Artificial Intelligence in Project Management: Systematic Literature Review

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Artificial intelligence in project management: systematic literature review

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Abstract: Project management is a common field in many industries, and it is not immune to the innovations that artificial intelligence is bringing to the world. Even so, the application of artificial intelligence is not that widespread in companies and especially not in all of project management areas. The reasons are not clear but seem to be related to the uncertainty of the application of artificial intelligence in project management. The purpose of this paper was to acknowledge the potentialities and limitations of artificial intelligence in the specific area of project management by doing a systematic literature review

with which it was possible to analyse and correlate the selected articles and reach some patterns and tendencies. In the end, it was clear that there is an increased interest in the scientific community in this field, although with some areas to explore.

Keywords: artificial intelligence; project management; data mining; decision support system; human resources management.

JEL codes: M10, M11, M15.

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Renato Lopes da Costa completed his PhD in General Management, Strategy and Business Development by ISCTE, Portugal has articles published in several specialised journals in the East, the USA, Canada, Africa, South

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1 Introduction

Artificial intelligence is a reality in our days getting more and more relevancy. However, there is still much to explore both scientifically and business wise. With the internet revolution a new phenomenon has been occurring, artificial intelligence. Being a new reality, markets and users have been awakening and adapting to what are now the inevitable changes. But in most industries, there is still reluctance in its full establishment. This is perfectly mentioned in Dwivedi et al. (2021) where authors even point out the uncertainty of the path. This problematic withholds the implementation of artificial intelligence and in some cases brought to light the necessity of the creation of boundaries and principles of use, with the intent of promoting responsibility and respect to all parties involved (Clarke, 2019; Haenlein and Kaplan, 2019; Lima et al., 2022).

However, there are clear signs that artificial intelligence has a large potential, which cannot be ignored, and that is recognised by companies that even believe that humans and artificial intelligence will work together in the future (Candelon et al., 2021). Together, they can take advantage of what some studies already indicate, that internal factors can deliver more innovation and better performance, assuring organisational growth (Kyläheiko et al., 2017). Having this into account it seems important to consider: do we know the full potential of artificial intelligence? Is it being applied to all areas? Do decision-makers use artificial intelligence? Are we implementing it through all the business structures? From CEO till the last employees? Are employees refusing its implementation with fear of losing their jobs?

Literature gives us some indication of the potential of artificial intelligence. For the first Ju et al. (2020) showed that innovation has a positive impact in a company's performance, and Ong and Uddin (2020) point out that with the new era of data, artificial intelligence applications will significantly expand. But several other articles observe findings in more specific areas as the advantages of artificial intelligence in project control (García et al., 2017) and production management (Durana et al., 2021), or the several areas pointed by Haefner et al. (2021) where artificial intelligence can already benefit the company's innovation. And the list continues with demonstrated benefits in project duration forecasting (Wauters and Vanhoucke, 2016), supply chain management (Toorajipour et al., 2021) and even in the purchasing process (Allal-Chérif et al., 2020). Other areas can also be considered, like the evaluation and measuring of different IT strategies (Loh and Mortara, 2017) and the development of strategic roadmaps and its implementation supported by project management (Kerr and Phaal, 2017).

To achieve our goals, and since this theme is wide and with a great deal to be explored, the chosen path was narrowed to the current state of the art, the areas within artificial intelligence that have been studied, the potential existing gaps and the market's

orientation for its development. Considering all this a systematic literature review has imposed itself as the best methodology to obtain most of the recent studies and have a clearer perspective of the path being outlined. The applications of artificial intelligence are vast, so it was chosen to restrict the analysis to project management as it is an area present in most business areas and with recognised importance to all of them.

Considering the theme in analysis and all its problems, the goal is to have an overview of the presence of artificial intelligence in project management. The research will focus on the gains that the use of artificial intelligence can deliver to project management, but also the limitation that organisations will face when trying to apply it and will look to what the literature points out as the main areas of project management where artificial intelligence can be use in a more extensive way and with more success.

The article is organised in four sections. After the introduction, there is a section dedicated to the followed methodology, specifying the methodology and tools used, the data collection and selection, and the data treatment. The intent was to clarify the options taken in the research, with the purpose of being adjusted to the objectives. The next section is the bibliometric analysis, where the obtained relevant data was critically analysed. To interpret the findings the discussion section critically analysed and discusses the findings of the application of the methodology and tools. To final section present the conclusions of the research, with its possible contributions to these fields and an indication for future lines of research.

2 Methodology

To reach the defined target the systematic literature review was conducted, due to the large amount of information available and its constant increase. The aim is to collect, select and analyse what would be most relevant studies on the last years for the respective topic. Being the systematic literature review the mean to achieve the goal, the next phase is to establish the terms to be researched, specify the databases in which it will be reproduced and the criteria to be met. With the constraints perfectly defined the matching articles will be compiled and analysed trying to correlate and evaluate the sampled articles.

The systematic literature review will use the preferred reporting items for systematic reviews and meta-analyses (PRISMAs) methodology approach (Moher et al., 2009). Its selection was mainly because of its capabilities to improve the results and guarantee its replicability and because it provides a very structed process that helps to conduct a rigorous systematic review. The PRISMA methodology considers a set of steps to achieve the intended results with a flow of information identical to one in Figure 1. For the data analysis we select Citespace because of its capabilities for visualising and analysing trends and patterns in scientific literature, mainly its functions for the interpretation of network patterns, finding citation hotspots and building clusters from citing articles.

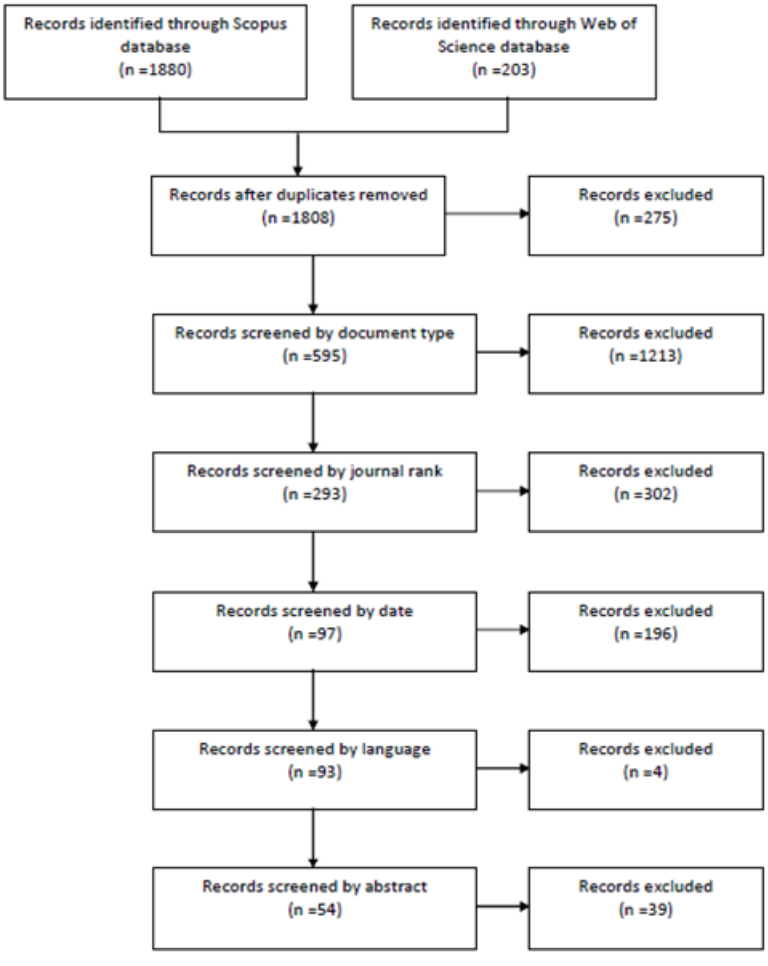
2.1 Data collection and selection

Data collection is a fundamental part of the systematic literature review, as it sets the primary source of data, from which the results will be deeply influenced. The definition of the search conditions was carefully considered.

For the data collection the defined search terms were 'artificial intelligence' and 'project management' or 'machine learning' and 'project management'. The quotation mark search returned the values that included the words exactly as they are. In the search engines these terms were searched in all the titles, abstracts, or keywords of the respective databases. Selected databases were deliberately limited to avoid excessive duplicates. The selected ones were the most considered in these types of research, Web of Science (http://www.webofknowledge.com/) and Scopus (https://www.scopus.com/). Important to highlight that the search data was of May 2021, so data from further that year was not considered and represented in the database collection. The database collection was of a total of 2.083 records, 1.880 of Scopus and 203 of Web of Science.

This initial database had to be more optimised to provide data only related to the proposed objective. As so the PRISMA methodology was continued, and the selection began always having in considerations the research questions. To improve the data selection, the results were all gathered in an excel spreadsheet.

Figure 1 Data selection process (PRISMA methodology)



Source: Author

Table 1 Selected articles

Title	*Authors*
A comparative study of artificial intelligence methods for project duration forecasting	M. Wauters and M. Vanhoucke
A decision support system (DSS) for facilitating the scenario selection process of the renegotiation of PPP contracts	A. Shalaby and A. Hassanein
A deterministic contractor selection decision support system for competitive bidding	N. Semaan and M. Salem
A hybrid method for improved stability prediction in construction projects: a case study of stope hanging wall stability	C. Qi, A. Fourie, G. Ma and X. Tang
A knowledge-based risk management tool for construction projects using case-based reasoning	O. Okudan, C. Budayan and I. Dikmen
A nearest neighbour extension to project duration forecasting with artificial intelligence	M. Wauters and M. Vanhoucke
A review of artificial intelligence-based risk assessment methods for capturing complexity-risk interdependencies: cost overrun in construction projects	F. Afzal, S. Yunfei, M. Nazir and S. M. Bhatti
Activity analysis of construction equipment using audio signals and support vector machines	C.F. Cheng, A. Rashidi, M.A. Davenport and D.V. Anderson
Activity classification using accelerometers and machine learning for complex construction worker activities	L. Sanhudo, D. Calvetti, J.P. Martins, N.M.M. Ramos, P. Mêda, M.C. Gonçalves and H. Sousa
An authoritative study on the near future effect of artificial intelligence on project management knowledge areas	T.V. Fridgeirsson, H.T. Ingason, H.I. Jonasson and H. Jonsdottir
An effective approach for software project effort and duration estimation with machine learning algorithms	P. Pospieszny, B. Czarnacka-Chrobot and A. Kobylinski
An empirical validation of the performance of project control tolerance limits	A. Martens and M. Vanhoucke
Assessment of construction workers' labor intensity based on wearable smartphone system	Z. Yang, Y. Yuan, M. Zhang, X. Zhao and B. Tian
Automated action recognition using an accelerometer-embedded wristband-type activity tracker	J. Ryu, J. Seo, H. Jebelli and S. Lee
Automated methods for activity recognition of construction workers and equipment: state-of-the-art review	B. Sherafat, C.R. Ahn, R. Akhavian, A.H. Behzadan, M. Golparvar-Fard, H. Kim, Y.C. Lee, A. Rashidi and E.R. Azar
Automated staff assignment for building maintenance using natural language processing	Y. Mo, D. Zhao, J. Du, M. Syal, A. Aziz and H. Li
Collaboration formation and profit sharing between software development firms: a Shapley value based cooperative game	M. Fahimullah, Y. Faheem and N. Ahmad

Source: Author

Table 1 Selected articles (continued)

Title	*Authors*
Comparing optimization modelling approaches for the multi-mode resource-constrained multi-project scheduling problem	M. Kannimuthu, B. Raphael, P. Ekambaram and A. Kuppuswamy
Critical success factors for modular integrated construction projects: a review	I.Y. Wuni and G.Q. Shen
Data-driven machine learning approach to integrate field submittals in project scheduling	M. Awada, F. Jordan Srour and I.M. Srour
Defect risk assessment using a hybrid machine learning method	C.L. Fan
Design science research in construction management: multi-disciplinary collaboration on the SightPlan system	I.D. Tommelein
Determine the optimal capital structure of BOT projects using interval numbers with Tianjin Binhai New District Metro Z4 line in China as an example	Y. Wang and X. Jin
Drivers, barriers, and social considerations for AI adoption in business and management: a tertiary study	M. Cubric
Dynamic feature selection for accurately predicting construction productivity using symbiotic organisms search-optimized least square support vector machine	M.Y. Cheng, M.T. Cao and A.Y. Jaya Mendrofa
Emergency informatics: using computing to improve disaster management	R.R. Murphy
Emotion-based automated priority prediction for bug reports	Q. Umer, H. Liu and Y. Sultan
Estimating construction duration of diaphragm wall using firefly-tuned least squares support vector machine	M.Y. Cheng and N.D. Hoang
Evaluating industrial modularization strategies: local vs. overseas fabrication	A. Nekouvaght Tak, H. Taghaddos, A. Mousaei and U.R. Hermann
Forecasting the scheduling issues in engineering project management: applications of deep learning models	S. Liu and W. Hao
Incentive structures in multi-partner project teams	J. Han, A. Rapoport and P.S.W. Fong
Intelligent purchasing: how artificial intelligence can redefine the purchasing function	O. Allal-Chérif, V. Simón-Moya and A.C.C. Ballester
Investigating profitability performance of construction projects using big data: a project analytics approach	M. Bilal, L.O. Oyedele, H.O. Kusimo, H.A. Owolabi, L.A. Akanbi, A.O. Ajayi, O.O. Akinade and J.M. Davila Delgado
Modelling the performance of healthcare construction projects	K.A. Iskandar, A.S. Hanna and W. Lotfallah
Neural network-based interval forecasting of construction material prices	M. Mir, H.M.D. Kabir, F. Nasirzadeh and A. Khosravi

Source: Author

Table 1 Selected articles (continued)

Title	*Authors*
Optimizing decisions in advanced manufacturing of prefabricated products: theorizing supply chain configurations in off-site construction	M. Arashpour, Y. Bai, G. Aranda-Mena, A. Bab-Hadiashar, R. Hosseini and P. Kalutara
Performance-based control of variability and tolerance in off-site manufacture and assembly: optimization of penalty on poor production quality	M. Arashpour, A. Heidarpour, A. Akbar Nezhad, Z. Hosseinifard, N. Chileshe and R. Hosseini
Predicting the occurrence of construction disputes using machine learning techniques	M. Ayhan, I. Dikmen and M. Talat Birgonul
Predicting the volatility of highway construction cost index using long short-term memory	Y. Cao and B. Ashuri
Prediction of risk delay in construction projects using a hybrid artificial intelligence model	Z.M. Yaseen, Z.H. Ali, S.Q. Salih and N. Al-Ansari
Project management: openings for disruption from AI and advanced analytics	F. Niederman
Reflecting on 10 years of focus on innovation, organisational learning, and knowledge management literature in a construction project management context	D.H.T. Walker
Research on image quality in decision management system and information system framework	J.C. Huang, H.C. Huang and S.H. Chu
Risk identification, assessments, and prediction for mega construction projects: a risk prediction paradigm based on cross analytical-machine learning model	D.B. Chattapadhyay, J. Putta and P. Rama Mohan Rao
Safety leading indicators for construction sites: a machine learning approach	C.Q.X. Poh, C.U. Ubeynarayana and Y.M. Goh
Smartphone-based construction workers' activity recognition and classification	R. Akhavian and A.H. Behzadan
Software development effort estimation using regression fuzzy models	A.B. Nassif, M. Azzeh, A. Idri and A. Abran
Symbiotic organisms search-optimized deep learning technique for mapping construction cash flow considering complexity of project	M.Y. Cheng, M.T. Cao and J.G. Herianto
The effectiveness of project management construction with data mining and blockchain consensus	W. Li, P. Duan and J. Su
The impact of entrepreneurship orientation on project performance: a machine learning approach	S. Sabahi and M.M. Parast
The present and future of project management in pharmaceutical R&D	A. Schuhmacher, O. Gassmann, M. Hinder and M. Kuss
The successful delivery of megaprojects: a novel research method	G. Locatelli, M. Mikic, M. Kovacevic, N. Brookes and N. Ivanisevic
Using classification techniques for assigning work descriptions to task groups based on construction vocabulary	M. Martínez-Rojas, J.M. Soto-Hidalgo, N. Marín and M.A. Vila
Vision-based action recognition of construction workers using dense trajectories	J. Yang, Z. Shi and Z. Wu

Source: Author

Due to the use of more than one research platform, naturally the first step was to eliminate duplicates, which excluded 275 records. Subsequently the screening was done for document type, keeping the one's marked as journal articles, 595 in total (excluded 1,213).

Within the journal articles it was considered important to do a credibility selection, as ambiguous as that is. The selected criteria were the Scimago ranks that qualifies the scientific prestige of journals from Q1 to Q4. To achieve this selection all the journals from the 595 journal articles were researched in the Scimago and classified, being that the non-recognised or 'not yet assigned' were eliminated. The reports considered were the published in Q1 journals, a total of 293 (302 excluded).

Since the initial data collection had results since 1982 it was important to limit the period to ensure the most recent data with the more recent developments on these fields. The defined period for the publishing was from 2016 until 2021, which eliminated 196 reports.

With the purpose of a later analysis of the abstracts all the non-English journal articles were excluded (4). All the 93 remaining reports were read to select only the ones that matched the research purposes, and that could eventually answer the research questions. In this last step of the selection 39 reports were excluded, in most of its cases due to be centred in a specific field of project management or a very specific part of an industry. Others were excluded for not being related with project management or to be more focused in machine learning. In the end the PRISMA methodology led to a total of 54 reports of the most representative for the purpose of the research.

2.2 Data analysis

Data treatment was a very relevant part of the research as the success of the whole research depends on its results. With a challenging database of 54 journal articles, the software and tools made it easier to process. The primary one was the excel which helped in the initial phase of the data selection, organising, and filtering the intended criteria. With the final database all available in the Scopus site, some of the more fundamental analysis was possible with outputs of the site for the created database. Analyse per year, country, subject area, source, and citation.

Another important software used was the Citespace program, with which a more visual analyse was possible, and specially a cross examination of different factors. This software enabled trend analyses, occurrence of patterns and the cross analysis of some factors. This free software besides the possibility of giving some useful tables, mainly provides visual information in the form of nodes and links. The nodes represent the value in analyse (authors or journals, for example) and the links the relationship between the nodes

3 Bibliometric analysis

Previously to the results it is important to contextualise the main terms in analysis to better understand the results and its significance to the present and future reality. Artificial intelligence is a popular term in our days although not as broadly implemented which can lead to some misleading conceptions. Clarifying the literature's concept of

artificial intelligence, for example Davenport and Ronanki (2018) divides artificial intelligence into three main categories: process automation, cognitive insight, and cognitive engagement. Process automation is the most common and easiest to implement and replicate in various businesses, being the automation of physical tasks. Cognitive insight is algorithm detecting and interpreting patterns in a big volume of data. Lastly the least used as referred by Davenport and Ronanki (2018), the cognitive engagement. This is the interaction of humans with machines that use natural language processing, providing a personalised and human experience to customers or employees (da Costa et al., 2020).

These types of artificial intelligence have a clear distinction from human developed tasks, the volume of data, it is complexity and its interrelatedness, without the human bias.

In addition, it is important to point out that at the rhythm that evolution is occurring in the artificial intelligence field this categorisation can also get obsolete.

An example of the mentioned evolutions is the 'self-innovating artificial intelligence' (Hutchinson, 2021). This is a concept that considers the application of artificial intelligence in innovative processes with the purpose of developing new solutions or to improve existing ones. This potential methodology has its gap's and requires further investigation, being for the moment a complementary approach.

As this concept many others can and will appear, so it is important to continuously improve in this area both theoretically and practically. As for the project management this is a crucial area to most businesses, as it promotes the accomplishment of the set objectives with success. To achieve success, a great deal of acquired techniques and competences must be aligned with the stakeholders to accomplish the set goal. However, goals may change or in some cases not even be perfectly clear to start with. This requires adapting the project and restructuring it to accompany the new reality. This is the denominated agile project management, and as stated by Zasa et al. (2020) is most frequently used by IT companies, as it better meets their specificities. Nevertheless, it is increasingly being introduced in their organisations due to the experienced uncertainty and fast-changing reality of our days. But agile may not always be the right method, so it is important to understand both methods very well, identifying its strengths, weaknesses, and limitations. It is also vital to understand what is required implicitly and explicitly from the stakeholders of the project. Additionally, Ciric et al. (2021) states that the combination of the two methodologies in the parts of the project that make the most sense is the most successful solution, being very important the identification of the stages in which one or the other should be used.

Also, important to understand the project management functions, and for this the more commonly considered areas of knowledge are: project integration, project scope management, project time management, project cost management, project quality management, project human resource management, project communication management, project risk management, project procurement management, project stakeholder management. These can be linked to the five major process groups:

1 initiation

2 planning

3 execution

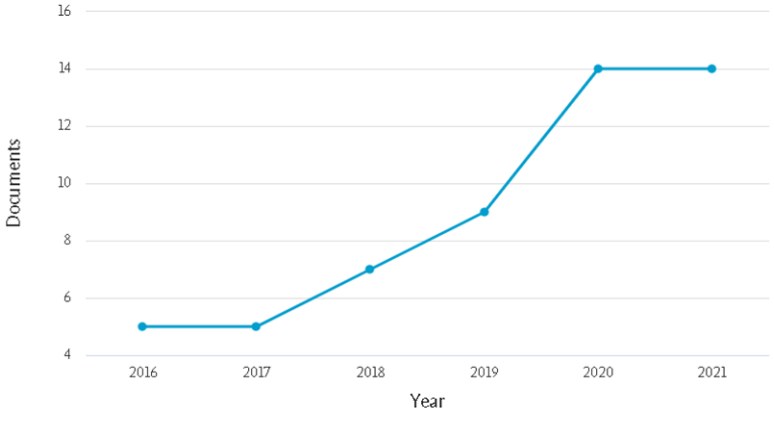
4 monitoring and controlling

5 closing.

Proceeding to the results, the selected articles for the analysis of the artificial intelligence influence in the project management area were 54 in total, in the period of 2016 until 2021. Considering all the results the analysis was carried out with the purpose of finding patterns and tendencies that could enlighten the developments that have been occurring and hopefully point out a possible direction for the artificial intelligence in the project management.

The numbers of results obtained are mostly concentrated in the last years, with 14 documents in each year of 2020 and 2021 (until May). The growth has happened since 2017 with an increase to 7 and 9 documents in the subsequent years.

Figure 2 Documents per year (see online version for colours)



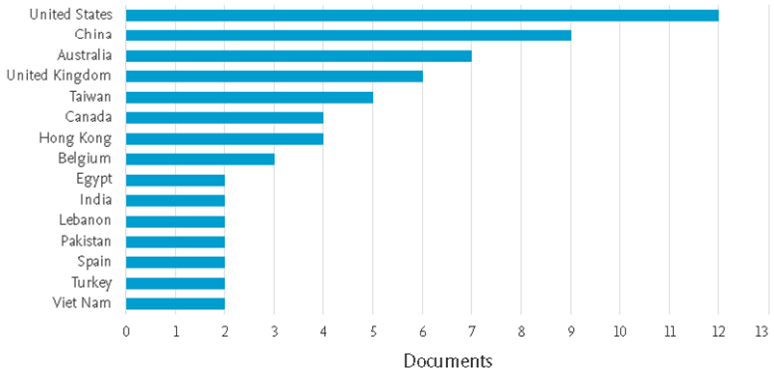
Source: Scopus

As for the country distribution of the results, the biggest contributor was the USA with 12 documents, followed by China with 9 and Australia with 7. Countries like the UK, Taiwan, Canada, Hong Kong, and Belgium have 3 or more documents. The remaining countries have 2 or less documents in the results in analysis. Important to notice that some articles were developed in more than one country, in a universe of a total of 30 countries. This partially confirms the data in Ruiz-Real et al. (2021) that mentions that the countries with the most published papers are USA, UK, and China. Also, important to point out that also as mentioned by Ruiz-Real et al. (2021) the pattern numbers are higher in USA, Hong Kong and France. This can have other reasons to occur, but it is an indicator of the gap between the research and its real-world applicability.

The most addressed subject areas were engineering with a total of 36 documents, followed by business, management and accounting with 20 and computer science with 17. Coincidently these are the subject areas more commonly associated with project management and artificial intelligence, although more related to project management. As so, it was expected that a greater number of documents were associated with computer science due to artificial intelligence, which can mean that this topic has broadened its basic subject and is disseminating to other fields.

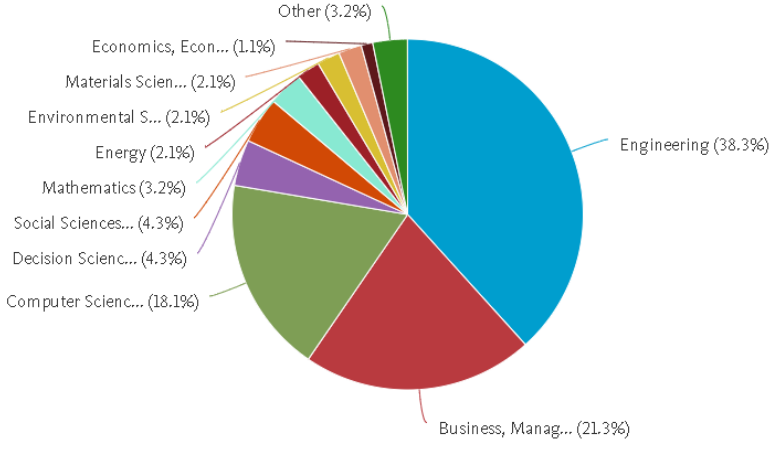
The remaining subject areas were not that relevant, with an occurrence of 4 or less results.

Figure 3 Top 15 of the countries with more documents (see online version for colours)



Source: Scopus

Figure 4 Documents by subject area (see online version for colours)



Source: Scopus

The results present a total of 160 authors, with a vast majority of them with only one article (93%). However M-Y. Cheng and M. Vanhoucke have three documents in the results, and other eight authors have two (R. Akhavian, M. Arashpour, A.H. Behzadan, M.T. Cao, I Dikmen, R. Hosseini, A. Rashidi, and W. Wauters).

The source of the documents in the results was also a crucial point to analyse. From the top 9 sources in Figure 5, the more relevant are *Automation Construction* (n = 7), *Engineering Construction and Architectural Management* (n = 6), *Journal of Construction Engineering and Management* (n = 5), and *Journal of Building Engineering* (n = 4). The remaining five have only two documents in the results.

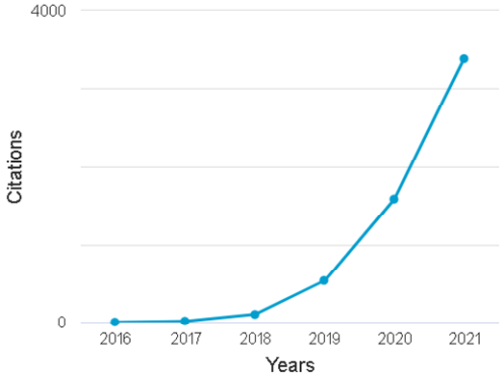
These sources are related to the subject areas more represented in the results as seen above (engineering, business, management and accounting, and computer science).

Citations from the documents in the results have increased significantly through the years, especially since 2018. In 2020 and 2021, the total citations were of 1,582 and 3,383 respectively.

Figure 5 Documents per year per source (top 9 sources) (see online version for colours)

Source: Scopus

Figure 6 Citations per year (see online version for colours)



Source: Scopus

As for the cited authors the more prominent are R. Akhavian, T. Cheng, J. Colin and M. Bilal. Other significant authors as K. Yang, M. Kuhn, Y.M. Goh, Z. Zhou, M.Y. Cheng, B. Amiri, Kang, M. Wauters, J. Batselier and F. Acebes, also stand-out in Figure 7. From the clusters of R. Akhavian with T. Cheng and with Bilal there is some relation, being Colin in an almost isolated cluster. An example of the relation between R. Akhavian and T. Cheng is one of the most cited articles 'Automated methods for activity recognition of construction workers and equipment: state-of-the-art review', in which R. Akhavian is one of the authors, citing his own work as well as T. Cheng's.

'A review of artificial intelligence-based risk assessment methods for capturing complexity-risk interdependencies: cost overrun in construction projects' also frequently cited T. Chen but with no mention to any of the other appointed authors.

The keywords in the results can provide some insights on the tendencies of the research.

In Figure 8 there are several keywords within the construction industry and construction management clusters, very related in highly connected clusters. This net of

clusters has other diverse keywords as wearable sensors, learning system, human resources management or accelerometer.

Figure 7 Cited authors (see online version for colours)

Source: Citespace

Figure 8 Keywords (see online version for colours)

Source: Citespace

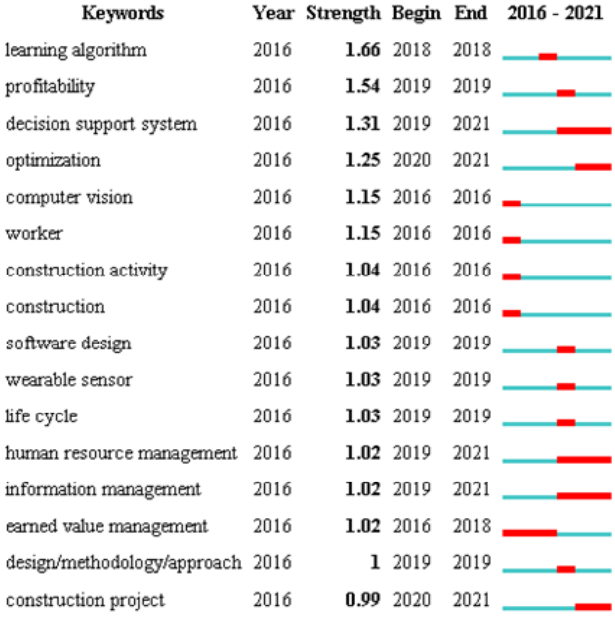
Another evident keyword is artificial intelligence in a cluster with less relation with others. Also, important to distinguish the data mining keyword deeply connected to the main clusters, and decision support system with some relation with artificial intelligence. These clusters are more related to artificial intelligence than the main ones that focus on a particular business of project management, construction.

The predominance of the clusters construction industry and construction management can be related to the main sources of articles collected as many of them are related to engineering or construction, as represented in Figure 5.

With a more deep analyse of the articles, the ones mentioning frequently the keywords construction industry or construction management are: 'Safety leading indicators for construction sites: a machine learning approach'; 'A review of artificial intelligence-based risk assessment methods for capturing complexity-risk

interdependencies: cost overrun in construction projects'; 'Automated methods for activity recognition of construction workers and equipment: state-of-the-art review'; 'Automated methods for activity recognition of construction workers and equipment: state-of-the-art review'; 'The effectiveness of project management construction with data mining and blockchain consensus'; and 'A hybrid method for improved stability prediction in construction projects: a case study of stope hanging wall stability'. Considering the article's titles this was an expected conclusion. However, there is more to it, most of these articles also mentions mining and some of them artificial intelligence, which confirms the unrelatedness of the main clusters to the keyword decision support system.

Figure 9 Top 16 keywords with the strongest citation bursts (see online version for colours)



Keywords	Year	Strength	Begin	End	2016 - 2021
learning algorithm	2016	**1.66**	2018	2018	
profitability	2016	**1.54**	2019	2019	
decision support system	2016	**1.31**	2019	2021	
optimization	2016	**1.25**	2020	2021	
computer vision	2016	**1.15**	2016	2016	
worker	2016	**1.15**	2016	2016	
construction activity	2016	**1.04**	2016	2016	
construction	2016	**1.04**	2016	2016	
software design	2016	**1.03**	2019	2019	
wearable sensor	2016	**1.03**	2019	2019	
life cycle	2016	**1.03**	2019	2019	
human resource management	2016	**1.02**	2019	2021	
information management	2016	**1.02**	2019	2021	
earned value management	2016	**1.02**	2016	2018	
design/methodology/approach	2016	**1**	2019	2019	
construction project	2016	**0.99**	2020	2021	

Source: Citespace

As for the artificial intelligence cluster the articles with more mentions of the keyword have only a small reference to the decision support system. In 'A comparative study of artificial intelligence methods for project duration forecasting', the decision support system is mentioned as the means to give warnings as to when the duration exceeds the defined initially. In 'A nearest neighbour extension to project duration forecasting with artificial intelligence', it is mentioned in the control limits as to where to find further information on project control approaches and its relation to decision support systems.

To analyse the keywords with the more relevancy in the more recent years Figure 9 can provide some insights with the 16 keywords with the strongest citation bursts. The keywords whose citation bursts ended in 2021 are decision support system, optimisation, human resources management, information management and construction project.

The strongest citation bursts are broader terms, which can indicate the tendency to generalise the investigation being carried out in the more recent years. This can mean that in the future the main clusters of keywords will differ from the construction field.

Interestingly keywords as decision support system and human resources management, that appear in the bursts as well as in the clusters, are deeply related to one of the concerns in the literature, the lower applicability of artificial intelligence in the areas of project management such as support leadership and cognitive skills.

4 Discussion

Artificial intelligence in project management is said to be one of the trends of the future, with automation and human-machine collaboration.

Although artificial intelligence applied to the project management area is not a novelty, its potentiality in all knowledge areas is still questionable (Pereira et al., 2021, 2022). It is recognised the benefits of artificial intelligence tools to optimise and perform tasks that are rule-based, such as scheduling, cost estimation or risk assessment. However, in areas that require empathy, human resources management or decision making the artificial intelligence applicability is more questioned.

In the research by Fridgeirsson et al. (2021) the results of the questionnaires showed that artificial intelligence is not considered to support leadership and cognitive skills. From the same research it also showed some evidence that there is a lack of knowledge of artificial intelligence in project management. Complementary to this approach Buah et al. (2020) set an artificial intelligence-powered communication and engagement system that was an alternative to the conventional system. The research concluded that it is missing human interaction and that it is emotionless. However, this last limitation can have its advantages as it eliminates eventual bias in decision making. With all this it is vital to reinforce the research in these areas so that knowledge is obtained in a level of certainty that allows companies and individuals to understand and comprehend the broader line of applicability of artificial intelligence in project management.

The study of such prolifically addressed subjects as artificial intelligence and project management may not be a soft task. However, the resort to a systematic literature review has proven to be a resourceful tool in this case. This systematic literature review was fundamental to process and analyse the large amounts of information obtained. After defining the objective of the study, the process of defining keywords, platforms in which to research, and the criteria for selecting the final articles to analyse, was quite simple.

The processing of the selected data was more challenging as the Citespace program can correlate and process a variety of variables, with the additional obstacles of an extremely complete program that always ended up surprising with its immense potentiality. The 54 results lead to several conclusions, some of which were more expected, such as the fact that the results are more concentrated in the last three years, even with the year of 2021 not fully represented and with the expected decrease in publications in the year of 2020 due to COVID. Other expected results were the countries with more articles prevalence, the considered world most powerful countries, USA, and China, followed by other significantly important countries. These two countries were already mentioned as the ones with more published papers.

The subject areas of the results reflect the covered areas, as the main documents are in the areas of engineering, business, management and accounting and computer science. This correlates with the articles per source, being the main sources extremely correlated to the subjects, *Automation Construction*, *Engineering Construction and Architectural*

Management, *Journal of Construction Engineering and Management*, and *Journal of Building Engineering*.

Table 2 Most relevant articles to the investigation

Author	*Title*	*Topics*	*Contributions*
O. Allal-Chérif et al.	Intelligent purchasing: how artificial intelligence can redefine the purchasing function	• Artificial intelligence • Purchasing function	AI useful in solving purchasing issues. Useful in tree areas, strategy, tactics and operationaly. Also improves companies adaptability capacities.
M. Bilal et al.	Investigating profitability performance of construction projects using big data: a project analytics approach	• Profitability performance • Big data	Profitability prediction largely affected by inadequate estimation approaches. Big data project important to define projects attribute and better predict profitability.
M.Y. Cheng et al.	Symbiotic organisms search-optimized deep learning technique for mapping construction cash flow considering complexity of project	• Deep learning technique • Construction cash flow	Cash flow's prediction optimisation attributed to the appropriate combination of AI techniques.
M. Cubric	Drivers, barriers, and social considerations for AI adoption in business and management: a tertiary study	• Artificial intelligence • Business • Management	AI applied mainly for economic reasons, being also economic as well as technical the barriers. Recommendations for a bigger investment in human, organisational and social aspects of AI
T.V. Fridgeirsson et al.	An authoritative study on the near future effect of artificial intelligence on project management knowledge areas	• Artificial intelligence • Project management areas	Promising future of AI in PM, especially in areas where data is useful in estimation and planning. schedules, adjust forecasts, and maintain baselines. The least influenced by AI knowledge areas are the ones with human leadership skills. More scientific research is required.
Y. Mo et al.	Automated staff assignment for building maintenance using natural language processing	• Staff assignment • Machine learning	Model with high accuracy of staff assignment.
A. Schuhmacher et al.	The present and future of project management in pharmaceutical R&D	• Artificial intelligence • Research and development • Project management	Recognition of the importance of adopting AI enabled project management systems in research and development. Prediction that in five years most major pharmaceuticals would not have AI fully implemented.

Source: Author

Table 2 Most relevant articles to the investigation (continued)

Author	*Title*	*Topics*	*Contributions*
M. Wauters and M. Vanhoucke	A comparative study of artificial intelligence methods for project duration forecasting	• Earned value management • Artificial intelligence	"The AI methods proved to outperform the current EVM/ES methods." Dependency on external out puts as historical data or expert judgement is the AI's biggest asset and liability.
Z.M. Yaseen et al.	Prediction of risk delay in construction projects using a hybrid artificial intelligence model	• Risk delay • Artificial intelligence	Proposed model proved its ability to "handle the nonlinearity and complexity of data in the construction sector."

Source: Author

As for the authors, the more published ones are M-Y. Cheng and M. Vanhoucke, but the more cited are R. Akhavian, T. Cheng, J. Colin and M. Bilal.

Through keywords, important information was collected especially in the prediction of the trends and tendencies of the investigations being carried out. In an analysis of the Cytespace cluster of keywords, what highlights is construction industry, construction management, wearable sensors, learning system, human resources management or accelerometer, but also the ones further from the main clusters, artificial intelligence, data mining and decision support system. There can be attributed a relation between the main clusters and the biggest source of articles, all related to engineering or construction.

Another important information where the citation bursts ending in 2021, decision support system, optimisation, human resources management, information management and construction project. With these keywords there is a high possibility that the tendencies in research are diverging from the main topic of construction to more broader fields of project management and more specific ones of artificial intelligence.

Of all the 54 articles the most relevant ones for the investigation were selected and are presented in Table 2 with their main contributions.

Considering the goals of the systematic literature review and the questions proposed in the introduction, not all became clear, but some insight could be accomplished. Considering the question: how artificial intelligence can potentiate project management, it is undeniable the increase of research being carried out the more and more specification of its terms, what can be seen by the identified keywords. This is a possible indicator of the potentialities of artificial intelligence in the project management area. Therefore, it can also be concluded that artificial intelligence is getting through more specific areas of project management as human resources management or information management, but maybe not in all the project management areas, or there was no data that could sustain this affirmation or not.

Lastly the limitations of the application of artificial intelligence in project management, where not clearly identified, but can be pointed some as the apparent lack of research in all of project management areas or the focus in the construction field or even the limitations in the data's input for artificial intelligence as mentioned in some of the articles in Table 2.

5 Conclusions

Artificial intelligence in project management represents a great challenge that most certainly will be a part of a nearby future.

The research showed inevitably the increase of investigation being carried out, which can be associated with an interest of the industries and their recognition of the potential of this matter to the future of their organisations.

Because of this, the countries that have been contributing with more publications are the world's powerful countries, China, and USA, as well as other important countries.

The main areas addressed by the researchers are related to construction and engineering, but lately show a higher tendency to diverge to other areas more specific to artificial intelligence, and some specific areas of project management that are of special concern as decision support system, or human resources management. This can be an approach to areas were empathy plays a more important role and were artificial intelligence applicability raises more doubts.

Looking to what as emerge from this research, organisations can find practical implications of this work by having paths to where they can find relevant work to explore, that will provide them relevant insights on how to use artificial intelligence in project management. Being project management an area that is present in almost every organisation and that can have a high impact in its results, the use of AI can have a very important role in addressing most of the issues that arise from project management. With this work we believe that organisations will have important guidelines about advantages, challenges, business areas and techniques, to help their research of how to apply AI in project management.

The research has some limitations in its reach. One that must be addressed is the limiting of the language to English, which automatically excludes articles from other authors and countries where this is not the predominant language in research. Another limitation is the data. Although the initial selection intended to give a perspective of the more recent work being developed in the fields of artificial intelligence and project management, the reality is that most of the collected articles are from the last three years, being that 2021 was only partially considered.

Given the appointed limitations it would be interesting to broaden the investigation to the full spectrum of journal articles in the last three years. With the fact that articles would not be excluded based on its Scimago classification and in their language. This would imply a bigger and more representative set of recent articles. Another matter that needs to be more considered is the applicability of artificial intelligence in project management. The suggested would be to reinforce the investigation into what have been the challenges and points to improve in the implementation of artificial intelligence tools in the several areas of project management.

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