A systematic literature review of human-autonomy teams in project management

Yongxi TIAN[a], Maxwell Fordjour ANTWI-AFARI[b*], JoonOh SEO[c], Hao-Yang MI[d], Sina FADAIE[e]

[a]Department of Civil Engineering and Management, School of Engineering, University of Manchester, Manchester, M13 9PL, United Kingdom. Email: tyxiximber@163.com

[b]Department of Civil Engineering, College of Engineering and Physical Sciences, Aston University, Birmingham, B4 7ET, United Kingdom. Email: m.antwiafari@aston.ac.uk

[c]Department of Building and Real Estate, Faculty of Construction and Environment, The Hong Kong Polytechnic University, Hung Hom, Kowloon, Hong Kong Special Administrative Region. E-mail: joonoh.seo@polyu.edu.hk

[d]National Engineering Research Center for Advanced Polymer Processing Technology, Zhengzhou University, Zhengzhou, 450002, China. Email: mihaoyang@zzu.edu.cn

[e]Department of Civil Engineering, College of Engineering and Physical Sciences, Aston University, Birmingham, B4 7ET, United Kingdom. Email: s.fadaie@aston.ac.uk

***Corresponding author:**

Department of Civil Engineering, College of Engineering and Physical Sciences, Aston University, Birmingham, B4 7ET, United Kingdom. Email: m.antwiafari@aston.ac.uk.

A Systematic Literature Review of Human-Autonomy Teams in Project Management

Abstract

Purpose – The advent of digital technology has increased both the autonomy and complexity of intelligent machines. As data functionality becomes more advanced, the demand for machines to engage in teamwork alongside humans is rising, leading to a transformation of intelligent machines from tools to teammates. As such, human-autonomy team (HAT) is a new concept in digital transformation, and HAT-related research has driven the application and development of artificial intelligence in industry and production. This study explores the prospects of HAT in project management through a systematic literature review of published articles, highlighting current research themes and proposing directions for future research.

Design/methodology/approach – While the systematic literature review follows the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines, VOSviewer was employed to assist in keywords co-occurrence analysis to visualize the connections and networks of included articles. A total of 38 publications were retrieved from both Scopus and Web of Science databases to examine the annual publication trends, geographical distribution, research methods, and keywords co-occurrence analysis.

Findings – The results revealed four mainstream research themes: (1) simulation of human-robotic system integration in project management, (2) algorithm design for human-centered artificial intelligence (AI), (3) the impact of digital transformation on teams towards agile project execution, and (4) generative AI model for risk analysis in project management.

Originality/value – From both theoretical and practical implications, this study would deepen the role and effectiveness of HAT in project management strategies. The proposed framework suggested potential future directions such as (1) expanded testing scenarios, (2) human factors in evaluation criteria, (3) agile transition issues in HATs, and (4) standards for AI model applications in project management. Ultimately, this study would foster a dialogue among

researchers and practitioners by encouraging a synergistic approach to the implementation of HAT solutions in project settings.

Keywords: Artificial intelligence, Human-autonomy team (HAT), Project management, Systematic literature review

Paper type: Literature review

Introduction

The concept of artificial intelligence (AI) was introduced by John McCarthy during the Dartmouth Summer Research Project in 1956 (McCarthy *et al.,* 2006). Over the next half-century, human beings have continued to enrich and expand the field of intelligent science, with new disciplines emerging from deeper investigations in this area (Wang *et al.,* 2021; Wang *et al.,* 2024; Zhang *et al.,* 2024). In the 21st century, as both AI theory and technology have matured, their application in industry and production has advanced significantly. For instance, robots are now integral to industrial production lines, driving the intelligent transformation and upgrading of industries (Evjemo *et al.*, 2020). Telemedicine and medical image analysis are alleviating regional inequalities in access to medical care and providing more accurate diagnoses (Kasina *et al.,* 2017). Additionally, AI-driven innovations such as facial recognition and autonomous driving are gradually bringing the vision of smart cities closer to reality (Lyons *et al.,* 2021; Adamu *et al.,* 2024).

Recent advances in AI suggest that information systems not only enhance team performance through tools but also strive for the transformation of intelligent machines from production tools to team members. The increasing integration of humans and AI has resulted in the modelling of intelligent agents that take into account human physical, emotional, and social behaviors (Castelfranchi, 1998). Consequently, a future in which humans collaborate with intelligent machines, such as virtual agents, is becoming a reality, a phenomenon known as

human-autonomy teams or human-AI teams (HATs) (Demir *et al.,* 2016). However, within HATs, it is worth noting that the acceptance of intelligent machines goes beyond merely introducing new technologies (Rix, 2022); it involves perceiving these machines as genuine teammates. Specifically, HATs exist where autonomous computerized agents collaborate with humans to achieve a shared goal (O'Neill *et al.,* 2023).

To successfully implement HATs, human teammates must first embrace intelligent machines or AI counterparts. Recently, robot teammates have been demonstrated to offer numerous potential benefits to projects, especially for high-risk, complex, or repetitive tasks. In comparison to humans, intelligent machines can support long-duration tasks with shorter rest periods (Chiou *et al.,* 2021). In terms of high-risk scenarios, such as rescue operations and public safety issues, robot teammates are more proficient, and their involvement can reduce risks or injuries compared to human teammates (Chiou *et al.,* 2021). In addition, robots or intelligent machines possess a degree of autonomy (Wynne and Lyons, 2018), since they are programmed to behave like humans or respond in ways that simulate human intelligence. Moreover, intelligent systems possess greater computing power, including faster data processing, and larger data storage capacities, than humans (Arkin, 2009). As a result, they can make faster and more accurate decisions, as well as perform tasks autonomously, without human intervention (Vagia *et al.,* 2016). These advantages of intelligent systems can save labor and time on project-based tasks (Arkin, 2009). Intelligent machines or systems can also work interdependently with humans to achieve overall team goals more effectively than teams composed solely of human participants (Marble *et al.,* 2004). Overall, HATs would become the prevalent form of teams, applicable in complex and realistic contexts (O'Neill *et al*., 2022; McNeese *et al.,* 2018).

Research gaps, aim, and objectives

AI development strives to simulate cognitive processes that mimic consciousness and thought, while also aiming to create a level of intelligence that surpasses human capabilities (Seeber *et al.,* 2020). However, intelligent robots still lack human empathy, which could potentially lead to disputes and conflicts among team members (Pflanzer *et al.,* 2023). In HAT scenarios, where intelligent machines collaborate with human team members, it remains to be examined whether existing project management theories and systems, which are based on human interactions, would be applicable in such settings.

Several previous studies primarily rely on human receptivity and perception of robot teammates' identity, while others examine trust and ethical issues between humans and AI (Lyons *et al.,* 2023). Perceived agency is a well-established factor influencing how people view technology as a teammate rather than a tool (Tokadli and Dorneich, 2022; Lyons *et al.,* 2019). Shifts in how humans perceive the role of AI can lead to trust issues between team members. The advantages of intelligent systems as teammates include their ability to share and integrate information resources, as well as their efficiency in repetitive tasks, project execution, and decision-making (Shoushtari *et al.,* 2024; Lakhmani *et al.,* 2022; Jarrahi, 2018). However, proactiveness, independence, and perceived lack of control over robot teammates can reduce trust among human team members (Hancock *et al.,* 2011). Furthermore, AI communication lacks emotional expression, which may result in information bias during task coordination, leading to an overreliance on human-human teammates. For example, robot teammates usually do not actively explain their decision-making process, and incomplete information transmission during communication could further weaken human trust in them (Kiesler and Hinds, 2004). Research has identified significant differences between HATs and human teams, including variations in cohesion, communication behaviors, and information resource sharing (Demir *et al.,* 2016).

In HATs, successful collaboration between humans and AI is essential to address the aforementioned issues. However, previous studies have been limited to exploratory research and have not focused on the mainstream themes in HAT research. Moreover, existing studies have focused on human-human teams for decades, with limited attention given to research on HATs. Unlike knowledge management systems of human teams, there is currently no research framework outlining the gaps and future directions of HATs. As with human teams, communication and shared intentions are key to effective collaboration. Communication conveys both emotions and information, enhancing performance in human-robot interactions (Parasuraman and Miller, 2004). Shared intentions enable autonomous agents to identify human decision-making trajectories and predict expected human behavior (Hughes *et al.,* 2020; Kapogiannis *et al.,* 2021). However, current studies lack established frameworks for collaboration patterns suited to human-machine teams within project management. Furthermore, no previous study has employed a systematic approach to review the body of literature on HATs.

Therefore, this paper conducts a systematic literature review of HATs-related research to identify mainstream research themes, research gaps, future research directions, and the conceptual framework of HATs in project management. To achieve this, the specific research objectives are: (1) to analyze annual publication trends, geographical distribution, research methods, and keyword co-occurrence in HATs research related to project management; (2) to discuss the mainstream research themes in HATs within the context of project management; and (3) to propose research gaps and future directions for HATs research in project management. The structure of this review is organized as follows. The next section discusses the research methods by following a standardized protocol. The results section presents the annual publication trends, geographical distribution, distribution of research methods, and keyword co-occurrence analysis. Then, the discussion section focuses on the mainstream

research themes, research gaps, and future research directions of HATs in project management. Lastly, the conclusions, contributions, limitations, and future studies are summarized.

Research methods

To achieve the research objectives, this study employed a systematic literature review. Unlike traditional narrative reviews, the systematic literature review follows a step-by-step process that minimizes biases during the research, enabling a more comprehensive and rigorous collection of publications that adhere to the study's predefined standards. This approach enhances the reliability of the findings and conclusions (Mengist *et al.,* 2020). Accordingly, the Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) guideline was adopted to conduct a systematic literature review. The PRISMA guideline is a widely recognized, evidence-based method for reporting literature, ensuring methodological accuracy, systematization, and reproducibility (Moher *et al.,* 2010; Cajal *et al.,* 2020; Yang *et al.,* 2024).

Identification of literature sources

To conduct a systematic literature review, relevant documents were sourced from electronic databases of Google Scholar, Scopus, and Web of Science. Google Scholar, a free digital resource covering a wide range of disciplines and document types, was initially used as a pilot database to identify publications related to the research topic and to refine the scope of the study. In contrast, Scopus and Web of Science were the primary databases used to retrieve and filter relevant literature through targeted search terms. These databases are known for containing more authoritative and high-impact publications compared to others. Notably, Scopus's advanced query function offers more precise search results, enhancing the quality and relevance of the literature retrieved (Tober, 2011).

By searching in Google Scholar, relevant keywords related to "human-autonomy team" and "project management" were identified, as outlined in Table 1. HAT involves the collaboration of humans, artificial intelligence and machine learning (AI/ML), and autonomous systems (AS) to enhance performance and efficiency across various fields (El Alami *et al.,* 2023). These keywords were then combined into search strings and used in the identified databases to retrieve relevant literature.

[Please insert Table 1 about here]

Search strategy and selection criteria

The search strings were applied in both Scopus and Web of Science, targeting the "title, abstract, and keywords" of documents. This thorough procedure resulted in the identification of 226 relevant publications, with 199 originating from Scopus and 27 from Web of Science. Following an initial overview of the identified documents, no duplicates were found between the two databases. To ensure the validity of the reported findings, specific inclusion and exclusion criteria were established in this study to screen eligible documents. The inclusion criteria were as follows: (1) subject areas were restricted to "engineering" and "business, management, and accounting"; (2) only full-text online articles and conference papers were considered; (3) publication sources were limited to journals and conference proceedings; (4) the language of the documents was limited to English; and (5) the studied or search period covered the past 24 years, from 2000 to 2024. Conversely, other academic and non-academic sources such as book chapters and trade journals were excluded to preserve the focus and integrity of the study. Journal articles were prioritized since they undergo rigorous peer review and provide an authoritative and specialized means for authors and readers to communicate and disseminate scientific research findings (Jiang *et al.,* 2024; Lu and Antwi-Afari, 2024). Likewise, conference papers were also included, as HAT is still an emerging field, and conference papers can unveil new trends in the industry, helping to mitigate publication bias. After the screening process, 67 articles were found. Next, the eligibility criteria were

established through a thorough reading of the titles and abstracts as well as the full texts. Two reviewers, YT and MFAA, independently assessed each of the 67 articles, and any disagreement was further discussed until a consensus was reached. During this stage, publications that were not representative (i.e., outside the scope of HATs) were removed. In addition, publications that were not focused on project settings were excluded. After the eligibility criteria, 38 articles were obtained in this study.

Data extraction and quality assessment

At this stage, 38 included articles comprising 17 from Scopus and 21 from Web of Science were used for data extraction and quality assessment. The extracted data from each article included titles, keywords, abstracts, publication years, sources, and other relevant information. A quality assessment checklist, as adopted in previous studies (Suhaili *et al*., 2021; Jiang *et al.,* 2024), was used to evaluate the included articles. Articles scoring between 70% and 100% were deemed suitable for further analysis. In this study, all 38 articles met the quality assessment criteria. Figure 1 presents an overview of the research methods, following the PRISMA guideline.

[Please insert Figure 1 about here]

Results

This section provides an overview of the results based on the analysis of publication trends, geographical distribution, research methods employed, and keyword co-occurrence analysis.

Annual publication trends

To gain an initial understanding of the selected literature, the distribution of publications per year is examined, along with relevant inferences. Figure 2 displays the distribution of papers by publication year. Given the relatively small sample size, the selected papers were counted

on an annual basis. Although the concept of AI has been proposed for a long time, it was not until the 21st century that AI began to be applied at production levels. Therefore, the year 2000 was chosen as the starting point for this review. Before 2017, studies on HATs in project management were relatively scarce, with an average of about one paper published per year. This may be linked to the emergence and developmental phase of the HAT field. Notably, there was a four-year gap during this period, with no articles published in either Scopus or Web of Science. The drop in publications in 2020 can be attributed to the global COVID-19 pandemic, which limited opportunities and conditions for academic exchange. Most papers have been published in recent years, with a significant peak in 2021 and 2024, reaching seven articles in a single year. In this study, the total number of publications for 2024 has not yet been fully counted; further articles are expected later in the year. The increased output in recent years may be attributed to the growing public interest in AI and human teams, reflecting a broader exploration of and interest in new team structures in the post-pandemic era. This trend suggests that HATs in project management remain an enduring and valuable area of research.

[Please insert Figure 2 about here]

Geographical distribution

The selected literature represents contributions from 17 countries, as shown in Figure 3. The United States and China are the top two contributors to research on HATs in project management. Approximately, one-third of the studies were conducted in the United States (34%), followed by China (13%) with five papers. Likewise, the contribution of European countries in this field is significant, accounting for over one-third of the selected literature. Notable outputs came from Belgium (8%), France (5%) and Finland (5%). Overall, studies have been conducted across all continents, indicating that this field has attracted global interest.

[Please insert Figure 3 about here]

Distribution of research methods

The research methodologies identified in the selected literature can be categorized into three distinct groups: (1) qualitative methods (e.g., case study, literature review, proof of concept, interview, design science research); (2) quantitative methods (e.g., cross-sectional study, descriptive analysis, modeling, simulation, survey); and (3) mixed methods, which integrate both qualitative and quantitative approaches.

The distribution of these research methodologies is presented in Figure 4, which delineates the proportion of studies employing each method in relation to the total body of selected literature (i.e., 38 papers). The case study method emerges as the most frequently utilized approach, representing 34.2% of the total, followed by modeling and simulation, each comprising 13.2%. These three methodologies thus constitute the predominant frameworks employed in the analyzed research. Within the qualitative domain, literature reviews rank as the second most utilized method, with 10.5% of the selected papers adopting this approach. Notably, a comparable proportion of mixed-methods studies incorporated a conceptual framework alongside quantitative analyses, such as modeling, to enhance the rigor of their research.

Based on the 38 included articles, previous studies have predominantly adopted qualitative methods, especially case studies and literature reviews, to elucidate the challenges and applications of HAT within specific project contexts. Conversely, quantitative methods offered a range of approaches, most studies opted to develop models and assess their validity across various scenarios.

[Please insert Figure 4 about here]

Keywords co-occurrence analysis

Keywords represent and summarise the content of an article, allowing readers to quickly capture the main points of information. Keywords co-occurrence analysis examines the content

of publications by assuming that frequently co-occurring words are thematically linked (Chiang *et al.,* 2023; Jiang *et al.,* 2024; Lu and Antwi-Afari, 2024). To conduct this analysis, VOSviewer is a versatile tool for effective representation and visualization of networks between articles (Van Eck and Waltman, 2010).

Based on 38 selected articles, keywords were analyzed using the "full counting" method in VOSviewer. The "author keywords" provided by the authors were found to be more precise in reflecting the themes of the articles. By setting a minimum occurrence threshold of two, only 30 out of the total 234 keywords met the criteria. Further refinement was performed by removing general keywords and merging those with the same semantic meanings, such as "artificial intelligence (AI)" and "artificial intelligence". Finally, 28 keywords and 4 clusters were identified. Figure 5 depicts the network visualization diagram of co-occurring keywords, showing 111 links and a total link strength of 134.

The size of each node in Figure 5 indicates the frequency of the corresponding keyword in the selected articles. As shown, in addition to the topic-related keyword "project management", author keywords such as "artificial intelligence", "personnel training", "machine learning" and "ChatGPT" have been frequently mentioned in previous studies of HATs in project management. Additionally, the distance between two or more keywords represents their interrelatedness, which is also indicated by the colours. For instance, "artificial intelligence" is closely related to "machine learning" and "project management", suggesting that artificial intelligence, predominantly machine learning, can play a significant role in project management (Taboada *et al.,* 2023). Furthermore, keywords with high total link strengths show strong connections with other terms. In addition to topic-specific terms, keywords such as "personnel training", "communication satellites" and "robotics", indicate that personnel training and communication systems need to be considered in the application of HATs. Overall,

this network highlights the growing potential of cutting-edge technologies, such as artificial intelligence, in project management and production.

[Please insert Figure 5 about here]

Table 2 lists the quantitative summary of the co-occurrence keywords related to HATs in project management, organized according to the average normalized citations count. It is worth noting that "project management" and "artificial intelligence" appeared more frequently than other keywords, followed by "ChatGPT", "personnel training", "machine learning" and "human resource management". These keywords were associated with and analyzed in studies on HATs in project management. The average publication year reveals the recency of keywords, indicating trends in scholarly research. Most relevant studies have been conducted post-2010, with keywords such as "big data", "machine learning", and "artificial intelligence" emerging in recent years. "ChatGPT", in particular, has become a prominent and controversial topic. In terms of average normalized citations, "construction management" ranked first with an average of 4.04, despite having only two occurrences. This was followed by "risk analysis" and "ChatGPT", with average normalized citations of 4 and 1.75, respectively.

[Please insert Table 2 about here]

Discussion

This section presents an in-depth analysis of the prevalent research topics currently recognized in the domain of HATs within project management. It also identifies existing gaps in research that warrant further investigation. Furthermore, the discussion delineates potential future research directions that could deepen our understanding and application of HATs in project management practices, building on the findings reported.

Summary of mainstream research themes of HATs in project management

Using VOSviewer, a keywords co-occurrence analysis was conducted to elucidate the interrelationships among author keywords. As visually represented in Figure 5, the analysis classified the keywords into four distinct clusters, each corresponding to a significant research theme. This categorization underscores the thematic diversity and critical trends associated with HATs in project management. Furthermore, the visualization illustrates the intricate connections between various research topics, thereby providing valuable insights into potential avenues for future scholarly inquiry in this evolving field.

Simulation of human-robotic system integration in project management

Robots are critical for tasks that are hazardous or beyond human capabilities. The integration of human-machine systems achieves seamless collaboration between humans and robots, fully leveraging the advantages of both, and improving overall work efficiency and safety. The surfaces of the Moon and other planets present some of the most extreme working environments accessible to humans, with their hostile external conditions posing significant challenges for the exploration of extraterrestrial resources and the broader understanding of our solar system. However, the development of human civilization is set to expand our reach beyond low-Earth orbit, with robotic systems forming the backbone of future aerospace missions (Singh-Derewa *et al.,* 2015). The concept of Human-Agent Teaming (HAT) has emerged to address the challenges associated with interacting with complex systems, envisioning autonomous systems as collaborative team members rather than mere tools. Planetary exploration requires cooperative robotics capable of operating independently of direct human influence; highly autonomous robotic systems can support enhanced cooperation and coordination between robots and ground teams, thereby reducing the delays and errors associated with long-distance operations (Kim *et al.,* 2021). Since 2006, NASA Ames Research Center has been developing and applying advanced intelligent-human systems integration

research to enhance mission operations support on the International Space Station (Smith *et al.,* 2014). This research has also contributed to developing sophisticated tele-supervisory system architectures that facilitate efficient human-robot interaction (Podnar *et al.,* 2007; Smith *et al.,* 2014). Despite advancements in robotic autonomy, human input is still required in some complex situations. Based on system integration, virtual reality would assist in simulation tests, provide intuitive visual supervision of robots, and enable experts to perform tele-visits (Huang *et al.,* 2024; Singh-Derewa *et al.,* 2015). In addition, the AEC industry is also gradually introducing robot technology (e.g., construction robots, automation equipment) for repetitive tasks such as bricklaying, welding, concrete pouring, as well as hazardous work such as building inspection and maintenance (Rafsanjani and Nabizadeh, 2023). However, the successful application of robot systems depends not only on the technology itself but also on effective integration with human operators.

Algorithm design for human-centered artificial intelligence

The transformative potential of AI is increasingly seized by organizations and companies, which are incorporating AI into team projects to improve the effectiveness and efficiency of various business functions. In current practices, AI machines are mainly involved in planning, managing, controlling, and optimizing work. However, insufficient consideration of human-related inputs and preferences can lead to collaboration challenges between humans and AI, underscoring the need for human-centered approaches. Considering current technology, AI has yet to reach a level where it can process information and experience on par with human capabilities; thus, human-centered AI is essential to bridge this gap. Human-centered AI involves integrating human preferences and relevant inputs into model algorithms and design, primarily through natural language processing and machine reading comprehension, thereby enabling AI models to generate ideas, prototypes, and solutions aligned with human expectations (Rafsanjani and Nabizadeh, 2023). Currently, two main directions define human-

centered AI algorithms. The first focuses on the preferences of project members, allowing AI to understand and learn from human interests, preferences, language, and behaviors. In such human-centered environments, AI is expected to enhance architectural processing, engineering capability, collaboration, and safety (Rafsanjani and Nabizadeh, 2023). The second direction considers stakeholders as the focal point, identifying their pain points, desires, and requirements to better fulfil the needs of the project's beneficiaries (Staub *et al.,* 2023; Miller, 2022).

The impact of digital transformation on teams towards agile project execution

The impact of digital transformation is being felt across all industries worldwide, largely driven by digital technologies such as artificial intelligence, robotics, and big data. Digital transformation empowers industries to manage different projects more effectively, intending to improve team efficiency. This wave of innovation has compelled traditional sectors to shift towards agile project management approaches to meet modern demands for both cost-efficiency and timeliness. The shift to agile practices presents a greater challenge in traditional industries compared to software or IT projects. In this context, research in sectors like oil and gas has begun to advocate for digital platform systems, proposing models such as "Open Project Management." This approach enables the flexibility to switch between traditional, agile, or hybrid methodologies, thereby facilitating adaptation and participation among team members and employees (Lamacchia *et al.,* 2020). An intelligent digital ecosystem further supports the integration of artificial intelligence and machine devices into project team collaboration, which can enhance efficiency and increase the likelihood of project success (el Khatib *et al.,* 2023). However, as organizations transition to agile methods, it becomes crucial for specific groups – such as project teams, management, and external vendors – to understand agile principles. Research underscores the importance of clear communication from management regarding project objectives in agile environments, as well as the need for a degree

of autonomy among team members to foster agile collaboration (Hekkala *et al.,* 2017; Sainio *et al.,* 2024).

Generative AI model for risk analysis in project management

In construction projects, AI models have demonstrated exceptional capability in generating comprehensive risk management plans that encompass key elements such as risk identification, risk analysis, and risk control measures. In quantitative assessments, AI forms like GPT-4 model consistently outperform the average human expert by delivering data-driven insights and analyses. However, when it comes to the practical implementation of risk strategies, human expertise is crucial, particularly in its ability to adapt these strategies to the specific conditions and challenges present in different project environments (Nyqvist *et al.,* 2024). Human professionals can refine and customize risk management plans according to the distinctive characteristics of each project, including its scope, budget, timeline, and stakeholder dynamics. In contrast, AI models primarily assemble and apply solutions derived from existing datasets. This distinction underscores AI's role as an augmentation tool that synergy with human expertise by improving efficiency and accuracy in risk identification and management.

In the context of agile project management, the limitations of AI have become particularly apparent since they lack human intuition and experience, which are vital to adapting strategies in real-time as project circumstances evolve, thereby, AI cannot substitute the essential human roles played by project managers (Sainio *et al.,* 2024). Nonetheless, AI models such as ChatGPT, GitHub Copilot excel at processing vast amounts of data quickly, efficiently categorizing information, and integrating diverse datasets, making them a valuable asset in providing design guidance, assisting, guiding, and automating specific tasks to optimize workflow efficiency (Mbizo *et al.,* 2024).

In summary, although generative AI exhibits outstanding performance in quantitative analysis and data processing, it cannot substitute human oversight and judgment needed in critical decision-making roles within project management. The nuanced understanding and contextual awareness provided by human professionals should remain central to any project management strategy. By integrating human expertise with generative AI's data-driven strengths, project teams can develop balanced and adaptable project management strategies that are more resilient and effective over the long term (Mbizo *et al.,* 2024; Aljaz, 2024).

Research gaps and future research directions for HATs in project management

Many existing studies on HATs primarily focus on defining what HATs are and analyzing the factors that contribute to their dynamics. The value of these studies is undeniable, some studies examine the differences by comparing the responses of human-machine teams with all-human teams under identical conditions, while others aim to develop models that enable intelligent teammates to simulate and better understand human behaviors. These studies offer insights into whether relationships validated within all-human teams hold in HATs and explore how the integration of AI models could enhance team and project performance. Despite that, a notable gap exists in research on HATs within the context of project management. This study's systematic review and analysis reveal that most research remains focused on model simulation and testing stages. However, the increasing integration of intelligent machines into project workflows is an undeniable reality. Even where intelligent machines currently replace labor-intensive tasks, such as aerial working or space exploration, advancements in machine autonomy are expected to enable these systems to support humans in more complex roles, including supervision and decision-making.

Real-life tests of human-robotic system integration

Existing research in HATs has widely been demonstrated in specific aerospace projects (Kim *et al.,* 2021; Smith *et al.,* 2014; McGowan *et al.,* 2017). These studies have explored various project management challenges including resource allocation, regulatory compliance, and stakeholder communication. In response to these challenges, systematic models were designed to effectively address them. However, those project specifics may restrict the broader applicability of the findings, as aerospace projects exhibit unique characteristics that set them apart from traditional industry initiatives. For instance, such projects necessitate substantial upfront investments, span long-term cycles, and are marked by a higher level of complexity and specialized expertise.

Currently, a considerable amount of research remains confined to the development and testing of models within controlled and simulated environments. While such simulations are vital for preliminary testing, they may not fully encapsulate the intricacies of real-world conditions. As a result, practical applications in real-world scenarios are often derived from computational predictions, a practice that can compromise the accuracy of the results (Kim *et al.,* 2021; Singh-Derewa *et al.,* 2015). To advance these systems for deployment in complex, unpredictable real-world conditions, it is essential to implement comprehensive phased testing protocols that simulate a range of operational scenarios. This should include stress-testing models under various conditions, such as unexpected mechanical failures, supply chain disruptions, and shifts in regulatory frameworks. Moreover, establishing robust strategies for managing unforeseen events is imperative. This could involve developing contingency plans, fostering stronger communication among stakeholders, and integrating adaptive strategies that enable agile responses to challenges as they emerge. By addressing these factors, various industries like aerospace, AEC, automobile, and manufacturing can significantly improve their readiness for real-world applications and bolster the resilience of their projects.

Research limitations in human-centered artificial intelligence (AI)

Current research highlights the preferences of human team members and explores ways to integrate these into machine algorithms, marking a significant advancement in the development of HATs. The emergence of human-centered artificial intelligence (AI) promises to enhance project management by incorporating beneficiary perspectives into planning schemes, thereby optimizing project outcomes (Rafsanjani and Nabizadeh, 2023; Staub *et al*., 2023). Moreover, the computational power of AI enables it to generate optimal solutions for organizing and sequencing multiple task packages, which can simplify project workflows and improve the efficiency of task handovers. However, human preferences and behaviors contain numerous subjective factors, and there is currently a lack of objective evaluation criteria to accurately measure these factors when designing algorithms (Singh *et al.,* 2021). Meanwhile, technological applications may involve sensitive data, raising ethical and privacy issues. In addition, algorithm development incorporates a standardized design process that reflects specific industry characteristics and the needs of service providers.

Team cognition of agile project execution

Agile project management is a flexible, iterative approach that enables teams to respond quickly to changing requirements and deliver value to customers more efficiently. However, in the context of agile transformation, especially within traditional industries, challenges arise due to information overload, limited experience with agile methodologies, and a lack of a unified understanding of "agility" and its key principles and practices (Hekkala *et al.,* 2017). These factors pose significant obstacles during the transition to agile project management, as specific measures to facilitate this transition are often lacking. Additionally, digital transformation can introduce additional challenges for team collaboration, structure, and procedure (el Khatib *et al.,* 2023; Lamacchia *et al.,* 2020). While digital tools enable remote collaboration and real-time communication, they can also create barriers to effective teamwork,

complicating the collaborative dynamics within agile projects. Future research should aim to standardize the understanding of "agility" and establish comprehensive training programmes focused on agile project principles (Hekkala *et al.,* 2017). Additionally, developing prompt modes for different agile scenarios, integrating them into AI tools to improve their practicality, and studying their sustained effects in long-term projects should be conducted in future research (Sainio *et al.,* 2024).

Standards of assessing AI models

In this field of research, scholars frequently compare the performance of human and AI models in risk management and decision-making to highlight AI's strength in data processing and integration. Although these studies assess results through both qualitative and quantitative dimensions, the quantitative aspect often lacks generalizability due to limited sample sizes, and the qualitative analysis is subject to potential bias from subjective factors (Nyqvist *et al.,* 2024). In addition, most studies focus on specific industries or similar projects, meaning that assessment outcomes reflect the unique characteristics of those projects, thus limiting broader applicability (Aljaz, 2024; Nyqvist *et al.,* 2024). Given these limitations, future research should aim to broaden the range of research samples and project scenarios. Additionally, it is essential to establish a comprehensive set of foundational assessment standards and processes for evaluating AI models. Such standards would enable a more rational and holistic integration of risk management elements relevant to diverse project contexts.

Future research directions for HATs in project management

Building on the identified research gaps and mainstream research themes within the HATs domain, this study aims to outline comprehensive future research directions to propel the advancement of this field. Additionally, a well-defined research framework is proposed to distill the essential components of the qualitative discussions, as depicted in Figure 6, which

illustrates the HATs research framework in project management. The recommended research directions for advancing the field of HATs in project management are as follows:

(1) Expanded testing scenarios.

It is critical to widen the range of testing scenarios for human-robot system integration. This involves evaluating the feasibility and effectiveness of these systems across various conditions, particularly during emergency events. By rigorously testing diverse scenarios such as natural disasters, industrial incidents, or complex project environments, research can more effectively assess system responsiveness and reliability. Meanwhile, ensuring timely updating of data is vital, as it enables systems to adapt and respond dynamically to environmental changes, ultimately enhancing effectiveness in critical situations.

(2) Human factors in evaluation criteria.

Developing objective evaluation criteria that emphasize human factors is essential for advancing HATs. This requires creating quantifiable metrics to assess how human-AI interactions and behaviors impact system performance. By incorporating these human factors into algorithms, researchers can improve model accuracy and prediction. Meanwhile, ethical and privacy issues should be paid attention. This may involve examining aspects such as user trust, physical workload, physiological response, and cognitive load, which significantly influence the effectiveness of human-AI interactions.

(3) Agile transition issues in HATs.

Forming an acceptable “agility” among team members is necessary to cultivate a unified understanding and framework for implementation. This includes establishing a detailed training program tailored for personnel engaged in agile projects, which covers critical aspects of agile methodologies, roles, responsibilities, and best practices. Furthermore, developing prompt modes integrated with AI tools for different agile scenarios is important for evaluating their sustained effects in long-term projects.

(4) Standards for AI model applications in project management.

To establish a more structured approach to the utilization of AI models in project management, it is crucial to broaden the array of research samples and project scenarios. This expansion should provide comprehensive insights into the factors influencing AI integration. Concurrently, prioritizing the development of foundational assessment standards and processes is imperative. These standards would enable practitioners to systematically incorporate risk management elements across diverse project contexts, ensuring that AI model integration is performed rationally and coherently to align with project objectives, and enhance overall success.

[Please insert Figure 6 about here]

Conclusions

Intelligent machines working alongside human teammates as part of HATs are increasingly becoming a reality. In response, scholars have focused on this emerging trend, developing conceptual frameworks and models to simulate HATs in real project scenarios. This study conducts a systematic literature review of published articles on HATs in project management, by identifying mainstream research themes, research gaps, and future research directions. By following the PRISMA guideline, 38 HAT-related research papers were identified. A descriptive analysis was then carried out, including annual publication trends, geographical distribution, and research methodologies. Additionally, a keyword co-occurrence analysis was conducted to facilitate a comprehensive discussion of the mainstream research themes, existing research gaps, and suggested directions for future studies on HATs in project management.

Between 2000 and September 2024, research on HATs in project management remained relatively limited, with a notable four-year gap in studies prior to 2017. A decline in publications occurred in 2020 due to the global impact of the COVID-19 pandemic, but interest peaked in 2021, reaching a maximum of seven published articles. The United States and China

emerged as the leading contributors to research in this field, with significant contributions also made by European countries. In terms of research methods, authors predominantly employed qualitative methods, such as case studies or literature reviews, to analyze the challenges and applications of HATs in specific projects. In addition, modelling and simulation were commonly used to analyze these systems. A subsequent keyword co-occurrent analysis revealed that "construction management", "Risk Analysis" and "ChatGPT" were the top three keywords with the highest average normalized citations, indicating their prominence in HAT-related project management research.

The qualitative discussion identified four primary research themes of HATs in project management: (1) simulation of human-robotic system integration in project management, (2) algorithm design for human-centered artificial intelligence (AI), (3) the impact of digital transformation on teams towards agile project execution, and (4) generative AI model for risk analysis in project management. These identified themes, along with the research gap analysis, indicate that current studies have proposed several models and frameworks that are often limited by the specific scenario conditions under which they were applied. As the field of HATs in project management is still in its developmental stages, further quantitative and statistical testing is required to strengthen these models with more extensive data accumulation.

Theoretical and practical contributions

The proposed research framework would provide scholars studying HATs with a clear overview of the current research landscape in project management. It highlights key themes from recent studies and suggests possible directions for future research. By focusing on HATs in project management, the study aims to enhance researchers, industry practitioners, and stakeholders' awareness of the transformative impact of AI on various project processes, showing how these technologies can optimize efficiency, improve decision-making, and foster

collaboration between human team members and AI systems. The results underscore the critical need for interdisciplinary academic exchange to explore how to better integrate robotics technology, human factors, and user experience design.

The significance of this study would inspire project management professionals in practical strategies, which include examining best practices for integrating AI tools into project workflows, as well as assessing their effectiveness in real-world scenarios. While AI can handle many repetitive tasks and demonstrate excellent quantitative abilities, the participation of human team members shouldn't be undermined by project managers. With proper training and support, humans can proficiently use intelligent systems and collaborate with robots to complete project tasks. However, project managers should be cautious since overreliance on AI may cause a deficiency in cognitive skills and problem-solving abilities.

AI developers should design systems that support teamwork between humans and machines, by fully leveraging the advantages of both parties. These systems need to support human teammates in decision-making rather than completely replacing them. Developers need to gather feedback from human users during the design process to ensure the systems meet their needs. Meanwhile, it is important to protect the sensitivity and privacy of information and data throughout AI development.

By fostering a comprehensive approach to the challenges of human-robot collaboration, scholars and industry practitioners can work together to successfully integrate HAT into project management. This teamwork is crucial for moving the various industries forward and addressing the multifaceted issues that come up in the evolving landscape of human-AI interactions.

Limitations and future research directions

The findings and contributions of this study point out several critical limitations that future research can address to deepen the understanding of HATs in project management. One major limitation lies in the relatively small body of literature sample. Due to constraints in available databases and the emerging nature of HAT research, the existing literature remains limited compared to more established domains such as traditional project management. This restricted quantity and breadth of work indicates that the research field has yet to mature, with many theoretical frameworks and empirical findings still in their infancy. Future studies could significantly enrich the literature by exploring diverse aspects of HATs, including their operational frameworks and implications across different industries.

Another notable limitation arises from the absence of field experiments and practical data feedback in the current study. While the research offers theoretical insights and practical recommendations, the lack of empirical evidence weakens the applicability of these recommendations in real-world contexts. To bridge this gap, future research could incorporate surveys and interviews to involve domain experts and practitioners. This would facilitate the gathering of first-hand insights, challenges, and success stories related to the implementation of HATs in project contexts. Furthermore, conducting field experiments and collecting empirical data would provide stronger support for the theoretical claims presented, enhancing the overall reliability of the study's findings.

Additionally, the scope of this study is relatively narrowed within project management subfields. While this emphasis is valuable, the broader domain of project management encompasses various specialized subfields, such as risk management, knowledge-sharing systems, and decision analysis. Investigating the role and effectiveness of HATs within these specific areas could yield nuanced insights that enhance our understanding of their potential

applications. Moreover, considering the significant differences between IT projects and traditional construction projects (often relating to team dynamics, project scope, and stakeholder engagement), future research could prioritize industry-specific case studies. This approach would enable researchers to capture the complexities and nuances associated with the deployment of HATs across different project types.

In summary, the proposed future research directions would not only provide valuable guidance for scholars aiming to contribute to the body of knowledge but also offer actionable insights for industry practitioners. By addressing these limitations, researchers can further illuminate the critical role of HATs in enhancing project management effectiveness and fostering innovation across various sectors.

Declarations of interest

No potential conflict of interest was reported by the authors.

References

Adamu, I. I., Okanlawon, T. T., Oyewobi, L. O., Shittu, A. A. and Jimoh, R. A. (2024), "Revolutionising construction safety: benefits of harnessing artificial intelligence tools for dynamic monitoring of safety compliance on construction projects in Nigeria", *International Journal of Building Pathology and Adaptation*, Vol. ahead-of-print No. ahead-of-print, doi: 10.1108/IJBPA-02-2024-0050.

Aljaz, T. (2024), "Leveraging ChatGPT for Enhanced Logical Analysis in the Theory of Constraints Thinking Process", *Organizacija*, 57(2), pp. 202-214, doi:10.2478/orga-2024-0014.

Arkin, R. (2009), *Governing lethal behavior in autonomous robots*. United States: CRC Press.

Ashby, W.R. (1956), *Automata Studies: Annals of Mathematics Studies. Number 34 (No. 34)*. Princeton University Press.

Cajal, B., Jiménez, R., Gervilla Garcia, E. and Montaño, J.J. (2020), "Doing a systematic review in health sciences", *Clínica y Salud*, Vol. 31, No. 2, pp.77-83, doi:10.5093/clysa2020a15.

Castelfranchi, C. (1998), "Modelling social action for AI agents", *Artificial intelligence*, Vol. 103, No. 1-2, pp. 157-182, doi:10.1016/S0004-3702(98)00056-3.

Chiang, D. C. I., Antwi-Afari, M. F., Anwer, S., Mohandes, S. R. and Li, X. (2023), "Occupational stress in the construction industry: a bibliometric-qualitative analysis of literature and future research directions", *International Journal of Building Pathology and Adaptation,* Vol. ahead-of-print No. ahead-of-print, doi: 10.1108/IJBPA-08-2023-0114.

Chiou, E.K., Demir, M., Buchanan, V., Corral, C.C., Endsley, M.R., Lematta, G.J., Cooke, N.J. and McNeese, N.J. (2021), "Towards human–robot teaming: Tradeoffs of explanation-based communication strategies in a virtual search and rescue task", *International Journal of Social Robotics*, Vol. 14, No. 5, pp. 1117–1136, doi:10.1007/s12369-021-00834-1.

Demir, M., McNeese, N.J. and Cooke, N.J. (2016), "Team communication behaviors of the human-automation teaming", *2016 IEEE International Multi-Disciplinary Conference on Cognitive Methods in Situation Awareness and Decision Support (CogSIMA)*, San Diego, CA, USA. 21st-25th March 2016. IEEE. pp. 28-34, doi:10.1109/COGSIMA.2016.7497782.

El Alami, H., Nwosu, M. and Rawat, D.B. (2023), "Joint human and autonomy teaming for Defense: Status, challenges, and perspectives", *Artificial Intelligence and Machine Learning for Multi-Domain Operations Applications V*, pp. 16, doi:10.1117/12.2665399.

el Khatib, M., al Ali, S., Alharam, I., Alhajeri, A., Peneva, G., Angelova, J. and Shanaa, M. (2023), "Drafting A Digital Transformation Strategy for Project Management Sector - Empirical Study On UAE", *Strategies for Policy in Science and Education-Strategii na Obrazovatelnata i Nauchnata Politika*, Vol. 31, No. 6, pp. 31-47, doi:0.53656/str2023-6s-3-dra.

Evjemo, L.D., Gjerstad, T., Grotli, E.I. and Sziebig, G. (2020), "Trends in smart manufacturing: Role of humans and industrial robots in smart factories", *Current Robotics Reports*, Vol. 1, No. 2, pp. 35-41, doi:10.1007/s43154-020-00006-5.

Hancock, P. A., Billings, D. R., Schaefer, K. E., Chen, J. Y. C., de Visser, E. J., and Parasuraman, R. (2011), "A meta-analysis of factors affecting trust in human-robot interaction", *Human Factors*, Vol. 53, No. 5, pp.517-527, doi:10.1177/0018720811417254.

Hekkala, R., Stein, M.K., Rossi, M. and Smolander, K. (2017), "Challenges in transitioning to an agile way of working", *Proceedings of the Annual Hawaii International Conference on System Sciences*, Big Island, United States. 3rd-7th January 2017. IEEE. pp. 5869-5878, doi:10.24251/HICSS.2017.707.

Huang, C.I., Chou, S.F., Liou, L.W., Moy, N.A., Wang, C.R., Wang, H.C., Ahn, C., Huang, C.T. and Yu, L.F. (2024), "An Evaluation Framework of Human-Robot Teaming for Navigation Among Movable Obstacles via Virtual Reality-Based Interactions", *IEEE Robotics and Automation Letters*, Vol. 9, No. 4, pp. 3411-3418, doi:10.1109/LRA.2024.3362138.

Hughes, D., Agarwal, A., Guo, Y. and Sycara, K. (2020), "Inferring non-stationary human preferences for human-agent teams", *2020 29th IEEE International Conference on Robot*

and Human Interactive Communication (RO-MAN), Naples, Italy. 31st August-4th September 2020. IEEE. pp. 1178-1185, doi:10.1109/RO-MAN47096.2020.9223520.

Jarrahi, M. H. (2018), "Artificial intelligence and the future of work: Human-AI symbiosis in organizational decision making", *Business Horizons*, Vol. 61, No. 4, pp. 577-586, doi: 10.1016/j.bushor.2018.03.007.

Jiang, Q., Antwi-Afari, M. F., Fadaie, S., Mi, H-Y., Anwer, S., and Liu, J. (2024), "Self-powered wearable Internet of Things sensors for human-machine interfaces: A systematic literature review and science mapping analysis", *Nano Energy,* Vol. 131, pp. 110252, doi: 10.1016/j.nanoen.2024.110252.

Kapogiannis, G., Fernando, T. and Alkhard, A.M. (2021), "Impact of proactive behaviour antecedents on construction project managers' performance", *Construction Innovation*, Vol. 21, No. 4, pp. 708-722, doi: 10.1108/CI-02-2020-0029.

Kasina, H., Bahubalendruni, M.R. and Botcha, R. (2017), "Robots in medicine: Past, present and future", *International Journal of Manufacturing, Materials, and Mechanical Engineering (IJMMME)*, Vol. 7, No. 4, pp. 44–64, doi:10.4018/IJMMME.2017100104.

Kiesler, S., and Hinds, P. (2004), "Introduction to this special issue on human-robot interaction", *Human–Computer Interaction*, Vol. 19, No. 1-2, pp.1-8, doi: 10.1109/TSMCA.2005.850577.

Kim, S.Y., Roffo, K., Laubach, S., Tan-Wang, G., Reeves, G., Pyrzak, G. and Ye, S. (2021), "Mission concept design for autonomous space missions using mission-level modeling and simulation", *Accelerating Space Commerce, Exploration, and New Discovery conference, ASCEND 2021*. 15th-17th November 2021. AIAA, doi: 10.2514/6.2021-4116.

Lakhmani, S. G., Neubauer, C., Krausman, A., Fitzhugh, S. M., Berg, S. K., Wright, J. L., and Schaefer, K. E. (2022), "Cohesion in human–autonomy teams: an approach for future research", *Theoretical Issues in Ergonomics Science,* Vol. 23, No. 6, pp. 687–724, doi:10.1080/1463922X.2022.2033876.

Lamacchia, D., Chowdhury, K. and Sharif, O. (2020), "A novel way of project management to ensure engagement for successful digital transformation", *Proceedings of the Annual Offshore Technology Conference*, Houston, USA. 4th-7th May 2020. OTC. V. 2020, doi: https://doi.org/10.4043/30860-MS.

Lu, M., and Antwi-Afari, M. F. (2024), "A scientometric analysis and critical review of digital twin applications in project operation and maintenance", *Engineering Construction and Architectural Management*, doi: 10.1108/ECAM-03-2024-0304.

Lyons, J.B., Hamdan, I.A. and Vo, T.Q. (2023), "Explanations and trust: What happen to trust when a robot partner does something unexpected?", *Computers in Human Behavior*, Vol. 138, pp. 107473, doi: 10.1016/j.chb.2022.107473.

Lyons, J.B., Sycara, K., Lewis, M. and Capiola, A. (2021), "Human–autonomy teaming: Definitions, debates, and directions", *Frontiers in Psychology*, Vol. 12, pp. 589585, doi:10.3389/fpsyg.2021.589585.

Lyons, J.B., Wynne, K.T., Mahoney, S. and Roebke, M.A. (2019), "Trust and human-machine teaming: A qualitative study", Lawless, W., Mittu, R., Sofge, D., Moskowitz, I.S. and Russell, S. (eds.) *Artificial intelligence for the internet of everything*. London: Academic Press, pp. 101-116.

Marble, J.L., Bruemmer, D.J., Few, D.A. and Dudenhoeffer, D.D. (2004), "Evaluation of supervisory vs. peer-peer interaction with human-robot teams'", *37th Annual Hawaii International Conference on System Sciences, 2004*, Big Island, HI, USA. 5th-8th January 2004. IEEE. pp. 9, doi:10.1109/HICSS.2004.1265326.

Mbizo, T., Oosterwyk, G., Tsibolane, P. and Kautondokwa, P. (2024), "Cautious Optimism: The Influence of Generative AI Tools in Software Development Projects", *South African Computer Science and Information Systems Research Trends*, Gqeberha, South Africa. 15th–17th July 2024. Springer. pp. 361-373, doi: 10.1007/978-3-031-64881-6_21.

McCarthy, J., Minsky, M.L., Rochester, N. and Shannon, C.E. (2006), "A proposal for the dartmouth summer research project on artificial intelligence, august 31, 1955", *AI magazine*, Vol. 27, No. 4, pp. 12, doi:10.1609/aimag.v27i4.1904.

McGowan, A.M., Bakula, C. and Castner, R. (2017), "Lessons learned from applying design thinking in a nasa rapid design study in aeronautics", *58th AIAA/ASCE/AHS/ASC Structures, Structural Dynamics, and Materials Conference, 2017*, Grapevine, USA. 9th-13th January 2017. AIAA. p.18, doi:10.2514/6.2017-0976.

McNeese, N. J., Demir, M., Cooke, N. J., and Myers, C. (2018), "Teaming with a synthetic teammate: insights into human-autonomy teaming", *Human Factors*, Vol. 60, No. 2, pp.262-273, doi:10.1177/0018720817743223.

Mengist, W., Soromessa, T. and Legese, G. (2020), "Method for conducting systematic literature review and meta-analysis for environmental science research", *MethodsX*, 7, pp. 100777, doi: 10.1016/j.mex.2019.100777.

Miller, G.J. (2022), "Stakeholder roles in artificial intelligence projects", *Project Leadership and Society*, 3, doi: 10.1016/j.plas.2022.100068.

Moher, D., Liberati, A., Tetzlaff, J. and Altman, D.G. (2010), "Preferred reporting items for systematic reviews and meta-analyses: the PRISMA statement", *International Journal of Surgery*, Vol. 8, No. 5, pp. 336-341, doi: 10.1016/j.ijsu.2010.02.007.

Nyqvist, R., Peltokorpi, A. and Seppänen, O. (2024), "Can ChatGPT exceed humans in construction project risk management", *Engineering, Construction and Architectural Management*, Vol. 31, No. 13, pp. 223-243, doi:10.1108/ECAM-08-2023-0819.

O'Neill, T., McNeese, N., Barron, A., and Schelble, B. (2022), "Human-autonomy teaming: a review and analysis of the empirical literature", *Human factors*, Vol. 64, No. 5, pp. 904–938, doi:10.1177/0018720820960865.

O'Neill, T.A., Flathmann, C., McNeese, N.J. and Salas, E. (2023), "Human-autonomy Teaming: Need for a guiding team-based framework", *Computers in Human Behavior*, Vol. 146, pp. 107762, doi: 10.1016/j.chb.2023.107762.

Parasuraman, R. and Miller, C.A. (2004), "Trust and etiquette in high-criticality automated systems", *Communications of the ACM*, Vol. 47, No. 4, pp. 51-55, doi:10.1145/975817.975844.

Pflanzer, M., Traylor, Z., Lyons, J.B. Dubljevic, V. and Nam, C. S. (2023), "Ethics in human–AI teaming: principles and perspectives", *AI Ethics,* Vol. 3, pp. 917–935, doi:10.1007/s43681-022-00214-z.

Podnar, G., Dolan, J., Elfes, A., Bergerman, M. (2007), "Human tele-supervision of very heterogeneous planetary robot teams", *A Collection of Technical Papers - AIAA Space 2007 Conference*, CA, USA. 18th-20th September 2007. AIAA. pp. 1834-41845, doi:10.2514/6.2007-6165.

Rafsanjani, H.N. and Nabizadeh, A.H. (2023), "Towards human-centered artificial intelligence (AI) in architecture, engineering, and construction (AEC) industry", *Computers in Human Behavior Reports*, Vol. 11, pp. 100319, doi: 10.1016/j.chbr.2023.100319.

Rix, J. (2022), "From tools to teammates: Conceptualizing humans' perception of machines as teammates with a systematic literature review", *Proceedings of the 55th Hawaii International Conference on System Sciences*, Hawaii, USA. 4th-7th January 2022. IEEE. pp. 398-407. Available at: http://hdl.handle.net/10125/79378.

Sainio, K., Abrahamsson, P. and Ahtee, T. (2024), "Prompt Patterns for Agile Software Project Managers: First Results", *14th International Conference on software business*, Lahti, Finland, 27th-29th November 2023. Springer. Pp. 190-204, doi: 10.1007/978-3-031-53227-6_14.

Seeber, I., Bittner, E., Briggs, R.O., De Vreede, T., De Vreede, G.J., Elkins, A., Maier, R., Merz, A.B., Oeste-Reiß, S., Randrup, N. and Schwabe, G. (2020), "Machines as teammates: A research agenda on AI in team collaboration", *Information & Management*, Vol. 57, No. 2, pp. 103174, doi:10.1016/j.im.2019.103174.

Shoushtari, F., Daghighi, A., and Ghafourian, E. (2024), "Application of artificial intelligence in project management", *International Journal of Industrial Engineering and Operational Research*, Vol. 6, No. 2, pp. 49-63.

Singh, R., Garg, V., & GPT-3. (2021), "Human factors in NDE 4.0 development decisions", *Journal of Nondestructive Evaluation*, Vol. 40, No. 3, pp. 71, doi: https://doi.org/10.1007/s10921-021-00808-3.

Singh-Derewa, C., Doule, O., Howe, S., Josan, P.K., Karlsson, D.E. and Srivastava, P. (2015), "Design and establishment of an analog planetary habitat facility to serve as a basis for human machine interface studies; alfa project - Strategy for design and establishment of an analog planetary habitat facility to serve as a basis for extreme environment human system integration research and development", *Proceedings of the International Astronautical Congress, IAC*, Jerusalem, Israel. 12th-16th October 2015. IAF. pp. 4131-4140.

Smith, E.E., Korsmeyer, D.J., Hall, V.F., Marquez, J., Iverson, D., Trimble, J., Keller, R.M., Frank, J., Chachere, J. and Clancey, W.J. (2014), "Exploration technologies for operations",

13th International Conference on Space Operations, SpaceOps 2014, CA, USA. 5th-9th May 2014. AIAA, doi:10.2514/6.2014-1619.

Staub, L., van Giffen, B., Hehn, J. and Sturm, S. (2023), "Design thinking for artificial intelligence: how design thinking can help organizations to address common ai project challenges", *HCI International 2023 - Late Breaking Papers*, Copenhagen, Denmark. 23rd-28th July 2023. Springer, Cham. pp. 251-267., doi: 10.1007/978-3-031-48057-7_16.

Suhaili, S. M., Salim, N., and Jambli, M. N. (2021), "Service chatbots: A systematic review", *Expert Systems with Applications*, Vol. 184, pp. 115461, doi: https://doi.org/10.1016/j.eswa.2021.115461.

Taboada, I., Daneshpajouh, A., Toledo, N. and de Vass, T. (2023), "Artificial intelligence enabled project management: a systematic literature review", *Applied Sciences*, Vol. 13, No. 8, pp. 5014, doi:10.3390/app13085014.

Tober, M. (2011), "PubMed, ScienceDirect, Scopus or Google Scholar–Which is the best search engine for an effective literature research in laser medicine", *Medical Laser Application,* Vol. 26, No. 3, pp. 139-144, doi: 10.1016/j.mla.2011.05.006.

Tokadli, G. and Dorneich, M.C. (2022), "Autonomy as a teammate: Evaluation of teammate-likeness", *Journal of Cognitive Engineering and Decision Making*, Vol. 16, No. 4, pp. 282–300, doi:10.1177/15553434221108002.

Vagia, M., Transeth, A.A. and Fjerdingen, S.A. (2016), "A literature review on the levels of automation during the years. What are the different taxonomies that have been proposed", *Applied Ergonomics*, Vol. 53, pp. 190-202, doi: 10.1016/j.apergo.2015.09.013.

Van Eck, N. and Waltman, L. (2010), "Software survey: VOSviewer, a computer program for bibliometric mapping", *Scientometrics*, Vol. 84, No. 2, pp. 523-538, doi:10.1007/s11192-009-0146-3.

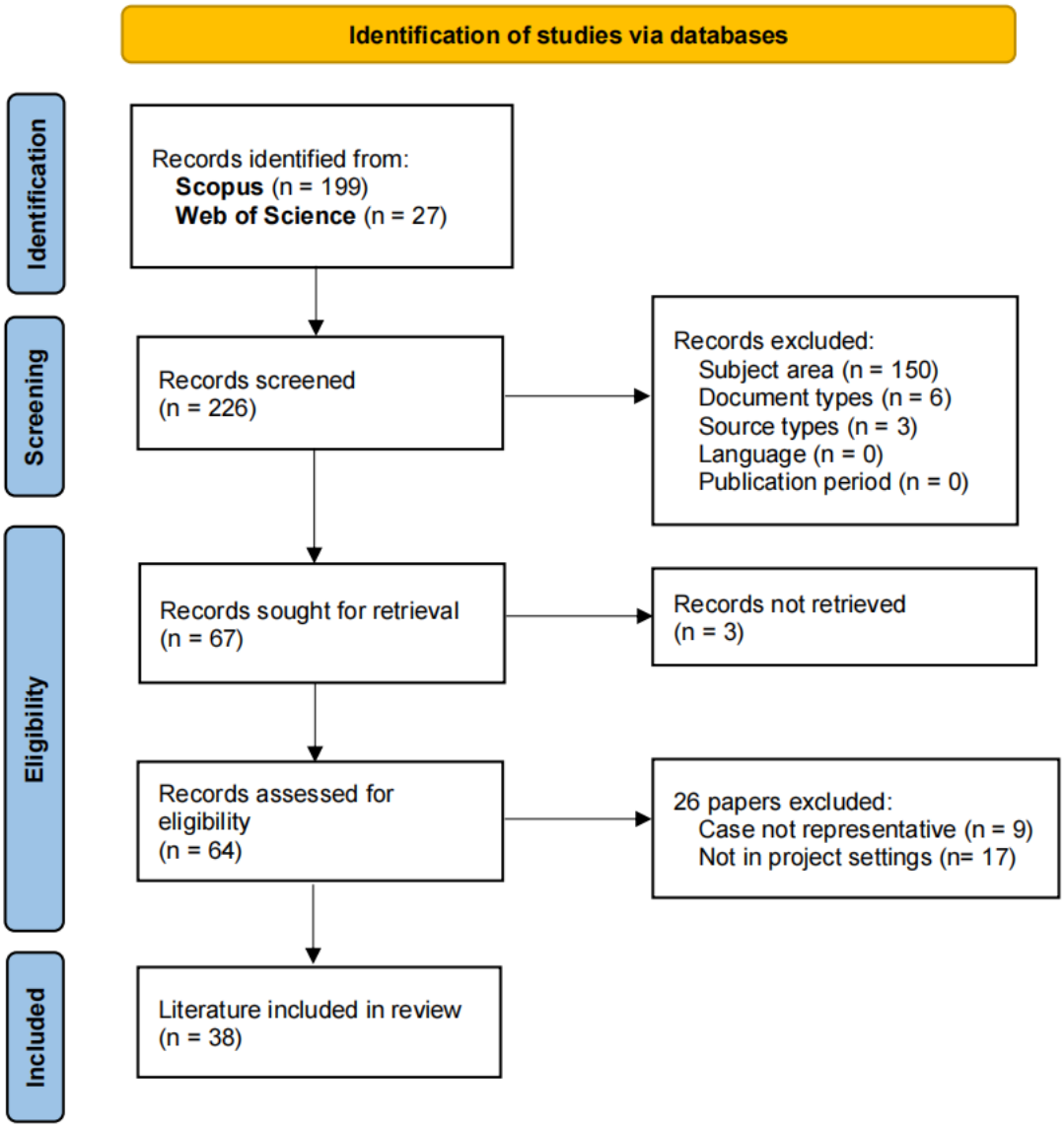
Wang, J., Antwi-Afari, M. F., Tezel, A., Antwi-Afari, P. and Kasim, T. (2024), "Artificial intelligence in cloud computing technology in the construction industry: a bibliometric and systematic review", *Journal of Information Technology in Construction (ITcon)*, Vol. 29, pp. 480-502, doi: 10.36680/j.itcon.2024.022.

Wang, L., Liu, Z., Liu, A. and Tao, F. (2021), "Artificial intelligence in product lifecycle management", *The International Journal of Advanced Manufacturing Technology*, Vol. 114, No. 3, pp. 771-796, doi:10.1007/s00170-021-06882-1.

Wynne, K. T. and Lyons, J. B. (2018), "An integrative model of autonomous agent teammate-likeness", *Theoretical Issues in Ergonomics Science*, Vol. 19, No. 3, pp. 353-374, doi:10.1080/1463922X.2016.1260181.

Yang, Y., Antwi-Afari, M. F., Imran, M. and Kong L. (2024), "Effects of transformational leadership and organizational climate on project performance in industrial revolution 5.0: A systematic literature review", *Journal of Engineering, Design, and Technology*, doi: 10.1108/JEDT-01-2024-0078.

Zhang, X., Antwi-Afari, M. F., Zhang, Y. and Xing, X. (2024), "The impact of artificial intelligence on organizational justice and project performance: A systematic literature and science mapping review", *Buildings*, Vol. 14, No. 1, pp. 259, doi: https://doi.org/10.3390/buildings14010259.

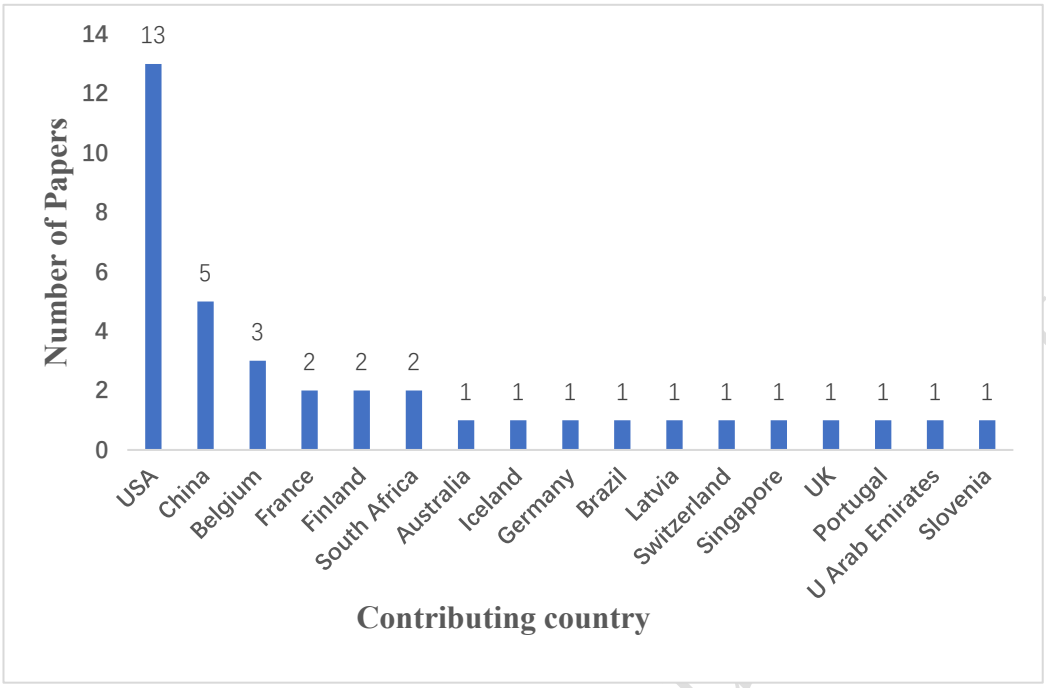


909

910 **Figure 1.** Research overview based on PRISMA guideline. **Source:** Authors own work

911

912 **Figure 2.** Annual publication trend of articles. Note: "*" means articles published in 2024 were
913 up to the end of September, hence the annual article in 2024 is incomplete. **Source:** Authors
914 own work



915

916 **Figure 3.** Geographical distribution of articles. **Source:** Authors own work

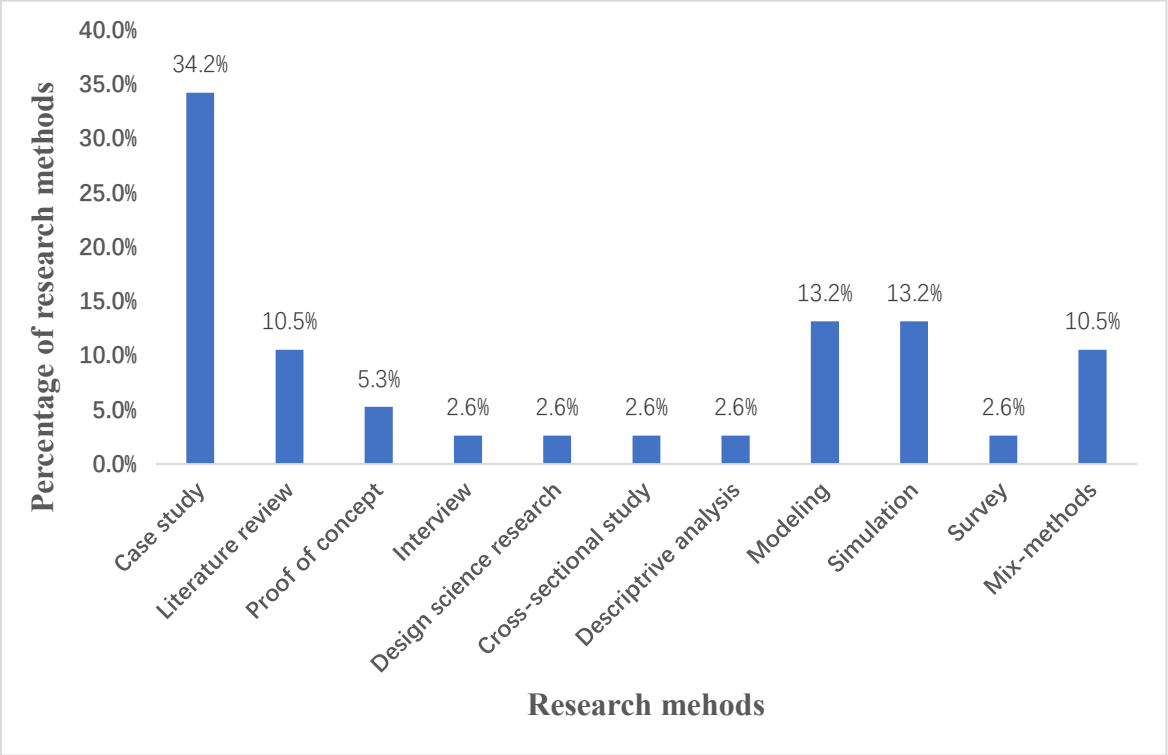


Figure 4. Distribution of research methods. Note: Qualitative methods include case study, literature review, proof of concept, interview, and design science research. Quantitative methods include cross-sectional study, descriptive analysis, modeling, simulation, and survey. **Source:** Authors own work

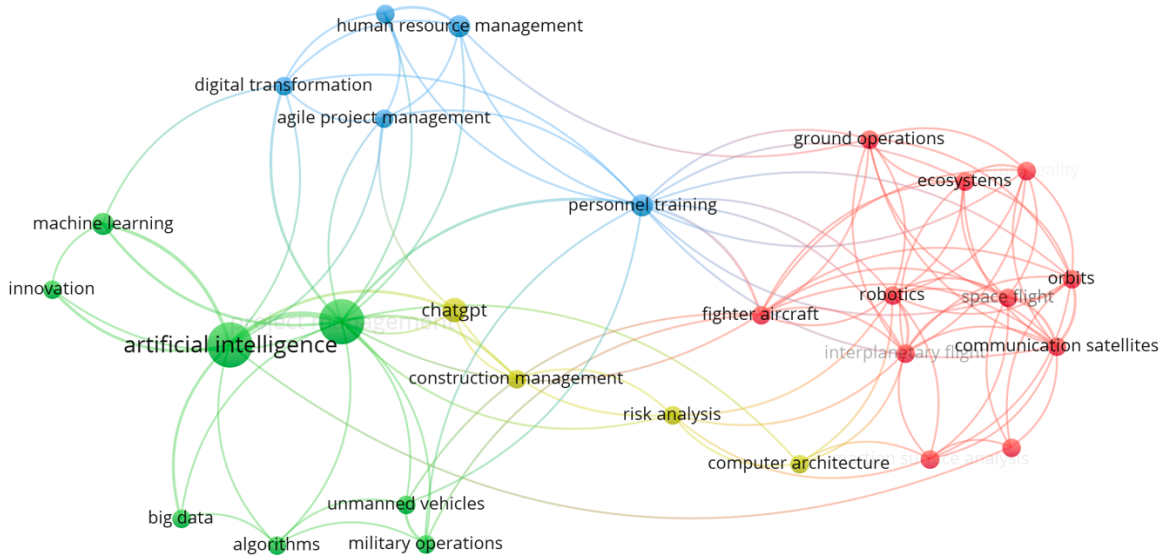


Figure 5. Network of co-occurring keywords related to HATs in project management. **Source:** Authors own work

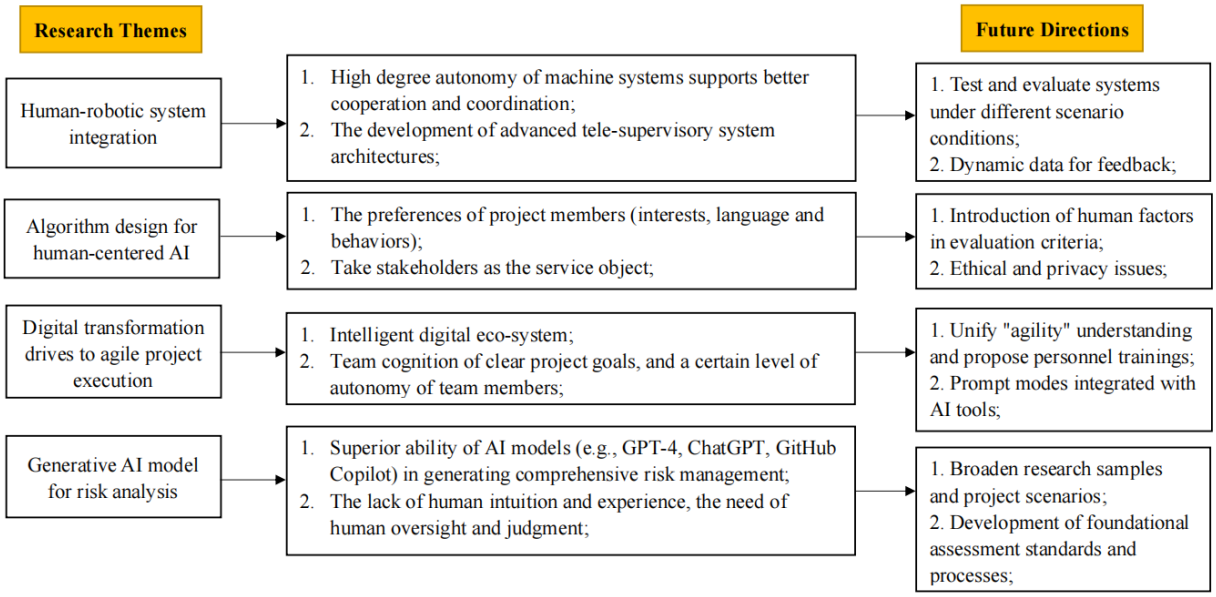


Figure 6. Research framework of HATs in project management. **Source:** Authors own work

927 **Table 1.** Keywords used for literature identification.

Keyword	Details of keywords
Human-autonomy team(s)	'Human-autonomy teaming', human and artificial intelligence (ai)', 'machine learning', 'human and robots', 'autonomous systems', 'multi-robot team'

Source: Authors own work

928 **Table 2.** Quantitative summary of the influence of keywords related to HATs in project management

Keywords	Occurrences	Average publication year	Links	Average citations	Total link strength	Average normalised citations
Construction Management	2	2023	3	4.50	4	4.04
Risk Analysis	2	2016	7	2.00	7	4.00
ChatGPT	4	2024	5	0.50	6	1.75
Big Data	2	2023	3	6.00	4	1.70
Project Management	15	2019	17	4.47	28	1.21
Software Engineering	2	2017	5	15.00	5	1.12
Algorithms	2	2013	5	1.50	5	1.00
Communication Satellites	2	2015	11	2.00	13	1.00
Computer Architecture	2	2007	5	6.50	5	1.00
Fighter Aircraft	2	2010	12	0.00	13	1.00
Interplanetary Flight	2	2011	12	1.00	13	1.00
Martian Surface Analysis	2	2011	8	3.00	8	1.00
Military Operations	2	2005	5	0.00	6	1.00
Orbits	2	2015	11	2.00	13	1.00
Robotics	2	2011	12	1.00	13	1.00
Space Flight	2	2015	11	2.00	13	1.00
Unmanned Vehicles	2	2005	5	0.00	6	1.00
Ecosystems	2	2016	9	6.50	9	0.96
Artificial Intelligence	15	2022	9	13.73	21	0.90
Agile Manufacturing Systems	2	2019	5	10.50	6	0.69

Personnel Training	3	2013	16	0.67	18	0.68
Machine Learning	3	2022	4	42.67	7	0.66
Ground Operations	2	2018	10	0.50	10	0.58
Innovation	2	2023	3	3.50	4	0.54
Human Resource Management	3	2019	6	7.33	7	0.51
Virtual Reality	2	2020	9	0.00	9	0.50
Agile Project Management	2	2022	7	1.00	7	0.02
Digital Transformation	2	2022	7	1.00	8	0.02

Source: Authors own work

929