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Artificial Intelligence for Risk Management

A Systematic Review

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A tutti i miei nonni
che mi hanno dato e mi danno
supporto, sostegno e amore incondizionato.
Chi dall'alto, chi invece ancora qui.
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1. Abstract of the work

Artificial Intelligence (AI) is presented as the most innovative and strong tool for its effective applications and benefits. This technology is compared with the intelligence of humans and can be trusted for its results. Artificial intelligence (AI) is expected to influence our societies in the near future significantly and the positive and negative impacts are evaluated and reflected on how technology can be managed to benefit businesses and society and what to expect.

In recent years, research has been done in order to obtain a deeper understanding of how AI could potentially impact business opportunities and growth in the future for its commercial use.

Artificial Intelligence has found its way in inventing new methods and techniques to allow project managers perform their tasks faster and more efficiently, although the inherent uniqueness of projects could hinder the automation of the complex activities. The rapid development of global economies also has a significant impact on the number and complexity of projects. Accordingly, increasing the complexity of projects makes project management a challenging and complicated task. In recent years, there have been several attempts to ease the difficulty of project management by using advanced analytical techniques as Artificial Intelligence, which has significant potential for improving the quality of project management.
There is a wider debate regarding whether project management will remain a profession in its own right or whether it will merge with the wider management practice. In the future, managers at all levels will have to adapt to the use of machines as part of their profession but the fundamentals of project management will continue to provide an irreplaceably human combination of leadership, integration of specialists, and ethical behaviour.

Aim and purpose

The aim of this research is to investigate the state of the art of artificial intelligence methodologies applied to project risk management and to analyse how AI systems can help increasing the efficiency of project managers within risk management. The first

chapters introduce the theory of the problem and are composed of a discussion on project management, risk management and artificial intelligence.

Afterwards, the methodology used has been explained. The study is conducted starting from a literature review on artificial intelligence applications to risk management. All academic publications that investigated the application of AI in different processes of RM are selected, categorized and reported. For this purpose, a systematic review is used to identify, summarize and analyse the findings of all relevant individual studies that are addressing predefined research questions. Subsequently the papers were analysed through inclusion and exclusion criteria, collecting the official sample on which to base the research. The results section provides outputs of the literature search, and the following discussion section describes the current level of AI applications to RM and conclusions were drawn.

The main topics explained were the current debate in the literature and the main AI tools used, how Artificial Intelligence is set to change risk management practice and what challenges need to be overcome. The study also provides an analysis of challenges faced by government and organization in implementing artificial intelligence and information based on facts that would contribute positively to risk management by both project managers and corporates. Indeed, the research also serves to organize the knowledge to provide valid guidelines to the various organizations on which direction to move in this area in a near future.

2. Introduction

2.1. Project Management

The Project Management Institute (PMI) has defined project management as a "temporary endeavour undertaken to create a unique product, service or result." Consequently, it is the application of knowledge, skills, tools and techniques to project activities in order to meet their requirements. The project manager is the person responsible for achieving the project objectives.

It is uncertain who invented the term "project management" but the approach has been developed and modified over time, with early strategic implementations confined to the construction industry over seventy years ago. Later, organizations started using and documenting specialized strategies and techniques to complex missions. Construction projects vary from each other due to differences in customer expectations, project complexity, environments and influences, and shortcomings to increase the complexity of PM.

It is also characterized by specific objectives such as: cost, time and quality. According to R.D. Archibald, project management is the systemic management of a complex, unique, limited-duration enterprise aimed at achieving a clearly predetermined goal, through a continuous process of planning and control of differentiated resources with interdependent cost-time-scope constraints. This "triple constraint" is also named as the Iron Triangle.

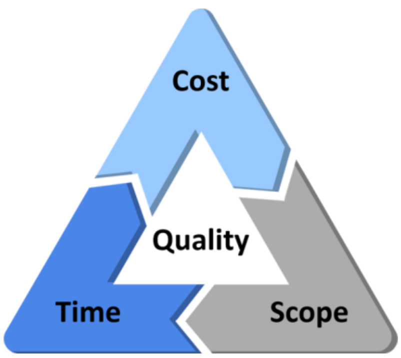

Figure 1 - Iron Triangle

The constant effort to balance these three factors affects the quality of the project. In facts, changing one factor influences the others and requires changes to one or more aspects within the triangle to keep the balance based on the predetermined parameters of the project. The top tip factor of the triangle is the cost or known as the financial plan of the task. Prediction plays a major role in developing the financial plan to decide if a task has the permission to continue against the planning stage. The left-side of the triangle is time. It is associated with the termination period of the project. Contrarily related to cost, for instance if the predetermined period of the undertaking is reduced, the costs to complete the project will increase. The right leg of the triangle has the scope of a project which determines the shortcomings of the project to explain what is included or not in the project. It is the aspect which frequently changes and therefore needs continual adjustments of the other critical elements of the project. In the heart of the triangle resides the quality that can be classified into two kinds: product quality that deals with the quality of the deliverable of the project and necessitates constant inspection. On the other hand, process quality deals with the quality of the PM process and concentrates on how well-executed the process has been historically, and how it can be refined. It is based on the stakeholder's satisfaction who can have different opinions regarding the project success. It is essential the acceptance by the customer and the mutual agreement relative to the changes of the objectives. Projects are rarely completed while respecting the original objective, often some changes of the objectives are inevitable and can also sink the project.

2.1.1. PMBOK: Fundamentals of Project Management

The Project Management Institute's Project Management Body of Knowledge is a standardized guide for project management that includes a collection of guidelines, terminologies, processes and best practices accepted as standards in project management.

The PMBOK framework consists in five main phases that form the process of project management. A Project Management Process Group is a logical grouping of processes to accomplish specific objectives regarding the project. The five process groups are as follows:

1. Initiating process group consists of processes that define a new project or define a new phase of an existing project by receiving the authorization to start. In this phase the benefits of a project are admitted, and the project is approved.

2. Planning process group is about establishing the project's scope, determining its objectives, and planning the course of action to achieve the desired outputs. In this stage basic parameters of the project are defined, activities are scheduled, risks are assessed, and team resource and budget allocation are occurred. For these reasons making a detailed plan for the project development is necessary, including dependencies. The plan must fit a logical time scale and workflow, which help in minimizing cost, duration, and illogical process in the real project. Particularly, the most critical issue is to rationally automate the process, which can also serve to track the actual process and allow for guidance to be completed within the estimated budget.

3.Executing process group includes the processes performed to finalize the work described in the planning process group to fulfil the proper requirements. In this stage the project manager directs and manages the work while the team starts the project work.

4.Monitoring and controlling process group needs to track the performance and progress of the project as well as initiating changes, if required, are included in the monitoring and controlling process group. Modifications are performed if the predetermined objectives cannot be met as planned.

5.Closing process group includes processes that formally close the project, both on time and within the right budget. All the tasks of the project are concluded, the contract is resolved, and the finances of the charged numbers are closed.

Project management is a complex task. The main factor of complexity is the large number of knowledge/skills involved in a project. The PMBOK also categorizes the processes into ten knowledge areas, in addition to the process groups. The knowledge areas are described as identified areas of project management, defined by their knowledge requirements. An explication of the 10 knowledge areas follows.

1. Integration Management concerns the setting of objectives and their connection with the activities/work necessary and sufficient to achieve the aim. Its primary objective is to define and control what is included in the project and what is not. This knowledge area relates to the requirement to co-ordinate these different processes.

2. Scope Management ensures that the project includes all and only the work required, to complete the project successfully. This is because a project usually tends to acquire new objectives and tasks as it proceeds.

3. Schedule Management concerns the processes necessary to ensure the completion of the project in the required time. Project time management involves defining and identifying the specific planned activities that must be carried out to produce the various project deliverables. After that, the documentation of dependency relationships between activities, their duration, the estimation of asset resources and the development and control of scheduling.

4. Cost Management concerns planning, estimation, allocation and control of costs to reach the target within budget constraints. Project cost management focuses on the cost of resources for completing scheduled tasks and to make sure that the project is completed within the approved budget.

5. Quality Management concerns the activities to be undertaken to ensure that the objective of the project meets the needs that motivated it. Project quality management processes are planning and quality assurance and execution of quality control to identify methods to eliminate the causes of unsatisfactory results.

6. Resources Management concerns the organization and management of the project group, assigning roles and responsibilities to ensure the successful completion of the project. The operations included in the project human resource management processes are: human resource planning, project team creation and developing and managing the project group.

7. Communications Management concerns the generation, collection, sharing, storage and retrieval of project information with the project sponsor, project team members and stakeholders.

8. Risk Management optimizes the chances of project success by increasing the probability and impact of positive risks and decreasing the probability and impact of negative risks. If risks stay unmanaged, it may cause delays, cost overruns or loss of reputation.

9. Procurement Management concerns the activities for acquiring the external products or services and necessary to achieve the objectives of the activities planned. Planning purchases and supplies, selecting suppliers and concluding contracts.

10. Stakeholders Management concerns managing communications to meet requirements and resolving any issues regarding project stakeholders. The project will affect many people, inside and outside an organization and, at the same time, they may affect the project scope. For this reason, they need to be identified and managed to minimize their effect on the project.

2.2. Project Risk Management

Risk is always contained within projects, but until now has never been taken into consideration. Risk, therefore, derives from the uncertainty that is characteristic and intrinsic of projects, but it is not necessarily an issue, so, a serious problem that cannot be solved through careful management. Rather, it is an uncertain event that, if it occurs, has a positive or negative effect on one or more of the project's objectives and must be kept under control. It is necessary for organizations to balance risks and opportunities, carefully planning countermeasures to deal with uncertainties through a proactive attitude. This approach is more about prevention than total elimination of risk.

In the past risk management exclusively aimed at projects of enormous size and environmental impact. Nowadays it has theoretically expanded to all projects due to tighter limits on project budgets, time to market and sudden changes in technology.

Project Risk Management (PRM) is the systematic process of identifying, analysing, and responding to project risks. PRM tries to maximize the probability of positive events occurring in the project development cycle and to minimize negative events that could therefore divert the project goal.

Project management differs from risk management because it focuses on risks that have already become visible and have therefore taken the form of problems.

Proper project risk management involves six steps: each of them covers different aspects and uses specific techniques.

2.2.1. The project risk management approach

Risk Assessment is the first phase, and its purpose is to develop agreed priorities for the identified risks. Indeed, it consists in the qualitative and quantitative evaluation of risks deriving from the development of the business activities knowledge phase that goes to affect the planning and programming phases of the project. It is made up of risk identification and risk quantification.

A preliminary stage is required to establish the context. The risk management planning involves determining how to conduct the risk management activities and how risk management will be structured and subsequently executed during the course of the project, becoming a key subset of the overall project management plan. It provides an overview of how to identify and address risks that may occur in the lifetime of a project.

The goal of risk identification is to identify all potential risks inherent and that could affect the objectives of the project. It must be comprehensive, as risks that have not been identified cannot be assessed, and their emergence at a later time may threaten the success of the project becoming a problem. Risks, in fact, can be thought as constraints and opportunities, both of which are affected by uncertainty.

Risk identification is useful to use a checklist of risks that the organization must implement over time, accompanied by supporting documentation and signed off by the project manager at the end or through interviews with PM or project field experts. Risk identification can also be done using other sophisticated techniques, such as, the Delphi method, What-if analysis, Event Tree analysis, cause-and-effect diagrams, SWOT analysis and the Risk Breakdown Structure (RBS) matrix. In addition, the identification process must not only determine what risks may affect the project but must also document the characteristics. This is all contained in the Risk Register.

The output is a comprehensive list of possible risks to the successful outcome of the project, usually in the form of a risk register, with management responsibilities allocated to them.

After risks have been identified and enumerated, risk analysis follows. The objectives of this step are mainly to scale the extent of the assumed consequences and give each risk a priority. An appropriate budget for risk reduction and management can therefore be defined.

Each risk is considered, and a judgment about the probability and the seriousness of the risk is made. The enhancement of risk can be performed in a qualitative, quantitative and semi-quantitative way.
The traditional tools for risk quantification are:

- Expert Judgement, which is useful in assessing the overall risk of the project. Designing of a questionnaire that contains main sources of risk, components of each source, variables that characterize each component, metric sizing of each variable.

- Matrix of Tasks and Matrix of Threats in which activities and processes are contained to be assessed grouped by homogeneous sets, threats or causes of the risks and the intensity thereof.

Using qualitative or semi-quantitative techniques, is possible to generate the risk/activity matrix, also known as the RBM (Risk Breakdown Matrix), a useful tool for classifying the most influential risks at project level and those that are individually more critical, as well as the activities most exposed to risk. In fact, this matrix associates the risks identified in the RBS (Risk Breakdown Structure) and their respective probability of occurrence with the critical activities (or activities close to criticality) of the WBS and their respective impacts. The purpose of quantitative analysis, instead, is to quantify the economic impact of the possible occurrence of adverse events on the Project's costs, after including the benefits of corrective actions in the assessment. The quantitative approach is a useful tool to support decision making and evaluates the possible benefits of mitigation actions through "ex ante" and "ex post" comparisons of the effect of corrective actions on the expected value of the risk. The most common quantitative risk assessment techniques are simulation techniques such as the Monte Carlo method and deterministic or probabilistic models to determine project costs such as CPM (Critical Path Method), PERT (Project Evaluation and Review Technique), GERT (Graphical Evaluation and Review Technique). The availability of time and budget and the need for quantitative descriptions of risks and impacts should guide the project manager in choosing to use quantitative techniques.

After the risks have been organized into a risk table, the team prioritizes them by ranking. It is too costly and perhaps even unnecessary to act on every identified risk. Some of them have a very low impact or a very low probability of occurring or both. Through the prioritization process, the team determines the risks to be addressed. The Risk Assessment Report is a document that defines the severity of the risk expressed as amount of economic damage, probability of occurrence, exposure, correlation with other events and manageability.

Risk Response is the second phase, and in this step, how to respond to the risk is decided. It consists of Response Development and Response Control. (Boehm, 1989)

After the risks are prioritized, the team, led by the project manager, defines a cut off line so that only the risks above the line are given further attention.
The purpose of risk treatment is to determine what will be done in response to the risks that have been identified, in order to reduce the overall risk exposure and to govern the risk and in particular those of prevention, surveillance and contrast. Unless action is taken, the risk identification and assessment process has been wasted. Risk treatment converts the earlier analyses into substantive actions to reduce risks.

There are several strategies for risk response. Strategic responses include eliminating uncertainty by changing objectives and considering alternative technical solutions or transferring financial effects to a third party. Tactical responses consist of mitigating risk by reducing causes and effects, modifying work procedures and correctly planning resources. Or accepting residual or secondary risks with monitoring and control through planning recovery plans and resource allocation to contain the effects of risks.

At the end of this phase of the risk response process, cards must be produced for each risk, in order to be able to monitor each risk afterwards. The Risk Plan is a document that contains the result of the identification steps and quantification defining the severity of the risk expressed as amount of economic damage, the probability of occurrence. Moreover, the countermeasures as description of the actions to be taken, the responsible for activating them, their cost and the residual risk following.

After risks are identified, analysed, and prioritized and actions are established, it is essential that the team regularly monitor the progress of the product and the resolution of the risk items, taking corrective action when necessary. This monitoring can be done as part of the team project management activities or via explicit risk management activities.
The scope of this activity is to assess the effectiveness and efficiency demonstrated in the field by the risk management plan in order to confirm its validity or to trigger a review phase of the risk management system. It is planned to issue an evaluation report for the management and stakeholders.

To verify the evolution of the risk, in order to search for the interventions aimed at meeting and improving the time targets, economic and qualitative verification of the risk and analysis of deviations of the forecasts are necessary. Then any corrective action with the use of contingency plans or contingency reserve is evaluated. This is followed by a re-planning and an update of the risk plan.

Risk monitoring and control must continually keep risks under control, scale back some areas of risk and place greater emphasis on others. The monitoring and control of risks in the broadest sense must include the continuous identification, analysis and planning of new risks and their registration in the risk database, as well as the monitoring of residual risks and the review of the execution of responses to risks while evaluating their effectiveness. The risk monitoring and control process extends throughout the project life cycle and must apply techniques, such as variance and trend analysis, that involve the use of data on the performance achieved by project execution.

If the risky events that occurred are unforeseen, it is necessary to assess the severity; estimate the cost of the countermeasures and implement them and update the Risk Plan with new threats.
If the risky events that occurred are expected, the countermeasures provided in the Risk Plan must be activated.

Finally, if there were not risky events, the reserves must be recovered and allocated to finance other unforeseen risks, increase the value of contingency and increase the margins of the order.
Communication and consultation with project stakeholders may be a critical factor in undertaking good risk management and achieving project outcomes that are broadly accepted. This ensures all parties are fully informed and may help maintain the consistency and ‘reasonableness’ of risk assessments and their underlying assumptions.

2.3. Artificial Intelligence (AI)

Artificial intelligence is a branch of software and computer science in which scientists are aiming to develop augmented intelligence within computer systems. Russel and Norvig (1995, pp. 5) described AI using one explanation as “the art of creating machines that perform functions that require intelligence when performed by people”. Ever since its introduction in the 1950s, the field of AI has witnessed alternating periods of intense growth and significant decline. In recent years, factors such as increasing computational power and availability of Big Data, among others, have led to renewed interest in the field. (Baryannis et al., 2019)

Investments into the research and development within this area have grown significantly over the past few years due to the unprecedented benefits for the human-machine collaborative future. Due to this constant evolution in AI research, the definition of what is considered AI is also continually evolving. Legg and Hutter (2007) have attempted a thorough analysis of well-known definitions of intelligence in order to come up with a formalised definition. In their analysis, they identify two fundamental prerequisite features for considering a human or machine intelligent:

(1) the ability to carefully choose their actions in a way that leads to success or profit, in terms of some kind of objective or goal.

(2) the ability to deal not with a fully known environment, but with a range of possibilities which cannot be wholly anticipated, through learning and adaptation.

Artificial intelligence is capable of doing things that are complicated for humans at the moment but are inspired by them. Such as the ability to process large amounts of data, or the ability to identify and recognize repeating patterns and to analysing them.
AI urges computers to understand and learn human-like inputs for cognition, knowledge representation and enabling them to handle complex and poorly defined issues in a deliberate, insightful and adaptive solution. AI also enables machines to learn from experience, to adjust new inputs and to perform human-like tasks. Data is being generated at an exponential rate. Big data and AI go hand-in-hand, one will not be useful without the other and the two reinforce each other. Although most think AI is driven by Big Data analytics, the scope of the technology under the umbrella term that is AI falls into three distinct categories: Big Data, vision and language. In essence, vision and language are related to machines being able to imitate and enhance human perception capabilities, while Big Data is related to how machines can analyse large amounts of data much quicker and more accurately than humans, find correlations, and even make predictions of how systems will behave in the future. (Prieto, 2019a)

The particular AI techniques that are exploited can range from traditional symbolic AI, relying on mathematical, or knowledge-based problem representations, to sub-symbolic AI, including, for instance, fuzzy systems and evolutionary computation, to statistical AI, encompassing Machine Learning approaches. (Baryannis et al., 2019)

2.3.1. Types of AI Systems

Artificial intelligence systems, in terms of learning and reasoning have been scientifically classified into three categories (Gurkaynak, Yilmaz and Haksever, 2016) as follows:

- Artificial Narrow Intelligence (ANI): also called Powerless or weak AI, is created to perform an assignment and can be specialized inside a limited area of tasks. Whereas these algorithms and software can be modified to do thousands of calculations per second, they are limited in their execution ability by the pre-defined variables set by the developers (Elrajoubi, 2019)
- Artificial General Intelligence (AGI): is also known as Strong AI and the ambition is to achieve it in the long-term view. It is also referred as Human-Level AI (Goertzel, 2007), and represents the type of AI which can mimic humans at almost all levels and, in theory, perform all kinds of tasks that humans can. The theory of these types of "thinking machines" was first posited by Alan Turing who developed the Turing Test to experiment the possibility of Human-Level AI (McCarthy, 2007). Since then, advancements in Computer Science coupled with the revolution in technology pertaining to higher processing power and several experiments were conducted over the years. The subsequent findings suggest that activities that are time consuming and tedious for humans, such as complex calculations, can be performed in seconds by AGI systems. AGI systems will truly reach maturity when cognitive skills will be fully incorporated into their systematic development to make the execution of "simple human tasks" a real possibility for these supercomputers. (Elrajoubi, 2019)
- Artificial Super Intelligence (ASI): is expected to be the sort of AGI system that would quickly evolve to the point it will be able to substitute humans in nearly every field.
  These systems also represent the type of AI that will, according to some theorists, "take over" humankind and lead to a phenomenon which is infamously known as singularity. There is a certain degree of disparity in the scientific community regarding the predictability of the actual occurrence of the point of singularity. Kurzweil (2005) predicts that singularity could be reached as early as 2045. Gurkaynak, Yilmaz and Haksever (2016) argue that due to the human

bias towards linear progress of nature, humans will actually fail to notice the arrival of ASI systems until after they become a part of daily human lives.

2.3.2. Machine Learning

For the artificial intelligence technology, machine learning is an outstanding implementation method. The latter is a subset of AI that supports designing and developing software, mostly mathematical algorithms, that primarily can learn to complete activities without being specifically told how to do so by the developer. From the most basic point of view, machine learning is to input valid data first, then use various algorithms to analyse the data, and summarize and learn the distribution of these data, and finally achieve the purpose to predict and decide in real life. The core of machine learning is data and algorithms. (Xiangbo Zhong, 2021)

It uses a huge amount of data to build algorithm models and learn how to use various algorithms to solve data tasks, by repeating behaviours. It is similar to the “experience” and “regulation” that human beings obtain after being exposed to many things and experiences. This is very different from traditional programming that is just to solve a specific task. (Xiangbo Zhong, 2021)When presented with a variety of instances, the algorithm learns which decision to make and builds a model, the machine can automate tasks based on the circumstances. (Younus, 2021a) (Deloitte, 2016)

Cleaned and appropriate data is necessary for machine learning to operate properly. Diverse ML algorithms are now being used more commonly in forecasting research, which can learn vast amounts of data from a variety of sources before focusing on predicting data inputs.

ML is an important step that trains machines how to identify patterns in large data and make data-driven forecasts on future tasks.

2.3.3. Deep Learning

The term "Deep Learning" refers to a subfield of Machine Learning. It is a subset of machine learning-based artificial intelligence. Typically, deep learning occurs in two stages. The first step is to estimate a model using data, referred to as observations, that are available and in finite quantities throughout the system's design phase. For example, resolving a practical problem, such as translating a speech, estimating a probability density, identifying the presence of a cat in a photograph, or operating an autonomous car. This phase is referred to "learning". It occurs prior to the model being used in practice. The second step relates to the production setting: the model is determined; additional data can then be submitted to reach the desired output. In practice, certain systems can continue to learn after they are put into production, if they have a mechanism for measuring the quality of the outcomes produced.

In 2010, the concept of Deep Learning was born: to take inspiration from how our brain functions, through networks of neurons, to advance the analysis and learn how to extract the data itself. Thus, deep learning is based on what are known as deep artificial neural networks, which are composed of a collection of neurons, small calculators that execute mathematical operations, that transmit themselves numbers in response to their connections, all the way up to output neurons. Deep Learning is capable of recognizing faces, synthesizing words, and even driving an autonomous automobile because of its architecture (Younus, 2021a)

2.3.4. Artificial Neural Networks (ANN)

A neural network is simultaneously one of the oldest and one of the newest areas of Machine Learning. (Nayak & Abdullah, 2020b) Because, although this technique is relatively new in the commercial world, the original theory was developed in the 60´s together with the algorithms and some theoretical approaches. (Jürgen Schwarz et al., 2015)

The main advantage of ANNs is that the whole process, training and testing, mimics the human's brain reasoning, conforming to data patterns and offering better results. In other words, it learns by the experience comparing neural network results with real and known data and is repeated so it adjusts until results of a very low error rate are achieved. Once a good database is developed the chances to obtain reliable predictions with ANNs are very feasible. (Jürgen Schwarz et al., 2015 and Magaña Martínez & Fernandez-Rodriguez, 2015b) Beyond that, it is adaptable to complex issues, with discrete solutions and a lack of data, making it impossible to solve by hand traditional ways the most widely used network type. (Younus, 2021a)

In the first version, the purpose of the ANN approach was to solve difficulties in the field of artificial intelligence, in the same way a human brain would. (Younus, 2021a)Actually, artificial neural networking is a type of artificial neural network inspired by biological neural networks that attempts to imitate human behaviour and made up of artificial neurons. (Nayak & Abdullah, 2020b)

The neural network itself consists of many small units called neurons which are responsible for data transport and processing. (Nayak & Abdullah, 2020b) An artificial neuron is a mathematical function in which inputs are separately weighted and the sum is passed through a transfer function. The input of an artificial neuron is a vector of numeric values. Artificial neurons are organized into layers to comprise a network. (Lishner & Shtub, 2022) The input layer takes the values of the independent variables as input and pass it on to the nodes of the output layer. Particularly a node receives information from multiple nodes of the previous layer with an own associated weight. Then it calculates its internal state by summing the weighted product of the input vector and a numerical parameter called bias. All inputs are summed giving the 'activation'. Activation functions are an extremely important feature of the ANN: they basically decide whether a neuron should be activated or not. Hence neural network consider as universal function approximators, means they can compute any function or any process. The main purpose of activation function is to introduce non-linearity in the network so it would be capable of learning more complex pattern. (Nayak & Abdullah, 2020b)This sum is passed through a nonlinear function, which scales all the possible values of the internal state into the desired interval of output values.

2.3.5. White box and Black box

Most machine learning systems require the ability to explain to stakeholders why certain predictions are made. When choosing a suitable machine learning model, the objective is the trade-off between accuracy and interpretability: accuracy is described by black box and interpretability by white box.

Black box

Black box AI is where AI produces insights based on a data set, but the end-user doesn't know how. Black-box models such as neural networks and deep learning reach conclusions from the data input and often provide great accuracy. This accuracy comes from the algorithms' complexity because of their non-linear nature, but it is not clear how the program came to them and a lack of transparency results. Moreover, the unseen issues affecting the output that are impossible to detect due to a lack of understanding of the black-box model's operations.

Neural network is a kind of black box which takes one or multiple inputs processing them into one of multiple outputs, executing the process without being visible to the developer.

These neural networks can be so complex that humans can't explain the outcomes, even if they prove accurate producing some of the most ground-breaking results of any AI type. Models employing the black-box approach doesn't have any constraints as far as its interpretability is concerned. However, this tends to give the models an extra boost in terms of its performance, since the only goal in this scenario is to perform better and make more profits, and when this happens, corporations often tend to settle in on the black-box approach, or at least, this is what has been happening since many years. Nevertheless, to make a black-box model explainable, several techniques have to been adopted to extract explanations from the inner logic or the outputs of the model.

White box

In contrast, white box AI is transparent about how it comes to its conclusions and with the increasing use of AI models in automated decision making in each and every domain, this becomes essential to a great extent. It enables the users to audit the decisions made by the AI models and to understand the features. However, at the same time, this interpretability, which is supposed to make these models much more reliable, exposes them to vulnerabilities which are often exploited for unacceptable purposes.

Simpler models such as linear regression and decision or regression trees models, on the other hand, provide less predictive capacity and are not always capable of modelling the inherent complexity of the dataset. They can still lead to reliable and helpful predictions but while they may not be as technically impressive, their transparency does provide a higher level of reliability and trust for the end user.

White box AI tends to be more practical for businesses. Since a company can understand how these programs came to their predictions, it is easier to act on them. Businesses can use them to find tangible ways to improve their workflows and to know what will happen if something goes wrong.

Additionally, white-box models produce prediction results alongside influencing variables, making prediction fully explainable. This is especially critical in situations where a model is used to support a very big business decision or to replace an existing model.

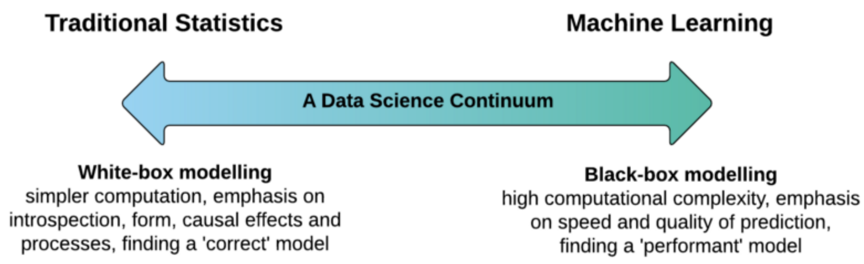

Figure 2 – White box and Black Box from Applied.AI

Both white box and black box AI have unique strengths and differences. As a result, many Machine Learning endeavours today try to balance the two to achieve both interpretability and accuracy.

Many companies have favoured white box approaches in recent years but haven't abandoned black box AI entirely. While black box AI may be unsuitable for highly regulated industries, it is still incredibly useful for other AI models.

3. Preliminary Literature Review

In order to make a preliminary literature analysis, SCOPUS was used as a digital library since it covers a wide range of peer-reviewed articles and high-quality scientific journals.

According to Archambault, SCOPUS is, in fact, the most popular database in academic research. All articles, conference papers, reviews, book chapters, conference reviews and books written in both English and Italian have been considered. In addition to SCOPUS were used other research methods that led to finding 90 papers, of which only 68 eligible to research questions.

The search string used is:

TITLE-ABS KEY (risk AND management AND artificial AND intelligence)

AND (LIMIT-TO (DOCTYPE , "cp") OR LIMIT-TO (DOCTYPE , "ar")

OR LIMIT-TO (DOCTYPE , "re") OR LIMIT TO (DOCTYPE , "cr")

OR LIMIT-TO (DOCTYPE , "ch") OR LIMIT-TO (DOCTYPE , "bk"))

AND (LIMIT-TO (LANGUAGE , "English")

OR LIMIT TO (LANGUAGE , "Italian")).

The initial list consisted of 5247 articles, considering the search keywords for this study. The correct number became 1703 excluding unqualified documents. This bibliometric survey has enabled an analysis of publications on this subject since 1981.

The analysis of the evolution of publications over time has shown an intensification since the year 2005. However, it can be said that this topic has been studied since 1998, with the first publications.

There is also a trend of continuous growth over time, demonstrating that risk management and artificial intelligence have had an increasing interest, both academically and in business. This is related to the increasing complexity of projects and technological innovation that, through more efficient databases, allows the storage of data of old projects. As a result, a better risk analysis and identification of future projects can be performed.

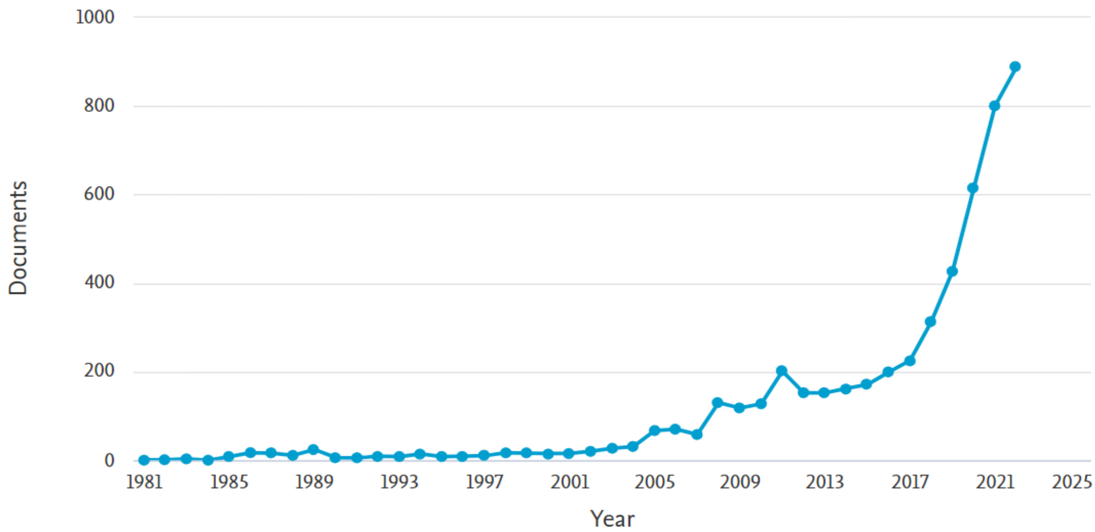

Figure 3 - Documents by year in SCOPUS

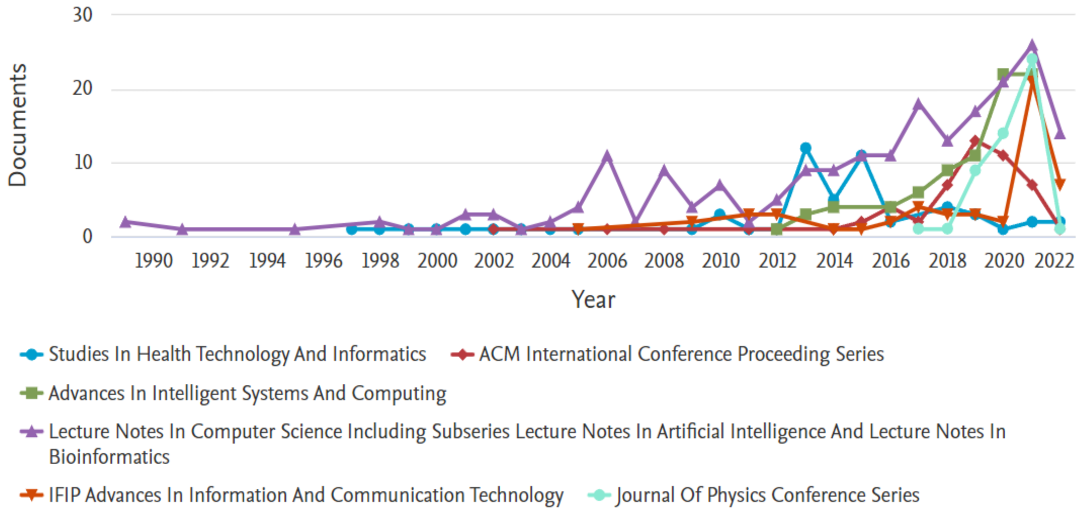

Figure 4 - Documents per year by source in SCOPUS

In terms of source relevance, the analysis indicated a concentration in 3 major sources, which published most of the Artificial Intelligence for risk management articles, as shown in the chart.

The ACM International is a leading global source for scientific information. ACM promotes computer research and innovation through its journals, magazines, and the proceedings of more than 170 annual conferences and symposia. ACM authors are among the world's leading thinkers in computing and information technologies, providing original research and first-hand perspectives. ACM also provides access to the ACM Digital Library, a comprehensive and expanding database of literature and detailed bibliographic resources for computing professionals from a wide range of publishers. It currently includes more than 600,000 full-text articles authored by leading researchers in computing.

The Journal of Physics is a scientific journal published by the Institute of Physics in the UK. It deals with theoretical physics focusing on mathematics and computer techniques necessary for the development of new theories. Another Journal, not in the top ten, but also relevant is *The International Journal of Project Management*, the leading source in the field of project management.

IFIP Advances in Information and Communication Technology publishes state-of-the-art results in the sciences and technologies of information and communication. The scope of the series includes foundations of computer science, computer applications in technology and artificial intelligence. Edited volumes and proceedings of refereed international conferences in computer science and interdisciplinary fields are featured. These results often precede journal publication and represent the most current research.

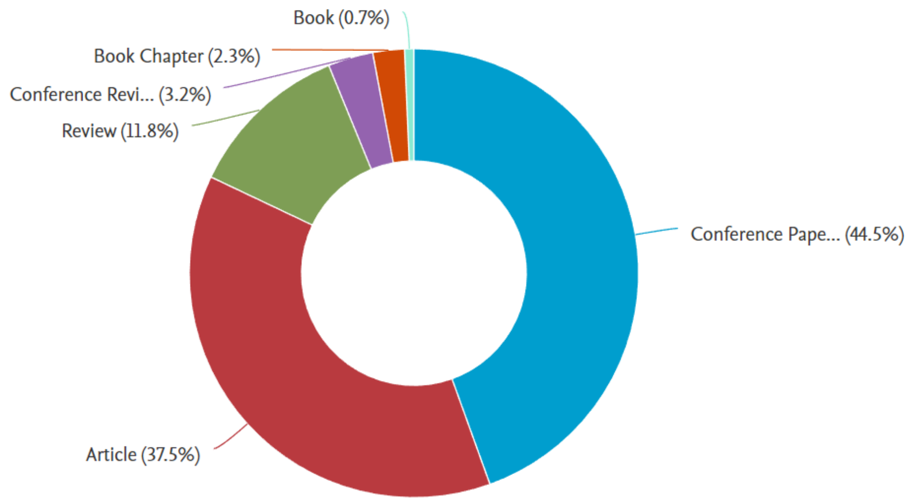

Figure 5 - Documents by type in SCOPUS

Most of the documents analysed are conference papers and articles. Altogether they cover 82% of the total documents from which the analysis started. Reviews cover almost 12% and even if a small percentage is covered adding the books and book chapters, they can prove to be of fundamental importance for a greater scientific authority regarding established definitions and processes, widely accepted by the scientific community.

The distribution of research in the AI for risk management applied to the various sectors is very diverse and heterogeneous. Above all, the predominance of Computer Science and Engineering, which can be reasonably explained through the focus on AI development. A large part of the research is also addressed in finding a model to succeed in identify the best way to manage risks in every area: on a theoretical level explained by 7.3% in Mathematics and Decision Science; on a practical level applied to Biochemistry, Energy, Social Science and Environmental Sustainability.

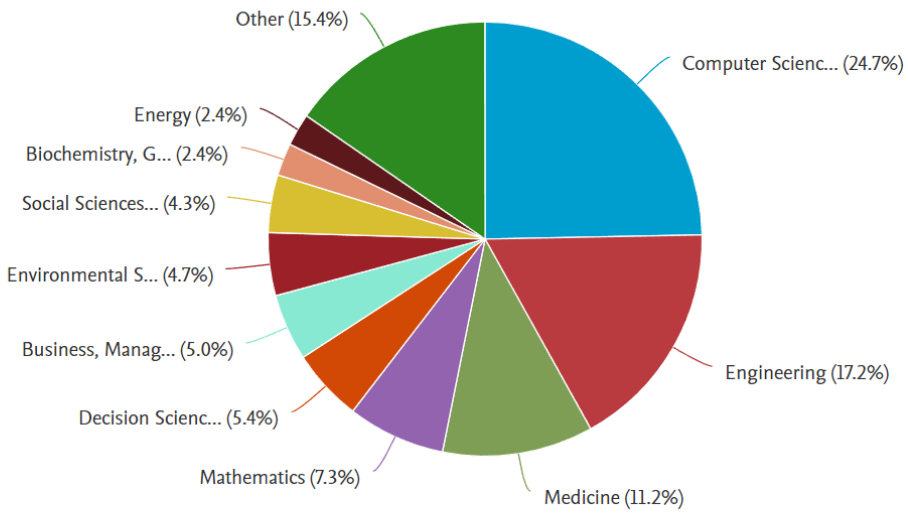

Figure 6 - Documents by subject area in SCOPUS

For authors with more publications, those with a higher h-index were considered, as can be seen in the attached table. The h-index may differ depending on the database in which the search is performed. However, it is an indicator that shows the impact of a researcher on the development of its scientific field. The higher the index is, the more times the research is cited. Four of the most prominent authors (Lauras, Gourc, Marmier, Benaben) have in common the Industrial Engineering Center of IMT Mines

Albi, in France. The latter is one of the three training & research Centers of IMT and belongs to Grandes Écoles, a French institution of higher education that is separate from the main framework of the French public university system.

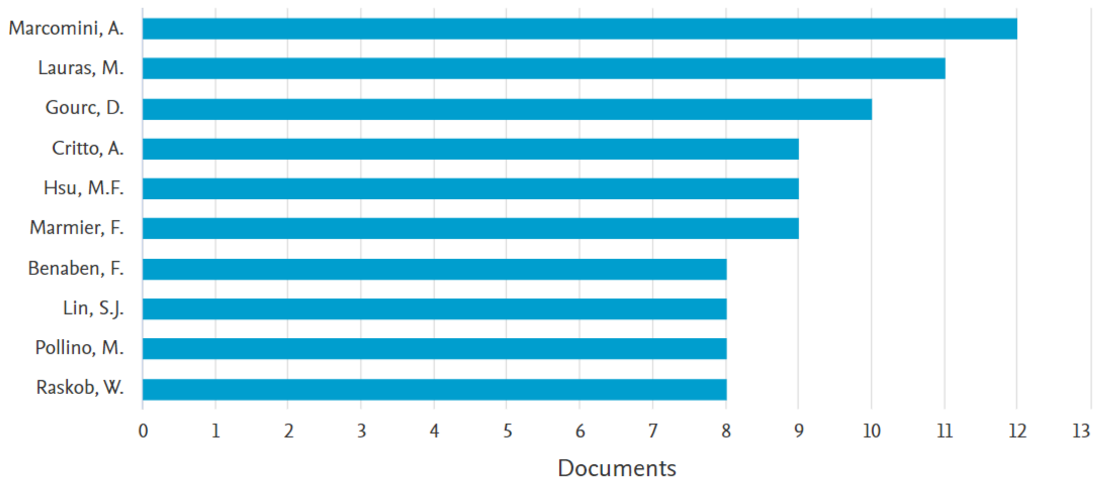

Figure 7 - Documents by author in SCOPUS

The name of the Professor Matthieu Lauras stands out as Deputy Head of the Center. He is also a member of the International Associated Laboratory SIReN (Sentient Immersive Response Networks Lab), directed by Benaben, between Georgia Institute of Technology (USA) and Institut Mines Telecom (France). Gourc and Marmier, as senior researchers, are working on developing models for evaluating the risk level of a situation, the set of available treatment strategies, and then aiding decision making.

Gourc's contributions are supported by a prototype, named ProRisk, the purposes of which are to assist the global project risk level evaluation on one hand, and to help choosing the best response strategies on the other.
Benaben, on the other hand, is the head of the Safety and Crisis Management research team. He basically defined an Artificial Intelligence Framework dedicated to combine Data Sciences and Industrial Engineering. The main application domains concerns information systems for complex situation management in crisis management and supply-chain contexts.

Marcomini and Critto are both professors of the Ca' Foscari University of Venice. Ca' Foscari enters with thirteen disciplines in the QS World University Rankings by Subject 2022, among the most influential rankings of world universities. It also is positioned for Economics and Econometrics among the top 200 universities in the world and fifth in Italy.

Marcomini is Vice-Rector in charge of relations with the territory and has an international thirty-year research experience. He has been on the National Research Council and in Consorzio Venezia Ricerche. Critto is Senior Scientist at the Euro-Mediterranean Center on Climate Change (CMCC), Risk Assessment and Adaptation Strategies Division. He has more than 120 scientific publications in international refereed journals.
The third Italian author in the ranking, Pollini, teaches at University La Sapienza, Rome, which is the first university in Italy for the Academic Ranking of World Universities, released on 15 August 2022 by the independent organization Shanghai Ranking Consultancy. It boasts ten Nobel Prizes as well as illustrious teachers and alumni.
The other two Taiwanese researchers, Lin and Hsu, belong respectively to the Chinese Culture University and the National United University, the latter has been awarded as one of the teaching excellence universities by Ministry of Education from 2006 to 2011 and is among the most cited universities in research and papers.

Raskob, lastly, with over 176 publications and 501 citations, has been head of group at Institute for Nuclear and Energy Technologies Karlsruhe Institute of Technology in Germany since 2004. The institute is a national research centre of the Helmholtz Association and a member of the TU9, an incorporated society of the largest and most notable German institutes of technology. As part of the German Universities Excellence Initiative, KIT was one of three universities which were awarded excellence status in 2006. KIT is among the leading technical universities in Germany and Europe. According to different bibliometric rankings, KIT is the German university with the strongest research in engineering and in terms of research performance in international business informatics.

It can be said that the application of artificial intelligence to risk management is an innovative field of research, on which universities look for a lot of information and are supported by state funds.

The impact of artificial intelligence on society, on economy and even on environment is expected to be significant. This is why many countries have begun to define strategies for research and industrial applications. Risk management appears as a well-established argument, but the predisposition to optimize risk management processes with Artificial

Intelligence tools, especially following the Covid-19 Pandemic, is increasingly affecting companies.

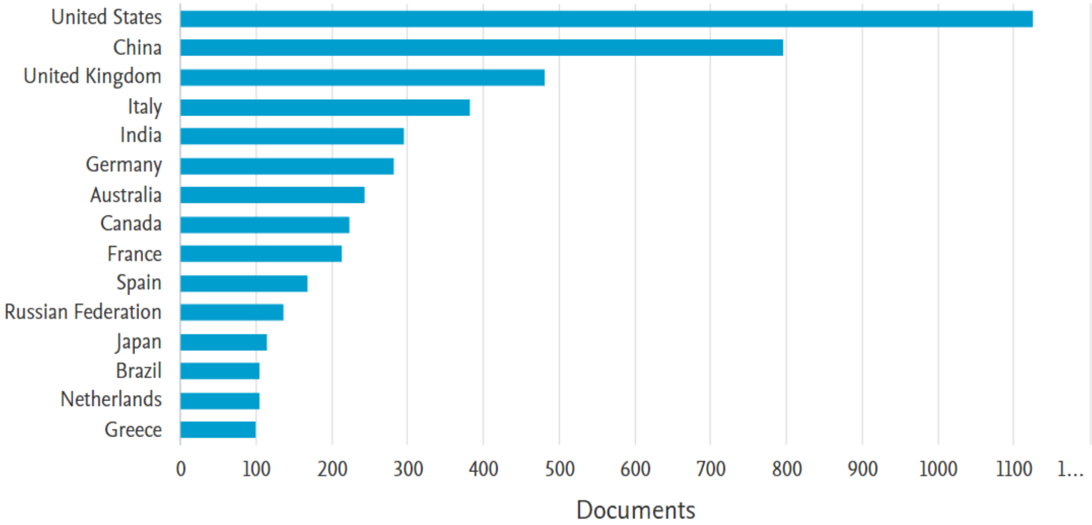

Figure 8 - Documents by country in SCOPUS

As it is possible to see in the table, most of the analysed documentation comes from American, Chinese and European institutions, three countries that have different histories, cultures and approaches not only in the field of Artificial Intelligence, but also political, economic and social. This type of distribution is almost normal because, as known, the disciplines of project management and risk management were born and developed in the United States of America. US appears also as a leader in the international AI competition for the well-established structure of the academic world that boasts a long tradition of interdisciplinary laboratories and the tendency to create worldwide collaborations, moreover a strong immigration of talents. The "American AI Initiative" is set up as a "multi-faceted approach": focused on R&D; access to data and models, creation of Standards, dissemination of technical skills and International links.

While China, as usual, stands out in terms of technology and artificial intelligence developing. Among China’s most recent AI steps, beside the 2017 New-Generation Artificial Intelligence Development Plan, there is the government’s $4 billion R&D budget and investment in the AI technology park in Beijing furthermore the AI research investments of giant Chinese companies. China has also declared its willingness to become, by 2030, the world’s largest power in the field of AI. With this purpose, the country is beginning to attract researchers from other parts of the world to increase research that is currently wholly focused on computer vision.

On the other hand, Europe, despite having the highest level of scientific production and international collaboration, has witnessed in recent years a substantial loss of talents in the research world who emigrate to countries with the highest career and salary opportunities (USA and China). Because of its still fragmentated conformation, the lack of a common strategy and research aggregating centres is also evident. In the last period the EU commission has declared its own approach to AI based on an increment of the public and private investments, has moreover invoked a cooperation between states called "European AI Alliance", an initiative of the European Commission to establish an open policy dialogue on Artificial Intelligence. Since its launch in 2018, the AI Alliance has engaged around 6000 stakeholders through regular events, public consultations, and online forum Exchanges. Other initiatives are the European Laboratory for Learning and Intelligent Systems (ELLIS) and the Confederation of Laboratories for Artificial Intelligence Research in Europe (CLAIRE).

4. Methodology

4.1 Research Questions

The first step required the formulation of research questions for the study (RQ's). The Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines were followed for this systematic review and three main features of research questions and search strategies were developed. The following research questions have guided this review:

RQ1**:** What is the current debate in the literature about Artificial Intelligence in Risk Management and what are the substantial differences between the use of AI and not in risk management?

The scope of this research question is understanding what the recurring topics in the literature are and having a background of the relevant problem, knowledge and methods since the first intersection between AI and RM. Also studying the current problems in the classical methods.

RQ2**:** What AI techniques have been applied to Risk Management processes? Why could the AI techniques help minimizing and efficiently managing risks in Project Management?

The scope of this research question is understanding on the basis of studies what the methodologies are designed to solve the problems and associate them to the given problem. If they have already been applied and under what conditions, and if there are some better than others or not suitable.

RQ3: What are the challenges faced by companies while implementing artificial intelligence? How AI applied to risk management affects the productivity of companies? Why do some firms still exhibit negligence towards implementing AI in their operations? How can risk management integrate AI, especially as a source of new risks across the organisations?

The scope of this research question is understanding how companies approach the topic. What are the advantages that could be brought at the KPI level and how the tools relate to costs, time, productivity and business performance. Moreover, the disadvantages and limitations that keep companies from introducing new tools. Understand if AI could bring risks in addition to managing them. Possibly figure out how to fix it and the future applications in firms and in PM role.

4.2 Study Selection

This step let identify which papers had to be included in the study, following inclusion and exclusion criteria. All the papers were downloaded with the help of Sci-hub and Research Gate and then collected on Mendeley to develop the research categorizing the papers more and less interesting and eliminating duplicates. With the help of Excel, it has been possible to keep track of the evaluation of papers and topics covered by each of them.

To answer research questions, a search strategy was developed by defining keywords and identifying all relevant records. Two sets of keywords were defined and a combination of the first set and the second set was used to identify relevant papers.

First set: Artificial intelligence, machine learning, deep learning, convolutional neural networks, and computational intelligence.

Second set: Project management, project risk management, risk management.

Web of Science, Research Gate e Scopus, Academia Edu, ScienceDaily, OpenAire, Science Direct and Google Scholar were used as a database to identify relevant materials.

In addition, the identified articles have been filtered, after performing manually the selection of the most suitable papers for the study.

The papers had been divided in 3 groups, according to the following inclusion/exclusion criteria.

INCLUSION CRITERIA	CRITERIA EXPLANATION from strict to partial relation
1	Studies focused on AI applied to RM
2	Identification of new digital methodologies to apply to RM
3	Studies written in English or Italian and published from 2005 to 2022

4	Research on current standards used on risk analysis and management
5	Research includes studies of AI models in risk areas
6	Studies analysing AI applied to Management

Table 1 - Inclusion criteria

EXCLUSION CRITERIA	CRITERIA EXPLANATION
1	Studies with no relationship to risk management
2	Studies in languages different to Italian and English
3	Studies dealing with AI in other areas not related to RM or properly management
4	Relevant studies for which complete information could not be retrieved

Table 2 - Exclusion criteria

4.3 Quality Assessment

In this step, the selected study's quality is evaluated to recognize the most important papers for the study. After reading abstracts and conclusions of each paper, everyone was assigned a parameter based on the degree of perceived importance, relative to some variables considered. The latter are the correlation with research questions, the specific content, the source and author relevance with respect to research scope.

The chart of selection strategy based on the PRISMA guidelines is shown in Figure: as a result, 61 papers were included in this literature review.

After the screening process has been completed, each article must be assessed for quality and bias. Subsequently the papers were appraised according on their relevance, reliability, validity and applicability.

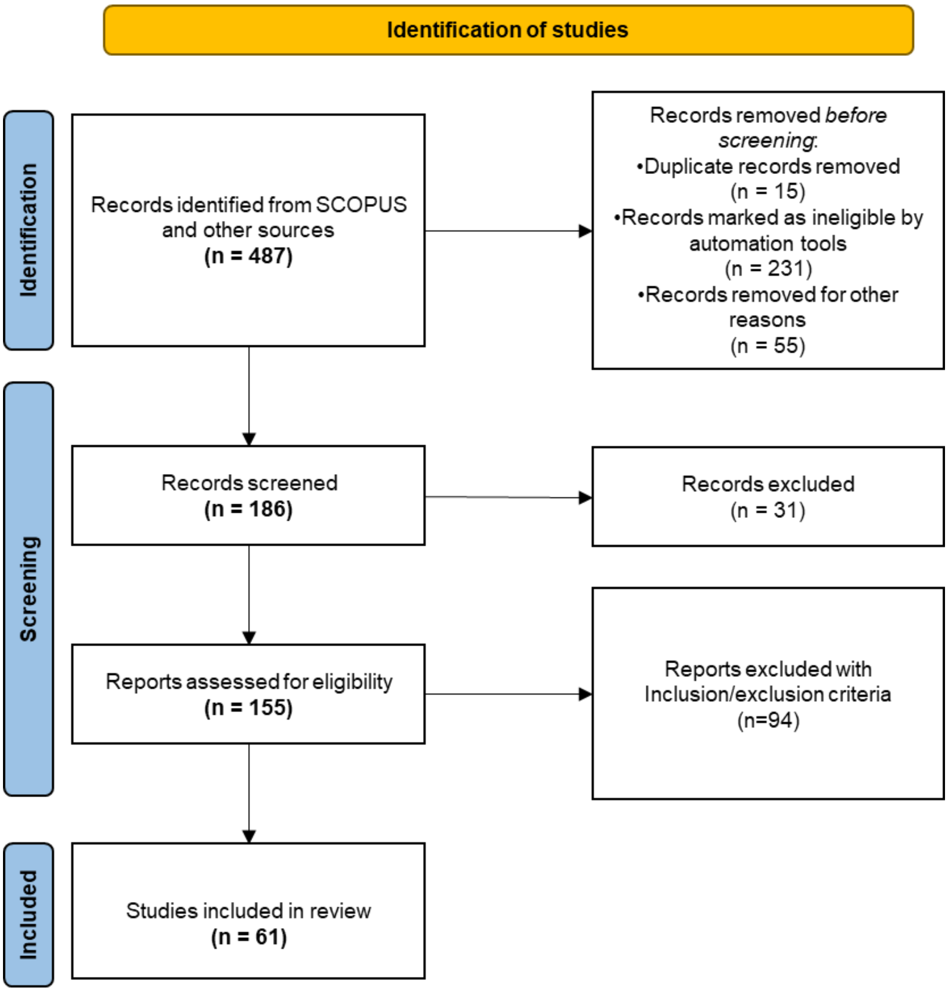

Figure 9 - Identification of papers following PRISMA's guidelines.

4.4 Data Analysis

In order to define the categories of recurring issues in the different papers related to the topic, for each study the following categorizations were made: the general background, the problem that each study faces, the specific research question answered, and the AI methodology used to face the problem. The information collection throughout the analysis process has been possible with the help of Excel. Moreover, to be able to understand more clearly the possible future directions of research, it was also kept track of the limitations, assumptions and future direction that each publication had identified.

5. Results interpretation

5.1. Current debate in the literature about Artificial Intelligence in Risk Management

Since the development of the computer in the 1940s, it has been demonstrated that computers can be programmed to perform quite complex tasks with great skill. Still, despite continuous advances in computer processing speed and memory capacity, there are still no programs that can meet human flexibility over broader fields or tasks that require much daily knowledge. (Zebo Muradovna Isakova, 2021) In relation to the field of project management, machines can copy cognitive functions related to the mind of the project manager such as decision making and problem solving. This includes the use of optimization strategies, automation intelligence, and mathematical methodologies. (Prifti, 2022)

After the mid of twenty centuries, the research on technological changes was more focused on the adoption and usage of new technologies. The technological innovation is perceived as an important factor for transforming the entire society, a factor which should be better understood, controlled and promoted.

On the other side, various project management methodologies were developed and introduced, based upon different project types. (Glowasz, 2022) The theory of innovation started to connect the markets' characteristics with the behaviour of firms (Scherer & Ross, 1990). Due to the continuous advancements of technologies and the intensification of the information flows on the global markets, knowledge began to be perceived as one of the main drivers of the economic growth, being considered as an important economic resource. Even though knowledge was always embodied in the economic activities, the digital technologies expanded its economic presence and has leaded to the acknowledgement of knowledge, as a productive factor. The extended usage of ICTs had changed the economy: new activities emerged, new behaviours of the economic actors, new competences required for the personnel.

Currently, the fourth revolution, or digital revolution, is triggering a profound change in the economy and society. With digitalization has been and will continue to be a key engine of global economic growth. Intelligent construction is rapidly increasing under the influence of Industrial Revolution 4.0 (Chacón,2021), which develop intelligent science and technology to reshape production and management in the whole engineering development lifecycle. (Chenya et al., 2022) The concept of disruptive technologies is highlighting the impact more than the novelty of the technologies, for this reason disruptive technologies are those which have a significant impact on the economic activity of firms. (Bodea et al., 2020). Artificial Intelligence technologies are considered as being one of the most relevant disrupting technologies. The adoption of AI technologies leads to significant changes in the business rules, organizational culture and organizational performance. Considering that the AI technologies adoption in management, more specific, in project management is still not yet well researched. (Bodea et al., 2020)

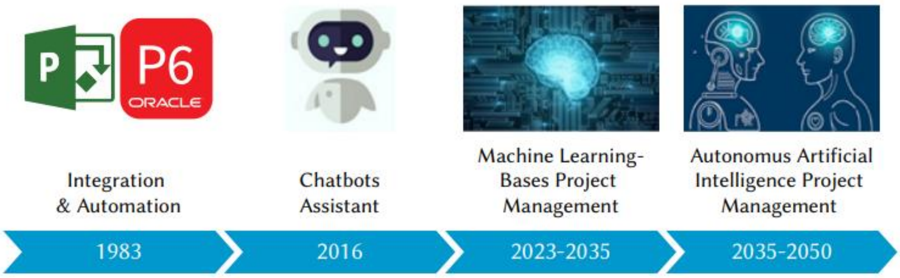

Figure 10 - Evolution in the last 37 years (Ruiz et al., 2021)

As one core branch of intelligent management, the use of intelligent risk management, by analysing and mining data, can assist management companies to establish a process of risk quantification enabling automatic identification, automatic evaluation, and automatic provision of response solutions for refined management, thus ensuring scientific, robust and sustainable development of projects in various areas. (Chenya et al., 2022) Traditional risk management has been studied in depth and has a solid foundation of results, but the integration of risk management with new management techniques is still in its infancy. Traditionally, risk identification methods have been based on subjective human experience. In the face of a large quantity of risk data and a variety of risk types, human-based risk management methods are prone to problems such as low analysis efficiency and insufficient identification of risk. The majority of risk evaluations make use of probabilistic calculations and mathematical statistics based on small samples, which are suitable for the analysis of risk sources. With the rapid advances in information technology, novel applications are being created for data, which cause exponential growth in size. A huge amount of data contains vast amounts of potentially valuable information, which can be used to develop the economy and society. (Chenya et al., 2022)

In recent decades, projects have also tended to increase in complexity, to the point where they have become mega projects. Adopting certain project management methodologies allows to manage the start and the evolution of a project in the most optimal way possible, controlling and responding to any problems that arise during the project, facilitating their completion and approval before any further risks arise. However, these methodologies are arguably not sufficient since the processes must be clearly structured with complete and clear control of the project in all the relevant areas. The aim must be to improve the experience of the project manager when dealing with the various adverse situations that will likely be encountered in the development of the project while simultaneously preventing errors. The current methodologies are largely insufficient since the project manager is generally left to deal with the decision making, who makes intuitive decisions based on previous cases of professional experience when facing a problem with infinite variables and possibilities. Here, it is virtually impossible to face all the issues and challenges that today's projects entail. In fact, there are several reasons why projects tend to fail. (Ruiz et al., 2021a)

5.1.1 Why Do Projects Fail?

Numerous project management organizations and other related bodies, such as the Project Management Institute (PMI), are frequently conducting surveys on the performance of projects across industries. The goal of these surveys is to better understand the effectiveness of measures taken to improve the performance and maturity of project management practices. However, most of the surveys showed an ongoing high rate of project failures. (Lishner & Shtub, 2022) The common measures for evaluating the success are factors of time, cost and quality, the quality of the project management process and the satisfaction of project stakeholders. Further research suggests that 20-45 percent of projects do not meet their targets involving time and cost for missing deadlines. (Lishner & Shtub, 2022; Glowasz, 2022).

Cognitive biases, which are systematic errors in thinking that prejudice decision quality when processing information, are one of the judgmental errors that may affect project managers and decision-making in projects. Moreover, the tendency and preference to maintain and proceed with an already made decision, instead of changing direction and following an available alternative. Additionally, when decision-makers are driven by their high confidence in their preferences and beliefs. Sunk costs and loss aversion could be another cause, especially the human's behaviour driven by the result from previously invested resources of time, money, or effort. The latter impacts decision-making in a way that could lead to a wrong judgment regarding the continuation of an initiative or project. (Glowasz, 2022)

Another root cause is generally referred to as big data, an increasing amount of information that plays a role within projects. According to the Harvard Business Review, approximately 80% of an analyst time is spent collecting, preparing, and analysing data. This not only takes significant effort, but also includes high costs for organizations. Collecting more data and using more project features as input for the prediction model will probably increase the prediction accuracy insights that helps reducing uncertainty in projects and help the risk management but will also make the regression calculation more complex to solve. Therefore, not more than 50% of structured data is being used in decision making. The non-repetitive nature of the projects and the increasing complexity of today's business environments, with frequent changes and rapidly changing information, results in a need for faster responses to changing circumstances. Therefore, the ability to predict the projects outcome is limited and the increasing human incapacity to process relevant data with traditional means is evidenced. (Glowasz, 2022)

The plausibility of project success expectation or distinguishing basic success components in progress could be a field to investigate. Introductory approaches have been based on statistical models that had not been able to reply to project management needs. (Elrajoubi, 2019)

5.1.2 Classical Methods used

The repertoire of techniques already used includes known mathematical-statistical methods such as Program Evaluation and Review Technique (PERT), Critical Path or Chain (CPM), Earned Value Management (EVM), Analytical Hierarchy Process (AHP) and Lean Six Sigma. While applying the CPM and PERT are a very popular way for project duration estimation, the uncertainty that characterizes projects affects the quality of project planning and, as a consequence, the estimation of the project duration is poor. With the right regression model and quality data extracted from past projects, the model can potentially produce better predictions than the traditional methods. (Lishner & Shtub, 2022) During the digitalization, however, more and more data as well as high-performance IT infrastructure is available for processing. Since the informational value of predictive analytics results depends heavily on the amount of data and the number of variables, special data analysis tools are indispensable for practical application. Some summarized this new development under the term Project Intelligence (based on Business Intelligence), which has not yet been widely accepted. AI Platforms for Project Management can be understood as an evolution stage the methods listed above, targeted to unlocking new potential through AI in the context of big data and analytics. (Auth et al., 2019) The above model does not present an opportunity to look at different possible scenarios with different sets of data for similarly completed projects and to be able to instantly assess and compare the project parameters during the planning stage. (Ben & Radhakrishnan, 2021)

In risk analysis two methods can be used: qualitative and quantitative. Typically, the analysis of risks is performed in the majority of cases qualitatively only using checklists in order to identify and categorize risks. Qualitative risk analysis assesses the probability and the consequences of each identified risk to determine its overall importance. (Izabela Kutschenreiter-Praszkiewicz, 2009)

The recent global crisis has demonstrated that the utilization of qualitative risk analysis is not enough for assessing properly risks.

Quantitative risk analysis is a way of numerically estimating the probability that a project will meet its cost and time objectives. It is based on a simultaneous evaluation of the impact of all identified and quantified risks. The result is a probability distribution of the project's cost and completion date based on the identified risks in the project. Quantitative risk analysis involves statistical techniques, primarily Monte Carlo Simulation shall become a requirement for risk analysis to provide more certainty for delivery projects and to reduce cost overruns and delays in the delivery process. (Izabela Kutschenreiter-Praszkiewicz, 2009) In addition, a formal quantitative risk analysis is needed for determining properly the contingency amount in terms of cost and time at the planning phase of the projects, it is recommended to create a risk register for supporting the contingency analysis. (Jürgen Schwarz et al., 2015)

New technologies need to be introduced into the overall risk management process facing the artificial intelligence. (Biolcheva, 2021) By taking advantage of the strengths of AI, risks and uncertainties of projects can be significantly reduced and the confidence level for successful delivery of projects increased. (Glowasz, 2022)

5.2. AI techniques applied to Risk Management processes

During the selection of articles, similarities emerged in the subjects discussed, in particular, used to respond to the second research question. The following provides a comparison of the artificial intelligence techniques used by researchers and described in the articles to manage risks in projects. Focusing on the Project management triangle: costs, time and quality that can, in turn, be sources of risk to manage, as well as the actual phase of project risk management. Some studies have focused on cost and duration issues. Since the wrong management of a project led by a wrong analysis of costs and time could be risky for the project, in the risk analysis were also considered the studies made on the latter.

In several papers, Machine Learning is described as an instrument, for example, it can find the induction of rules: condition-action rules, decision trees or similar knowledge structures. Software learns automatically to recognize complex patterns and to take intelligent decisions based on data. (Couto & Rangel, 2022). For the artificial intelligence technology, machine learning is a very good implementation method. From the most basic point of view, machine learning is to input valid data first, then use various mathematical algorithms to analyse the data, summarize and learn the distribution of these data, and finally achieve the purpose to predict and decide in real life. (Xiangbo Z, 2021). The Machine Learning methods are divided in supervised (classification cases; training data has a label), non-supervised (clustering case; training data has no label) and semi-supervised (a combination of both previous methods) (Couto & Rangel, 2022). Among these methods the following emerge.

Neural Networks have been already described because of their frequent emergence in research. They are artificial intelligence tools that have proven very useful in identifying patterns in complex data structures, especially those involving nonlinear relationships. They are considered more accurate than linear models based on regression models, which have been frequently used in project management (Magaña Martínez & Fernandez-Rodriguez, 2015a) for example in projects where the goal was to reduce the risk of project failure. (Wu et al., 2014).

Artificial Neural Networks (ANNs) algorithm has specially designed to run on technical variables in the purpose of predicting risk involved to undertake a project. Integration of ANN in the field of risk management is the new idea and methodology. It shows better percentage rate of risk prediction compared to other methods so far this domain. It opens for future work with respect to other Machine learning algorithms such as Support Sector Machine (SVM), Genetic Algorithm, Independent Component Analysis (ICA) and others. Experiment may be conducted to see its practical application on Genetic Algorithms. One can extent this work for long term prediction with rigorous experiment on benchmark datasets. (Nayak & Abdullah, 2020a)

ANNs have advantages that make its implementation in computational models highly interesting in all fields of research especially in project management, and that are shared by fellow authors (Ruiz et al., 2021b): the storage of information throughout the network; the ability to work with incomplete knowledge; the fault tolerance; the ability to carry out machine learning; a parallel-processing capacity.

One example of the practicability of the ANNs is the Neuronal Risk Assessment System (NRAS). This method shows a very practical manner for implementing ANNs for assessing the risks in infrastructures projects. The main goal of the system is to determine the contingency amount based on specific project risks. The results show the capabilities of ANNs to mimic the data, offering a great new approach for performing risk analysis. In addition, nowadays it is possible to find commercial ANN tools. (Jürgen Schwarz et al., 2011)

Other Neural networks tool have been explored by (Wu et al., 2014), such as Neural Networks of High Order (HONNS) were originally proposed in the 1960s to perform nonlinear discrimination but were discarded due to the enormous number of higher-order terms. (Prieto, 2019b) Beginning in the mid-1990s, several researchers relied on HONNs rather than ONNs to resolve specific classification problems. In a high-order neuronal, the neuron outputs are fed back to the same neuron or to neurons in the previous layers. The signals are transmitted in forward and backward directions. High-order artificial neural networks are mainly based on the Hopfield model. The Hopfield Neural Network (HNN) is a form of high-order artificial neural network with a single layer of fully connected neurons and provides a method to resolve combinatorial optimization problems. A HNN is guaranteed to converge to a local minimum if a problem can be described as an energy function with a minimum corresponding to the optimal solution.

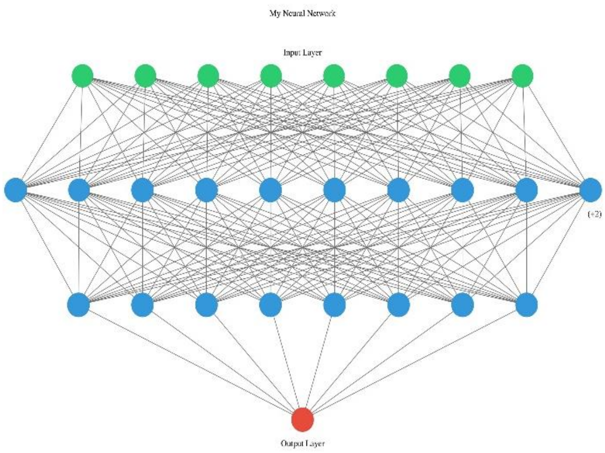

Figure 11 - ANN structure

Many authors also supported the **Fuzzy Logic** process, in other words, the process that maps fuzzy set to a crisp set. (Kutschenreiter-Praszkiewicz I, 2009; Ruiz et al., 2021, Prieto, 2019). Thanks to this tool is possible to simulate the risk and uncertainty that are always associated with projects. The advantages for projects managers include speeding up decision-making and simulation of potential development projects (Elmas & Babayev, 2021).

Fuzzy Cognitive Maps, on the other hand, present an extension of cognitive maps and constitute a fuzzy graphical structure used to represent causal reasoning.(Magaña Martínez & Fernandez-Rodriguez, 2015b) Their application is recommended for domains where the concepts and relationships are fundamentally fuzzy, such as projects. Each node represents a fuzzy set or an event that occurs to some degree. Here, it should be clarified that nodes are causal concepts and can model events, actions, values, objectives, or processes. Using this technique also provides the benefits of visual modelling, simulation, and prediction. Scenario analysis contributes to the identification of different alternatives to reach a future state. (Ruiz et al., 2021). Furthermore, despite the DCM applications for the selection of information technology projects, the technique has not been linked to the organizational models that are obtained by describing the business architecture through business modelling activities. (Ruiz et al., 2021b)

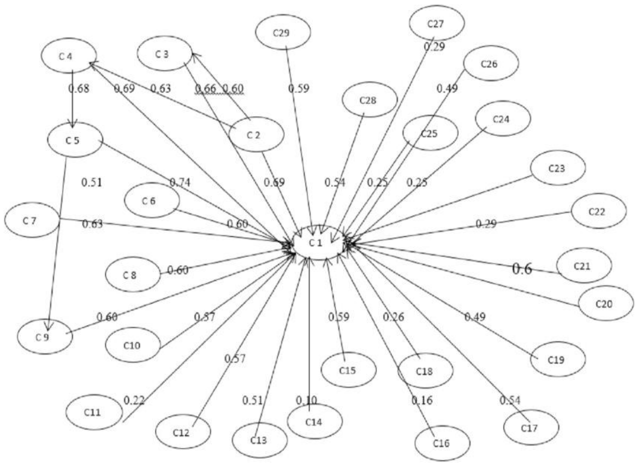

Figure 12 - Fuzzy Cognitive Map

Monte Carlo Simulation, on the other hand, is the best-known quantitative technique and is widely used by risk analysis practitioners (Jürgen Schwarz et al., 2011). Actually, it has emerged a promising technique among the various risk assessment techniques in construction projects to measure stochastic behaviour of risk while expecting complex interdependencies between project activities and resources for cost estimation. In a recent study, a simulation model has been developed to measure the impact of schedule delays on cost overrun. This model applies a risk integration approach in generating random scenarios and computes the cost impact of a delayed milestone in the expected budget. (Afzal et al., 2021a)

Even **Support Vector Machine** are more complex in formulation than decision trees but have the same essential end goal of creating groups based on input characteristics to classify and predict outcomes. In the case of SVM the approach is to map characteristics on a plane and classify groups based on similarity of where they are on this plane. Clustering machine learning techniques has some similarity with SVM in that they involve mapping characteristics on a plane. (Aziz & Dowling, 2018). SVM's characteristics allow it to deal better with unknown data and, generally speaking, present some advantages over neural networks. They are being applied successfully to cost estimation in the construction industry and in the financial area. (Magaña Martínez & Fernandez-Rodriguez, 2015a). In (Jürgen Schwarz 2015)'s opinion, supported by (Ruiz et al., 2021b)and (Magaña Martínez & Fernandez-Rodriguez, 2015b), SVM represents a very promising method, better than MCS and ANNs because it permits to learn from the data and simulating without assumptions. Simulation, indeed, is an implementation of artificial intelligence into risk management decision-making processes in construction projects based on the identified hyper planes, which increase certainty, however the method is based on the artificial intelligence theory and requires a considered amount of data to perform its learning process. SVM permits to integrate a learning process with the performing of simulations based in the random generation numbers for a better forecast of risks, nevertheless there is until today no commercial software for its utilization in the praxis. For this reason and for the practical purpose of this work, SVM is only mentioned as a possible future commercial tool but is not included in the model and simulation.

Method	*Required Inputs*	*Learning Process*	*Robustness*	*Appliance in the market*
Monte Carlo Simulation	Just three or two values needed (minimal, expected, maximal)	Not possible	In directly relationship of the mathematical model and inputs	Many commercial software
ANNs	Data banks needed	Based on learning from Data	High because of its learning process	Some commercial software
SVM	Data banks needed	Based on learning from Data	High because of its learning process	No commercial software

Table 3 - Comparison among MCS, ANNs and SVM

Genetic Algorithms (GAs), try to simulate the evolutionary natural process and were originally proposed by Holland. They are easy to apply so they can be fused with other heuristic methods creating ad-hoc solutions. (Magaña Martínez & Fernandez-Rodriguez, 2015a). The wide application of Genetic Algorithms, indeed, is related to the problems for which there are no specialized techniques. In fact, these algorithms are used in countless applications. In general, the application of GAs to the planning of multiple projects that are to be executed simultaneously has yielded good results. In certain studies, a method based on penalties has been adopted since it is difficult to obtain wholly correct solutions due to the complexity of the problem of optimization. While the identified solutions have, overall, been good, it is important to highlight that, in some cases, the solutions lay outside of the algorithms, since the best solutions do not always meet all the restrictions of the problem.

The GA is used to solve both constrained and unconstrained optimization problems. GAs are excellent for searching through large and complex data sets. With GA it is possible to simulate the risk and uncertainty that are always associated with projects, and in addition they can solve resource levelling, optimization, and management problems. (Elmas & Babayev, 2021a). However, although they all claim that they are suitable for big problems, (Magaña Martínez & Fernandez-Rodriguez, 2015a)disagrees claiming GA's difficulty application to large and complex problems.

The use of GA with other tools as a hybrid method is increasingly being used to search for the optimal construction project time and cost trade-off under different risk levels. This technique helps to find the ideal balance of the time and costs under different risk levels as characterized by decision makers. (Afzal et al., 2021a)

K-Means is another intuitive approach that incorporates heuristics algorithms, such as Lloyd's one, and it is simple to implement for creating data cluster from random data, even in terms of large datasets. It has been widely used. Its main problem is that it cannot ensure an optimal convergence but is widely used due to its simplicity. (Ruiz et al., 2021b). K-means clustering is the most popular approach, although other methods such as X-means and hierarchical clustering are growing in popularity. The idea of the iterative process behind the technique is to maximize the difference in means between determined groups. (Aziz & Dowling, 2018).

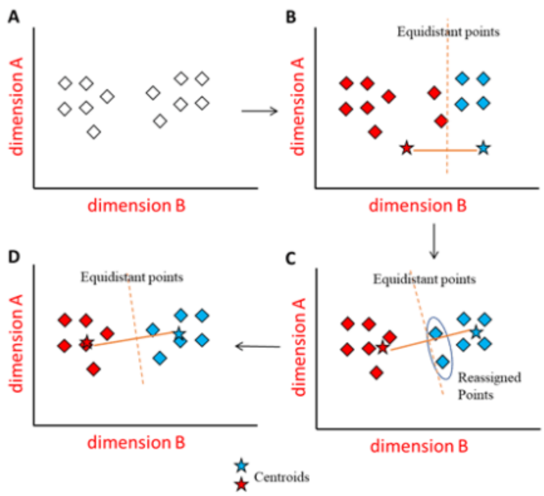

Figure 13 - K-means approach

Other less considered Models

Bootstrap Technique is a widely applicable and extremely powerful statistical technique used to estimate quantities across a specific population by averaging estimates from multiple small data samples. Importantly, the samples are constructed by drawing observations from a large data sample one at a time before returning them to the data sample after they have been chosen. This allows a given observation to be included in a small sample more than once. This sampling approach is known as "replacement sampling." The bootstrap method can be used to estimate the size of a given population. This is achieved by repeatedly taking small samples, calculating the statistics, and then extracting the average. It can be used to quantify the uncertainty associated with a given estimator or statistical learning method. (Ruiz et al., 2021a)

Bayesian belief networks adopted by (Afzal et al., 2021b) for risk management in tunnel development and highlight the key issues of experts' judgment bias ignored by previous studies. They further suggest the significance of subjective judgment in BBN to guarantee the reliability of the model's result. In another study, a probabilistic causal model dependent on Bayesian network has been created, which identifies and evaluates the complex cost-risk network of tunnel development projects. It was proposed for a quantitative risk evaluation structure using Bayesian networks for probabilistic risk analysis. This model characterizes a conditional path network among complexity and risk interdependencies for cost overrun. Recently, the effectiveness of BBN in project cost-risk analysis has been found in various studies to measure interdependencies among project complexity and risks factors. In contrast with other risk evaluation techniques such as ANNs and MCS, BBN has appeared to be a popular technique in managing cost due to its simplicity for use by experts and its precision of results. Because of the absence of adequate information for the risk evaluation in complex construction projects, BNN can be effective to produce adequate results in limited experts' judgment. (Prieto, 2019b) (Afzal et al., 2021b)

Fast Messy Genetic Algorithm (FmGA)can efficiently identify optimal solutions to problems with a large number of permutations. This type of algorithm is known for its flexibility due to its capacity for being combined with other methodologies to obtain better results. The difference between it and other genetic algorithms is based on the possibility of modifying building blocks to better identify partial solutions, which help us to focus on a faster global solution. (Magaña Martínez & Fernandez-Rodriguez, 2015a; Ruiz et al., 2021b)

An Expert System (ES) is a computer program that uses AI to simulate the judgment and behaviour of a human or organization that has expertise and experience in a particular field. The power of an ES is based on its knowledge base - an organized collection of facts and heuristics about the system domain. ES can be applied areas include, scheduling, planning, risk estimation and classification. (Elmas & Babayev, 2021b)

Analytical network processing (ANP) are risk assessment tools that deal with risk effects independently have raised some concerns of network interdependency. These methods have limited applications in construction projects where system complexity and uncertainty are high. An ANP method has been developed to address the priority of criteria and sub-criteria having interdependencies between the higher and lower level elements of the system. Unlike analytical hierarchy process where decision problems are framed in the hierarchy, however, ANP network resolves the issues in related network structure. While addressing the interdependency, ANP evaluates the project cost risks in complex network interactions. The basic limitation of this approach is that it performs a pair-wise comparison while assigning a crisp value to capture uncertainty and stochastic behaviour in risk data of complex projects. Similarly, this pair-wise comparison requires more complex network links and additional computation if risk elements increase in the system. (Afzal et al., 2021b)

Structure equation modelling (SEM) has been increased in the construction management domain where complex relationships exist. For example, (Afzal et al., 2021b) employed SEM to calculate the interdependency coefficients of risk-related factors and the impact of each risk path on project cost overrun. One of the limitations of SEM is that it does not assume the uncertainty and stochastic behaviour of events. This multi-variate model is suitable only to find complex interactions of system elements where uncertainty is low. SEM has limited applications for complex projects, under high uncertainty, and where limited and vague information is available. (Afzal et al., 2021b)

Case-based reasoning (CBR) is a sustained learning and incremental approach that solves problems by searching the most similar past case and reusing it for the new problem situation. Therefore, CBR mimics a human problem solving. CBR is a cyclic process of learning from past cases to solve a new case. The main processes of CBR are retrieving, reusing, revising, and retaining. The case can be defined by key attributes. Such attributes are used to retrieve the most similar case, whereas, reusing process is utilizing the new case information to solve the problem. Revising process is evaluating the suggested solution to the problem. Finally, retaining process is to update the stored past cases with such a new case by incorporating the new case to the existing case-base. (Elmousalami, 2019)

These methods employ ANP network theory, BBN, MCS and ANNs. Such probabilistic techniques alone are not appropriate in evaluating the cost-related risks under uncertainty and due to lacking risk information. Conversely, fuzzy techniques are exceptionally productive in modelling the vulnerabilities experienced in experts' decisions and have been often utilized as hybridized strategies for construction risk assessment, throughout the last decade. Fuzzy structured methods include, FANP, FBBNs, FMCS and FANNs. In recent studies, few optimized algorithms called GA and multi-variate SEM are also found to be useful in measuring project risk interdependencies for the optimal cost solution under uncertainties. (Afzal et al., 2021b)

Other nature-inspired popular meta-heuristic optimization algorithms include: Particle Swarm Optimization (PSO), Artificial Ant Colony Optimization Algorithms (ACO), Artificial Fish Swarm Algorithms (AFSA), Artificial Bees Colony Algorithms (ABC), Firefly Algorithms (FA), Bat Algorithms (BA), and Shuffled Frog-Leaping Algorithm (SFLA). (Prieto, 2019b)

The adoption of these will result in a new set of Tools Techniques and Procedures (TTPs)s for better PM performance well beyond what is currently being used.

In this research, three project elements, namely Cost, Time and Risk will be explored with their impacts on the application of AI Tools, Techniques, and Procedures (TTRs). (Ben & Radhakrishnan, 2021)

5.2.1. Cost Modelling Methods

A three-stage model of input, process and output was created where the input evaluated are: cost data, evaluation data, productivity and safety data.

For the project cost, because of their volatility, the formulation of a regularization neural network and the presentation of a neural network architecture for cost estimation of projects are discussed. As an illustration, the model is used to forecast the cost of a reinforced-concrete structural unit. The new computational model is mathematically sound, which makes cost estimation more reliable and predictable over time. ANNs have been also used for monitoring project Productivity and Safety. Numerous alternative neural network structures were studied; the three-layered network with a fuzzy output structure was chosen as the optimal configuration. Due to the subjective nature of much of the data, it was determined that this structure gave the most suited model. (Younus, 2021b). ANNs (4-5-0-1) structure where respectively the numbers represent the number of inputs (four key cost drivers), the number of hidden nodes in the first hidden layer; zero means no second hidden layer used and one represents one node to produce the total cost of the FCIPs. (Elmousalami, 2019).

One of the first challenges faced by any project manager is the responsibility of scheduling a project with all its identified tasks and their dependencies. Highly developed analytical scheduling techniques have been developed and in use now by many standard tools. For AI large amount of such project, data is key for analysis and more accurate output. For this research as noted in earlier sections, a large AI database with similar data was created with over six hundred projects to reflect real-world data for this research and was deployed into Watson. Once the database is accepted into Watson, the project manager now is ready to input a new project tasks data, and Watson will output the expected actual duration for the new project within a short time. This is really risk identification and the practitioners now can look at the specific tasks identified by AI and start mitigation plans early in the project cycle. This was done successfully for this research project with many project inputs. In addition to the estimated time duration output to complete a given new project, this research verified the following attributes of AI, as noted in the Introduction. This is orders of magnitude shorter than a practitioner might be able to do with spreadsheet software and applies only to one project. To verify that the model can be trusted, one of the project data already in the AI database was input as a new project and AI Watson's estimated actual completion output was 99.9% of the value of the actual value entered in the database. This also reflects the accuracy of the output of AI. The algorithmic pipeline also suggests influencers on the project, which tasks and their relationships can potentially pose a problem. This is not possible in a spreadsheet type of estimation. These are risks and PM can develop a mitigation plan. (Ben & Radhakrishnan, 2021)

5.2.2. Time Modelling Methods

The use of ML for prediction is very common, and in the last few years, many studies have also focused on the use of ML and ANN to predict project outcomes. ANN and linear regression were used to estimate IT project efforts; however, the methodology was too complicated to be generalized as a generic tool. ANN performance was found superior compared to other multiple regression models in project effort estimation, and an algorithm for software project prediction exists but does not fit other types of projects and is validated only with the quite old ISBSG public dataset. The common theme of all of these studies is that none of them presented a validated project duration prediction model that applied to real projects; none of the existing studies presents a practical AI duration prediction tool that is flexible enough to fit different types of projects and organizations and includes a prediction model which can be dynamically adjusted and optimized for any given organization's dataset. For these reasons, (Lishner & Shtub, 2022)presented the dynamic project duration prediction (DPDP) method. The DPDP methodology employs a supervised machine learning technique to build a predictive model, based on a dataset of features that encapsulate relevant characteristics of projects, to map true inputs to true output. As there are not many constraints regarding the inputs, it is required that the dataset include the actual duration of recorded projects used as an output for the model training. The DPDP uses historical data from past projects and learns from them what future projects will look like according to the project features. The method is agnostic to many biases between organizations and project types. The biases are usually caused by different ways of measuring project features, such as risks, duration estimation, parameter definition, different project management procedures, different types of projects, etc. The prediction model is based on ANN; the ANN was chosen as the preferred ML method as it can address almost any regression problem and supply decent results as long as it is constructed with the proper architecture and optimization. Nevertheless, the generalization comes with a price of not always being optimal in terms of computing resources. The DPDP method is constructed from two sequential phases: data processing and ANN model optimization and compilation. The data processing phase includes loading the data, cleaning it, and converting it into a format that the ANN can accept. In the ANN model optimization phase, the model is trained and tested multiple times until it is optimized to produce the most accurate prediction.

5.2.3. Risk Modelling Methods

Benefits acquired from Artificial intelligence applied to risk management are essentially of two types: (a) Direct benefits cater cost, people and product; (b) Indirect or secondary benefits to process management, optimization and decision making. (Nayak & Abdullah, 2020)

To start the Risk Identification stage, input information is needed about the types of business processes carried out in the given organization. Experts must also define all activities that are performed within each individual business process. These activities are carried out through the human factor in the organization. Within its scope, all the parameters that affect the activity of each business process are defined. This includes parameters from the macro environment (economic, geopolitical, social, cultural, etc.); from the microenvironment (customers, contractors, competitors, etc.); from the internal environment (organizational, managerial, human resources, technologies, financial potential, etc.). At this point, the role of the human factor is to define all the parameters that it considers relevant. This analysis is complemented by the capabilities of AI and, more precisely, the conduct of semantic analysis – scanning over the Internet and to identify other parameters missed by experts in individual business processes. (Biolcheva, 2021)

The availability of this information is the basis for reaching the essence at this stage, namely the identification of the risk. For the most part, it is done through the capabilities of AI: • Analysis of a database from previous periods, performed on the risk register, which is maintained by the organization. Here the AI seeks a connection between historically manifested risks and the specific activities of each business process. • Analysis of a database by main indicators, conducted again through AI, the difference with the previous analysis is only in the type of database. Here the necessary database is purchased from the market of information products. Such databases are available for various macro indicators and other indicators that can be widely used. • Semantic analysis by AI, to supplement the identified risks outside the available databases. Its ability to analyse various structured and unstructured sources and establish a relationship between them is the basis for identifying an additional set of identified potential risks relevant to the business processes of the organization. • Expert analysis which has rather control functions and goals considering the views of experts on individual activities in the organization. (Biolcheva, 2021)

The result of the identification is the generation of a list of potential risks to each individual activity within each business process. These risks should be described and categorized in a way that meets the needs of the risk register. Another advantage of risk identification through artificial intelligence is the ability to automatically update the identified risks in the event of a change in some of the indicators of the environment. The outcome of this stage is the application of the identified risks to the risk register. It also uses the functionalities of deep learning, which provides information based on multiple layers of parameters and a system of algorithms. Of great importance, especially for risk identification, is the ability of AI to conduct semantic analysis. Its main advantage is the work with structured and unstructured data used for general analysis. In this way, data from diverse sources can be linked and provided for machine learning in a more cost-effective way. On this basis, semantic analysis can conduct various analyses, including on the Internet, to identify various risk factors. (Biolcheva, 2021)

Risk assessment is made once the potential risks have been identified and described. The possibilities of artificial intelligence are also used for it. First, an assessment is made of the frequency with which the potential risk would manifest itself. This analysis is performed through historical database analysis and predictive environmental analysis.

AI's capabilities for combinatorics and deep learning are used here. The risk analysis continues with an assessment of the risk manifestation on the quality of business processes. This analysis is performed in a similar manner. Another thing to keep in mind when assessing the risk is what would be the financial consequences of its implementation. This is a reason to make an assessment in this direction too. Here, artificial intelligence provides an assessment based on market values of assets, accounting for time and human capital costs, the cost of reputational damage. The fourth part of the assessment is performed again by AI and refers to the potential time losses from the delay of the respective business processes, due to realization of the potential risks. The summarized results of these assessments are visualized in a "probability matrix". There the risks are arranged according to their magnitude. In the matrix, the risk gradation is visualized with colours and allows for a good illustration of their level. Apart from this analysis, AI also performs an assessment aimed at establishing a causal relationship between individual risks. This is necessary to withstand the chain effect of the risk and greater accuracy of its assessment. This assessment is also needed to prioritize risks, according to their relationship to certain activities and BP. All results so far are the basis for conducting a simulation using the Monte Carlo method, based on which the numerical values of each individual risk are derived. From this one of the most labour-intensive stages of the risk management process is much easier to implement, and its assessments are more detailed and accurate. (Biolcheva, 2021) Another study investigated the risk of requirements as a part of the risk assessment problem by using different machine learning techniques such as Bayesian networks classifiers, k-nearest neighbours and decision tree. (Davahli, 2021)

The next stage of the risk management, Risk treatment process, is aimed at influencing the assessed risks, i.e., this is the stage in which their management is actually carried out. At this stage, artificial intelligence finds its place again. Here his task is primarily related to conducting analyses, but the specific choices of means and way to have an impact are in the hands of experts in the business organization. The input information needed to start the stage is the result of the risk assessment. Based on it, artificial intelligence integrates all interrelated risks and seeks their relationship with the expected negative consequences of their potential realization. The result of this activity is aimed at obtaining a complete profile of each individual risk. According to these values, AI activates its deep learning algorithms and shows the appropriate strategies that would give positive results. The specific measures that are appropriate for each specific risk are also visualized. The experts can make their choice from among the proposed ones or choose others according to their own choice. Once the measures are implemented, their effect is monitored. In case such is not registered, the procedure for selection of measures is activated again. If an effect is found, the level of residual risk is assessed (according to the already known procedure from the previous stage). If the assessment of the residual risk corresponds to the risk appetite of the organization, it is considered that the risk treatment has been successful, and the risk monitoring stage is started. If not, the procedure goes back to choosing new risk management measures. Once the measures are implemented, their effect is monitored. In case such is not registered, the procedure for selection of measures is activated again. If an effect is found, the level of residual risk is assessed (according to the already known procedure from the previous stage). If the assessment of the residual risk corresponds to the risk appetite of the organization, it is considered that the risk treatment has been successful, and the risk monitoring stage is started. If not, the procedure goes back to choosing new risk management measures. (Biolcheva, 2021)

Risk monitoring is the stage in which full monitoring of the manifestation of risk is performed. It should not be forgotten that organizations operate in highly dynamic environment. Changes in the environment must be recognized in order timely changes to the system to be applied. The approach proposed in this material for monitoring, through the capabilities of AI, begins with monitoring the risks of the risk register. AI monitors for changes in the parameters of each risk. If such is identified, the risk identification phase is reactivated and the whole risk management process is triggered. The experts in the organization also take part in this activity: they supplement the analysis with an available upcoming change in counterparties or when they have information about upcoming future events that are not reflected by artificial intelligence. Another indicator under observation is the change in the effect of the risk response. When over time it turns out that its benefits diminish or need additional impact. The last indicator that is proposed for monitoring the planned and reported activities and their financial values. Depending on the type of organization, additional monitoring indicators may be offered and any change in them is a prerequisite for starting the whole process again. (Biolcheva, 2021)

5.2.4 Hybrid Models

There are also hybrid models that serve to extract the characteristics of each algorithm and are able to provide a resolution more suited to the risk management problem, making the strengths of one cover the weaknesses of the other. These hybrid systems are the future of AI and automated project management, a list of the main techniques used in the review of articles follows.

Fuzzy hybrid methods (FHMs): AI-based hybrid methods have been extensively used for risk assessment in complex projects. These methods effectively cover the uncertainty and stochastic behaviour of project risk events. Fuzzy techniques are exceptionally productive in measuring the vulnerabilities experienced in complex construction projects and have been widely adopted as hybridized strategies for construction risk assessment in the previous decade. (Afzal et al., 2021b)

Fuzzy-analytical network processing (FANP): ANP and design structure method in the network theory assign absolute values in the pair-wise assessment of risks and do not consider the vagueness and vulnerability in risk analysis. The FANP first recognizes potential risk factors and their interdependencies and then constructs a network model demonstrating their weighted connections. FANP consists of multiple stepwise processes, such as a pair-wise comparison between the risks utilizing an appropriate fuzzy linguistic scale, calculation of consistency ratio, calculation of priority weights matrix, a creation of super-matrix and ranking of risk scores.

Fuzzy Monte Carlo Simulation (FMCS): to overcome the shortcoming of probabilistic nature of risk in certain circumstances, presented a novel approach for risk evaluation comprises of fuzzy logic and simulation. Similarly, also presented a schedule and cost-risk measurement strategy while using the FST and MCS for assessing risk-related activities while considering the uncertainties in risk elements. The fuzzy-simulation approach is quite helpful to assess the dependencies among risk element under high uncertainties, exist in complex construction projects. However, the fuzzy-simulation method is not simple for mega construction projects because, in the absence of adequate information, this hybrid technique is also not reliable for decisions and is unable to present true interdependencies among risk factors.

Fuzzy-artificial neural network (FANN): the various logic and neural networks have special computational properties that make them suitable for certain cases. For example, while neural networks offer advantages such as learning, adaptation, fault tolerance, parallelism, and generalization, they are not good at explaining how they have reached their decisions. In contrast, fuzzy systems – which reason using inaccurate information through an inference mechanism under linguistic uncertainty – are good at explaining their decisions but cannot automatically acquire the rules they use to make them. Meanwhile, neuro-diffuse systems combine the learning capacity of RNAs with the linguistic interpretation power of diffuse inference systems. They are used in a multitude of applications and fields including and risk identification and modelling in project management. (Ruiz et al., 2021a)

Fuzzy-Bayesian belief network (FBBN): an integration of fuzzy logic and Bayesian theory presents an important role in assisting project risk analysis under complex and uncertainty. Based on fuzzy logic and Bayesian probability strategy, presented a reliability-based model for damaging impact of tunnel construction on the other neighbouring infrastructures. Contrasted with other probabilistic techniques, this technique can adapt to the learning of continues dynamic changes in parameters and hidden vulnerabilities with limited information. This proposed hybrid method overtly expresses the dependencies of events and constantly updates the probabilities under uncertainty. Though, recent studies show the popularity of similar FBBNs for presenting uncertain information in probabilistic frameworks to address a range of risk analysis problems in construction.

Evolutionary Fuzzy Neural Inference Model fuses genetic algorithms, fuzzy logic, and neural networks. So genetic algorithms are used for optimization purposes, fuzzy logic deals with uncertainty and neural networks for mapping Inputs and outputs. (Magaña Martínez & Fernandez-Rodriguez, 2015b)

Evolutionary Fuzzy Hybrid Neural Network includes four algorithms of artificial intelligence: Neural Network; High Order Neural Network; Fuzzy Logic; Genetic Algorithm. The first two, named together as Hybrid Neural Network (HNN), manage the inference engine while Fuzzy Logic deals with the fuzzy layer. Genetic algorithms optimize the final model. This model is able to manage problems more deeply than EFNIM thanks to the large number of HNN models. (Magaña Martínez & Fernandez-Rodriguez, 2015b)

Bootstrap aggregating neural networks are a combination of multiple artificial neural network classifiers. They use more than one classifier based on ANNs, so the final decision is taken from each classifier by a voting system

Neural-Network-Adding Bootstrap is a bootstrap that adds neural networks presents a combination of multiple artificial neural network classifiers. This method uses more than one ANN-based classifier, meaning the final decision is made from each classifier through a voting system. The model output is obtained as a linear combination of the experts' output and the combined weights are calculated based on the input. (Ruiz et al., 2021b; Magaña Martínez & Fernandez-Rodriguez, 2015a)

Adaptive boosting neural networks is different from Bootstrap aggregating neural networks because of the use of weights that are readjusted on every iteration giving less importance to those solutions that have not been classified correctly. As a result, classifiers focus on more complex samples obtaining a faster solution each time. (Magaña Martínez & Fernandez-Rodriguez, 2015b)

5.3. Challenges faced while implementing AI

In this section, the objective benefits of using AI for risk management are studied. There are also papers on interviews with experienced Project and Risk managers' opinions to the possible application across firms.

5.3.1. Advantages

Across industries, AI is ever more recognized for its potential. It will change people's day-to-day activities, including in risk management. Insights, that now become visible only when losses occur, can emerge before in future, through learning from large volumes of historical data. (Naim, 2022)

With the effective implementation of AI in business has led to develop business to great extent. It has not only changed the process of business for companies but also increased the level of working. Businesses got a new approach to gain success with the implementation of AI. In addition, communication and networking process by companies has become more effective and faster with the advancement of AI. This, in turn, leads to develop efficacy of business as well. Effective implementation of AI with combination to human intelligence has a great effect of productivity of a business process. (Balooshi & Papadaki, 2018)

It is showed that AI would most likely have a high effect on the processes of project risk management. According to Fridgeirsson's study, 63% of partecipants believed that AI would have a very high or high effect on monitoring risks and 54% an effect on performing quantitative risk analysis. (Fridgeirsson et al., 2021) The result shows that AI was believed to have the lowest effect on planning and implementing a risk response. (Munir, 2019)

Advantages in firms

A study collected interviews with experienced Project and Risk managers' opinions to the possible application across firms. (Zebo Muradovna ISAKOVA, 2021) The results of this survey of 551 project management experts, from around the world, show that the involvement of technologies continues to grow, and this situation requires positive changes in project management, as well as in the implementation of organizations'own strategies. The impact of artificial intelligence on organizations and project managers shown is very broad: 81% of respondents says that technology affects their organization 37% of them consider the introduction of these technologies to be a priority for their organizations, while project experts expect the share of AI-managed projects to increase from 23% to 37%. According to innovators, 69% of the projects they implemented have revealed 95% or more of their business advantages. Overall, AI technology is continuously improving the productivity, profitability and yielding better business outcomes. The chances of failure are 1 in 10,000,000 as compared to human error which is 1 in 10,000. This accuracy did not only reduce time but saved the organization from any financial cost because of PMIS information processed by a human. (El Khatib & al Falasi, 2021)

As known, artificial intelligence is a technology developed wholly for the sole purpose of making individual life easier. In addition, implementation of AI by companies has made decision-making process more transparent along with informed decision process. (Balooshi & Papadaki, 2018) According to (Bodea et al., 2020)'s study, three reasons for adopting AI in PM, indicated by more than half of the participants in the survey are linked to the needs in increased productivity which will free up project managers allowing them to focus on more important decisions (53%), followed by better decision-making capabilities (52%) and the necessity to improve overall project performance and reporting (51%).

The expected benefits, styled by IPMA, for adopting the AI in PM are the same, including also the 53% increase in productivity and decision flexibility, 52% increase in integration and communication.

The risks and amount of data in an organization both increase with the size of the operations. The management of data collection, data processing, combinations of data sets and organization through AI can help reduce the risk. For instance, AI had proven to manage a more significant amount of data than any other source used in the past by organizations. It helps, also, improving efficiency, accuracy of data, through greater insights and visibility of risk, by revealing trends. The high accuracy of data management under AI is one of the most significant advantages to use AI. There is also a positive impact on making a quality decision through AI, indeed, it can help identifying and notifying the decision makers in advance for any such users. (El Khatib & al Falasi, 2021). Other two key benefits are related to cost reduction by automating day-to-day assistance and guidance in the risk management processes, moreover the preventative risk advice increasing and faster response time in critical situations. (Naim, n.d.) This, in turn, leads to reduction of errors and fraud issues. Companies are found to use AI to deliver exceptional customer services to their users. (Balooshi & Papadaki, 2018). Finally, AI plays right now and will play even important role in maintaining the company's competitiveness and increasing profits.

Advantages for Project Managers

Benefits also need to be considered from the project manager's perspective. The latter focus their attention on more innovative ways to grow the business and groom employees. (Munir, 2019) Expert systems can assist project managers in grasping experiences of managing previous projects to share experiences easily. Project managers face challenges in predicting future scenarios and proactively taking corrective measures. Subsequently, predictive analytics improves foreseeing 'what if' developments and uncovering real-time insights. Some of the failures in PM are a direct result of human limitations. The use of AI can reduce the mistakes project managers make. An increasing in project success rates is expected as PM and AI become progressively integrated. Adopting AI in project management assists project managers in effectively and efficiently managing their daily tasks. (Maphosa & Maphosa, 2022)

One other advantage of Artificial Intelligence to the project manager is the workload reduction on his employees such as documentation, record-keeping, and various other activities which would normally involve a significant amount of time to get done by hand. The use of AI is made for the automation purposes by project managers for setting alerts and for managing the flow of work and to handle some repeatable procedures. The AI future includes the provision of support to the workforce through tacking some of the complicated approaches of workflows of project for spotting wasted time and for the evaluation of performance. According to (Schwarz, 2015), it also allows the quantification of results and it helps in doing analysis in an easier way. With this being taken care of, staffs can be utilized for other important roles that are important for the project. The overall gain is that time and budget expenses will be reduced. (Munir, 2019) AI helps companies to achieve long-term objectives successfully by further solidifying the significance of roles by adding value to them. AI bots are capable of stepping up and handling these fewer intensive tasks for the project manager with current systems cutting time spent on busy work in half. This is a big timesaver, enabling project managers to concentrate more on the dynamic processes behind their strategic management; to focus more time on their employees, which in turn can help them to empower their employees and find further efficiencies. (Adel BELHARET et al., 2020). AI helps project managers to become more productive that what the ones actually are.(Munir, 2019) and to increase the efficiency of the project team. (Zebo Muradovna Isakova, 2021)

Using AI, managers are able to identify projects that need immediate action and the specific actions that project managers need to take. This is essential in significantly reducing response time to project issues identified to be outside acceptable limits. (Prifti, 2022) The successful introduction of artificial intelligence technology requires organizations to change priorities. The entry of data is identified as notoriously patchy when it comes to the concept of project management. While some of the employees give minute details related to the time and tasks, others are identified as relatively less diligent. Artificial intelligence can be used in order to give more assistance dependent on the given data and it makes the users enough able to give more preside data. This accuracy can assist the project managers to make avoidance from some of the costly setbacks. (Munir, 2019)

5.3.2. Barriers

It is necessary to have a clear view of the implemented AI process in order to assess the risk and advantages related to its implementation. However, there are limitations associated with its implementation which must be taken care of.

Lack of knowledge, understanding and willingness to change

Over 70% of respondents of IPMA's study indicated, as a barrier, the limited understanding of AI technologies which could be overcome by an AI strategy which is aligned with the organizational business goals and is followed by investment in AI talent, trainings and a set of standards and methodologies which must be in place. (IPMA and PwC, 2020) There are no significant differences in the perception of the barriers between the respondents working in organizations using AI and those who are working in companies not using AI. 68% of the respondents working in organizations with AI indicated the data privacy, digital ethics and security risks as second barrier after limited understanding of AI technologies. When asked about the current barriers in using AI tools in project management, a majority of 70% of the participants in (Bodea et al., 2020)'s survey indicated the limited understanding of AI technologies as the main barrier, followed closely by 62% which have difficulties in deciding the best AI applications, due to limited experience.

One of the central reasons of the utilization of only qualitative risk analysis methods is the lack of knowledge about the benefits and chances provided by quantitative risk analysis and as consequence, from the risk management process. Many practitioners are anxious of using simulation for many reasons, mainly by the lack of knowledge about the technique's benefits, causing this a misunderstanding of how use the tool properly. (Balooshi & Papadaki, 2018) Some managers also claim not to fully understand how AI predicted outcomes were derived. Furthermore, employees are found with issue of system handling and familiarity with the system processes. However, companies while implementing AI in business faces challenges due to lack of clear vision and insight knowledge of the innovation. The challenge for those people supporting the enhancement of risk management is to convince by real examples, benefits and to deliver comprehensible risk reports for all sorts of management levels. (Jürgen Schwarz et al., n.d.)

Sunk costs are a further relevant consideration: having already invested heavily in legacy software systems, many executives may be hesitant to invest in new software solutions. Moreover, data analytics are developing at a rapid pace, making it difficult to keep up with technology advancements and the benefits associated with them. (Prieto, 2019a) The team responsible for the implementation of AI needs to interact with the stakeholders on a regular basis. In one case, it took them more than four months to implement a simple task because the employees were not ready and briefed about the changes. Several organizations have already overcame this barrier and shifted the paradigm of their organization growth. (El Khatib & al Falasi, 2021)

Lack of data

Artificial intelligence requires data for learning things, AI and machine learning rely on high quality data for observing the behaviours pattern and trends. This enables to quickly adapt and improve the accuracy of the data analysis, indeed, system requires more data and information in comparison to human. In addition, quality of data also matters for interpretation of results by system. In this context, it is important for companies to provide extreme balanced and representative data else, system adopts bias data sets. This, in turn, leads to increase the chances of data disparity and providing wrong information by system. (Balooshi & Papadaki, 2018) Difficulties in deciding the best AI applications, due to limited experience and use cases, limited IT capabilities. In addition, many AI solutions are not mature enough for the full deployment. (Bodea et al., 2020). Significant time is required for data cleaning and processing, ensuring data integrity. There can be a lack of interoperability across protocol, device types, data types, data sets and algorithmic standards. Moreover, new standards and regulations to be set. (Prieto, 2019a)

Lack of resources

Another dimension of risk, according to studies, is the skills shortage and availability of experienced technical staff and training to deploy and operate AI in addition to the fact that they simply do not have an in-house IT infrastructure. (Prieto, 2019a) Since the field applied to project management is quite new, companies may need to invest in raising the level of their employees to meet the demands and challenges of this new way of project management. (Prifti, 2022). There is also a lack of industry-specific best practices: this environment, especially in Artificial Intelligence (AI), will require an educational system which provides industry with talent that is immediately ready to add relevant value. The education system must then keep engineers on the cutting edge of being able to gainfully deploy, using and managing the technology it further advances. (Prieto, 2019a)

Risks addition

Algorithms are being designed to emulate as closely as possible what a human would do, hence algorithms can introduce human biases. While AI is useful for unstructured datasets, automatic classification, and forecasting and prediction, it is not ideal in understanding the 'why,' especially when many external factors are involved.

First, intelligent machines often have hidden biases, especially from the data provided to train the system. For instance, if a system learns which job applicants to accept for an interview by using a data set of decisions made by human recruiters in the past, it may inadvertently learn to perpetuate biases.

A second risk is that, unlike traditional systems built on explicit rules of logic, neural networks deal with statistical truths rather than literal truths. That can make it difficult, if not impossible, to prove with complete certainty that a system will work in all cases, particularly in situations that were not represented in training data. Moreover, incomplete or missing data can reduce the statistical power of a forecast and produce estimates that lead to invalid conclusions. (Prifti, 2022)

A third risk is that, when machine learning systems make errors, diagnosing and correcting the precise nature of the problem can be difficult. What led to the solution set may be unimaginably complex, and the solution may be far from optimal, if the conditions under which the system was trained happen to change.

Given all this, the appropriate benchmark is not the pursuit of perfection, but rather, the best available alternative. (Prieto, 2019a)

5.4. Future directions

AI will change the projects' conduction and how project management as a field will advance even in the near future. (Zebo Muradovna Isakova, 2021) Current project management tools and software can assist programme and project managers in optimizing their efficacy and tracking key metrics against KPIs and project milestones. However, they cannot predict 'what if' and future scenarios or proactively alert project managers before a major issue arises. In addition, current tools provide information in 'pull' format and not 'push'.(Adel BELHARET et al., 2020) According to PwC's Workforce of the Future Report, 2018, the constantly changing technical landscape will present tremendous opportunities for exploration and experimentation. Moreover, innovations in learning will continue to make it possible for the new worker to learn anything, anytime, and anywhere. In the increasingly complex project management environments that we see today, the need for such tools to proactively 'think' and 'do' on behalf of the project manager and provide on demand information to support their efficiency and effectiveness is clear. (Adel BELHARET et al., 2020) As AI becomes more effective, project managers will rely on the decisions of the machines that will advise future trends, automate time scheduling and respond to requests coming from superiors and staff. (Prifti, 2022)

The ability of AI and machine learning to automate repetitive tasks and to organise, retrieve, and cluster nonconventional data such as documents is naturally going to confer cost benefits on firms that move more into this area. AI will also increasingly deliver accurate real-time information on all types of risks being taken by the firm. The techniques of machine learning offer this ability in the way that traditional ones could never hope to. Thinking even further ahead there is no technological impediment to a truly AI risk management system that will automatically intervene to prevent unwarranted risks, to immediately unwind dangerous exposures and to dynamically adjust the risk appetite of the firm based on the system's estimate of the broader risk environment. (Aziz & Dowling, 2018b)

5.4.1. Implementing AI in organizations

The introduction of artificial intelligence technology requires organizations to change priorities. (Munir, 2019)To guarantee a successful use of AI in project management, it is vital to begin at the administration level of any company or organization. Whereas project managers have built up a clear requirement and also a need for utilizing, what is called, AI-based project management arrangements. Therefore, different areas were re-evaluated and came up with next main results:

- Detecting and removing the use of ineffective work methods and procedures.
- Implementing training programs for the project managers and risk managers regarding the importance of AI and how it can be used in project management.
- Training programs should continue to all employees within the organization about the benefits of using AI and how this will increase the efficiency of their work.
- Acquiring and retaining people with the right digital expertise represent a frequent challenge for organisations on their AI journey. Based on the potential of AI, risk assessments, risk consulting and risk monitoring can be more closely integrated with other specialist areas such as IT/ AI development, data science and data analysis. Bringing together different skills, such as analytical thinking, the translation of technology into business processes, programming, data collection/cleaning/processing and risk consulting can create an interdisciplinary team. AI specialist and engineers should be hired for each department with the organization to identify where AI can be used and to put a plan to of change.
- Project managers and risk managers should establish an integrative cooperation with the AI specialists or engineers to ensure accurate matching of needs-based plan of development, data collection and exchange, data quality, data governance and the quantification of qualitative data for AI. Choosing the technical solution that will provide the best insights for risk management will require digital understanding and an ability to compare the costs and benefits of traditional quantitative modelling versus AI.

In terms of strategic leadership, their actions should lead to a better decision-making process for the leadership of the organisation. Top management needs to be aware of potential growth opportunities and the risk implications of digital technologies in general, including AI, in this way strategic advantage, priorities and budgets will be set accordingly.

There is a lot to be done to have AI actively as supportive element for the project management in different types of projects, and to develop and create plans for a smooth transition to a new era of stakeholders involved in all sectors. (Zebo Muradovna Isakova, 2021)

5.4.2. Project Team

Future needs will require project teams to understand neural networks and multi-layer data abstraction, empowering analysis and utilization of data. It is required to implement Artificial Intelligence techniques for problem-solving and formalize a given problem in the language/framework of different AI methods. (Prieto, 2019a)

Improvements in collecting, storing and processing big data will continue to enable the expansion of AI and other technological advancements' which will have significant effects upon the engineering and project management professions. Teams will need to have access to a wide variety of skills and experiences. They will need to be collaborative, seamlessly synchronized and able to fully leverage the advantage of their collective intelligence and capabilities, both human and artificial. The teams composition will need to grow and adapt to a rapidly changing working environment. Artificial Intelligence will present unique opportunities for the profession but for those opportunities to be fully realized we will have to carefully understand and appreciate AI applications' strengths and limitations. The AI environment will not be static by any means. Existing AI applications will evolve, and new applications will rapidly merge both from commercial, "off the shelf" and internally developed sources. Adaptability will be a key characteristic as the obsolescence of past practices will take on an accelerating pace to match advancements in technology. Effective use of technology can provide an advantage within a very competitive industry and AI systems must be continuously improved and evaluated to achieve quality results. (Prieto, 2019a)

IPMA's study analysed the perceived AI impact in project management interviewing project team members. The results showed that 40% of respondents claimed that will decrease the time for routine managerial tasks and the average number of projects to manage, according to 89% of the sample interviews.

5.4.3. Project Managers and Risk Managers

In the middle of this advancement, it is important to realize that there is something AI cannot do which is to be ''Human''. This implies that project supervisors will remain necessary in the age of AI, and they have to concentrate on the important skills of project management and dynamically move into work that emphasizes human abilities. This includes leadership, emotional intelligence, negotiation, and verbal and nonverbal communications. AI can be accelerator agent and game changer for project managers and help increment projects success rates and avoid project risks. (Zebo Muradovna Isakova, 2021) AI and project managers will have to collaborate in the digital era. The most probable role that AI tools will have in project management, according to (Bodea et al., 2020) is expected to be either that of an advisor or of an assistant of the project manager. As awareness of the profession continues to increase, it is expected that a greater proportion of project work will earn more distinct attribution for the profession itself, giving more recognition and appreciation to the role of the project manager.

As the core of the PMOs functions is data-intensive, it is inevitable that adoption of artificial intelligence - with its much higher capabilities in handling and processing data than humans - will bring about some major disruptions. Administrative PMO: serves a primarily administrative function and is not directly responsible for project success. It is a passive PMO, providing services only on request. These functions can mostly be replaced by AI. The functions of the tactical PMO cannot be outrightly replaced by AI systems, as they require a lot of the human element which machines simply cannot possess. They can, however, be supported by AI, and stand to gain the benefits of being freed from performing mundane tasks, thus, having more time to spend on the valuable ones. Strategic level PMOs ensure projects are aligned with strategic objectives of the organization. These functions will remain largely undisturbed by AI in the foreseeable future, as these require purely human competencies that machines cannot replicate. (Adel Belharet et al., 2020)

The risk manager will add value from a combination of risk management skills, knowledge of the organisation and a level of broad digital understanding. The current risk management skills – a thorough understanding of a wide range of risk management techniques, people management and communication skills – remain essential. The risk manager will also need a minimum level of digital knowledge, which will require continuing updating. (Naim, 2022) In this way, the risk manager will have the knowledge and skills to work with the subject experts in a multi-disciplinary team, understand the enterprise risk implications and communicate with senior management. He will also be able to explore the value of AI for risk management tasks notably for governance, risk and compliance applications.

6. Conclusions

There is no doubt about AI having significant influence in the near future and remarkable progress has been made in the field. It is reshaping many areas of the business environment as well as the daily life of people.

The current challenges in project management are rooted in the influence of human biases, as well as the human limitations to process large amounts of information. These biases and limitations are causing
ongoing problems with the quality of project decisions. Most project management environments within organizations have not yet adopted a culture that accounts for the importance of data and its value to the organization. As a result, there is a disconnection in most organizations between project management culture and organizational culture.

This impacts the performance of project management and its deliveries contributing to low project management performance and project failures. A logical consequence, therefore, is that project management practices need to be adjusted and augmented with intelligence that fills the current gaps, which cannot be addressed by human intelligence.

This thesis has aimed to develop an understanding, through a systematic review, regarding the artificial intelligence by expanding a relation in between the risk management and artificial intelligence. The results can pave the way for better understanding the challenges ahead, aligning project management discipline to a new era in management.

The introductory chapter aimed to highlight the significance of the review, focusing on the causes to explore artificial intelligence applied to risk management. There is gradually increasing a technological development as well as its various application of artificial intelligence.
Following, a brief understanding of artificial intelligence and risk management by analysing different theories and model. It has dealt with the background, explaining what Project management is and what the main areas are. Focusing on the risk management phases and the analysis used nowadays by risk managers.
Furthermore, an explanation on artificial intelligence, its significance and its applications through machine learning tools.

Afterwards, an overall understanding of research methodology, research approaches, and its technique as well as research tools. This methodological analysis included several data collection method such as qualitative data collection method and quantitative data collection method.
On the other hand, the last chapters of this research paper have focused on discussing the data analysis along with research findings. In order to identify appropriate answers to research questions and developing the current topics of the papers.

This report summed up that the traditional statistical models that had not been able to answer to project Management needs. Using machine learning methodologies, the process will be faster, more impartial, more accurate, more transparent and generally more complete. The main conclusions obtained from the reviewed papers are that artificial intelligence tools are more accurate than traditional ones but are still complementary to them. Artificial Intelligence tools are really helpful for the project manager to control and monitor the project. However, some of the reviewed models have weaknesses and limitations that indicate project managers should still use expert judgement and compare artificial intelligence results with traditional tools before making decisions, so they can adjust them if necessary.

Only when artificial intelligence technology is combined with data analysis technology can it truly create commercial benefits. On the whole, artificial intelligence is an industry, and the realization of artificial intelligence mainly relies on machine learning algorithms.

Best results are obtained when fusing machine learning tools to generate new rules and results like fuzzy systems, CBR, ANNs, SVM, and transformed regression models. These methods are predominantly adopted for risk identification, assessment and prioritization in complex projects.

The importance of ensemble methods is improving the prediction accuracy, handling noisy and missing data is evident. Moreover, taking advantage of the strengths of a tool and cover the weaknesses of the rest, the most accurate can be selected enhancing the quality of the decision based on it, returning the best results. However, the key limitation of the ensemble methods is actually the inability to interpret the producing results.

Artificial Intelligence adoption is facing many challenges for firms and PM, from the impact of current models and associated barriers which shows signs according to which it will be overcome in the following years, to the disruptive nature of current technologies which are changing the project management models in both public and private sector.

The results clearly indicated that AI would have more impact on tasks where historical data is available and for repeated tasks. When producing data, AI can be trained to learn how to deliver the expected output. The analysis reveals that decision-making processes in organizations need to be changed. Today's decision-making culture is based mainly on intuition, personal experience and preferences of decision makers. A change to an AI and data-driven culture within organizations, will require decisions to be taken based on insights from data. AI can create new data, and if real-time data is available, AI can be used to monitor. However, biases in project managers‘ decision-making process will always impact the outcome and it is essential to consider them when managing schedule, cost and risk. It is clear that the human factor will not be replaced. Expert opinion and views complement the analysis of AI and serve for its training and development. The specific decisions for risk management remain in the hands of experts, and the main task of artificial intelligence is to conduct analyses and time-consuming activities. The results are never better than the data inserted into the system, thus it is essential to be careful what to trust. However, when dealing with tasks where human skills and communication are required, AI will have less impact.

Overall, then, project managers will continue to play a crucial role when the AI is fully developed.

The slow progress of AI in the field of project management is largely due to the lack of investment from private companies, which means progress has only been made in the universities and the public research organizations. In addition, the retention to the use of the artificial intelligence because of the incomprehension of the instruments, diffidence to the change of paradigm and lack of technical requirements.

In the end, it can be concluded that AI plays right now and will play even important role in maintaining the company's competitiveness and increasing profits. Artificial intelligence can help to make some perception related to the environment and it helps in taking such decisions that can lead to the achieving of specific goals. AI provides good assistance to project managers, in several ways using different material from daily tasks easier to complex projects.

Project managers could have more support, insight, accuracy and strategy by using it. Furthermore, increasing the efficiency of the project team and the project delivery, avoiding project failures.

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