Analysis Of The Application Of PERT/CPM In Development Of Projects With Artificial Intelligence

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***Abstract*—The present document has as objective to present different studies of literature in order to perform a comparative about the basic concepts and develop a historical review of two project management techniques, as well as of artificial intelligence.**

Additionally, analyze how to conjugate both techniques and apply them to the management of the development of projects that use artificial intelligence.

Keywords—project management; techniques; artificial intelligence; project; development

I. INTRODUCTION

Currently, artificial intelligence (AI) has acquired greater relevance, transforming entire industries, thanks to its efficiency and ability to generate innovative solutions.
This advance has allowed the development of attractive systems that assist professionals and users in various fields, including education, finance, medicine, engineering, information technology, industry in general and even scientific research and art, to mention a few examples [1,2,3,4,5,6].

Although challenges still exist, continued research promises to open new frontiers in the field, promoting a future where AI plays an even more crucial role in project development [7]. However, the development of AI projects is a complex process and is full of uncertainty, which can lead to delays and overruns. The lack of proper project management can transform the potential of AI, resulting in inefficient projects.

In this context, project management techniques such as PERT (Program Evaluation and Review Technique) and CPM (Critical Path Method), adapted to the particularities of AI, acquire certain relevance. PERT, with its ability to manage uncertainty through probabilistic estimates and CPM with its focus on schedule optimization and critical path identification [8], offer a solid framework to address the unique challenges of AI projects.

Effective application of these tools can help significantly to improve planning accuracy, reduce risks, and optimize resources, allowing AI projects to reach their full potential and generate significant strategic value [9].

II. THEORICAL FRAMEWORK.

Project management plays a fundamental role in the development of a project, since it facilitates decision making; one of its main objectives is to manage resources to achieve the success of a project of any kind.

In an environment full of new technological advances, those in charge of projects are constantly looking for techniques to improve their management and increase the probability of success in them, since good project management can reduce the risk of failure and avoid loss of time and money [10].

Project management is a set of processes and activities, which, through individual or team skills, are carried out to define, initiate, develop, control and conclude a project successfully, within a predetermined time, cost and quality [11,12].

Two important techniques in project management had their origins in the 1950s. Although both techniques were created and applied since the beginning an alien area to the industrial and commercial company, they were soon incorporated into the same sector where they became valuable tools.

Although all these techniques are important for the economics of the company, this text will focus on those that are applied to project scheduling and control, particularly those known as PERT and CPM [13].

PERT was created in 1957 by the North American Navy to evaluate and monitor the progress of the Polaris ballistic missile program, managed by the Office of Special Projects and the Office of Ordnance. Its objective was to develop a method to provide management with a comprehensive, numerical view of the progress and expectations of success of the FBM (Fleet Ballistic Missile) program [14].

This technique seeks to improve the development and execution of complex projects by analyzing all interdependent activities in advance. It is useful when the duration of tasks is uncertain, requiring probability analysis to estimate completion times.

On the other hand, CPM was created in 1957 by Kelly of Remington and M. Walker of Dupont Company to manage industrial projects where task times were uncertain; it focuses on calculating the shortest possible duration of a project. This is achieved by identifying critical activities that do not allow delay. CPM needs accurate information about the duration and relationships between tasks, being suitable for projects with reliable historical data. Its greatest disadvantage is the assumption that activity times are exact and predictable [15].

Finally, Artificial Intelligence (AI) is a branch of computer science dedicated to developing systems that exhibit progressively, more intelligent behavior. These systems can perform tasks that normally require human intelligence, even exceeding human problem-solving capabilities in certain domains. Although its development has experienced exponential growth in recent years, the outsets of AI date back to the end of the 19th century [16].

In 1769, Johan Wolfgang Von Kempelen created a fake chess machine that seemed to play by itself. Although it was deception, this invention inspired the creation of real chess robots in the future.

In 1816 he conceived the analytical engine, a device that, although never fully built in its time, laid the foundation for modern computers.

Leonardo Torres Quevedo, in 1912, built "El Ajedrecista", a pioneering, autonomous robot capable of playing chess without human intervention. It is considered one of the first examples of a computerized game [17].

In 1943, some claim that the onsets of AI began with the definition of the neuron that laid the conceptual foundation for AI. However, it was in 1956 when AI was consolidated as an independent field of study within computer science [18].

The scientific community adopted the concept of artificial intelligence in 1950, thanks to Alan Turing, who raised the question: “Can machines think?” in his article “Computing Machinery and Intelligence” [19].

The field of Artificial Intelligence (AI) was formally established in 1956, when John McCarthy coined the term during the Dartmouth Conference. That same year, Allen Newell, Herbert Simon and Cliff Shaw created "Logic Theorist", considered the first AI program capable of proving mathematical theorems. These initial milestones are followed by developments such as "Unimate" (1961), George Devol's first industrial robot, and "ELIZA" (1964), Joseph Weizenbaum's chatbot that simulated human conversations. However, obstacles also arose, such as "The XOR Problem" (1969), which revealed the limitations of perceptrons and temporarily slowed progress in neural networks. Despite these challenges, the field experienced a resurgence in 1986 with the popularization of the backpropagation algorithm by Rumelhart, Hinton, and Williams, which enabled the effective training of multilayer neural networks, and the introduction of Recurrent Neural Networks (RNNS) by Michael Jordan, a major advance in sequential data processing.

The 1990s and early 21st century saw significant advancements and application of AI in various fields. In 1997, IBM's Deep Blue computer defeated world chess champion Garry Kasparov, demonstrating the ability of machines to outperform humans at complex tasks. Robotics took a step forward with the launch of "Roomba" (2002), the first commercially successful autonomous vacuum cleaner for home. In 2009, Fei-Fei Li launched ImageNet, a free database of 14 million images, revolutionizing the training of neural networks for image recognition. This advancement culminated in 2012, when a convolutional neural network achieves "superhuman vision" by winning the ImageNet competition, surpassing human performance for the first time. Furthermore, in 2014, Ian Goodfellow introduced Generative Adversarial Networks (GAN), which allowed machines to generate realistic synthetic data, and Amazon launched "Alexa", a smart virtual assistant with a voice interface, popularizing virtual assistants in at home.

The democratization of AI accelerated with the launch of open-source libraries (2015-2016), which facilitated the development of machine learning projects. In 2017, Google's AI AlphaGo beat world champion Ke Jie in the complex board game Go, demonstrating AI's ability to master complex strategic games. Finally, in 2018, Google developed BERT, a bidirectional language model that significantly improved the ability of machines to understand and generate natural language. It is important to note that, throughout its history, AI has experienced periods of stagnation due to low interest and lack of funding at certain times [20].

In more recent years, Artificial Intelligence has been present in our daily lives. From virtual assistants and recommendation systems that make decision-making easier, to autonomous vehicles that promise to revolutionize transportation and medical diagnoses that save lives, AI is transforming our world. The most advanced AI models, benefiting from an exponential increase in processing power and the availability of vast amounts of data, continue to challenge the limits of what we thought possible.

As we have witnessed exponential advances in fields such as natural language processing (NLP) and computer vision. Large-scale language models, such as transformers, have made it possible to create systems capable of generating coherent and creative text, accurately translating languages, and maintaining natural conversations. In the field of computer vision, convolutional neural networks have achieved unprecedented levels of accuracy in image recognition and object detection. Furthermore, learning by reinforcement learning has achieved impressive milestones in robotics and the development of autonomous agents, opening new possibilities in areas such as autonomous driving and space exploration [21].

It is important to note that throughout its history, AI has experienced periods of stagnation due to low interest and lack of funding at certain times. Although it should be noted that today and with the origins of AI, there are no signs of slowing down.

III. Methodology

Project management in AI development faces unique challenges due to uncertainty in algorithm research and development, as well as the need for efficient implementation. The combination of PERT and CPM techniques provides a structured approach that allows you to optimize planning, mitigate risks and improve resource allocation of these projects.

While PERT focuses on probabilistic estimation of task durations, which is useful in the early phases of the project, CPM allows you to identify the critical path to ensure the completion of the project in the shortest possible time. The correct application of both methodologies allows work teams to effectively manage the complexity inherent in AI projects.

A. Application of PERT in AI project planning.

To apply the PERT technique, the first step is to identify and list all the tasks necessary to complete the project. Subsequently, the precedence relationship between them must be established, determining which tasks must be completed before others can begin. This structure is represented by a network graph that visualizes the sequence of the project and its dependencies.

One of the key aspects of PERT is time estimation, considering that in the initial phase of AI development the uncertainty is high. To address this variability, three time estimates are used for each task.

- Optimistic time (a): The shortest possible duration of a task, assuming ideal conditions.
- Pessimistic time (b): The maximum duration of a task, considering the worst possible scenarios.
- Most probable time (m): The most realistic time estimate to complete a task, based on experience and normal expectations.

Although the abbreviations may change depending on the author, the notion is the same, determining the duration of each task.

From these estimates, the expected time for each task is calculated using the PERT formula:

$$t = \frac{a + 4m + b}{6}$$

This calculation allows modeling the variability of the duration of activities, providing a more realistic and flexible planning for the initial phase of the project, in which data exploration and experimentation with algorithms can affect execution times.

B. Application of CPM in schedule optimization.

As the project progresses into more defined phases, such as model deployment and testing, CPM becomes a critical tool for optimizing time management. CPM allows you to identify the critical path, that is, the sequence of tasks which total duration determines the minimum time in which the project can be completed.

To apply for CPM, the following steps must be followed:

- Define all activities and their estimated duration.
- Determine dependencies between tasks.
- Build the project network diagram.
- Identify the critical path, considering the different types of times found:
    - Earliest Start (IC): The earliest time a task can start, respecting previous dependencies.
    - Earliest Completion (TC): The earliest time a task can finish.
    - Latest Start (IL): The latest possible time to start a task without the entire project being delayed.
    - Latest Finish (TL): The latest possible time to finish a task without impacting the project end date. The goal is to efficiently use time and resources to avoid delays.

Critical path analysis allows project managers to prioritize essential activities and take preventive measures to avoid delays that could affect the submission date. Additionally, by optimizing resource allocation to critical tasks, costs can be reduced and project development efficiency improved.

IV. Results

The joint implementation of PERT and CPM in AI projects offers a solid strategy to manage the complexity and uncertainty inherent in these projects. By implementing these techniques, teams can optimize planning, maximize resources, and increase the likelihood of successfully meeting project objectives. In addition, it provides several advantages such as:

- Greater control of uncertainty: PERT facilitates the modeling of various scenarios and the anticipation of possible delays in the initial phases of the project.
- Improved implementation time: CPM recognizes essential tasks and facilitates the concentration of efforts on activities that directly influence the total duration of the project.
- Adequate distribution of resources: By identifying the critical path, human and technological resources can be effectively distributed.
- Reduction of dangers: The fusion of both techniques helps to foresee problems and establish strategies for their mitigation.
- Greater ability to adjust: It is possible to make modifications to the schedule based on specific data without jeopardizing the feasibility of the project.

V. Conclusion

Implementing PERT and CPM in Artificial Intelligence projects offers a comprehensive methodological approach to manage uncertainty and improve project execution. PERT is particularly useful in the early stages, where the duration of tasks can vary considerably, while CPM is crucial in the implementation and submission stage, ensuring that the project is completed in the shortest possible time.

By combining both techniques, work teams can improve their planning capacity, minimize risks and ensure that AI projects achieve their objectives efficiently and within established deadlines. This methodology not only facilitates project management but also contributes to maximizing the impact of Artificial Intelligence in its application context.

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