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ARTIFICIAL INTELLIGENCE APPLICATIONS FOR PROACTIVE DISPUTE MANAGEMENT IN THE CONSTRUCTION INDUSTRY: A SYSTEMATIC LITERATURE REVIEW

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SUMMARY*: Disputes have become an inevitably accepted reality in the current nature of construction projects. These disputes are typically resolved through amicable settlements or by following legal procedures such as arbitration and litigation, which can result in cost and time overruns, disruptions in relationships, project abandonment, and even the insolvency of contracting organisations. This has prompted construction practitioners to seek proactive dispute management methodologies. Recently, there has been a growing trend of integrating traditional dispute management practices with innovative technologies of the digital era. Thus, this paper aims to explore the Artificial Intelligence (AI) technologies to predict disputes and thereby manage them effectively. This research begins with a scientometric analysis, followed by a systematic review of AI applications in dispute management within the construction industry. The scientometric analysis examines research trends over the past decade through keyword co-occurrence, citation country networks, number of publications by year, and publication trends in terms of various journals. Following PRISMA guidelines, the systematic review identified 19 previous studies on AI applications in construction dispute management. The analysis revealed that existing literature primarily focused on predicting four aspects: litigation outcomes, dispute resolution methods, dispute propensity, and causes of disputes. Furthermore, the systematic review found that most studies utilised machine learning predictive models, predominantly using structured categorical data as input features. Recent studies have identified a new trend involving the use of natural language processing together with the availability of digital construction data. The research suggests that AI techniques show the potential to predict disputes real-time before they materialise. Thus, adopting artificial intelligence into existing dispute management practices could help construction professionals proactively manage disputes in construction projects and enhance decision-making processes. Finally, the research recommends that regulatory bodies develop guidelines for the ethical use of AI in proactive dispute management within construction projects.*

KEYWORDS*: Construction Disputes, Artificial intelligence, Predict, Dispute Management.*

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1. INTRODUCTION

The construction industry plays a significant role in driving national economic growth. Despite its major economic contribution, several construction projects encounter cost and time overruns and severe disputes (Barbosa et al. 2017). Such disputes are common in construction projects and often have a considerable impact on both costs and time (Zhong et al. 2024). This is attributable to the interwoven interactions of parties with conflicting interests in construction projects, leading to severe disputes (Barman & Charoenngam 2017). El-Sayegh et al. (2020) asserted that several construction projects have been experiencing conflicts and disputes due to its complex and competitive nature. In addition, the involvement of high-cost of projects is accounted as one of the reasons for frequent disputes between a general contractor and a client (Anysz, Apollo & Grzyl 2021). On a different note, Kebede (2022) suggested that construction contracts are particularly prone to disputes due to very complex multi-party relationships. In addition, the uncertainty and complexity which inherent in the construction industry often undermine effective communication and information exchange among project stakeholders. With projects involving multiple stages, from inception to completion, these challenges contribute to the prevalence of disputes, which can be difficult to resolve (Gamil & Rahman 2022).

The construction industry is overwhelmed by an increasing number and severity of disputes (Ayhan, Dikmen & Birgonul 2021). In support, the Global construction Dispute Report revealed that the average value of disputes remains at historically high levels during the years 2020 and 2021. The average time taken to resolve disputes increased significantly, by almost 15%, compared to the years 2019 and 2020 (ARCADIS 2022). Francis, Ramachandra and Perera (2022) indicated that disputes negatively impact the project budget, schedule, and quality, ultimately affecting overall project performance. In the worst-case scenario, disputes lead to bankruptcy of the contractor and termination of construction projects. Therefore, disputes should be properly administered to minimize undesirable impacts on the project and its stakeholders (Rahnamayiezekavat et al. 2022). Therefore, construction executives and academic researchers have directed their attention towards effectively managing from the early stage of construction projects. Several studies have been conducted over decades to manage disputes effectively from different perspectives: the sources of disputes which leads to disputes; litigation and alternative dispute resolutions to resolve disputes; dispute avoidance strategies to avoid them beforehand. On this note, the paradigm has shifted along with the emerging AI technologies to predict and mitigate disputes in the construction industry in recent decades. Thus, this research reviews the literature on existing dispute management practices and investigates the potential of artificial intelligence to manage disputes more effectively and proactively.

2. LITERATURE REVIEW

2.1 Dispute Management in the Construction Industry

Numerous studies have explored strategies to prevent and resolve disputes before they escalate to litigation (Chen & Hsu 2007). ARCADIS (2022) highlights that the key to mitigating and resolving disputes early lies in the willingness of both owners and contractors to reach a compromise. Litigation is the most traditional method of formally resolving disputes. Generally, parties feel unpleasant due to the extended time of disclosure, rigid procedures and prolonged delays (Alaloul, Hasaniyah & Tayeh 2019). This adversarial procedure escalates the issue, increases the cost, and damages the business relationship (Arar, Papineau & Poirier 2022). As a result, professionals are increasingly focusing on alternative dispute resolution (ADR) methods to avoid and resolve disputes more efficiently. ADR includes a range of techniques outside the traditional court system, such as arbitration, mediation, mini-trials, dispute review boards, and adjudication, which are widely employed in the construction industry (Alqaisi et al. 2024). However, any resolution method requires highly specialised skills and proof documents, and disputes are highly technical which involve legal aspects (Cappiello & Carullo 2021). Such challenges have prompted the construction industry to prioritize dispute avoidance, embracing the proverb, "prevention is better than cure" (Cheung & Yiu 2006).

Dispute avoidance methods include negotiation, risk allocation, early non-binding neutral evaluation, and partnering. Among these, negotiation is considered the most effective approach in the UAE, as it allows proactive measures to be taken during negotiations to prevent disputes from arising (El-Sayegh et al. 2020). Gamil and Rahman (2022) suggested that the most effective way to prevent disputes is by establishing a robust communication system to bring all the parties in one platform and that will bring easy access to project information and frequent updates to all stakeholders. The authors further suggested the importance of promoting transparency and mutual trust through regular progress meetings, where changes, challenges, and project advancements can be openly discussed. Arar, Papineau and Poirier (2022) highlighted that implementing preventative measures during the planning stage to minimize the resources lost in later dispute resolution procedures.

Several causal models have been developed in recent years to manage disputes in the construction industry. For example, Ahmed and El-adaway (2023) determined key relationships among causes related to the bidding stage that could potentially lead to disputes. They used network analysis (NA), spectral clustering, and Association Rule Analysis (ARA) to help avoid disputes during the bidding process. Rahnamayiezekavat et al. (2022) identified the underlying causes of disputes in the New South Wales construction industry and analysed the inter-relationships between these causes using Partial Least Squares Structural Equation Modelling (PLS-SEM) and the Decision-Making Trial and Evaluation Laboratory (DEMATEL) technique. In addition, Tanriverdi et al. (2021) undertook a comprehensive approach using domain analysis, centrality analysis, and loop analysis to perceive the underlying causes as multifaceted parts of a relatively complex causal network, rather than focusing solely on individual issues.

Despite the various approaches adopted by construction professionals to manage disputes, ranging from identifying their sources and developing causal models to employing litigation, alternative dispute resolution methods, and dispute avoidance strategies, disputes remain prevalent in recent construction projects. On this note, there appears to be a paradigm shift in the construction industry with the advent of AI technologies, offering new approaches to predict and mitigate disputes. The next section reviews Artificial intelligence technologies and its applications.

2.2 Review of Artificial Intelligence Technology and its Applications

2.2.1 Artificial Intelligence Technology: An Overview

Artificial Intelligence is a field of computer science focused on enabling machines to replicate human intelligence and behavior (Sarmah 2019). Yadav et al. (2017) stated that the term "Artificial Intelligence," introduced by John McCarthy in 1955, refers to a pioneering field of computer science focused on developing intelligent machines capable of performing a wide range of tasks. AI is increasingly recognised as both a strategic priority for businesses and a key element of national agendas. AI has emerged as a pivotal arena in the new wave of scientific and technological revolution and industrial transformation. It represents a significant breakthrough in seizing opportunities for future development (Shao et al. 2022). AI serves as a key driver of industrial advancement and plays a vital role in facilitating the integration of emerging technologies, such as graphic processing units, Internet of Things, cloud computing, and the blockchain, in the new generation of big data and Industry 4.0 (Lu 2019).

Sunal, Karr and Sunal (2003) indicated that three major Artificial Intelligence concepts commonly used in scientific system modeling are fuzzy logic, neural networks, and genetic algorithms. Fuzzy logic systems provide a mechanism by which subjective concepts are incorporated into if-then rules, producing a rule-base akin to the “rule of thumb” approach generally implemented in human decision-making (Sunal, Karr & Sunal 2003). Artificial Neural Network (ANN) is a computational model designed for information processing using a connectionist approach to computation. It is configured for specific applications, such as pattern recognition or data classification, through a learning process. ANN is remarkable for its ability to derive meaning from complicated or imprecise data (Gupta & Nagpal 2020). Genetic algorithms are well-known computerised search and optimization algorithms modeled after natural selection. It is one of the most popular methods for solving optimization problems (Garud, Jayaraj & Lee 2021). Further, the authors stated that ANN and fuzzy models are integrated with generic algorithms to enhance the accuracy of prediction. Expert systems can complement these three concepts by incorporating rule-based reasoning and domain-specific knowledge to enhance decision support. Expert systems possess a broad knowledge base within a specific domain and utilise complex inferential reasoning to perform tasks that would typically require human expertise (Ghanbari, Abbasian-Naghneh & Hadavandi 2011).

Confusion often arises when distinguishing between the terms Artificial Intelligence, Machine Learning(ML), and Deep Learning (DL). Artificial Intelligence is a broad scientific discipline, with ML representing its most widely adopted implementation. Within ML, DL serves as a specialised subset and is currently most prominent (Lu 2019). Machine learning is the process, where computer systems that acquire intelligence by analysing large amout of past data (Sarmah 2019). Machine learning algorithms operate by exploring a range of potential predictive models to identify the one that best represents the relationship between the descriptive features and the target feature within a dataset (Kelleher, MacNamee & D'Arcy 2015). On another note, Murphy (2012) defined ‘Machine Learning’ as a collection of techniques designed to automatically identify patterns within data, which were subsequently employed to forecast future data or facilitate decision-making in situations characterised by uncertainty. Sarmah (2019) described deep learning as the multi-layer approach which is often referred to as an artificial neural network and is designed to replicate that of a human brain artificial neural network. Deep learning has significantly transformed numerous applications, including computer vision, speech recognition, and natural language processing (Muhammad & Yan 2015).

Natural Language Processing (NLP) is an automated technique used to analyse text data and extract valuable insights from documents. Over the past decade, NLP has become a prominent area of research in the construction industry, as construction projects generate a vast amount of documentation that can benefit from automated analysis (Moon, Chi & Im 2022). Large Language Models (LLMs) have become a revolutionary technology, showcasing remarkable proficiency in natural language processing tasks (Khan et al. 2023). LLMs are trained on vast amounts of textual data from diverse sources, including books, articles, websites, social media, and other documents. They are capable of capturing the semantic and syntactic patterns and relationships inherent in natural language (Taiwo et al. 2024). Recently, the rise and rapid adoption of advanced LLMs such as OpenAI's GPT, Google's PaLM and BERT, and Meta's Llama have shown great potential and sparked considerable global interest (Ghimire, Kim & Acharya 2023; Taiwo et al. 2024). Thus, AI encompasses various technologies and has applications across numerous fields, yet its fundamental methodology remains consistent.

2.2.2 AI Applications in Dispute Management - In General

In recent years, there has been a rapid evolution in AI and its applications. This is due to four major reasons: Availability and accessibility of digital data; development of hardware; the possibility to rent “computer power” on demand to train ML models; and emerging AI development frameworks and programming languages (Badgery et al. 2022). Generally, the evolution of AI applications in various industries has led to the emergence of several recognised subfields of AI. These include machine learning, computer vision, natural language processing, knowledge-based systems, optimization, robotics, and automated planning and scheduling (Abioye et al. 2021). AI is becoming a potent instrument in the junction of law and technology, with the potential to revolutionise the facets of legal practice. AI’s capacity to analyse extensive data and derive insights from patterns presents novel opportunities for enhancing dispute resolution with more efficiency and effectiveness. (Nayak & Samaddar 2024).

As digital trade becomes increasingly important for economic growth, trade-related disputes must be settled in both business and consumer situations (Wang, S, Li & Khaskheli 2024). The authors examine the advantages of using digital technology to resolve disputes involving digital trade and discuss and suggest that using digital technologies, especially artificial intelligence, can enhance the efficacy of dispute resolution. Similarly, Abad (2024) indicated that by automating complex decisions and processing extensive datasets, AI promises to enhance both the efficiency and effectiveness of trade and dispute resolution. The author investigated AI's potential applications within the World Trade Organisation, highlighting how predictive analytics and decision support systems could transform trade dispute resolutions.

Barnett and Treleaven (2018) stated that the widespread adoption of algorithmic discovery could enable predictive legal advice on dispute outcomes before individuals choose litigation or Alternative Dispute Resolution (ADR). Additionally, the authors highlighted that integrating AI with other technologies such as blockchain and smart contracts can accelerate dispute resolution, leading to faster conclusions and substantial cost reductions in litigation. Smart contracts, which are self-executing agreements with predefined rules encoded on a blockchain, ensure automation in dispute settlements. Similarly, (Tsurel et al. 2020) developed a set of multi-door Online Dispute Resolution (ODR) models that integrate ODR platforms to manage disputes in cross-border e-commerce. Their study highlighted the incorporation of Artificial Intelligence into the ADR system and confirmed that eBay effectively utilizes an AI-powered ODR system. (Magd & Palanissamy 2021) The digital platforms dealing with e-commerce disputes have enabled various Alternative Dispute Resolution Systems to utilize virtual processes by incorporating Artificial Intelligence, paving the way for future use of virtual platforms in the adjudicatory system.

On a different note, Zhang et al. (2023) explored the potential of AI to accelerate dispute resolution in road traffic accident (RTA) insurance claims, offering advantages to all stakeholders. The study specifically developed and applied a structured AI-driven methodology to generate cost estimates and support negotiation decisions, contrasting with traditional approaches that rely on official guidelines and legal expertise. (Alhussen & Ansari 2024) developed predictive models to identify potential traffic issues and assess their severity in real time. This real-time traffic forecasting enables proactive measures such as resource allocation, dynamic route advice, and traffic signal optimization to reduce congestion. Subsequently, AI shows its potential to predict and mitigate disputes and thereby enhance proactive dispute management in construction projects.

3. METHODOLOGY

Artificial intelligence has received significant attention within the construction industry, demonstrating its potential through various applications. Thus, integrating AI into proactive dispute management stands out as a timely development, and over the last decades, this has attracted researchers as well. Therefore, this poses a question that "what are the AI applications in dispute management in construction industry?". As shown in Figure 1, a total of 329 articles are drawn from two primary databases of construction management research: Scopus and Web of Science using the search string (TITLE-ABS-KEY (dispute) AND TITLE-ABS-KEY ("Artificial Intelligence" OR "Machine Learning" OR "Deep Learning" OR "Neural Network" OR "Supervised Learning" OR "Unsupervised Learning" OR "Reinforced Learning" OR "Natural Language Processing" OR "Computer Vision" OR "Named Entity Recognition" OR "Text classification" OR "Text mining" OR "Dimensional Reduction" OR "Predictive Modeling" OR "Clustering" OR "Classification" OR "Generative AI" OR "Artificial General Intelligence" OR "Large Language Model" OR "Generative Adversarial Networks" OR "Feature Engineering" OR "Feature Extraction" OR "Automated Machine Learning" OR "Fuzzy Logic" OR "Expert Systems") AND TITLE-ABS-KEY (construction OR building OR infrastructure)) for title, abstract and keywords. Using driven articles initially, a scientometric analysis is conducted followed by a systematic review to address the research question. Table 1 details the search string.

Table 1: Keywords for systematic search.

Coverage Area	Keywords
Dispute Domain	
Dispute	Dispute
Artificial Intelligence Domain	
AI and its main technologies	Artificial Intelligence, Machine Learning, Deep Learning, Neural Networks, Natural Language Processing, Large Language Model, Computer Vision
Learning types	Supervised Learning, Unsupervised Learning, Reinforcement Learning
AI applications	Named Entity Recognition, Text classification, Text mining, Dimensionality Reduction, Predictive Modelling, Clustering, Classification
Other AI related terminologies	Generative AI, Artificial General Intelligence, Generative Adversarial Networks, Feature Engineering, Feature Extraction, Automated Machine Learning, Fuzzy Logic, Expert Systems
Construction Domain	
Construction	Construction, Building, Infrastructure

Scientometric analysis can be described as a quantitative approach to studying how scientific research evolves over time. This method involves using numerical data to assess the influence and reach of research outputs. By examining citation patterns and connections, scientometric analysis allows researchers to create a visual representation or 'map' of a particular field of knowledge. Additionally, it helps identify emerging trends and patterns by analysing data from academic repositories and databases (Ghaleb et al. 2022). Consequently, this study conducts a systematic review of AI applications in dispute management in the construction industry, following a PRISMA flow diagram. The PRISMA flow diagram illustrates the movement of information through the various stages of a systematic review. It details the number of records identified, screened, included, and excluded, along with the reasons for exclusions. Various templates are available, tailored to the type of review and the sources used to gather studies (PRISMA 2023). The steps undertaken in the systematic literature search are presented Figure 1, which follows an updated version of PRISMA (Page et al. 2021).

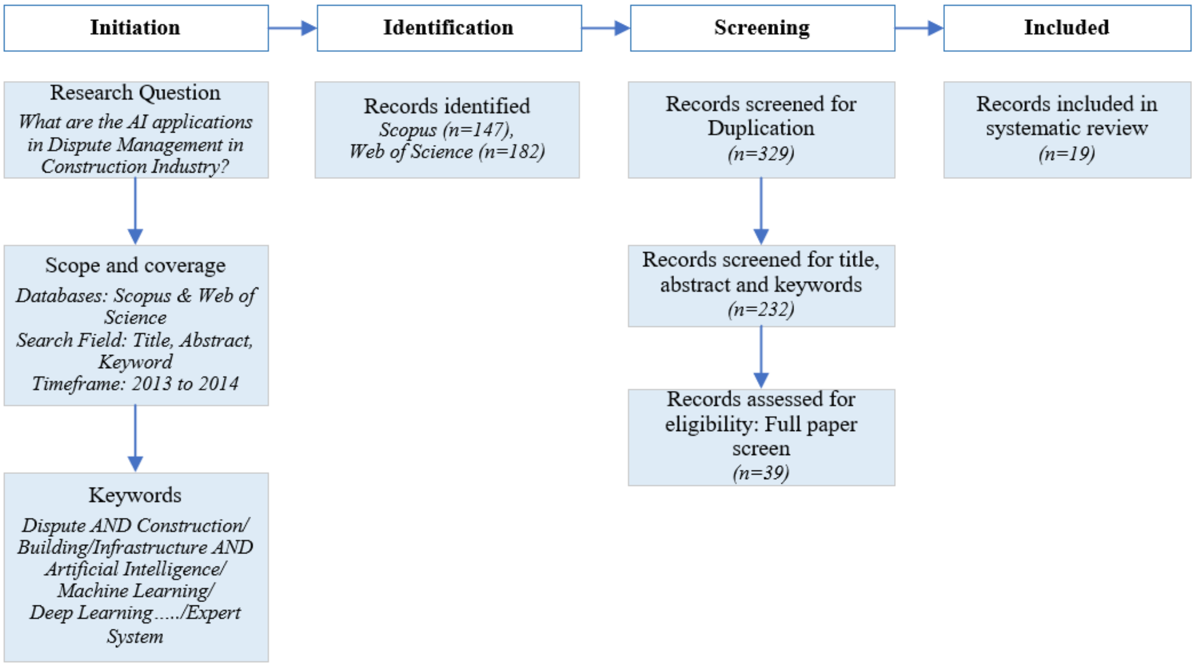

Figure 1: Systematic literature review process.

During the initial screening process, the duplicate articles (97) are eliminated and resulting in 232 articles. Subsequently, screening for title, abstract, and keywords is conducted, leading to a total of 39 articles which are taken for full paper screening. Finally, the systematic review process sorts 19 research papers that specifically investigate AI applications in construction disputes and its management. The next sections describe the scientometric analysis and the systematic review of selected papers on AI applications in dispute management in the construction industry.

4. RESULTS AND FININGS

4.1 Scientometric Analysis

The scientometric technique, used in this study to analyse AI applications in dispute management within the construction domain, is adopted as an approach for visualizing using VOSviewer software.

4.1.1 Keyword Co-occurrence Network

Keywords are words or phrases that reflect overall document content and express the researched area inside the domain boundaries (Ghaleb et al. 2022). Figure 2 depicts the keyword co-occurrence network.

As shown in Figure 2, the size of node reflects the frequency of that keyword used in the reviewed research articles, while the lines indicate the co-occurrence relationships between terms. The network is represented into different colour clusters with key nodes including "artificial intelligence," "project management," "construction projects," and "machine learning. These central concepts are linked to a wide array of related topics, spanning from technical aspects like "deep learning," "natural language processing," and "blockchain" to more industry-specific areas such as "contract management," and "dispute resolution”. It is important to note that the key areas focus on AI techniques which is depicted in red colour and AI applications in dispute management which is shown in green colour. As depicted in Figure 2, the AI applications in dispute management are related to dispute resolution, construction dispute, decision making and decision support systems in the construction industry. In addition, various AI techniques such as deep learning, machine learning, natural language processing, decision tree, artificial neural network, and learning algorithms are applied in the dispute management domain. Especially, AI applications such as prediction, forecasting, semantics and text classification are utilised in the reviewed research articles. Thus, this scientometric analysis on key word co-occurrences provides significant areas and emerging trends in the existing literature on AI applications for dispute management in the construction sector.

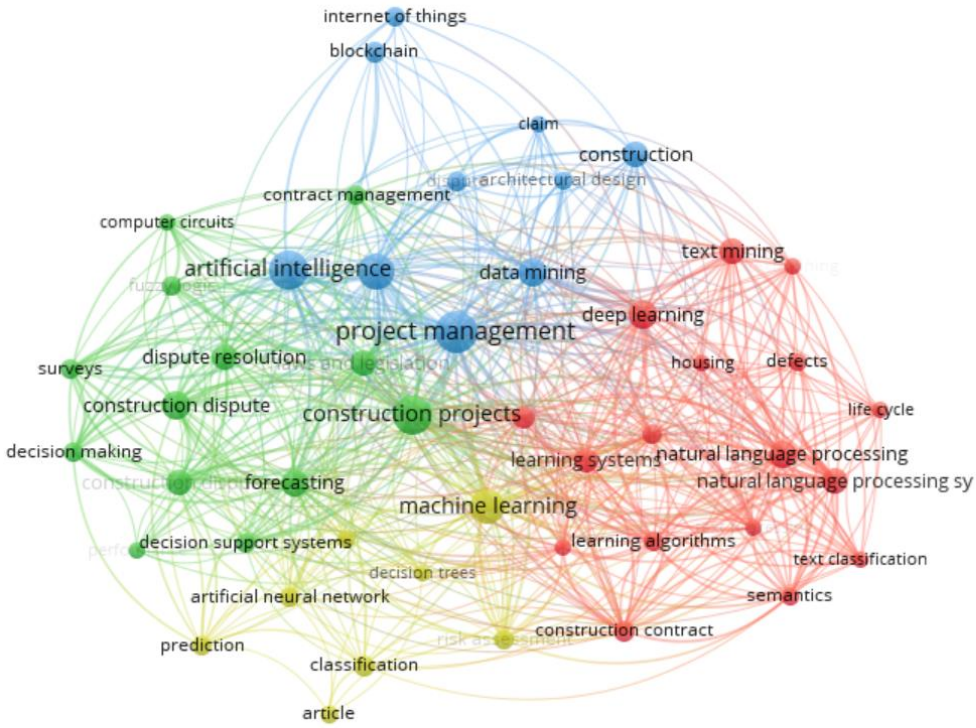

Figure 2: Keyword co-occurrence network.

4.1.2 Citation Country Network

The scientific collaboration network of countries aids in ascertaining the countries which are advancing research in a particular field (Opoku et al. 2021). Figure 3 shows the citation country network analysis.

The distribution of research contributions in AI applications for construction dispute management varies significantly across countries. The network highlights several key countries as nodes, with varying sizes likely indicating their relative importance in contributions. China appears as the largest node, suggesting it is a dominant player in this field. The network also includes countries like United States, Australia, Turkey, Taiwan, Qatar, Iran, India, and Egypt, highlighting the contribution to knowledge in the research domine across globe. As shown in Figure 3, there are several citation collaborations among countries. For example, citation collaborations are observed between the Turkey and United States, Australia, Taiwan, and Qatar. Following

Figure 3: Citation country network.

4.1.3 Author Co-citation Network

This author co-citation network provides a visual representation of the intellectual structure and influential researchers in the field under review. Figure 4 demonstrates the Author Co-citation network.

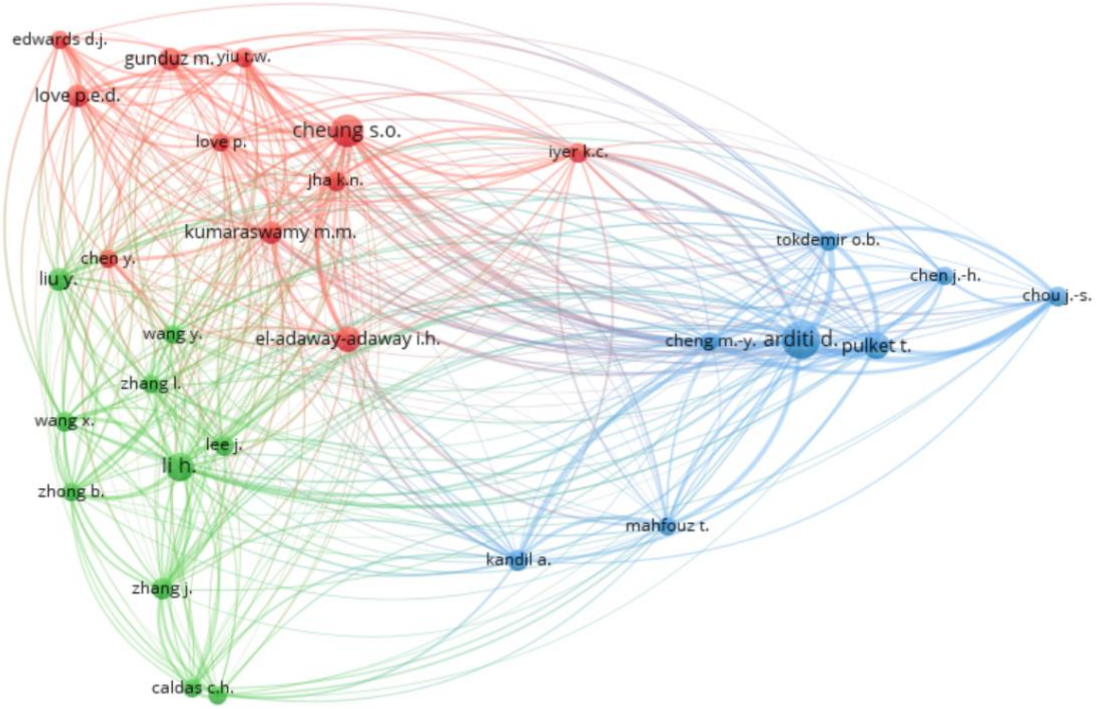

Figure 4: Author Co-citation network.

Ji et al. (2022) explained that when two authors are frequently cited together in the same articles (i.e., co-cited), it suggests that their works are scientifically connected and that they have common research interests. Author co-citation networks assist in identifying latent communities, and measure research diversities. The network is structured into several distinct clusters, indicating various researchers and subfields within the research domain. Key nodes such as Cheung S.O., Li H., and Arditi D. appear to be central figures, likely representing influential authors in the field. The varying sizes of nodes likely correlate with citation frequency, highlighting the relative impact of different researchers. Thus, the author co-citation network illustrates the complex relationships between authors and their works.

4.1.4 Number of Publication by Year

Figure 5 illustrates the trend of publication in terms of the number of publications over time for the research area which is AI applications in construction dispute management.

As depicted in Figure 5, starting from the year 2013, there was an early fluctuation in publication numbers, particularly a prominent decline in 2015. Conversely, AI applications in dispute management have experienced significant growth in publications from 2018 onward. This indicates an increasing interest and activity among academics and researchers in the research area. The trend shows a sharp rise between 2018 and 2021, with the peak number of publications recorded in 2023 with about 43 publications. As per the graph, there is a slight decline in 2024, which might be due to incomplete data for the current year. Most likely, the number of publications in 2024 will exceed expectations. Overall, the analysis of publication trends suggests a rapidly evolving and expanding field of study, particularly in recent years, along with the emergence of AI applications in other fileds of the construction industry. Following Figure 6 shows the trend of publications in terms of different journals.

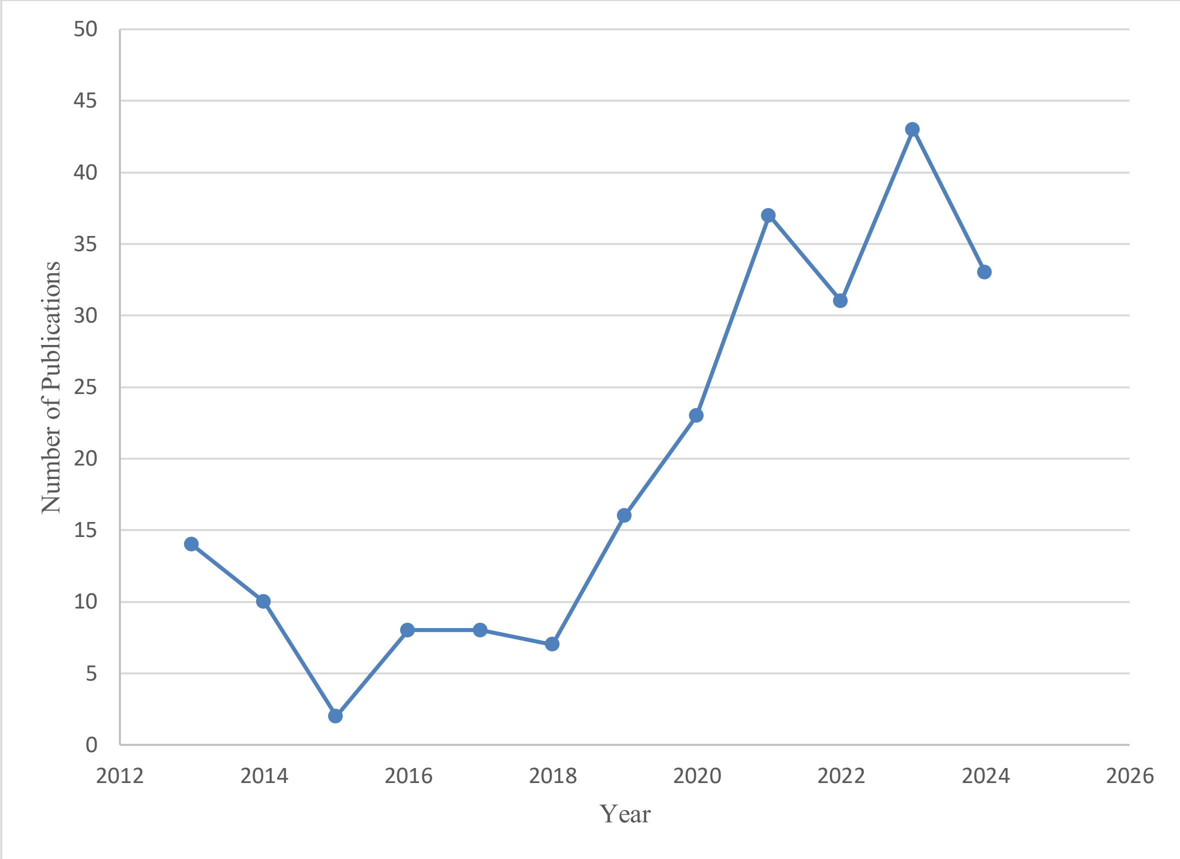

Figure 5: Number of Publications by Year.

4.1.5 Publication Trend in terms of Various Journals

Figure 6 represents the distribution of publications across various journals in AI applications in managing disputes in the construction industry.

The trend of the selected 19 papers in terms of the journals is depicted in Figure 6. The selected papers were published in 15 different journals. Among these, the Journal of Legal Affairs and Dispute Resolution (Q1) was the most significant, with three publications. Expert Systems (Q1) with Applications and the Journal of Construction Engineering and Management (Q1) were notable, each with two publications. The graph also exhibits a diverse range of other journals with a smaller number of publications (1 out of 19), suggesting a broad scope of research across different aspects of civil engineering, construction, and related fields.

4.2 Systematic Review on Artificial Intelligence Applications in Construction Dispute Management

Construction executives are increasingly exploring new approaches to prevent and resolve disputes (Alqaisi et al. 2024). Aligning with the evolution of AI and its applications, research studies have emerged that combine AI technologies with proactive dispute management. Accordingly, this section of the study systematically reviews AI applications in construction dispute management. Table 2 summarises the facts on the AI applications in construction dispute management over two decades merely from 2013 to 2024, in terms of the AI techniques utilised, algorithms used to develop the model, dataset used for training the model, input features, output or target features which the developed model provide as the prediction, and model accuracy. These details are derived from a detailed analysis of the selected papers

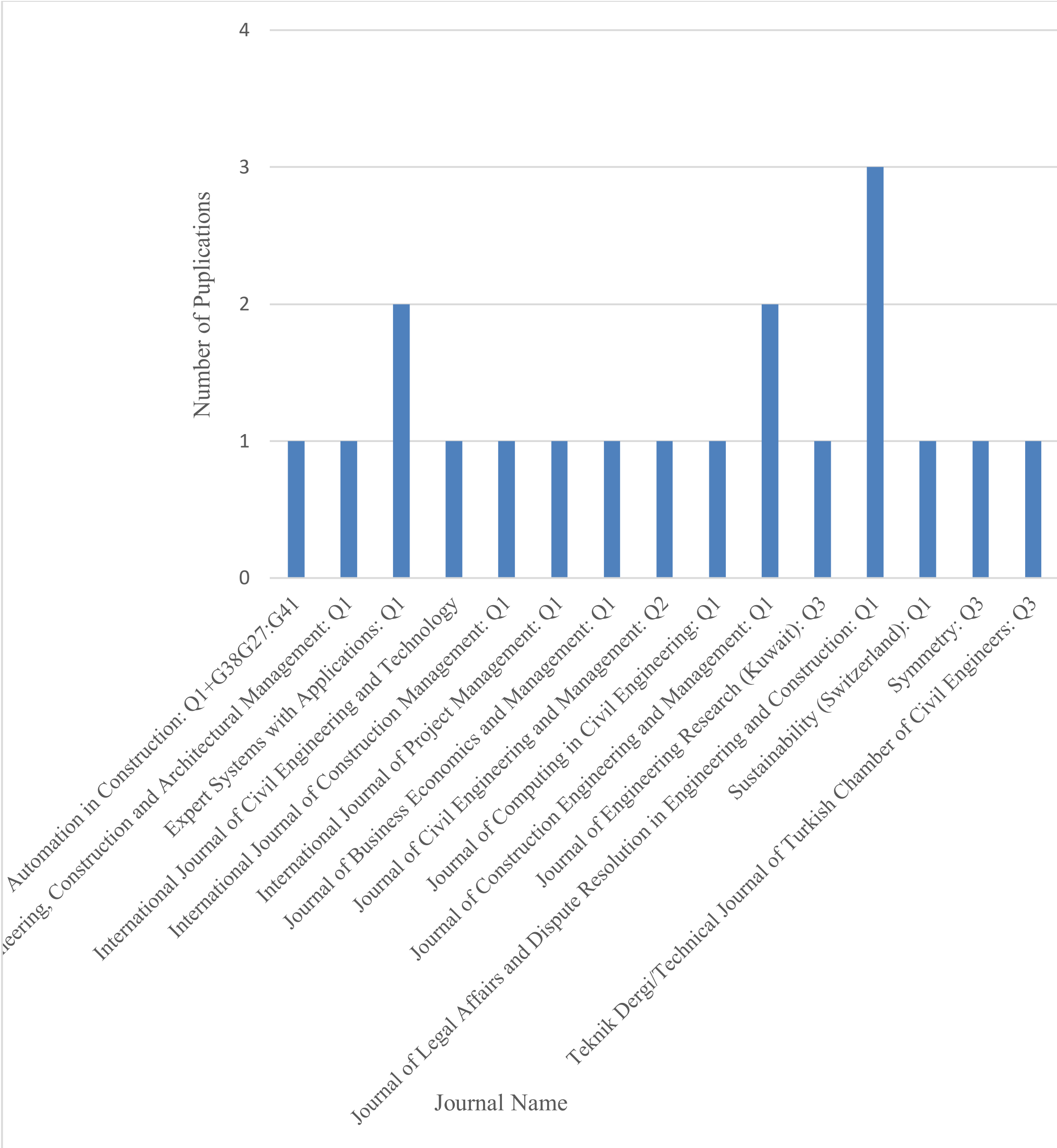

Figure 6: Publication Trend in Terms of Various Journals.

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Table 2: Profile of Articles on Artificial Intelligence Applications in Construction Dispute Management.

Source	AI Technique	Algorithm used	Cases/Data Set	Input	Output (Target)	Accuracy
Alqaisi et al. (2024)	Machine learning	Decision Tree (DT), Random Forest (RF), Support Vector Machine (SVM), Neural Network (NN)	15 change orders from 10 cases	Factors to change order disputes	Litigation outcome win/lose	95%
Elelu et al. (2024)	Topic clustering Natural language processing	Latent Dirichlet Allocation (LDA)	24 utility manuals	Utility manual clauses	Classification of topics: Planning and scheduling Dispute resolution and communication, Infrastructure design, Project management and government regulations	-
Un et al. (2024)	Machine learning predictive model	Logistic Regression, Support Vector Machines, Decision Trees, K-Nearest Neighbors, and Random Forest	141 arbitration precedents	12 variables work type, root causes, delays from a contractor, extension of time, different site conditions, poorly written contracts, unit price determination, penalties, price adjustment, acceptances, delay of schedule, and extra payment claims	Dispute outcome: In favour of the contractor In favour of the administration To some extent in favour of the contractor Without clear decision	71.65%
Zhong et al. (2024)	Deep learning – Text mining	Multilabel Text Classification Models SVM, LR, NB, DT, k-NN, TextCNN, TextCNN + LSTM, RCNN, Transformer	11,617 judgment documents	Construction dispute fact case	Applicable statutes, Litigation outcome win/lose	66%
Ayhan, Dikmen and Birgonul (2023)	Machine learning predictive Classification	NB, KNN, C4.5, MLP, Polynomial Kernel Support Vector Machines (PSVM), and Radial Basis	82 dispute cases	Type of Contractor, Type of Contract, Changes, Delays, Disputant Party, Dispute Source, Disputed Amount (Financially), Disputed Extension of Time Amount	Compensation of disputes: No, cost, time, both cost and time	80.61%

Source	AI Technique	Algorithm used	Cases/Data Set	Input	Output (Target)	Accuracy
Ye et al. (2023)	Text mining and NLP	TF-IDF (Term Frequency-Inverse Document Frequency), SVD (Singular Value Decomposition) K-Means ++.	3150 litigation cases	Litigation cases	37 causes of disputes	-
Ayhan, Dikmen and Birgonul (2022)	Machine Learning Predictive Classification	NB, KNN, C4.5, MLP, Polynomial Kernel Support Vector Machines (PSVM), and Radial Basis	82 dispute cases	Type of contractor, Changes, Dispute source, Resolution cost, Resolution duration, Litigation knowledge, Arbitration knowledge	Dispute resolution methods: litigation, arbitration, Dispute resolution Board, mediation, senior executive appraisal, negotiation	86.48%
Wang, P et al. (2022)	Machine Learning Predictive Classification	Bayesian belief network, Multilayer perceptron	222 project related data filled using questionnaire	8 critical success factors for dispute avoidance	Dispute index: 0-3 early warning, 4-10 warning, and above 10 emergency	95%
Anysz, Apollo and Grzyl (2021)	Machine Learning Predictive Classification	Decision Trees and Artificial Neural Networks	100 project data	Contract value, planned cost, planned profit, financial reserve, contract scope, planned duration, direct cost of additional works, delay in days, Additional fixed cost for contractor, Total fixed cost increase	Litigation outcome: win or loss	93%
Ayhan, Dikmen and Birgonul (2021)	Machine Learning Predictive Classification Models	Ensemble classifier, Support Vector Machine classifiers	108 projects	Project location, Project value, Project duration, changes, delays, another 9 skills attributes	Disputed or undisputed	91.1%

Source	AI Technique	Algorithm used	Cases/Data Set	Input	Output (Target)	Accuracy
Zheng et al. (2021)	Machine learning predictive model	gradient boosting decision tree (GBDT), k-nearest neighbor (KNN) and multi-layer perceptron neural network (MLP)	171 litigation cases of PPP	Legal factors including Causes of disputes, contract clause, objective facts	Litigation outcome (win/lose)	96.42%
Fatima, Prasad and Sekhar (2019)	Machine learning	Artificial Neural Networks (ANN)	72 Filled questionnaires on dispute attributes	Dispute attributes	Causes of disputes	Mean Absolute Percentage Deviation (MAPD) of 12.22%
Jallan et al. (2019)	NLP, Topic Modelling	Latent Dirichlet allocation (LDA)	1,498 Legal cases related construction defects	Case summary	14 categories (topics) of defect cases	
Mahfouz, Kandil and Davlyatov (2018)	Machine learning, NLP	Term Frequency, Logarithmic Term Frequency, Augmented Term Frequency, and Term Frequency Inverse Document Frequency Naïve Bayes (NB), Decision Trees (DT), Projective Adaptive Resonance Theory (PART)	600 cases related to differing site conditions	Legal cases	Category of legal factor:15 significant legal factor	88%
Chaphalkar, Iyer and Patil (2015)	Machine Learning Predictive Classification Models	MLP	239 variation claims referred to Arbitration	16 extracted intrinsic factors from Arbitration documents	Claim allowed/rejected/partially allowed	
Chou et al. (2014)	Predictive, Classification	SVM, CART, QUEST, C5.0, CHAID, and GASVM	645 PPP projects	13 project attributes	No dispute occurred or dispute occurred	89.3%
Chou, Tsai and Lu (2013)	ML Predictive classification	MLT+MLT, DT+DT	569 data set of PPP projects through survey	Project attributes	Dispute propensity	97.08%
Chou, Cheng and Wu (2013)	Machine Learning Predictive Classification Models	SVM, SVMs and fmGA hybrid, Hybridization of SVMs, fmGA, and FL	152 data set of PPP projects	Project attributes	Dispute resolution method	77.04%
Chou and Lin (2013)	Machine learning	Multilayer Perceptron (MLP), Support Vector Machines (SVM), Tree-Augmented Naïve Bayesian (TAN), Classification and Regression Tree (CART), Quick, Unbiased and Efficient Statistical Tree (QUEST), SVMs+ANNs+C5.0	569 filled questionnaires	13 PPP Project attributes	Dispute or No dispute	84.33%

As per Table 2, several studies (7 out of 19) predict the outcome of dispute resolution in terms of win or loss or in terms of compensation (Alqaisi et al. 2024; Anysz, Apollo & Grzyl 2021; Ayhan, Dikmen & Birgonul 2023; Chaphalkar, Iyer & Patil 2015; Un et al. 2024; Zheng et al. 2021; Zhong et al. 2024). These studies are considered a reactive approach to disputes, as they predict the outcome only after a dispute has occurred. Zhong et al. (2024) not only predict litigation outcome but focus on extracting valuable information from government-issued statutes that is involved in construction contract dispute. Their study makes three key contributions: first, they explore and evaluate various multilabel classification models for construction dispute classification tasks, followed by further model optimizations; second, they enable the automatic identification of government-issued statutes, assisting contract administrators in assessing the validity of their claims before pursuing litigation; and third, they propose strategies to mitigate and resolve disputes in construction contract management.

Alqaisi et al. (2024) propose a machine learning model designed to predict the outcomes of construction change order disputes. The model is trained on historical data from past cases retrieved through keyword searches in online legal databases such as Westlaw and Lexis Nexis. Forecasting the outcomes of disputes related to construction variations, the model provides significant value to the industry by enabling the early identification of potential risks, thereby facilitating timely actions to prevent disputes from escalating. Moreover, parties can use the model to negotiate settlements before escalate to court, helping to minimise legal expenses and avoid delays. Zheng et al. (2021) investigate the primary causes of PPP disputes, analyse their outcomes, and predict litigation results using data from 171 PPP litigation cases obtained from Judgements in China. Their study reveals that an ensemble model combining Gradient Boosting Decision Tree (GBDT), k-Nearest Neighbor (KNN), and Multi-Layer Perceptron Neural Network (MLP) outperforms nine other individual machine learning models, achieving a prediction accuracy of 96.42%.

Un et al. (2024) develops a novel model that integrates project characteristics, root causes, and underlying causes to predict the outcomes of construction disputes. Using a dataset of arbitration cases from Türkiye, the model was evaluated with five different machine learning algorithms namely Logistic Regression, Support Vector Machines, Decision Trees, K-Nearest Neighbors, and Random Forest in a Python environment. Amongst, the Support Vector Machine algorithm achieved the highest prediction accuracy at 71.65%. Anysz, Apollo and Grzyl (2021) developed a machine learning model incorporating decision trees and artificial neural networks to predict dispute outcomes. The model aids in evaluating the appropriateness of pursuing litigation as a resolution method for disputes between general contractors and clients. Another study predicted the compensation of disputes in terms of; no compensation, cost, time, and both cost and time (Ayhan, Dikmen & Birgonul 2023). The authors emphasised using machine learning techniques to predict compensation outcomes in construction disputes based on past project data. The authors claim that this approach can provide decision support for new projects, enhancing understanding and potentially preventing prolonged disputes. In another study, Chaphalkar, Iyer and Patil (2015) investigated the feasibility of using neural network models to predict the outcomes of disputes related to construction variations. Their study found that the Multi-Layer Perceptron (MLP) network outperformed the General Feedforward (GFF) network in terms of prediction accuracy. The model predict the output of variation claims set to arbitration in terms of 'claim allowed', 'claim rejected' and 'claim partially allowed.

As depicted in Table 2, few studies (5 out of 19) predict the dispute propensity (Ayhan, Dikmen & Birgonul 2021; Chou et al. 2014; Chou & Lin 2013; Chou, Tsai & Lu 2013; Wang, P et al. 2022). Such studies proactively predict disputes and pave the way for dispute avoidance. Wang, P et al. (2022) focused on construction dispute avoidance, creating paired mechanistic and empirical models to assess the viability of pursuing a mechanistic understanding of construction disputes. The authors develop a model to predict propensity in terms of dispute index: 0-3 early warning, 4-10 warning, and above 10 emergency with an accuracy rate exceeding 95% under ideal conditions. Ayhan, Dikmen and Birgonul (2021) predict the occurrence of disputes by utilizing machine learning (ML) techniques on empirical data using the variables affecting dispute occurrence in terms of "Disputed" or "Undisputed". Chou et al. (2014) proposed an optimized hybrid artificial intelligence model for early prediction of dispute propensity in the initial phase of public-private partnership projects. This model integrates a fast messy genetic algorithm (fmGA) with a support vector machine (SVM), forming a hybrid approach referred to as GASVM (fmGA-based SVM). The purpose of this model is to offer proactive warning and decision-support information, aiding in the effective management of potential disputes. Chou, Tsai and Lu (2013) compared 20 different classifiers using both single and hybrid machine learning techniques to predict disputes. The findings revealed that hybrid models combining multiple classification techniques outperformed those using k-means and

DT. Notably, the hybrid model combining multiple MLP classifiers achieved a prediction accuracy of 97.08%, while the combination of multiple DT classifiers attained 95.77%, outperforming other hybrid approaches. Specifically, the combination with multiple MLP classifiers and multiple DT classifiers outperforms other hybrid models, achieving prediction accuracy of 97.08% and 95.77%, respectively. Chou and Lin (2013) utilised classification models to predict dispute propensity in PPP projects. Their study demonstrated the efficiency and effectiveness of data mining techniques for the early prediction of disputes in public infrastructure PPP projects. Experimental results showed that an ensemble approach combining SVMs, ANNs, and the C5.0 algorithm achieved the highest cross-fold prediction accuracy of 84.33%.

Few studies (4 out of 19) utilised AI technologies to predict the causes of disputes, proactively forecasting their occurrence. For example, Elelu et al. (2024) develop a comprehensive database of utility-related clauses in highway construction projects by applying unsupervised topic modeling with LDA and NLP techniques. Similarly, Ye et al. (2023) examined the causes of disputes in subcontracting practices by employing text mining and NLP methods to analyze 3,150 publicly available litigation cases in China. TF-IDF (Term Frequency-Inverse Document Frequency), and SVD (Singular Value Decomposition) used for preprocessing while K-Means ++ utilised for clustering analysis of data which identified a total of 37 causes of disputes. Jallan et al. (2019) automated the systematic exploration of construction-defect lawsuits in the public domain by utilising modern computational techniques, including NLP and text mining. The study conducted a comprehensive survey of legal cases over a decade, utilising LDA in the model to identify keyword frequencies in the cases and uncover important topics and themes for classifying the case data.

Furthermore, two research articles developed predictive models to determine the most suitable or possible dispute resolution methods. Ayhan, Dikmen and Birgonul (2022) compared the classification performances of various ML techniques to forecast dispute resolutions in construction projects. Consequently, Chou, Cheng and Wu (2013) compared the performance of various classification models that combined fuzzy logic, a fast and messy genetic algorithm, and SVMs to predict suitable dispute resolution methods in public-private partnership (PPP) projects. In addition, Mahfouz, Kandil and Davlyatov (2018) developed a robust methodology for automating the extraction of latent knowledge, specifically significant legal factors influencing verdicts in differing site condition litigations, from textual data. They applied several machine learning models, including Term Frequency (TF), Logarithmic Term Frequency (LTF), Augmented Term Frequency (ATF), Term Frequency Inverse Document Frequency (TF-IDF), Naïve Bayes, Decision Tree, and PART. Among these, the Naïve Bayes classifier achieved the highest prediction accuracy of 88%.

The aforementioned detailed the AI application in construction dispute management in terms AI model, algorithm, dataset, input and target variables, and accuracy. The previous models focused on predicting the outcome of litigation, possible dispute resolution method, dispute propensity, and dispute causes. In terms of AI technologies, the majority of studies utilised machine learning models compared to deep learning models and natural language processing. A new trend is emerging in dispute management, utilising AI technologies to analyse unstructured data from construction projects. This approach employs natural language processing models to extract features, learn from the data, and predict potential disputes from project documents. In terms of algorithms used, popular algorithms include Support Vector Machines, Decision Trees, Neural Networks, and more recent approaches like CNNs and Transformers. In terms of training and testing data, data sources vary from judgment documents to surveys. The accuracy of models generally fall between 80% and 98%. Thus, the systematic literature review demonstrated the potential effectiveness of AI in addressing construction disputes. AI technologies pave the way for proactively mitigating disputes in construction projects.

5. DISCUSSION

This study investigated AI applications in dispute management through a systematic literature review following the PRISMA flow diagram. It began with a scientometric analysis, which demonstrated the keyword co-occurrence network, citation country network, author co-citation network, and publication trends in terms of the number of publications and various journals. A similar study conducted by Kalogeraki and Antoniou (2024) investigated the current trends in novel technologies for claim management and dispute resolution in the construction industry. The authors conducted a systematic review following the PRISMA flow diagram, utilising the Scopus database. They also employed network analysis to examine country collaborations, keyword co-occurrence, publication sources, and author networks, presenting their findings using VOSviewer software.

The current study highlights a growing trend in the application of AI in dispute management, with its peak observed in 2024. Similarly, a study by Abioye et al. (2021) explored AI applications in the construction industry and identified a rising use of AI since 2020. Consistent with the findings of the present research, Kalogeraki and Antoniou (2024) also recognised the Journal of Legal Affairs and Dispute Resolution in Engineering and Construction as one of the most prominent scientific journals in this field.

The research explored AI applications in dispute management across various industries in general and conducted a deeper investigation into the construction industry. The e-commerce industry has demonstrated a significant utilisation of Online Dispute Resolution, incorporating AI technologies to support and accelerate decision-making. Additionally, a few studies in road traffic management have developed prediction models to estimate claims and predict traffic flow. This indicates that AI has been utilised in other industries for both dispute resolution and dispute avoidance. Subsequently, the review revealed that prediction models have been developed to forecast four different aspects: litigation outcomes, dispute propensity, dispute causes, and dispute resolution methods, paving the way for dispute resolution and proactive dispute management in the construction industry. In addition, the review found a growing trend in the adoption of natural language processing techniques, which utilise text-based data from construction projects to develop predictive models (Elelu et al. 2024; Jallan et al. 2019; Mahfouz, Kandil & Davlyatov 2018; Ye et al. 2023; Zhong et al. 2024). Moon, Chi and Im (2022) also opined that NLP has emerged as a key research area in the construction industry, given that construction projects produce a large volume of documentation.

This research contribution to knowledge in terms of the identification of the previous studies which utilise the various AI technologies in managing disputes in the construction industry. The study summarised the key AI technologies and a range of algorithms, providing a foundation for future research on developing AI models for dispute prediction. This can guide studies in determining whether to focus on dispute avoidance or resolution, selecting appropriate AI techniques and algorithms, identifying relevant training data, and defining the expected outcomes of the models. In terms of limitations, the study did not address the ethical use of AI. The ethical implications of AI and data security in developing predictive models for dispute management in the construction industry could be an important and timely area for future research.

6. CONCLUSION

Disputes are an accepted reality of construction projects, routinely arising and significantly affecting costs and scheduling (Zhong et al. 2024). Construction practitioners and academic researchers have investigated mechanisms to avoid beforehand or resolve disputes once materialised. Several dispute avoidance strategies and well-established dispute resolution methods are also practiced. Nevertheless, recent literature confirms that disputes critically affect construction projects, with repercussions extending beyond the projects themselves to impact project stakeholders and the national economy as a whole. Therefore, this study explored the potential of artificial intelligence and its various technologies to manage disputes effectively and thereby suggest artificial intelligence technology for proactive dispute prediction in construction projects.

A critical literature review was initially conducted, focusing on two major areas: disputes in the construction industry and Artificial Intelligence (AI). The review of construction industry disputes primarily described available dispute management mechanisms, while the AI technologies review identified various AI technologies, their features, and general machine learning methodologies. Subsequently, the research conducted a systematic literature review on AI applications in construction dispute management, following the PRISMA flow diagram, accompanied by a scientometric analysis. The study initially retrieved 329 articles from Scopus and Web of Science databases. After several screening processes, 19 articles were identified as relevant to AI applications in construction dispute management. These research studies fell into four categories based on the output feature of the developed model: litigation outcome, dispute propensity, dispute causes, and dispute resolution method. The majority of models utilised predictive machine learning classification, with ensemble models recording higher accuracy using categorical data. Most notably, in recent years, the use of natural language processing to predict disputes from unstructured data generated in construction projects has shown significant promise, paving the way for improved decision-making among stakeholders. This study demonstrates the potential of AI technologies in construction dispute management, particularly in developing an early warning system that predicts disputes in real time. Therefore, this study recommends that industry professionals adopt AI technologies to enable proactive and dispute management practices in construction projects. To academia, the study lays the foundation for understanding AI applications in terms of the AI technologies, algorithms used, and the types of data required to train the models, especially highlighting dispute avoidance and dispute resolution perspectives. This landscape identifies the research gap in this area, making it easier for researchers to identify further research opportunities. The research finally suggests that the regulatory bodies develop guidelines for the ethical use of AI for proactive dispute management in construction projects.

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