies that dealt with neural networks modeling techniques and multiple regression were applied in construction cost and project durations estimation.

The sample size included more than thirty projects used for developing models, after analyzing data.

The researcher reached the following results: Neural networks have proven their efficiency by dealing with many variables and they have been classified as the best model that deals with estimating cost and time of projects in comparison with regression models according to the results its application is more practical in terms of project management despite its inability to determine the most accurate model when the number of variables becomes large, unlike artificial neural networks.

(Tijanić, Car-Pušić and Šperac, 2020); the researcher conducted a study with the title "Cost estimation in road construction using artificial neural network" which aimed to model smart neural networks of all kinds to estimate road construction costs like Multilayer perceptron (MLP), Generalized regression neural network (GRNN) and Radial Basis Function Neural Network (RBFNN) which was conducted in Croatia.

The methodology used to collect data was by interviewing contractors, investors and supervisory engineers and surveying using the existing database then analyze it.

The sample size was 57 Road sections included the type of road project and scope.

The researcher reached the following results:

The three models used Multilayer perceptron (MLP), generalized regression neural network (GRNN), Radial Basis Function Neural Network (RBFNN), are proven suitable for rapid and effective analysis of road construction cost forecasting.

After comparison, it was found that the best values were to use the (Generalized regression neural network) GRNN (approach in road projects and to be within the initial design stage.

The researchers recommended that the models used can be applied in all countries, in addition to the research in the future to reach the best results.

It is good to use a larger and broader database and homogeneity with more number of variables

(Shemi and Asok, 2020); the researcher conducted a study with the title" Examination of Cost Overrun in Highway Projects Using Artificial Neural Networks in Kerala" which aimed to develop neural network models and regression models to analyze the cost overrun of future projects by identifying the reasons that contribute to the cost escalation of projects which was conducted in Kerala.

The methodology used by the researcher is to collect data from previous projects, the research tool included a questionnaire, and the research sample included contractors, engineers and architects. After determining the correlation between the factors that contribute to the escalation of costs in projects and using them in developing a model based on the neural network and the multiple regression method.
The researchers reached the following results.

The neural network shows the most likely model to measure costs in projects, and the best network model that shows a measurable model that is of one hidden layer is cost overrun.

The researchers recommend that in future research investigations can be carried out on various projects such as housing projects, railway projects and dam development and it is recommended to use different model parameters.

(Chandanshive & Kambekar, 2019); the researcher conducted a study with the title "Estimation of Building Construction Cost Using Artificial Neural Networks ", The study aimed to develop a self-learning model based on a neural network to estimate the cost of building construction at an early stage of construction.

This study was conducted in India, the research methodology used is based on the survey and feedback from design professionals and building contractors, where the research sample included 78 projects for buildings in the city of Mumbai, India and the researcher reached the most important design parameters that most affect the construction cost of buildings, which are(ground floor area, typical floor area, number of floors, structural parking area, quantity of elevator wall , quantity of exterior wall ,quantity of exterior plaster , area of flooring , number of columns, types of foundation and number of householders).

They are adopted and used as design inputs for developing neural network models. Two different approaches were introduced, including early stopping and settlement in order to improve the ability of neural networks and after conducting several tests.
The researchers reached the following results:

The best neural network model is the organizational approach where it outperforms by using the early stop approach, where the Bayesian organization (training) performs better and that the trained neural network can accurately predict the cost of setting up the early stage of construction. This depends on the size of the data, the more the data, the more accurate the prediction.

(Hakami & Hassan, 2019); the researcher conducted a study with the title "Preliminary Construction Cost Estimate in Yemen By Artificial Neural Network "which aimed to use the artificial neural network application to determine the initial cost of projects and compare it with the

traditional method used in Yemen. The method used qualitative and quantitative literature survey (chosen 17 independent variables) such as area of floors, type of HVAC system, floor height, project location and type of external finishing, dependent variable, preliminary cost estimation and collected historical data for 136 projects during the years(2011-2015)with condition that these projects be finished and in use to become approved to collect the data cost form sheet and then build the model of ANN trained, tested, analyzed, by using Neuro Solution software the researchers reached the following results:

That modern technology ANN has proven its effectiveness and efficiency with high initial cost with the smallest time and thus project costs can be estimated easily and quickly as this technology is easy to use and can be implemented through Excel and NeuroSolution program. The results are highly dependent on the amount of data used

(Abd & Naseef, 2019); The researcher conducted a study with the title "Predicting the Final Cost of Iraqi Construction Project Using Artificial Neural Network"(ANN) which aims to use ANN to develop a mathematical equation to estimate the budget of construction projects, This study was conducted in Iraq. The researcher followed the method of data collection for 501 construction projects in Iraq during the years (2005-2015) and 25 items of construction projects (items bill of quantities)were selected and identified such as(reinforced concrete foundation, Plastic Paints, plaster finishing works) and these factors were adopted as inputs to design the artificial neural network, and after building the model, training it many times then testing it and verifying it, by choosing the best building model depends on testing error (lowest)and coefficient of correlation (higher).

The researchers reached the following results:

In the early stages of a construction project's life cycle, neural network technology has the capacity to develop an effective mathematical equation for calculating the cost of the project, especially when data is incomplete.

(Al-Zubaidi et al., 2019); The researcher conducted a study with the title "Guess the time of implementation of residential construction projects using neural networks ANN "which aimed to develop a model to foresee the implementation period of a residential project using an artificial neural network.

The researchers followed the method of data collection for a similar project which was built on 2016.

The researchers identified the factors (items bill of quantities) then build the model ANN, trained it, test it.

The researchers reached the following conclusion:

That after making a comparison between the proposed model of smart neural networks and the traditional computational and statistical model of conceptual design for complex residential design projects, the smart neural networks proved its efficiency for forecasting, estimating the duration of residential project implementation and predicting the theoretical design time and the researchers recommends to evaluate the applicability of multivariate datasets and databases in enhancing the accuracy of ANN in the conceptual estimation of the duration of implementation of a project.

(Barros et al., 2018);The researcher conducted a study with the title "Construction Cost Estimation of Brazilian Highways Using Artificial Neural Networks" which aims to develop an accuracy estimate for highways using artificial neural network, This study was conducted in Brazil, The methodology was used consisted of three stages: cost estimation studies employing ANN were analyzed in the first step after which the design of the model for use in highway building was defined. In the last stage, the model was put to the test to determine the ideal network design for increased accuracy, the researcher followed the method of data collection for 14 highway projects in Brazil (11 factors that effect on final budget), use these factors to build networks, by trials and errors.

The researchers reached the following results.

It turned out that smart neural networks are an effective tool and have a significant role in cost estimation.

This was confirmed by the mathematical results where a high level of accuracy was obtained.

The researchers offered here helps and supports road designers by allowing them to perform a better analysis using the criteria presented, which can then be replicated and applied to other highways.

The researchers recommended that in the Future research should expand datasets in order to build a more broad and accurate construction highways estimation model. In order to reduce the number of parameters, it may also be necessary to investigate other possible important input parameters

(Peško et al., 2017); The researcher conducted a study with the title "Estimation of Costs and Durations of Construction of Urban Roads Using ANN and SVM-"which aims to study the precision that artificial intelligence may attain when estimating cost and time in building projects, This study was conducted in Serbia, The researcher followed the method of data collection for 166 construction Projects in city of Novi Sad.

The Republic of Serbia, (based on historical data records), applied the data to build artificial neural networks (ANN), trained, tested, validated and used the same data to build support vector machines. After analyzing the results and comparing it the researchers reached the following results

using an approach that provided an option to estimate the design and construction contracts. Two models were made to compare the artificial neural network with support vector machines (SVM) where the artificial neural network has proven its ability to estimate the cost, and estimate the time period in an excellent way if each network is built separately But when the cost estimation data and the time period forecast data were collected and built in a single network, the model was not accurate, while the support vector machines (SVM) model proved its efficiency in estimating the time and cost better.

(Alqahtani & Whyte, 2016); The researcher conducted a study with the title "Estimation of life-cycle costs of buildings: regression vs artificial neural network "which aimed to compare between artificial neural network and the performance of regression to improve accuracy for estimation the cost of building projects.

The researchers used the data collection method, for 20 projects (based on historical data records), applied the data to build artificial neural network, trained, tested, validated and used the same data to build multiple regression model.

The researcher reached the following results: After modeling multiple regression (MR) and artificial neural network (ANN) and testing them in order to improve the quality of the assessment process it turned out that the artificial neural network (ANN) model is better than multiple regression model to predict running-cost of building projects.

(Naik & Radhika, 2015); The researcher conducted a study with the title "Time and Cost Analysis for Highway Road Construction Project Using Artificial Neural Networks "which aimed to compare between two successful projects in highway roads based on artificial neural networks

The data collected for these two projects and 15 items of construction projects (items bill of quantities) were selected and identified such as(Sub Base Works, Drainage Works, Site Clearance, Traffic Signs) then these items were used to build the networks, to be trained and tested, statistically analysed, validated and comparison between the actual data and predicted values(Artificial neural network output) was done.

The researchers reached the following results: that after comparing the estimated and actual values using artificial neural networks, and the results of the expected values for both cost and time, it was found that they do not have the largest deviation indicating that the approach taken reduces the risks of exceeding the budget and the time schedule for construction.

Increases the quality of the decisions taken. Therefore, it is effective and useful for estimating the cost and time used in construction projects in addition to the construction of highways.

(Yildirim, 2015); The researcher conducted a study with the title"Machine Learning Algorithms for Construction Projects Delay Risk

Prediction“ which aimed to develop machine learning models in order to facilitate accurate project delay risk analysis and prediction using objective data source. The researchers followed the method of data collection literature survey (based on historical records for 51 projects) and industry meetings such as consultations, construction sector experts.

The researchers Identified the risk sources of delay (owner, consultant, contractor, design, labor Materials, equipment, project external) then the researchers identified delay risk factors such as (Inadequate project planning by owner, Delays in reviewing and approving design documents by consultant, Delays in producing design documents by design source, Shortage of labor by labor source, Shortage of equipment by equipment source risk , Mistakes or discrepancies in contract documents by project source risk, Delays in obtaining permits from municipality by external source risk)to build two different machine learning algorithms (decision tree)and (naïve Bayesian), then trained predictive models, evaluated using 10-fold cross validation, Confirmed the validity of both models and the effectiveness of their predictive performance, after comparing the two models, the naïve Bayesian model outperforms than the decision tree model in terms of overall performance.

The researchers reached the following results: The ability of machine learning algorithms to analyze and predict project time performance using historical data Apply machine learning (ML) algorithms to develop two construction projects risk forecasting body Two different machine learning (ML) algorithms were carefully selected based on The characteristics of the collected project data and were employed to create the trained predictive models, and the results of the analysis revealed the validity and effectiveness of the two models, but the values of the results indicate that the (ML) based approach is the most appropriate in terms of dealing with variables and the most efficient, the researchers recommend that sensitivity analysis be performed primarily as an essential step to establish the selection of appropriate machine learning algorithms for the application.

(Asadi et al., 2015); The researcher conducted a study with the title “A machine learning approach for predicting delays in construction logistics“ which aims to develop a prediction model based on project delay variables to determine the time required for project implementation, This study was conducted in Qatar, The researchers followed the method of data collection literature survey (based on historical data records) to build questionnaire survey and research sample professionals at a construction company in Qatar, then (identified 49 factors causing delay in construction projects based on project parties, such as Implementation of safety procedures by client , Incomplete contract documents by consultant, Lack coordination with subcontractors by contractor), then used these data to

build two different algorithms based on machine learning (Decision Tree) and (Naïve Bayesian),Trained ,tested and analyzed.

The researchers reached the following results about the power of machine learning algorithms to predict construction project delays in the future by making a model to predict project delays. Two algorithms were made and the algorithms were evaluated through the WEKA program, Naïve Bayes showed the lowest accuracy and the highest error rate, while Decision tree is more accurate and has a lower error rate.

(El-Sawalhi & Shehatto, 2014); The researcher conducted a study with the title "A Neural Network Model for Building Construction Projects Cost Estimating ", The study aimed to develop a model to predict the cost of future projects through the industrial neural network.

This study was conducted in Gaza Strip and the researcher adopted the method of data collection through a questionnaire, data collection related to construction projects that were established since (2009-2021) and 169 of the construction sectors in the Gaza Strip.

The research sample includes construction institutions.

A questionnaire was distributed to them with a number of 80 questionnaires to determine the most important factors of the most effective criteria for knowing the cost of projects.

It turned out that there are 13 cost factors for the skeleton stage and 18 factors for the finishing stage.

The artificial neural network model was put to many tests.

The researchers reached the following results: After developing an artificial neural network (ANN) model to estimate the estimated cost of construction projects in the early stages, artificial neural network (ANN) was used to predict the future parametric cost of the project and the best more accurate model were a Multilayer Perceptron Network (MLP) model.

2.9.1 Commenting on Previous Studies

A study (Egwim et al., 2021) agreed on the independent variable, which looked at (Applied artificial intelligence for predicting construction projects delay), and this study helped in understanding artificial intelligence and contributed to building study variables, The study (Yaseen et al., 2020) agreed on the independent variable, which searched for (Prediction of Risk Delay in Construction Projects Using a Hybrid Artificial Intelligence Model), and this study helped to know and understand the nature of artificial intelligence and contributed to building the study variables, The study (Al-Tawal, Arafah and Sweis, 2020) agreed on the independent variable and agreed in one of the dependent variables, which is the cost, which was examined in (A model utilizing the artificial neural network in cost estimation of construction projects in Jordan(, and this study contributed to building the study mode, The study (Chandanshive

and Kambekar, 2019) agreed in the independent variable and agreed in one of the dependent variables, which is the cost, which was researched in (Estimation of Building Construction Cost Using Artificial Neural Networks(, and this study contributed to building the study model, The study (Hakami and Hassan, 2019) agreed in the independent variable and agreed in one of the dependent variables, which is the cost, which was researched in (PRELIMINARY CONSTRUCTION COST ESTIMATE IN YEMEN BY ARTIFICIAL NEURAL NETWORK), and this study contributed to building the study model, The study (Abd and Naseef, 2019) agreed in the independent variable and agreed in one of the dependent variables, which is the cost, which was searched in (Predicting the Final Cost of Iraqi Construction Project Using Artificial Neural Network(, and this study contributed to building the study model, The study (Barros, Marcy and Carvalho, 2018) agreed in the independent variable and agreed in one of the dependent variables, which is the cost, which was examined in (Construction Cost Estimation of Brazilian Highways Using Artificial Neural Networks(, and this study contributed to building the study model, The study (Al-Zubaidi, Yas and Abbas, 2019) agreed on the independent variable and agreed in one of the dependent variables, which is time, which was examined in (Guess the time of implementation of residential construction projects using neural networks ANN), This study contributed to understanding the nature of artificial intelligence in addition to construct the study variables, The study (Peško et al., 2017) agreed in the independent variable and agreed in one of the dependent variables, which is the cost, which was examined in (Estimation of Costs and Durations of Construction of Urban Roads using ANN and SVM(, and this study contributed to building the study variables, The study (Alqahtani and Whyte, 2016) agreed in the independent variable and agreed in one of the dependent variables, which is the cost, which was examined in (Estimation of life-cycle costs of buildings: regression vs artificial neural network(, and this study contributed to building the study variables, The study (Naik and Radhika, 2015) agreed in the independent variable and agreed in the dependent variables, which were discussed in (Time and Cost Analysis for Highway Road Construction Project Using Artificial Neural(, which will be used later in comparing the results of the study, The study (Yildirim, 2015) agreed on the independent variable, which looked at (Machine Learning Algorithms for Construction Projects Delay Risk Prediction(, and this study contributed to understanding the nature of artificial intelligence and building the study model, The study (El-Sawalhi and Shehatto, 2014) agreed in the independent variable and agreed in one of the dependent variables, which is the cost, which was searched in (A Neural Network Model for Building Construction Projects Cost Estimating(, and this study contributed to building the theoretical framework in addition to

constructing the study variables, The study (Kyivska and Tsiutsiura, 2021) agreed on the independent variable, which looked at (Implementation of Artificial Intelligence in The Construction Industry and Analysis of Existing Technologies(, and this study contributed to building the theoretical framework in addition to understanding the nature of artificial intelligence, The study (Regona, Yigitcanlar and Xia, 2022) agreed on the independent variable, which looked at (Opportunities and Adoption Challenges of AI in the Construction Industry: A PRISMA Review(, and this study contributed to building the theoretical framework in addition to understanding the nature of artificial intelligence, The study (Arba, 2021) agreed on the independent variable and agreed in one of the dependent variables, which is the cost, which was researched in (Future Directions of Cost and Productivity Estimating using Artificial Intelligence (AI)(, and this study contributed to building the study variables, The study (Galli, 2020) agreed in the independent variable and agreed in the dependent variables, which were searched in (Application of Multiple Regression and Artificial Neural Networks as Tools for Estimating Duration and Life Cycle Cost of Projects(that will be used later in comparing the results of the study, The study (Varouqa, 2021) agreed on the independent variable, which looked at (Using Artificial Intelligence and computation Enhanced apply in neural network(, and this study contributed to building the theoretical framework in addition to understanding the nature of artificial intelligence, The study (Huang, Li and Fu, 2019) agreed on the independent variable, which looked at (Review on Application of Artificial Intelligence in Civil Engineering(, and this study contributed to building the theoretical framework in addition to understanding the nature of artificial intelligence, The study (Tijanić, Car-Pušić and Šperac, 2020) agreed on the independent variable and agreed in one of the dependent variables, which is the cost, which was researched in (Cost estimation in road construction using artificial neural network(, and this study contributed to building study variables and understanding the nature of artificial intelligence, The study (Shemi and Asok, 2020) agreed on the independent variable and agreed in one of the dependent variables, which is the cost, which was examined in (Examination of Cost Overrun in Highway Projects Using Artificial Neural Networks in Kerala(, and this study contributed to building the study variables and understanding the nature of artificial intelligence.

Table 2.7 summarizes the main points of the previous studies.

Table (2.7)
Summary of previous studies

Researcher Name	Year	Research title	The aim	Methodology	Results
Regona, Yigitcanlar and Xia,	2022	Opportunities and Adoption Challenges of AI in the Construction Industry: A PRISMA Review	To grant a precis of a full array of artificial intelligence technologies and identify the key challenges worried in their applications.	Descriptive analytical approach	The use of AI applications for example smart sensors, in the construction industry throughout the life cycle of the project, and the integration of AI applications with current technologies is the future of the construction industry.
Egwim et al.	2021	Construction Schedule Risk Assessment and Management Strategy for Foreign General Contractors Working in the Ethiopian Construction Industry.	To demonstrate that sophisticated models of artificial intelligence are capable of predicting project delays.	Descriptive analytical approach	Reduce the delay of construction projects by using Machine Learning Algorithms.
Cheng & Darsa	2021	Construction Schedule Risk Assessment and Management Strategy for Foreign General Contractors Working in the Ethiopian Construction Industry.	To create a project time-delay forecasting model using artificial neural networks and the Garson algorithm	Descriptive analytical approach	The ability of synthetic neural networks to predict the delay of future construction projects is a useful technique for managing and controlling the schedule of future construction projects.
Kyivska and Tsiutsiura	2021	Implementation of Artificial Intelligence in The Construction Industry and Analysis of Existing Technologies	To use artificial intelligence to apply an approach that links information technology and artificial intelligence in the construction industry.	Descriptive analytical approach	Forecasting the time in construction projects, improving construction processes and making better decisions

Researcher Name	Year	Research title	The aim	Methodology	Results
Varouqa,	2021	Using Artificial Intelligence and computation Enhanced apply in neural network	To reduce cost and time in prefabricated construction by focusing on artificial neural network technology.	Descriptive analytical approach	Forecast the time and cost of construction projects.
Huang, Li and Fu,	2019	Review on Application of Artificial Intelligence in Civil Engineering.	To review the development and application of Intelligent algorithms for artificial neural networks in civil engineering.	Descriptive analytical approach	Big Data and deep learning technologies have been successfully implemented in different parts of civil engineering such as highway engineering, geotechnical engineering, health engineering.
Jaiswal et al.,	2021	Time delay and cost escalation in construction works.	It aims to demonstrate and quantify the consequences of delays in building projects, such as time and cost overruns.	Descriptive analytical approach	The causes that contribute to delays in Indian construction projects, the first reason was (Material related delays), the second reason was (Labor-related delays), the third reason was (Equipment related delays).
Tarawneh et al.,	2020	Time and Cost Overruns in Jordanian Building Construction Projects	To determine the primary elements that influence and cause cost overruns and time delays in Jordanian building projects.	Descriptive analytical approach	Contractors assure clients that issues with money and competence have a substantial impact on schedule delays and cost overruns. Clients and consultants acknowledge that design issues can potentially have a big bang, yet Additionally, the experts believe that there are a number of issues that significantly contribute to the time and expense overruns caused by poor workmanship.
Herrera et al.,	2020	Cost Overrun Causative Factors in Road	To review the previous literature to find out the most important factors	Descriptive analytical	The top-ranked factors to cost overruns (Failures in design, price variations of

Researcher Name	Year	Research title	The aim	Methodology	Results
		Infrastructure Projects: A Frequency and Importance Analysis	and reasons that lead to cost overruns in road infrastructure projects.	approach	materials, Inadequate project planning, Project Scope change, Design Changes, Unrealistic contract duration, and Inadequate bidding method).
Roumeissa,	2019	Impact of Delay on Cost Overrun in Construction Projects in Algeria	To determine the effect of schedule delays on cost overruns.	Descriptive analytical approach	The proposed model is suitable for cost overrun prediction, and construction project practitioners can use it as a preventative strategy to lower potential cost overruns.
Akhund et al.,	2018	Contributing Factors of Time Overrun in Public Sector Construction Projects.	To identify and classify time overrun reasons in Pakistani public-sector projects.	Descriptive analytical approach	the Four top-ranked factors for time overruns, the first was the financial issues faced by constructors are a crucial element in time overruns and scheduling, and Inadequate planning was ranked as the second most common cause of time overruns by the stakeholders, The client's financial troubles were the third most significant factor affecting the expected completion time of the construction project, and Client decision-making delays were ranked fourth contributing to time overrun.
Bekr,	2018	Study and Assessment of Causes and Effects of Delay in Large Public Construction Projects in Jordan.	To determine the most major reasons of delays in big public projects in Jordan.	Descriptive analytical approach	The top factors to delay in large public construction projects first reason was the contractor's management and supervision, the second reason falls the constant change of customers on the design, and the third most major cause of delay for

Researcher Name	Year	Research title	The aim	Methodology	Results
					large-scale public construction projects in Jordan is cash flow challenges encountered by contractors.
Rezaei & Jalal,	2018	Investigating the causes of delay and cost-overrun in construction industry.	To determine the major causes and factors of delay and cost overrun in projects.	Descriptive analytical approach	The top three causes of delay in projects, the first cause was safety precautions, the second cause was the same contractor has a large number of subcontracts, the third cause was labor productivity is low. The top three causes of cost overruns were, the first cause was the unavailability of labor skills, the second cause was contractor policies that are not acceptable, and the third cause was the dominance of the construction industry by foreign companies.
(Arba,)	2021	Future Directions of Cost and Productivity Estimating using Artificial Intelligence (AI)	To develop a model for estimating the cost of engineering services using an artificial neural network approach based on the data of previous projects.	Experimental approach	The effectiveness of analytical statistical methods in cost estimation, in addition to their wonderful contribution to the modeling of artificial neural networks.
Yaseen et al.,	2020	Prediction of Risk Delay in Construction Projects Using a Hybrid Artificial Intelligence Model	To development of integrated hybrid and classified artificial intelligence models Random forest (RF) and with improved genetic algorithm (RF-GA) to predict the delay problem of the project.	Descriptive analytical approach	The genetic algorithm's ability to tackle problems with multiple solutions.
Al-Tawal et al.,	2020	A model utilizing the artificial neural network in	To verify the effectiveness of artificial neural networks in	Descriptive analytical	There are no significant differences between the estimated cost and the actual

Researcher Name	Year	Research title	The aim	Methodology	Results
		cost estimation of construction projects in Jordan.	overcoming cost estimation problems in the early stages of the building design process.	approach	budget value.
Galli,	2020	Application of Multiple Regression and Artificial Neural Networks as Tools for Estimating Duration and Life Cycle Cost of Projects	To compare the accuracy of artificial neural network models and multiple regression as well as forecasting the project duration and cost by applying simulations in the building models.	Descriptive analytical approach	That Neural networks have proven their efficiency, and they have been classified as the best model that deals with estimating cost and time in projects.
Tijanić, Car-Pušić and Šperac,	2020	Cost estimation in road construction using artificial neural network	To model smart neural networks of all kinds to estimate road construction costs like Multilayer perceptron (MLP), Generalized regression neural network (GRNN), Radial Basis Function Neural Network (RBFNN).	qualitative and quantitative Approaches	the best values were to use the (Generalized regression neural network) GRNN approach in road projects and be within the initial design stage.
Shemi and Asok,	2020	Examination of Cost Overrun in Highway Projects Using Artificial Neural Networks in Kerala	To develop neural network models and regression models to analyze the cost overrun of future projects by identifying the reasons that contribute to the cost escalation of projects.	Descriptive analytical approach	That The neural network shows the most likely model to measure costs in projects, and the best network model that shows a measurable model that is of one hidden layer is cost overrun.
Chandanshive & Kambekar,	2019	Estimation of Building Construction Cost Using Artificial Neural Networks	To develop a self-learning model based on a neural network to estimate the cost of building construction at an early stage of construction.	Descriptive analytical approach	that the best neural network model is the organizational approach where it outperforms by using the early stop approach, where the Bayesian organization (training) performs better, and that the trained neural network can

Researcher Name	Year	Research title	The aim	Methodology	Results
					accurately predict the cost of setting up the early stage of construction, and this depends on the size of the data, the more data, the more accurate the prediction.
Hakami & Hassan,	2019	Preliminary Construction Cost Estimate in Yemen By Artificial Neural Network	To use of the artificial neural network application to determine the initial cost of projects	qualitative and quantitative Approaches	the modern technology ANN has proven its effectiveness and efficiency with high initial cost with the smallest time and thus project costs can be estimated easily and quickly, as this technology is easy to use and can be implemented through Excel and Nonresolution program, the results are highly dependent on the amount of data used.
Abd & Naseef,	2019	Predicting the Final Cost of Iraqi Construction Project Using Artificial Neural Network.	To use ANN to develop a mathematical equation to estimate the budget of construction projects.	Descriptive analytical approach	Neural network technology has the capacity to develop an effective mathematical equation for calculating the cost of the project, especially when data is incomplete.
Al-Zubaidi et al.,	2019	Guess the time of implementation of residential construction projects using neural networks ANN	To develop a model to foresee the implementation period of a residential project using an artificial neural network.	Experiment approach	The smart neural networks proved its efficiency for forecasting, estimating the duration of residential project implementation and predicting the theoretical design time.
Barros et al.,	2018	Construction Cost Estimation of Brazilian Highways Using Artificial Neural Networks.	To develop an accuracy, estimate for highways using artificial neural network.	qualitative and quantitative Approaches	It turns out that smart neural networks are an effective tool and have a significant role in cost estimation, this was confirmed by the mathematical results, where a high level of accuracy was

Researcher Name	Year	Research title	The aim	Methodology	Results
					obtained.
Peško et al.,	2017	Estimation of Costs and Durations of Construction of Urban Roads Using ANN and SVM	To study the precision that artificial intelligence may attain when estimating cost and time in building projects.	Descriptive analytical approach	The artificial neural network has proven its ability to estimate the cost, and estimate the time period in an excellent way if each network is built separately, when the cost estimation data and the time period forecast data were collected and built in a single network, the model was not accurate. while the support vector machines (SVM) model proved its efficiency in estimating the time and cost better.
Alqahtani & Whyte,	2016	Estimation of life-cycle costs of buildings: regression vs artificial neural network.	To compare between artificial neural network and the performance of regression to improve accuracy for estimate the cost of building projects.	qualitative and quantitative Approaches	the artificial neural network (ANN) is model better than multiple regression model to predict running-cost of building projects most accurate means and method for estimating operating costs.
Naik & Radhika,	2015	Time and Cost Analysis for Highway Road Construction Project Using Artificial Neural Networks.	To compare between two successful projects in highway roads based on artificial neural networks.	Descriptive analytical approach	The approach taken to use Artificial neural networks reduces the risks of exceeding the budget and the time scheduled for construction and increases the quality of the decisions taken.
Yildirim,	2015	Machine Learning Algorithms for Construction Projects Delay Risk Prediction	To develop machine learning models in order to facilitate accurate project delay risk analysis and prediction using objective data source.	Descriptive analytical approach	the (ML) based approach is the most appropriate in terms of dealing with variables and the most efficient

Researcher Name	Year	Research title	The aim	Methodology	Results
Asadi et al.,	2015	A machine learning approach for predicting delays in construction logistics	To develop a prediction model based on project delay variables to determine the time required for project implementation	Descriptive analytical approach	To predict construction project delays in the future, by making a model to predict project delays. Two algorithms were made, Naïve Bayes showed the lowest accuracy and the highest error rate, while Decision Tree is more accurate and has a lower error rate.
El-Sawalhi & Shehatto,	2014	A Neural Network Model for Building Construction Projects Cost Estimating.	study aimed to develop a model to predict the cost of future projects through the industrial neural network.	Descriptive analytical approach	To predict the future cost of the project, the best more accurate model was a Multilayer Perceptron Network (MLP) model.

2.9.2 What Distinguishes This Study from Previous Studies

By reviewing previous studies related to the subject of the current study, it is possible to summarize what distinguishes the current study from the previous one in the following areas:

1. **Study topic:** previous studies presented the various variables and discussed the most important reasons for making changes to them, their most important problems, and the most important recommendations to preserve them, while the current study examined the impact of artificial intelligence in reducing cost and time in Jordan specifically, knowing that this environment lacks this type of study in light of the great waste in cost and time, and thus the researcher relied mainly on the study tool, which is the questionnaire and through which access to the results is gained. Within the limits of the researcher's knowledge, the construction projects have not received much luck from the studies.
2. **Study environment:** most of the previous studies were conducted on foreign countries that are characterized by the continuous development of modern tools and concepts that relied heavily and early on artificial intelligence and studied its impact and role in reducing some negative phenomena in societies, while the current study was conducted on the environment of Jordan, specifically the city of Aqaba.
3. **Objective of the study:** previous studies aimed to study one variable related to the current study with other variables and to identify their characteristics. To the best of the researcher’s knowledge, he did not find any study linking the impact of artificial intelligence in reducing cost and time, and therefore the current study seeks to link the variables together to obtain results for the first time.
4. **Study methodology:** the researcher agreed with most of the previous studies and adopted the questionnaire method to analyze the information and to identify the characteristics of the variables. However, what distinguishes the study is that the researcher conducts the study on construction projects in an attempt to obtain the greatest degree of accuracy in collecting information, and thus that information is reflected in order to extract the correct results.
5. **The time of conducting the study**: this study was conducted at a time when there was an urgent need to reconsider business and find sufficient flexibility for a new working mechanism to keep pace with the rapid changes and because the world is now in a transitional stage from the era of knowledge to the era of artificial intelligence, and as a result of the Corona pandemic, left in the stage of recovery For the world as a whole, and given the accumulation it caused in the local and global markets and the suspension of work and production, all of this constituted a challenge and, at the same time, opportunities for organizations.

6. **Study population:** The study was conducted in construction projects represented by (contractors, engineering offices, supervision offices) and this gives the study the distinction of distinguishing those projects whose works are distributed in all the governorates of the Hashemite Kingdom of Jordan, and because they work in different sectors. The work in these projects is a strategic and dependent It is in the huge construction, and it is in constant need of amendments and making change orders. Therefore, flexibility and possession of tools and successful management for the stability of this sector, which has recently proven to possess superior strategic capabilities, is considered one of the most important organizations that have a contribution to supplying the national economy, which has proven its presence and capabilities in Natural and exceptional circumstances.
7. **The sampling unit and the study sample:** the sampling unit represented functions of strategic importance in those projects :(project managers, site engineers, computer quantities engineers, computer engineers) working on construction projects in Aqaba, and this category represents leadership and supervisory jobs In projects, it is considered the main driver, which has a direct impact on business and work procedures, and they are directly involved in the formulation, planning, organization, and control of the variables and dimensions of the study, while what distinguishes the study sample is that it relies on a proportional stratified random sample, where this type of sample is more representative and provides homogeneity Within each stratum, the number of all strata was taken proportional to the size of the stratum in the total study population.

Chapter three
Research Design and Methodology

3.1 Preface

This chapter reviews the study methodology that was used, which includes the method and procedures, the population and the sample, in addition to providing evidence of validity and reliability for the study tool (the questionnaire), as well as the most important statistical procedures that were used to process the data collected from the study sample.

3.2 Methodology

The quantitative approach based on hypothesis testing was used to reach and achieve the study's objectives, as this approach is considered one of the common scientific approaches in many studies and different fields of knowledge. The relationship between the study's variables and the impact of artificial intelligence to reduce cost and time in construction projects is as follows: as the following dimensions were used to measure artificial intelligence (neural networks, genetic algorithms, expert systems, and intelligent agents).

The following sources were used to achieve the objectives of the study:

1- Primary sources include the data collected through the study tool (the questionnaire).

2- Secondary sources include literature and previous studies related to study variables, including books, published and unpublished scientific papers, and websites.

3.3 Population

The study population consists of all engineers working in engineering offices, consulting companies, and contracting companies, a total of 320 engineers in Aqaba city. According to the Jordanian Contractors Association's data, there are 15 construction firms registered in Aqaba for the year 2021 in the sectors of building, roads, electromechanical, sewage, and specialized works. Their classifications are first-degree, second-degree, and third-degree. According to the Jordanian Engineers Association’s data, Aqaba branch, there are 8 engineering offices registered in Aqaba for the year 2021. According to Aqaba Development Corporation (ADC), the number of projects in Aqaba at the time of the application of this study was 19 projects containing construction work, and every project has a consultant company to supervise the project. The researcher chose a simple random sample from the study community and, depending on the size of the total community, so that the permissible error rate is 5%, and based on the sample size table, the sample size will be 175

engineers. After collecting the data, the number of the retrieved questionnaires reached 169, with a percentage of 96.5%, and the validity of these questionnaires was verified for conducting statistical analysis.

3.4 Study Tool (Questionnaire)

In order to reach the achievement of the main and sub-objectives related to this study, the researcher conducted a comprehensive review of the literature related to the subject of the study and then developed a tool for the study, which is a questionnaire. Data on the study variables were collected in order to verify the effect of artificial intelligence (neural networks, genetic algorithms, expert systems, intelligent agents) to reduce cost and time in construction projects.

The questionnaire consisted of the following sections:

1- The first section includes items that talk about the demographic and functional characteristics of the participants, such as gender, age, educational qualification, years of experience, job title, and work sector.

2- The second section, includes items on the independent variable related to artificial intelligence and its sub-variables (artificial neural networks, genetic algorithms, expert systems, intelligent agent) and this section consists of 25 items.

3- The third section includes the items on the dependent variable related to reducing cost and time in construction projects. This section consists of 18 items.

Table (3.1) shows the distribution of the questionnaire items on the study dimensions.

Table (3.1)
The distribution of the questionnaire items

Variable	Items numbers	References
Neural networks	7	(Varouqa, 2021); (Shemi and Asok, 2020); (Al-Tawal et al., 2020); (Abd & Naseef, 2019) (El-Sawalhi & Shehatto, 2014)
Genetic algorithms	5	(Arba, 2021); (Kyivska and Tsiutsiura, 2021); (Huang, Li and Fu, 2019);
Expert systems	6	(Cheng & Darsa, 2021);
intelligent agent	7	(Regona, Yigitcanlar and Xia, 2022);
Reducing cost and time	18	(Egwim et al., 2021); (Jaiswal et al., 2021); (Shemi and Asok, 2020) (Asadi et al., 2015)
All items	43	-

The five-point scale developed by Likert was used to evaluate the statements related to the study's axes, and the evaluation levels were relied on as follows:

Table (3.2)
Likert scale

strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
1	2	3	4	5

Likert scale is processed mathematically according to the following mathematical equation:
(Upper level-Lower level)/Levels of importance.
(5-1) /3=1.33
Thus, the degrees of importance are as follows:
1 + 1.33 = 2.33 Low level (1-2.33)
2.33 + 1.33 = 3.66 Medium level (2.34-3.66)
3.66 + 1.33 = 5 High Level (3.67-5).

3.5 Statistical Methods Used in The Analysis

In order to achieve the objectives of the study and test its hypotheses, a procedure was carried out by resorting to the statistical package for the social sciences (SPSS) and the following statistical methods:

a. Descriptive statistics (frequencies, percentages, mean, standard deviations).
b. Exploratory factor analysis to detect construct validity in the items of the questionnaire.
c. Cronbach's alpha test to measure the internal consistency between the questionnaire items.
d. Testing the normal distribution of the study variables.
e. Variance inflation factor to ensure that there is no multicollinearity between the independent variables.
f. Multiple regression analysis is used to test hypotheses.

3.6 The Validity and Reliability of The Study Tool

Before testing the hypotheses, the validity and reliability of the questionnaire items and the main variables were ascertained. These procedures are considered among the important methodological procedures before testing the hypotheses.

In order to ensure the validity and reliability of the study tool, and that this tool can be trusted with the results of its statistical analysis, the researcher performed the following procedures:
1- Content Validity
2- Construct validity
3- Cronbach's alpha coefficients.

3.6.1 The Content Validity

In order to verify that the study tool (the questionnaire) can measure the scientific phenomenon and the variables that were set to achieve the objectives of the study, this was confirmed through the content validity as the procedures and directions of many academics and specialists in the field of engineering management science with scientific experience were used. The academic researcher distributed the questionnaire for arbitration purposes to many faculty members in universities and specialists in engineering projects, in addition to an expert in artificial intelligence, and Appendix No. (3) shows their names.

3.6.2 The Construct Validity

Construct validity can be defined as "the extent to which the scale represents, or a group of measures related to the concept of the study to be studied" (Hair et al., 2010). To measure the validity of the linked items through several statistical tests, where exploratory factor analysis is one of the most important tests to ascertain the level of construct validity between the items of the study variables combined.

The main purpose of this test is to verify the extent to which the items of the factor are related to each other and the extent to which they are saturated with the factor, thus achieving the maximum validity of the scale (Hair et al., 2014).

The following statistical measures were used when exploratory factor analysis was used:

1- Kaiser-Mayer-Olkin KMO test: to verify the sufficiency of the sample size to perform the test and that the statistically acceptable threshold should be higher than (0.50).

2- Factor loadings: to describe variability, where the loading factors are considered the statistical indicator that measures the duration of the correlation and saturation of the items on the factor and the minimum limit for accepting the item and considering it valid for statistical analysis (0.50) and that any item whose loading factor is less than (0.50) is excluded.

3.6.2.1 The Construct validity of The Items of the Artificial Intelligence Variables.

Table (3.3)

Exploratory factor analysis of the dimension of Artificial intelligence items

No	Item	Factor loading	KMO Test
	Neural networks		
1	Artificial neural network systems in construction projects simulate the way workers deal with engineering problems.	0.726	0.746
2	Artificial neural networks help predict problems before they arise using big data and analytics	0.785	
3	Artificial neural networks help workers in construction projects improve the quality of work.	0.714	
4	Artificial neural networks in construction projects do not help solve engineering problems.	0.511	
5	The construction projects provide training programs for workers in the use and understanding of artificial neural networks.	0.537	0.746
6	Artificial neural networks aid deep learning among construction project workers.	0.691	
7	Artificial neural networks in construction projects help to identify errors in the implementation of projects.	0.654	
	Genetic algorithms		
8	Genetic algorithms help to find the best solutions to problems in construction projects.	0.710	0.789
9	Genetic algorithms are one of the techniques that help in searching for the best option among all the available options.	0.723	
10	Genetic algorithms help to calculate the best costs for construction projects.	0.748	
11	Genetic algorithms contribute to devising new strategies for implementing construction projects.	0.773	0.789
12	Genetic algorithms help in developing computer programs used in construction projects.	0.736	

No	Item	Factor loading	KMO Test
	Expert systems		
13	Expert systems help to change the solutions that have been reached in construction projects.	0.674	
14	The expert systems in construction projects are characterized by the ease that their users can understand.	0.636	
15	Expert systems contribute to reducing construction project costs.	0.789	0.791
16	Expert systems help specialists perform high in construction projects.	0.764	
17	Expert systems have an effective role in solving the problems facing construction projects.	0.814	
18	The costs of using expert systems in construction projects are high.	0.525	
	intelligent agent		
19	The smart agent helps to avoid wasting time in construction projects.	0.745	
20	The costs of using the smart agent in construction projects are high.	0.528	
21	The smart agent helps continuous learning in construction projects.	0.707	0.855
22	The smart agent has a superior ability to store and retrieve data when needed in construction projects.	0.810	
23	The smart agent in construction projects contains an integrated system that can accomplish difficult tasks through smart behaviors	0.664	
24	The smart agent is applied in construction projects to realize future needs in order to provide better performance	0.679	0.855
25	The smart agent contributes to reducing the costs of construction projects.	0.708	

Table (3.3) refers to the EFA test in order to verify the construct validity of the questionnaire items for the independent variables related to artificial intelligence.

It is evident from the results in Table (3.3) that all values of the KMO test were greater than (0.50), and this indicates the sufficiency of the sample size to conduct the analysis.

The values of factor loadings were higher than (0.50), and this indicates the validity of these items in the interpretation of factors or variables.

3.6.2.2 The Construct Validity of The Items of The Variable Cost and Time Reduction

Table (3.4)
Exploratory factor analysis of the dimension of reducing cost and time items

No	Item	Factor loading	KMO Test
	reducing cost and time		
26	The contractor's lack of financial liquidity leads to an increase in time in construction projects.	0.656	0.878
27	Weak technical and administrative skills lead to an increase in time in construction projects.	0.668	
28	The consultant’s delay in approving the executive plans leads to an increase in the time in the construction projects.	0.671	
29	Engineering design modifications are one of the reasons for delaying the project implementation period.	0.691	
30	Irregular financial payments are one of the reasons for delaying the project completion period.	0.694	
31	Non-compliance with the technical specifications leads to re-work and a delay in the completion of the project.	0.741	
32	The competence and experience of the supervising authority plays a key role in not exceeding the project implementation period.	0.604	0.878
33	The existence of inconsistencies between the bid documents leads to an increase in the project implementation period.	0.639	
34	Change orders are one of the reasons that contribute to increasing the duration of construction projects.	0.625	

No	Item	Factor loading	KMO Test
35	Continuous monitoring has a role in limiting the increase in the time period for project implementation.	0.505	
36	Commitment to quality leads to an increase in the time period for implementing construction projects.	0.600	
37	The contractor's lack of financial liquidity leads to an increase in the cost of construction projects.	0.662	
38	Weak technical and administrative skills lead to an increase in the cost of construction projects.	0.627	
39	The consultant’s delay in approving the executive plans leads to an increase in the cost of construction projects.	0.604	
40	Engineering design modifications are one of the causes of increased project costs.	0.622	0.878
41	The existence of inconsistencies between the bid documents will result in project costs being overrun.	0.628	
42	Variation orders are considered to have a clear impact on the cost of construction projects.	0.634	
43	Continuous monitoring has a role in reducing the cost increase in construction projects.	0.591	

Table (3.4) refers to the EFA test in order to verify the construct validity of the questionnaire items for the dependent variable related to reducing time and cost.

It is evident from the results in Table (3.4) that the value of the KMO test was greater than (0.50), reaching (0.878), and this indicates the sufficiency of the sample size to conduct the analysis.

The values of factor loadings were higher than (0.50), and this indicates the validity of these items in interpreting the factor or variable.

3.6.2.3 The Reliability of The Study Tool

Reliability is defined as the degree of internal consistency between the items in the questionnaire, as the internal consistency between the items is explained by the presence of stability in the answers of the participants in

the study over time, as the stable and stable test give consistent results over time when applied to the same group.

The internal consistency between the questionnaire items was verified by Cronbach's alpha test, where the result is statistically acceptable if the value of Cronbach's alpha coefficient is greater than (0.70) (Hair et al., 2019). Table (3.5) shows the test results.

Table (3.5)

Cronbach alpha values for variables items

Variables	Cronbach alpha values	Items No
Neural networks	0.758	7
Genetic algorithms	0.791	5
Expert systems	0.754	6
Intelligence agent	0.814	7
Reducing cost and time	0.888	18
All items	0.921	43

Table (3.5) refers to the values of Cronbach's alpha test, which aims to test the reliability of the study tool. It is clear from the results contained in Table (3.5) that all values of Cronbach's alpha coefficient were greater than (0.70), where the values ranged between (0.754-0.888) and the general stability of all items was (0. 921), it can be said that the reliability of the questionnaire items is reliable and its results can be trusted over time.

3.7 Demographic Characteristics of The Study Participants

Table (3.6) refers to the data of the demographic study sample members, which includes (gender, age, educational qualification, and years of experience, job title, and work sector).

Table (3.6)

Demographic characteristics of the study participants

Variable		Frequency	%
Gender	Males	94	55.6%
	Females	75	44.4%
Age	Less than 30 years	51	30.2%
	30- less than 40	67	39.6%
	40- less than 50	27	16%
	50 years and above	24	14.2%
Education	Diploma	1	0.5%
	Bachelor	134	79.3%
	Master	28	16.6%
	PhD	6	3.6%
Experience	Less than 5 years	46	27.2%
	5- Less than 10	48	28.4%
	10- Less than 15	27	16%
	15 years and above	48	28.4%
Job position	Project manager	27	15.9%

Variable		Frequency	%
	Engineer	42	24.9%
	Engineer with administration title	36	21.3%
	Planning Engineer	12	7.1%
	Design Engineer	20	11.8%
	Quality Engineer	2	1.2%
	Quantity Surveyor Engineer	5	3%
	Site Engineer	25	14.8%
Sector	government sector	61	36.1%
	Engineering Consulting Company	37	21.9%
	contracting company	47	27.8%
	engineering offices	24	14.2%
Total		169	100%

Table (3.6) summarizes the results of the demographic characteristics of the study sample members, as the results were as follows:

1- Gender: the majority of the participants in the study were males, with a number of (94) individuals, and a percentage of (55.6%), while the number of females was (75) individuals and a percentage of (44.4%), which indicates that the number of males is greater than the number of females in construction projects in the city of Aqaba. The researcher attributed the reason to the nature of the type of construction projects, where there is a difficulty that requires the presence of males in a greater proportion.

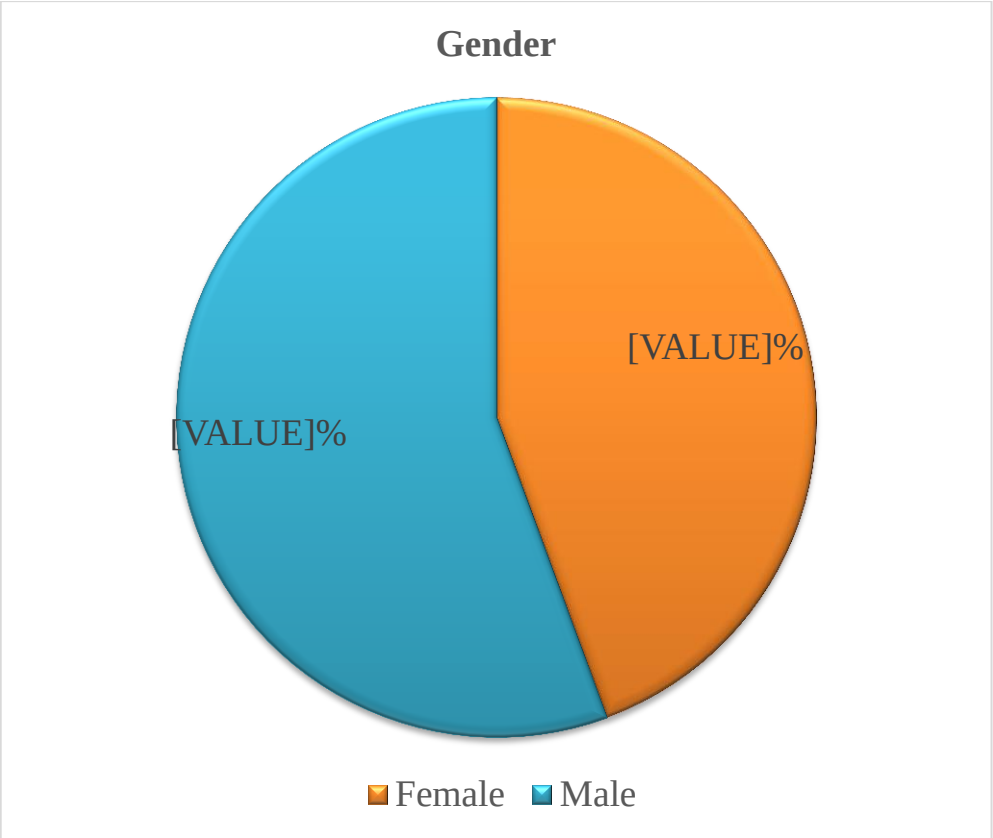

Figure (3.1)
Percentages of sample According to Gender

2- Age: Most of the participants in the study were aged between 30 to less than 40 years old, with a number of (67) individuals and a percentage of (39.6%), and this occupies the first place, and the justification from the researcher's point of view is that this age group includes giving and vitality in addition to experience, and the number of participants in the study who were less than 30 years old was (51) and a percentage (30.2) %) The number of participants in the study whose ages ranged between 40 and less than 50 years was (27) individuals with a percentage (16%), and finally, the number of participants in the study who were aged 50 years and over was (24) individuals with a percentage (14.2%), and the justification from the researcher's point of view is that this is due to the early retirement age of employees.

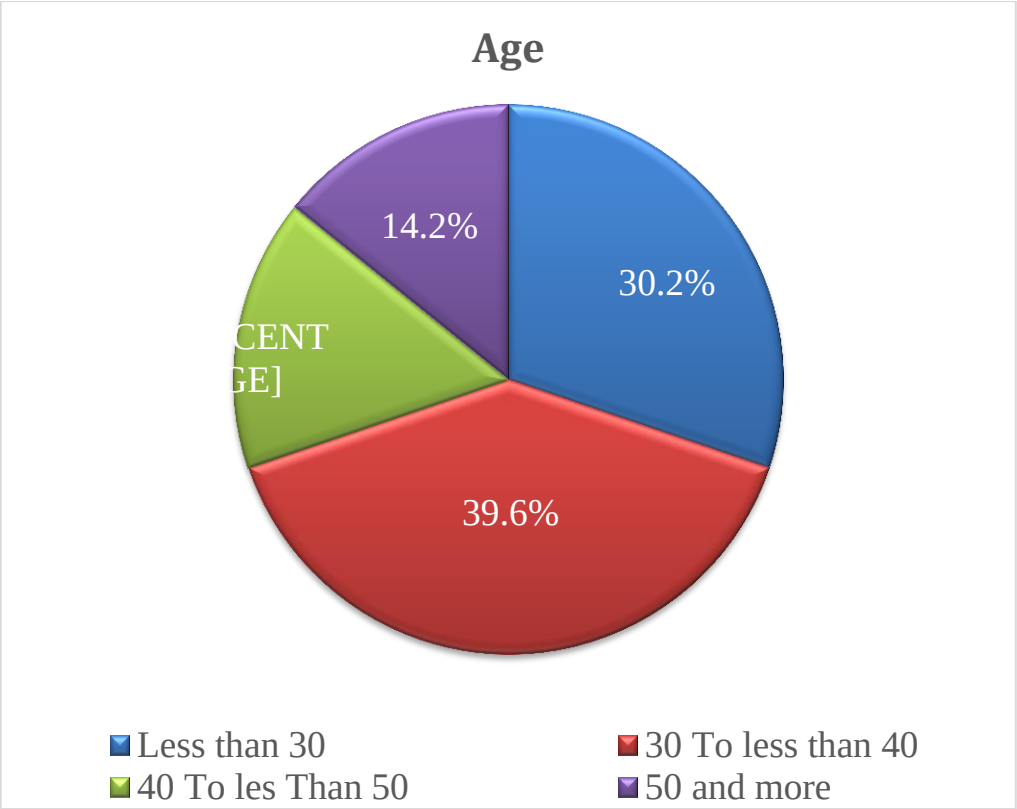

Figure (3.2)
Percentages of sample According to Age

3- Education: in the study sample, the majority of participants were holders of a bachelor's degree, with a number of 134 individuals and a percentage of (79.3%), the number of those who obtained a master's degree was 28 at a rate of (16.6%), and the number of those who obtained a PhD was 6 Individuals (3.6%). Finally, there was only one individual who had a diploma, at a rate of (0.5%).

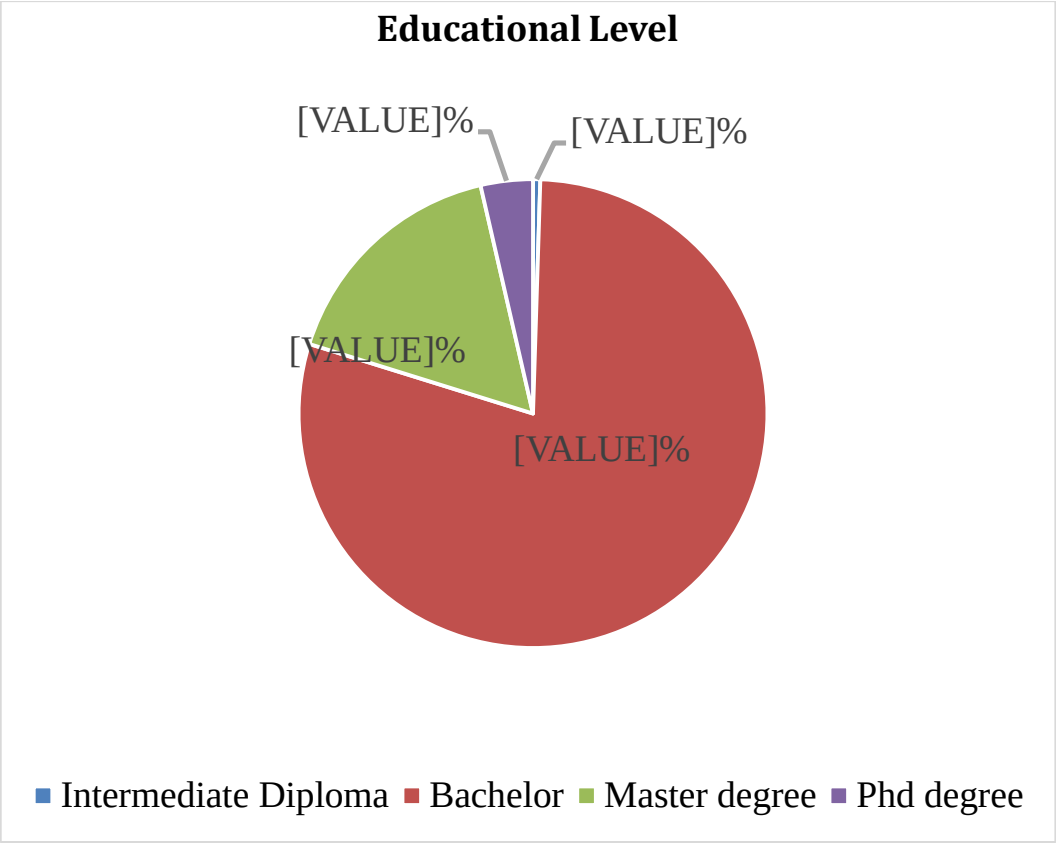

Figure (3.3)
Percentages of sample According to Educational Level

4- Experience: the majority of respondents to the study were those whose years of experience ranged between 5-10 years and also 15 years and more, as their number was (48) individuals for each category, at a rate of (28.4%), the researcher point of view that in the period from(5 years to 10 years) they have the ability and energy ,enthusiasm to applicable the tasks with perfect way, and the employees in the period from (15 years and more) they have a lot of experience , wisdom, and they can applicable the orders tasks faster by the short way that was absorbed from previous experiences in construction projects ,and the number of participants in the study who had five years of experience or less (46) individuals at a rate of (27.2%), and finally the number of individuals whose years of experience ranged from 10 to less than 15 years was (27) and at a rate of (16%).

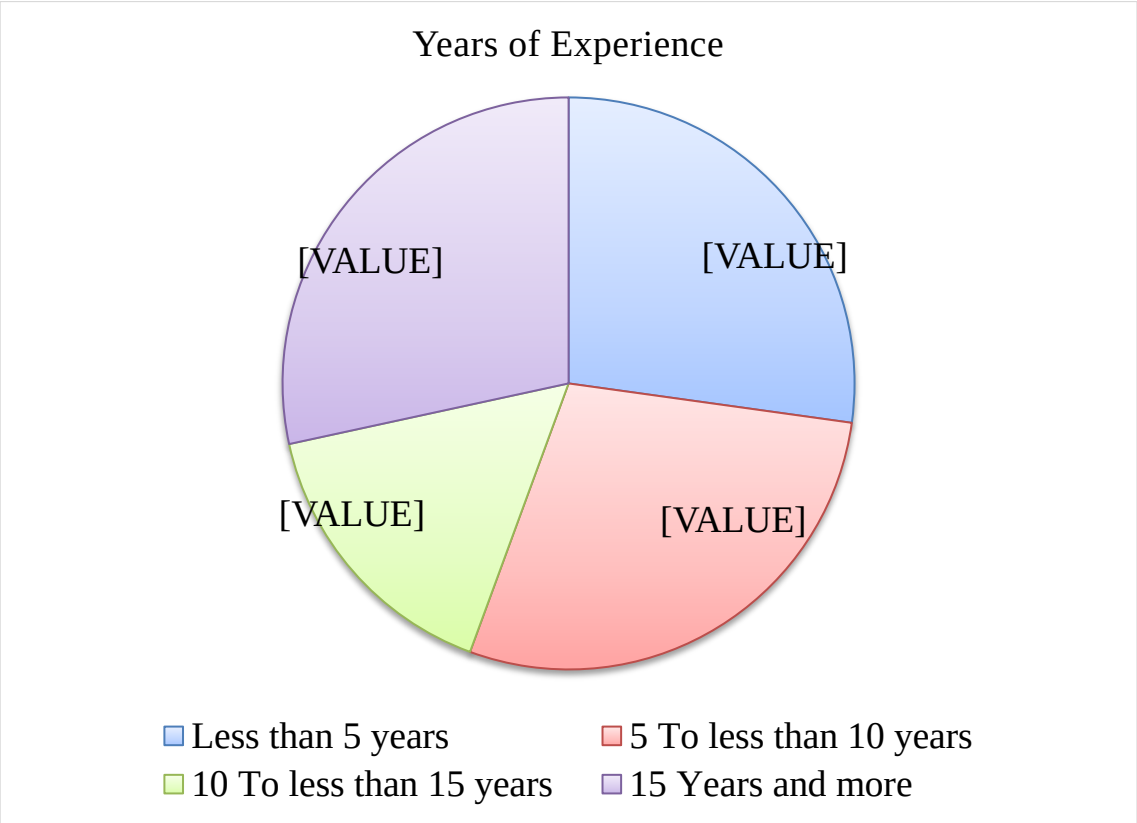

Figure (3.4)
Percentages of sample According to years of Experience

5- Job position: According to the study sample (169), the number of engineers was (42) with a percentage of (24.9%), the number of engineers with administrative titles was (36) at (21.3%), and the number of project managers was (27). At a rate of (15.9%), the number of Site Engineer was (25) individuals at a rate of (14.8%), and the number of Design Engineer (20) was at a rate of (11.8%), and the number of Planning Engineer was (12) individuals at a rate of (7.1%), and the number of Quantity Surveyor Engineer was (5) Individuals with a percentage of (3%), and finally, the number of Quality Engineers was (2) individuals, at a rate of (1.2%).

6- Sector: Most of the participants in the study were employees in the government sector, with a number of (61) individuals and a percentage of (36.1%).

As for the number of the study sample members working in the contracting company, it amounted to (47) individuals, at a rate of (27.8%), and the number of engineers working in the engineering consulting company was (37) individuals, with a percentage of (21.9%). Finally, the number of engineers in the study sample were employees in engineering offices (24) individuals, or a percentage (14.2%).

Chapter Four
Analysis of Results, Conclusions and Recommendations

4.1 Preface

The current chapter reviews the results of data analysis and hypothesis testing. This chapter contains all the tests required to verify and test hypotheses.

This chapter presents the results of descriptive statistics for the study variables, as well as testing the study's hypotheses and conducting the accompanying tests for regression analysis, such as the normal distribution test and multicollinearity.

4.2 Descriptive Statistics Results

The descriptive statistics values were calculated by calculating the values of the mean and standard deviations for all the items of the questionnaire.

4.2.1 Descriptive Statistics for Artificial Network items

Table (4.1)
Descriptive Statistics for Artificial Network items

No	Item	Mean	Standard Deviation	Rank	Importance level
1	Artificial neural network systems in construction projects simulate the way workers deal with engineering problems	3.87	0.737	4	High
2	Artificial neural networks help predict problems before they arise using big data and analytics	4.01	0.699	3	High
3	Artificial neural networks help workers in construction projects improve the quality of work.	4.09	0.709	1	High
4	Artificial neural networks in construction projects do not help solve engineering problems.	2.66	0.677	7	Medium
5	The construction projects provide training programs for workers in the use and understanding of artificial neural networks.	4.08	0.872	2	High
6	Artificial neural networks aid deep learning among construction project workers.	3.64	0.798	6	Medium

No	Item	Mean	Standard Deviation	Rank	Importance level
7	Artificial neural networks in construction projects help to identify errors in the implementation of projects.	3.86	0.725	5	High
	Overall mean	3.74	0.529	-	High

Table (4.1) refers to the descriptive statistics for the items of the neural networks variable, where the overall mean of the items for this variable was (3.74) with a standard deviation of (0.529) and a high level of importance.

This result indicates the importance of applying neural network applications in construction projects, as these applications can solve problems related to cost and time, according to the respondents' point of view.

Item No. (3), which states "Artificial neural networks help workers in construction projects improve the quality of work," was the largest in terms of arithmetic averages, as the arithmetic mean for this item was (4.09) with a standard deviation of (0.709) and a high level of importance.

Item (6), which states "Artificial neural networks aid deep learning among construction project workers," was the lowest with an arithmetic mean (3.64), a standard deviation (0.798), and a medium level of importance.

4.2.2 Descriptive Statistics for Genetic Algorithms Items

Table (4.2)
Descriptive statistic of the items of genetic algorithms

No	Item	Mean	Standard Deviation	Rank	Importance level
8	Genetic algorithms help to find the best solutions to problems in construction projects.	3.88	0.662	4	High
9	Genetic algorithms are one of the techniques that help in searching for the best option among all the available options.	3.89	0.668	3	High
10	Genetic algorithms help to calculate the best costs for construction projects.	3.92	0.727	2	High
11	Genetic algorithms contribute to devising new strategies for implementing construction projects.	3.79	0.808	5	High

No	Item	Mean	Standard Deviation	Rank	Importance level
12	Genetic algorithms help in developing computer programs used in construction projects.	3.93	0.717	1	High
	Overall mean	3.88	0.529	-	High

Table (4.2) indicates the descriptive statistics for the items of the mean variable, where the overall mean of the items for this variable was (3.88) with a standard deviation of (0.529) and a high level of importance.

This result indicates the importance of applying genetic algorithms in construction projects, as these applications can solve problems related to cost and time, according to the respondents' point of view.

Item No. (12), which states "Genetic algorithms help in developing computer programs used in construction projects" was the largest in terms of mean, as the mean for this item was (3.93) with a standard deviation of (0.717) and a high level of importance.

Item (11) which reads "Genetic algorithms contribute to devising new strategies for implementing construction projects." It is the lowest with a mean (3.79), a standard deviation (0.808), and a high level of importance.

4.2.3 Descriptive Statistics for Expert Systems Items

Table 4.3

Descriptive statistic of the items of expert systems

No	Item	Mean	Standard Deviation	Rank	Importance level
13	Expert systems help to change the solutions that have been reached in construction projects.	3.83	0.745	4	High
14	The expert systems in construction projects are characterized by the ease that their users can understand.	3.76	0.750	5	High
15	Expert systems contribute to reducing construction project costs.	3.95	0.657	2	High
16	Expert systems help specialists perform high in construction projects.	4.01	0.650	1	High
17	Expert systems have an effective role in solving the problems facing construction projects.	3.90	0.713	3	High
18	The costs of using expert systems in construction projects are high.	3.43	0.986	6	Medium
	Overall mean	3.89	0.519	-	High

Table (4.3) indicates the descriptive statistics for the items of the expert systems variable, where the overall mean of the items for this variable was (3.89) with a standard deviation of (0.519) and a high level of importance.

This result indicates the importance of applying expert systems in construction projects, as the application of such systems can enhance solving various problems and thus reduce costs and time in construction projects.

Item No. (16), which states "Expert systems help specialists perform high in construction projects" was the largest in terms of arithmetic averages, as the arithmetic mean for this item reached (4.01) with a standard deviation of (0.650) and a high level of importance.

Item (18) which states “The costs of using expert systems in construction projects are high.” was the lowest with an arithmetic mean (3.43), a standard deviation (0.986) and a Medium level of importance.

4.2.4 Descriptive Statistics of Intelligence Agent Items

Table 4.4

Descriptive statistic of the items of Intelligence agent

No	Item	Mean	Standard Deviation	Rank	Importance level
19	The smart agent helps to avoid wasting time in construction projects.	3.98	0.707	1	High
20	The costs of using the smart agent in construction projects are high.	3.67	0.829	7	High
21	The smart agent helps continuous learning in construction projects.	3.89	0.676	3	High
22	The smart agent has a superior ability to store and retrieve data when needed in construction projects.	3.95	0.666	2	High
23	The smart agent in construction projects contains an integrated system that can accomplish difficult tasks through smart behaviors	3.85	0.696	4	High
24	The smart agent is applied in construction projects to realize future needs in order to provide better performance	3.71	0.751	6	High
25	The smart agent contributes to reducing the costs of construction projects.	3.73	0.777	5	High
	Overall mean	3.82	0.502	-	High

Table (4.4) summarizes the results of the descriptive statistics for the items of the Intelligence agent variable, where the overall mean was (3.82) with a standard deviation (0.502), and it is clear from this result that there is a high application of the principles and applications of the Intelligence agent, according to the opinions of the participants in the study.

It was item number (19) which states “The smart agent helps to avoid wasting time in construction projects.” It is the largest according to the mean, as its mean was (3.98) with a standard deviation of (0.707).

As for the lowest item in terms of the arithmetic mean scale, it was item No. (20), which states "The costs of using the smart agent in construction projects are high." The mean value was (3.67) with a standard deviation (0.829).

4.2.5 Descriptive Statistic for Reducing Cost and Time

Table 4.5

Descriptive statistic of the items of reducing cost and time

No	Item	Mean	Standard Deviation	Rank	Importance level
26	The contractor's lack of financial liquidity leads to an increase in time in construction projects.	4.38	0.739	2	High
27	Weak technical and administrative skills lead to an increase in time in construction projects.	4.44	0.706	1	High
28	The consultant’s delay in approving the executive plans leads to an increase in the time in the construction projects.	4.24	0.734	7	High
29	Engineering design modifications are one of the reasons for delaying the project implementation period.	4.19	0.802	11	High
30	Irregular financial payments are one of the reasons for delaying the project completion period.	4.27	0.760	5	High
31	Non-compliance with the technical specifications leads to re-work and a delay in the completion of the project.	4.28	0.823	4	High
32	The competence and experience of the supervising authority plays a key role in not exceeding the project implementation period.	4.24	0.752	7	High

33	The existence of inconsistencies between the bid documents leads to an increase in the project implementation period.	4.31	0.656	3	High
34	Change orders are one of the reasons that contribute to increasing the duration of construction projects.	4.25	0.716	6	High
35	Continuous monitoring has a role in limiting the increase in the time period for project implementation.	4.14	0.707	12	High
36	Commitment to quality leads to an increase in the time period for implementing construction projects.	2.11	1.09	18	Low
37	The contractor's lack of financial liquidity leads to an increase in the cost of construction projects.	3.45	0.657	17	Medium
38	Weak technical and administrative skills lead to an increase in the cost of construction projects.	4.24	0.728	7	High
39	The consultant’s delay in approving the executive plans leads to an increase in the cost of construction projects.	4.06	0.814	15	High
40	Engineering design modifications are one of the causes of increased project costs.	4.12	0.773	13	High
41	The existence of inconsistencies between the bid documents will result in project costs being overrun.	4.12	0.754	13	High
42	Variation orders are considered to have a clear impact on the cost of construction projects.	4.24	0.712	7	High
43	Continuous monitoring has a role in reducing the cost increase in construction projects.	3.62	0.728	16	Medium
	Overall mean	4.03	0.809	-	High

Table (4.5) summarizes the results of the descriptive statistics for the items of the reducing cost and time variable, where the general arithmetic mean was (4.03) with a standard deviation of (0.809).

Item No. (27), which states, “Weak technical and administrative skills lead to an increase in time in construction projects.” It is the largest

according to the arithmetic averages, as its arithmetic mean was (4.44) with a standard deviation of (0.706).

As for the least items in terms of the arithmetic mean scale, it was item No. (36) Which states, "Commitment to quality leads to an increase in the time period for implementing construction projects." As the arithmetic mean value reached (2.11) with a standard deviation (1.09).

4.3 Hypothesis Testing

In order to achieve the objectives of the study, a hypothesis test was conducted by employing the statistical software SPSS, as to perform a multiple linear regression analysis.

Before starting the multiple linear regression test, several tests were conducted that are required to be performed before starting to test the study hypotheses, where the test of the normal distribution of the study variables was conducted and the multicollinearity test was conducted.

4.3.1 Normality Test

To ensure that the study data are distributed to a normal distribution, as one of the main requirements that must be met before conducting a linear regression test. The values of the skewness coefficients were calculated, which should be between (-1, 1) and the values of the kurtosis coefficients, which should be between (-3, 3).

The skewness values and kurtosis values were calculated according to the following equations:

Skewness = $$\frac{n}{(n-1)(n-2)}\sum\left(\frac{(x-\bar{x})}{s}\right)^3$$.

Kurtosis = $$\frac{\sum\left(x-\bar{x}\right)^4}{(n-1)\cdot S^4}$$.

n: the number of items in the sample.
S: standard deviation.
$\bar{x}$: Mean.

The skewness values and kurtosis values s it can be seen in Table (4-6) the normality test.

Table 4.6
Normality test

Variables	Skewness values	kurtosis values
Neural networks	-0.875	2.021
Genetic algorithms	-0.508	1.892
Expert systems	-0.557	2.405
Intelligence agent	-0.472	1.904
Reducing cost and time	-0.908	0.717

It is evident from the results presented in Table (4.6) that the normal distribution was achieved in all the variables. Where all values of skewness from (-0.472, -0.908) were within the acceptable statistical range (-1,1) and all values of kurtosis from (0.717,2.405) were within the acceptable statistical range (-3,3) therefore, it can be said that the data are distributed normally, and a linear regression test can be performed.

4.3.2 Multicollinearity Test

When applying the multiple linear regression test, it must be ensured that the independent variables are free from high correlations that could create a false regression (Hair et al., 2012). The presence of this problem in the independent variables leads to problems in estimating the regression equation. The value of VIF must be less than (10) and the tolerance greater than (0.10) in order to judge that this problem does not exist in the independent variables. Table (4-7) shows the test results.

Table 4.7
Multicollinearity test

Independent variables	Variance inflation factor VIF	Tolerance
Neural networks	2.98	0.335
Genetic algorithms	2.519	0.397
Expert systems	2.469	0.405
Intelligence agent	1.945	0.514

It is evident from Table (4.7) that the results of the Multicollinearity test for the independent variables show that all values of VIF were less than (10), as the values of VIF ranged (1.945-2.98) and all values of Tolerance were greater than (0.10), as the values ranged (0.335-0.514).

And therefore, it can be judged that there is no multicollinearity problem between the independent variables, and this indicates the possibility of conducting a multiple linear regression test (Hair et al., 2010; Sekaran and Bougie, 2016).

4.3.3 Hypothesis Test Results

To test the hypotheses of the study, a simple and a multiple linear regression analysis test was run to find out the effect of artificial intelligence in its dimensions (Neural networks, Genetic algorithms, expert systems, intelligence agent) on reducing cost and time in construction projects in Jordan.

4.3.3.1 The Simple Linear Regression for Testing the Main Hypothesis

To test the first main hypothesis the researcher, conduct the simple linear regression, the table (4.8) shows the analysis for this hypothesis.

Table 4.8

Simple linear regression test results

Independent variables	Dependent variable	R	R^2	F	Sig (F)	Beta	Std. Error	t-values	Sig	Result
Artificial intelligence	Reducing cost and time	0.514	0.264	55.705	0.000	0.511	0.075	6.81	0.000	Significant

Table (4.8) indicates the first main hypothesis is tested, which states "There is no statistically significant effect at ($\alpha \leq 05.0$) level to artificial intelligence in its dimensions (neural networks, genetic algorithms, expert systems, intelligent agent) in reducing cost and time in construction projects".

It is clear that the value of the F-test was (55.705) at the level of significance (0.000), meaning that this level is less than (0.05). Therefore, it can be said that the regression model is statistically significant and the value of the correlation coefficient was (0.514), and the value of the coefficient of determination was (0.264). This value indicates that the independent variable has contributed (26.4%) to the change in the dependent variable.

To test the hypothesis of the study, the beta value of the impact of artificial intelligence on reducing cost and time was calculated, as the beta value was (0.511). The calculated t-value was (6.81), meaning that it was greater than the theoretical value of (1.96) and the value of the level of statistical significance was (0.000), which is less than (0.05) and this indicates:

Reject the null hypothesis and accept the alternative hypothesis which states "There is a statistically significant effect at ($\alpha \leq 0.05$) level to intelligence in its dimensions (neural networks, genetic algorithms, expert artificial systems, intelligent agent) in reducing cost and time in construction projects".

4.3.3.2 The Multiple Linear Regression for Testing the Sub-Hypotheses

To test the sub- hypothesis the researcher, conduct the multiple linear regression, the table (4.9) shows the analysis for these hypotheses.

Table 4.9
Multiple linear regression test results

Independent variables	Dependent variable	R	R^2	F	Sig (F)	Beta	Std. Error	t-values	Sig	Result
Neural networks						0.107	0.098	1.09	0.255	Not Significant
Genetic algorithms	Reducing cost and time	0.544	0.295	20.705	0.000	0.205	0.094	2.18	0.043	Significant
Expert systems						0.054	0.102	0.529	0.502	Not Significant
Intelligence agent						0.312	0.100	3.12	0.000	Significant

Table (4.9) refers to hypotheses testing through the use of multiple linear regression test, as it is clear from the test results that the relationship between the independent variables and the dependent variable amounted to (0.544) and the value of the coefficient of determination R^2 was (0.295) and this value indicates that the independent variables Together, (Neural networks, Genetic algorithms, expert systems, intelligence agent) explained an amount of (29.5%) of the change in the dependent variable.

The value of F reached (20.705) at the level of significance (0.000), and this value indicates that the regression model is statistically significant, as the value of the significance level is less than (0.05).

The sub-hypothesis test values were as follows:

4.3.3.2.1 The first Sub-Hypothesis (H_0.1)

There is no statistically significant effect at ($\alpha \leq 0.05$) level of Neural Networks in reducing cost and time in construction projects.

The value of the beta regression coefficient was (0.107) and this value indicates that the effect of Neural networks on reducing cost and time was positive, however, the relationship was weak. The value of the t-test was (1.09), where this value was less than the tabular value of (1.96) and the value of the level of statistical significance was (0.255), meaning that it is greater than the level of statistical significance at the level (0.05), and therefore the null hypothesis can be accepted, which states "There is no statistically significant effect at ($\alpha \leq 0.05$) level of Neural Networks in reducing cost and time in construction projects".

4.3.3.2.2 The Second Sub-Hypothesis (H_0.2)

There is no statistically significant effect at ($\alpha \leq 0.05$) level of genetic algorithms in reducing cost and time in construction projects.

The value of beta was (0.205), and this value indicates a medium relationship between Genetic algorithms and the reduction of cost and time, and the value of t was (2.18), meaning that it is greater than the theoretical

value of (1.96) and the value of the level of statistical significance was (0.043). That is, it is less than (0.05), and therefore it can be said that the null hypothesis is rejected which states "There is a statistically significant effect at ($\alpha \leq 0.05$) level of genetic algorithms in reducing cost and time in construction projects."

4.3.3.2.3 The Third Sub-Hypothesis ($H_0.3$)

There is no statistically significant effect at ($\alpha \leq 0.05$) level of expert systems in reducing cost and time in construction projects.

The value of the beta regression coefficient was (0.054), and this value indicates that the effect of Expert systems on reducing cost and time was positive, yet the relationship was weak. The value of the t-test was (0.529), where this value was less than the tabular value of (1.96) and the value of the level of statistical significance was (0.502), that is, it is greater than the level of statistical significance at the level (0.05), and therefore the null hypothesis can be accepted, which states "There is no statistically significant effect at ($\alpha \leq 0.05$) level of expert systems in reducing cost and time in construction projects".

4.3.3.2.4 The Fourth Sub-Hypothesis ($H_0.4$)

There is no statistically significant effect at ($\alpha \leq 0.05$) level of intelligence agent in reducing cost and time in construction projects.

The value of the beta regression coefficient was (0.312), and this value indicates that the effect of the Intelligence agent on reducing cost and time was positive, and the relationship was strong. The value of the t-test was (3.12), where this value was greater than the tabular value of (1.96) and the value of the level of statistical significance was (0.000), that is, it is less than the level of statistical significance at the level (0.05), and therefore the null hypothesis can be rejected and the alternative hypothesis accepted, which states "There is a statistically significant effect at ($\alpha \leq 0.05$) level of intelligence agent in reducing cost and time in construction projects".

It can be concluded through hypothesis testing that the intelligence agent is the most important variable in reducing cost and time through the opinions and responses collected from the study sample, then Genetic algorithms is a medium relationship and the neural networks and expert systems are the weakest relationship.

4.4 Conclusions

Based on the objectives and results of the study, the researcher has made the following conclusions:

1. There is a relationship between the artificial intelligence in its dimensions (neural networks, genetic algorithms, expert systems, smart agent) in reducing cost and time in construction projects.

2. There is no influence of neural networks in reducing cost and time in construction projects, weak relationship.
3. There is a medium relationship between the genetic algorithms in reducing cost and time in construction projects.
4. There is no influence of expert systems in reducing cost and time in construction projects, weak relationship.
5. There is a strong relationship between the intelligent agent in reducing cost and time in construction projects.
6. The useful one based on artificial intelligence to overcome time and costs overrun in construction projects is, intelligent agent.

4.5 Recommendations

Based on the results of the study, the researcher has made the following recommendations:

1. The need for decision -makers in the field of construction projects to pay attention to the applications of artificial intelligence and to work on adopting these techniques in all activities.
2. The necessity of training engineers working in the field of construction projects to use and benefit from the applications of artificial intelligence.
3. It is necessary to use artificial intelligence applications in building predictive models to reduce the time required to complete work.
4. It is necessary to apply artificial intelligence applications to build advanced mathematical and statistical models that reduce the operational costs of construction projects.
5. The importance of using artificial intelligence applications in collecting, storing and transferring huge data and benefiting from this data in enhancing the efficiency of work in construction projects.
6. The need to link artificial intelligence applications in all sections and work activities in construction projects to achieve the maximum possible benefit from these applications.
7. The need to strengthen the administrative concepts of the workers because of their role in the success of business in construction projects.
8. The need to pay attention to total quality management because it is concerned with all elements of the construction process and aims to reach the maximum degree of accountability for all parties involved in the production process for the total quality of the project, product and final service.

4.6 Future Works

Artificial intelligence is one of the topics of importance in the modern era and can be studied through several variables, so the researcher suggests several topics related to the title of the research, where they are complementary addresses to some of them, as follows:

1. Studying the risks of artificial intelligence on the security of construction projects.
2. Studying the impact of deep learning on the development of workers in construction projects.
3. Studying the impact of artificial intelligence on achieving total quality in construction projects.
4. Conducting other studies for the same title in other organizations and comparing their results with the results of this study.

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Appendices

Appendix I
Questionnaire of the Study English Form

Section 1: Neural networks

NO		Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
1	Artificial neural network systems in construction projects simulate the way workers deal with engineering problems					
2	Artificial neural networks help predict problems before they arise using big data and analytics					
3	Artificial neural networks help workers in construction projects improve the quality of work.					
4	Artificial neural networks in construction projects do not help solve engineering problems.					
5	The construction projects provide training programs for workers in the use and understanding of artificial neural networks.					
6	Artificial neural networks aid deep learning among construction project workers.					
7	Artificial neural networks in construction projects help to identify errors in the implementation of projects.					

Section 2: Genetic algorithms

NO		Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
8	Genetic algorithms help to find the best solutions to problems in construction projects.					
9	Genetic algorithms are one of the techniques that help in searching for the best option among all the available options.					
10	Genetic algorithms help to calculate the best costs for construction projects.					

11	Genetic algorithms contribute to devising new strategies for implementing construction projects.					
12	Genetic algorithms help in developing computer programs used in construction projects.					

Section 3: Expert Systems

NO		Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
13	Expert systems help to change the solutions that have been reached in construction projects.					
14	The expert systems in construction projects are characterized by the ease that their users can understand					
15	Expert systems contribute to reducing construction project costs.					
16	Expert systems help specialists perform high in construction projects.					
17	Expert systems have an effective role in solving the problems facing construction projects.					
18	The costs of using expert systems in construction projects are high.					

Section 4: Intelligent Agent

NO		Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
19	The smart agent helps to avoid wasting time in construction projects.					
20	The costs of using the smart agent in construction projects are high.					
21	The smart agent helps continuous learning in construction projects.					

22	The smart agent has a superior ability to store and retrieve data when needed in construction projects.					
23	The smart agent in construction projects contains an integrated system that can accomplish difficult tasks through smart behaviors					
24	The smart agent is applied in construction projects to realize future needs in order to provide better performance					
25	The smart agent contributes to reducing the costs of construction projects.					

Section 5: Reducing Cost and Time

NO		Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
26	The contractor's lack of financial liquidity leads to an increase in time in construction projects.					
27	Weak technical and administrative skills lead to an increase in time in construction projects.					
28	The consultant’s delay in approving the executive plans leads to an increase in the time in the construction projects.					
29	Engineering design modifications are one of the reasons for delaying the project implementation period.					
30	Irregular financial payments are one of the reasons for delaying the project completion period.					
31	Non-compliance with the technical specifications leads to re-work and a delay in the completion of the project.					
32	The competence and experience of the supervising authority plays a key role in not exceeding the project implementation period.					

33	The existence of inconsistencies between the bid documents leads to an increase in the project implementation period.					
34	Change orders are one of the reasons that contribute to increasing the duration of construction projects.					
35	Continuous monitoring has a role in limiting the increase in the time period for project implementation.					
36	Commitment to quality leads to an increase in the time period for implementing construction projects.					
37	The contractor's lack of financial liquidity leads to an increase in the cost of construction projects.					
38	Weak technical and administrative skills lead to an increase in the cost of construction projects.					
39	The consultant’s delay in approving the executive plans leads to an increase in the cost of construction projects.					
40	Engineering design modifications are one of the causes of increased project costs.					
41	The existence of inconsistencies between the bid documents will result in project costs being overrun.					
42	Variation orders are considered to have a clear impact on the cost of construction projects.					
43	Continuous monitoring has a role in reducing the cost increase in construction projects.					

Appendix II
Questionnaire of the Study Arabic Form

بِسْمِ ٱللَّهِ ٱلرَّحْمَٰنِ ٱلرَّحِيمِ

استبانة الدراسة

السيد/ة .....

تحية طيبة وبعد،،،

تقوم الباحثة باجراء دراسة بعنوان : (الذكاء الاصطناعي لخفض التكلفة والوقت في المشاريع الانشائية) ، وذلك استكمالاً لمتطلبات الحصول على درجة الماجستير في الإدارة الهندسية من جامعة مؤتة.

أرجو التكرم بالإجابة على فقرات الاستبيان بموضوعية ودقة لإثراء رسالتي بمعلوماتكم القيمة التي نأمل أن تنعكس إيجاباً على قطاع المشاريع الانشائية في الأردن من خلال التوصيات التي سنقوم بطرحها لاحقاً، علماً أنه سيتم التعامل مع المعلومات المقدمة منكم بسرية تامة إذ أنها ستستخدم لأغراض البحث العلمي فقط.

الرجاء بيان الرأي بالعبارات التالية لتحديد مدى الاتفاق بما يرد في كل عبارة ، علماً أن المقياس لفقرات الاستبانة يأخذ التدرج التالي:

موافق بشدة	موافق	محايد	غير موافق	غير موافق بشدة
5	4	3	2	1

شاكرين ومقدرين حسن تعاونكم

و تفضلوا بقبول فائق الاحترام و التقدير،،،

اشراف: أ.د.سلطان الطراونة
النعيمات

الباحثة: م.آلاء هارون

كلية الهندسة/جامعة مؤتة

أولاً: المتغيرات الديموغرافية :يرجى وضع إشارة (√) أمام كل عبارة بما يتفق معك.

المتغير	الفقرة	
1- الجنس	☐ ذكر	☐ أنثى
2- العمر	☐ أقل من 30 سنة	☐ 30 - أقل من 40 سنة
	☐ 40 – أقل من 50 سنة	☐ 50 سنة فأكثر
3- المؤهل العلمي	☐ دبلوم متوسط	☐ بكالوريوس
	☐ ماجستير	☐ دكتوراه
4- سنوات الخبرة	☐ أقل من 5 سنوات	☐ 5- أقل من 10 سنوات
	☐ 10-أقل من 15 سنة.	☐ 15 سنة فأكثر
5- المسمى الوظيفي	☐ مدير مشروع	☐ مهندس موقع
	☐ مهندس حاسب كميات	☐ مهندس جودة
	☐ مهندس تصميم	☐ مهندس تخطيط
	☐ مهندس بمنصب اداري	☐ مهندس
6- قطاع العمل	☐ قطاع حكومي	☐ شركة استشارات هندسية
	☐ شركة مقاولات ☐	مكاتب هندسية

ثانياً: متغيرات الدراسة : يرجى وضع إشارة (√) أمام كل عبارة وفقاً لمستوى موافقتك أوعدم موافقتك :

ت	الفقرة	موا فق بشدة	موافق	محايد	غير موافق	غيرموافق بشدة
	المتغير المستقل: **الذكاء الاصطناعي:**هو مجموعة من الأنظمة الحاسوبية التي تساعد على إنجاز المهام في المشاريع الانشائية.					
أ-	**الشبكات العصبية الاصطناعية:**هي مجموعة من النماذج المستخدمة في معالجة وتحليل البيانات في المشاريع الانشائية.					
1	تحاكي نظم الشبكات العصبية الاصطناعية في المشاريع الانشائية طريقة تعامل العاملين مع المشاكل الهندسية.					
2	تساعد الشبكات العصبية الاصطناعية على التنبؤ بالمشكلات قبل ظهورها باستخدام البيانات والتحليلات الضخمة.					
3	تساعد الشبكات العصبية الاصطناعية العاملين في المشاريع الانشائية على تحسين جودة العمل.					
4	لا تساعد الشبكات العصبية الاصطناعية في المشاريع الانشائية على حل المشاكل الهندسية.					
5	توفر المشاريع الانشائية برامج تدريب للعاملين في استخدام الشبكات العصبية الاصطناعية وفهم ماهيتها.					
6	تساعد الشبكات العصبية الاصطناعية على التعلم العميق لدى العاملين في المشاريع الانشائية.					
7	تساعد الشبكات العصبية الاصطناعية في المشاريع الانشائية على معرفة الأخطاء في تنفيذ المشاريع.					
ب-	**الخوارزميات الجينية:** هي أحد طرق البحث والتي تستخدم في ايجاد حلول لتحقيق الأمثلية في المشاريع الانشائية.					
8	تساعد الخوارزميات الجينية على ايجاد أفضل الحلول للمشاكل في المشاريع الانشائية.					
9	تعتبر الخوارزميات الجينية من التقنيات التي تساعد في البحث عن الخيار الأفضل بين مجموع الخيارات المتاحة.					
10	تساعد الخوارزميات الجينية على حساب أفضل التكاليف للمشاريع الانشائية.					
11	تساهم الخوارزميات الجينية في ابتكار استراتيجيات جديدة لتنفيذ المشاريع الانشائية.					
12	تساعد الخوارزميات الجينية في تطوير البرامج الحاسوبية المستخدمة في المشاريع الانشائية.					

ت	**الأنظمة الخبيرة:** هي مجموعة من القواعد و المعطيات التي تحتوي على معلومات معرفية التي تستخدم في اتخاذ القرارات في المشاريع الانشائية.					
13	تساعد الأنظمة الخبيرة على تغيير الحلول التي تم الوصول اليها في المشاريع الانشائية.					
14	تتميز الأنظمة الخبيرة في المشاريع الانشائية بسهولة تمكن مستخدميها من استيعابها.					
15	تساهم الأنظمة الخبيرة في خفض تكاليف المشاريع الانشائية.					
16	تساعد الأنظمة الخبيرة المتخصصين أداء مرتفع في المشاريع الانشائية .					
17	للأنظمة الخبيرة دور فاعل في حل المشاكل التي تواجه المشاريع الانشائية.					
18	تعتبر تكاليف استخدام الأنظمة الخبيرة في المشاريع الانشائية مرتفعة.					
ث	**الوكيل الذكي :** هو المكون المسؤول عن إجراء تحسينات في المشاريع الانشائية بناءً على قواعد المعرفة المخزنة للمشاريع السابقة.					
19	يساعد الوكيل الذكي على تجاوز الهدر في الوقت في المشاريع الانشائية.					
20	تعتبر تكاليف استخدام الوكيل الذكي في المشاريع الانشائية مرتفعة.					
21	يساعد الوكيل الذكي على التعلم المستمر في المشاريع الانشائية.					
22	يتمتع الوكيل الذكي بقدرة فائقة على التخزين واسترجاع البيانات عند الحاجة لها في المشاريع الانشائية.					
23	يحتوي الوكيل الذكي في المشاريع الانشائية على نظام متكامل يمكنه انجاز المهام الصعبة عن طريق سلوكيات ذكية.					
24	يتم تطبيق الوكيل الذكي في المشاريع الانشائية لادراك الحاجات المستقبلية بهدف تقديم أداء أفضل.					
25	يساهم الوكيل الذكي في خفض تكاليف المشاريع الانشائية.					
	المتغير التابع **التكلفة والوقت في المشاريع الانشائية :**هو الالتزام بالمعايير اللازمة لتنفيذ المشاريع الانشائية من خلال الاستخدام الأفضل للموارد.					
26	يؤدي عدم توفر السيولة المالية لدى المقاول الى زيادة الوقت في المشاريع الانشائية.					
27	ضعف المهارات الفنية والادارية يؤدي الى زيادة الوقت في المشاريع الانشائية.					
28	تأخر الاستشاري في اعتماد المخططات التنفيذية يؤدي الى زيادة الوقت في المشاريع الانشائية.					
29	تعديلات التصاميم الهندسية تعتبر من مسببات تأخر مدة تنفيذ المشروع .					
30	عدم انتظام الدفعات المالية من مسببات					

	التأخير في مدة إنجاز المشروع.					
31	يؤدي عدم الالتزام بالمواصفات الفنية الى إعادة العمل وتأخر مدة انجاز المشروع.					
32	تساهم كفاءة وخبرة الجهة المشرفة دوراً أساسياً في عدم تجاوز مدة تنفيذ المشروع.					
33	يؤدي وجود التعارض بين وثائق العطاء إلى زيادة مدة تنفيذ المشروع.					
34	تعتبر الاوامر التغيرية أحد الاسباب التي تساهم في زيادة مدة تنفيذ المشاريع الانشائية.					
35	الرقابة المستمرة لها دور في الحد من زيادة المدة الزمنية لتنفيذ المشروع.					
36	يؤدي الالتزام بالجودة الى زيادة المدة الزمنية لتنفيذ المشاريع الانشائية.					
37	يؤدي عدم توفر السيولة المالية لدى المقاول الى زيادة التكلفة في المشاريع الانشائية.					
38	ضعف المهارات الفنية والادارية يؤدي الى زيادة التكلفة في المشاريع الانشائية.					
39	تأخر الاستشاري في اعتماد المخططات التنفيذية يؤدي الى زيادة التكلفة في المشاريع الانشائية.					
40	تعديلات التصاميم الهندسية تعتبر من مسببات زيادة تكاليف المشروع.					
41	يؤدي وجود التعارض بين وثائق العطاء إلى تجاوز تكاليف المشروع.					
42	تعتبر الأوامر التغيرية ذات تأثير واضح على تكلفة المشاريع الانشائية.					
43	الرقابة المستمرة لها دور في الحد من زيادة التكلفة في المشاريع الانشائية.					

جامعة مؤتة

الدكتور/ المهندس: المحترم

السلام عليكم ورحمة الله وبركاته،

الموضوع /تحكيم استبانة لرسالة ماجستير في الادارة الهندسية

الدكتور الفاضل ، تقوم الباحثة باجراء دراسة لغايات استكمال الحصول على درجة الماجستير في الادارة الهندسية بعنوان:**"الذكاء الاصطناعي لخفض التكلفة والوقت في المشاريع الانشائية"**

وذلك تحت اشراف :الأستاذ الدكتور سلطان الطراونة.

ولما لكم من خبرة في ودراية في الأبحاث والدراسات وتحكيم الاستبانات فأنني ألتمس منكم تحكيم الاستبانة وفق المتغيرات المرفقة مع الاستبيان .

علما" أن كل ما يرد في ملاحظاتكم سيكون موضع تقدير واحترام.

وتقبلوا بقبول فائق الاحترام

الباحثة :الاء هارون النعيمات

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Appendix III
List of the Committee of Validation Questionnaire

List of the Committee of Validation Questionnaire:

No	Name	Place
1	Dr.Ramadan Jaber Mustafa	Mutah University
2	Dr.Talib Kashash Mortada	Mutah University
3	Dr.Hani Alrawashdeh	Al-Hussein Bin Talal University
4	Dr. Shehada Khalil Al-Qarini	Al- Balqa' Applied University
5	Eng. Hossam Mustafa Abu Karaki	Saraya Aqaba Project
6	Eng. Khaled Al-Maaytah	Engineer in the private sector
7	Eng.Nidal Abdullah Al Batoush	Supervising engineer in the private sector

المعلومات الشخصية

الاسم: الاء هارون حامد النعيمات.

التخصص: الادارة الهندسيـــة.

الكليـــة: كليـة الهندســـة.

هاتــف:00692.775178369

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