Systematic Literature Review for the Application of Artificial Intelligence to the Management of Construction Claims and Disputes

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Abstract: Claims and disputes are major causes of cost and schedule overruns in the construction business. In order to manage claims and disputes effectively, it is necessary to analyze various types of contract documents punctually and accurately. Since volume of such documents is so vast, analyzing them in a timely manner is practically very challenging. Recently developed approaches such as artificial intelligence (AI), machine learning algorithms, and natural language processing (NLP) have been applied to various topics in the field of construction contract and claim management. Based on the systematic literature review, this paper analyzed the goals, methodologies, and application results of such approaches. AI methods applied to construction contract management are classified into several categories. This study identified possibilities and limitations of the application of such approaches. This study contributes to providing the directions for how such approaches should be applied to contract management for future studies, which will eventually lead to more effective management of claims and disputes.

Keywords: Claim management, Construction Claim, Dispute, Artificial Intelligence Application, Systematic review

1. INTRODUCTION & BACKGROUND

Claims and disputes are major causes of cost and schedule overruns in the construction industry [1]–[3]. Arcadis (2021) reported that the global average excess losses in terms of cost and schedule are 54.3 million USD and about 13.4 months, respectively [4]. Due to the nature of the project-based process, claims are inevitable as complex contractual relationships are created in the construction industry [3], [5]. Thus, effective management of claims and disputes has been one important topic being studied ub various fields.

For the purpose of effective claim management, various management methods have been proposed. For example, Chong et al. (2011) proposed a way of analyzing contract documents and on-site documents in a timely manner [6]. Identificaiton of factors influencing claims is another research topic that has been investigated as well [7], [8]. In addition to the idenfitication, monitoring events potentially leading to claims is also an important topic for claim management [9]. In order to properly prevent and respond to potential claims and disputes when implementing projects, information must be accumulated systemically and continuously, and clear definitions of roles and

responsibilities for key tasks must be provided [10]. In this respect, establishment and systematization of management work processes have been investigated [11]. In addition to the effective claim prepararion managmenet, monitoring after the claim submission is another important issue for the successful claim management [12].

In addition to these attempts in project site and organizational approach, many research studies have been conducted to improve the claim and dispute management through contractual and legal approaches. For better decision making in the process of claim and dispute resolution, lessons learned from previous contracts and legal background are also required. To deal with legal and contractual issues, various legal approaches have also been taken in the construction industry [13]. Some examples include the contract analysis methods to identify toxic clauses and requirements based on previous arbitration or litigation cases [14], [15]. Various factors affecting the legal decision output in the dispute resolution process by project claim are also investigated in various ways [16], [17].

Recently, AI approaches have been applied in various aspects in the construction claim management area. AI application for better work efficiency is one example [18], [19]. One main characteristic of construction projects is that massive amounts of information are exchanged [20]. Therefore, application of AI can be a natural trend. As one of the various application cases, Marzouk and Enaba (2019) conducted a study to visualize the construction contract document by matching it with the existing building information modeling (BIM) model [9]. Yoon (2020) investigated the efficiency of the construction claim by comparing the construction claim cost with the earned profit through case analysis [21]. Also, in terms of contracts, application of NLP for contract and legal texts has been also actively carried out [22]. In addition, research studies to explore the elements of disputes in the field and to predict the occurrence of potential disputes have been also actively carried out [23], [24]. Although several studies have been conducted on the application of AI to project document and contract analysis in the construction industry, there have been few stuties that the outcomes are applied in real world ir outcomes have not yet been applied in real-world [25].

Considering the current body of knowledge in the field of AI application to the claim management, it is necessary to examine the current status and trends of the goals, methodologies, and application results of the AI approaches in detail. In this study, AI applied research studies are defined as follows. According to John McCarthy, father of the concept of "artificial intelligence", AI is defined as "the computational component of the ability to achieve goals" [26]. In line with this, this study covered previous research studies that performed information analyses for various purposes such as decision support, target document analysis, and strengthening of the existing web-based system. This study systematically analyzed the AI applied research studies for contract, claim and dispute management. According to Kitchenham and Charters (2007), systematic literature review (SLR) is a means of evaluating and interpreting all available research relevant to a particular research question, topic area, or phenomenon of interest [27]. Through this process, this study tries to identify the limitations of AI in the field of construction claims and suggest directions for future applications. Under the background and purpose of this study, the following research questions are established.

- Research Question 1. What are the trends in AI technology applied in the claim management?
- Research Question 2. What are the future directions for AI research in the claim management?

2. RESEARCH METHODOLOGY

The purpose of this study is to identify the overall research status, limitations, and performance of applying AI to the claim management for better construction claim management. The overall research flow from defining the research questions to data analysis is illustrated in Figure 1. In this paper, we conducted a systematic literature review (SLR) for reasoning a conclusion proposed by Kitchenham and Charters (2007). According to this guidance, we set the research questions first and collected data as per the research objective. Based on the previous literature data, we examined and analyzed the research trends in the field of claim management with AI. In order to analyze the data, both qualitative and quantitative analyses were used. First, before performing qualitative analysis, we briefly identified the trends in prior data through bibliometric keyword analysis. With reference to the result, outline of the AI application field was analyzed by establishing a standard for data classification and mapping (organizing) data accordingly.

This paper involves a literature review of the academic articles that focus on the utilization of AI in the claim management. For this analysis, research papers were collected based on the keywords from databases of Scopus, Web of Science and Google Scholar. The detail procedure for data collection is as follows.
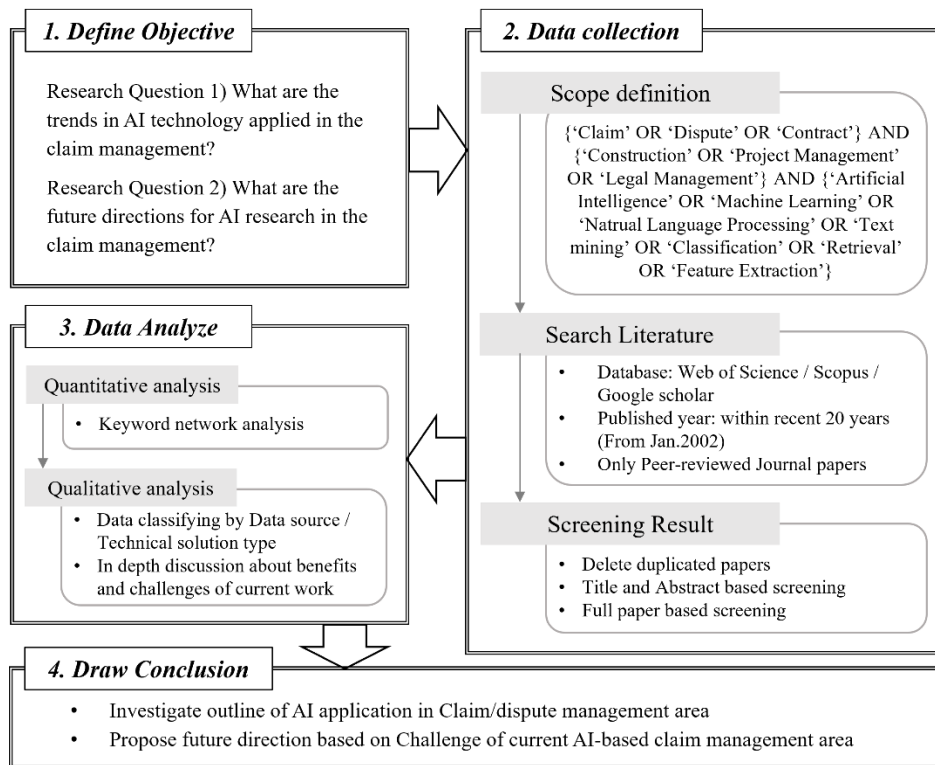

Figure 1. Research Procedure flow map

First, in order to designate the keywords for data collection, scope was classified into three dimensions: management area, academic area, and AI application. For the management area, three keywords, claim, dispute, and contract, were used. For the academic area, three keywords including construction, project management, and legal management were used. This academic field was established to cover both claims and disputes based on project-related contracts by expanding the field of contract claim management research to the construction industry. For the keywords related to AI application, technology related queries such as AI, Machine Learning (ML), NLP, Text Mining (TM), Classification, Retrieval, and Feature extraction were used. The search string for finding relevant studies was constructed by joining these terms from three dimensions.

Through this process, a total of 272 related papers published over the past 20 years were collected, and a total of 147 papers were organized by arranging overlapping data in each database. In the third step, the screening of the collected articles was carried out. During this step, only peer-reviewed journal papers have been filtered. After that, articles more closely related the topic of our research study were chosen by reviewing each paper.

Table 1 shows the distribution of papers by publication source and year. As shown in the table, various jounals published the papers about the AI application to the claim management in the construction industry. The right side of the table shows the longitudinal trend. During the first 10 years from 2003, there were relatively few papers that met the keyword search criteria (less than 4 articles per year). However, it showed an increasing trend between 2018 and 2021. In particular, a total of 17 papers were discovered in 2021. This trend indicates that more researchers are interested in implementing AI to the claim management.

Although many researchers have investigated the application of AI to the contract based claim management area, the current body of knowledge lacks the cases that AI is actually implemented to the claim management. This study performed analyses to find the reasons for this lack and proposed the direction for future application. The following sections provide detailed critical analyses of prior studies found in this state-of-the-art review.

Table 1. Distribution of papers based on publication source and published year

Journal Title	Count	Published Year	Count
Automation in Construction	14	2003-2006	2
Journal of Legal Affairs and Dispute Resolution in Engineering and Construction	10	2007	2
		2008	1
Journal of Computing in Civil Engineering	5	2009	2
Journal of Construction Engineering and Management	5	2010	2
		2011	1
Expert systems with Applications	3	2012	1
International Journal of Project Management	3	2013	4
Journal of Civil Engineering and Management	2	2014	2
		2015	2
Korean Journal of Construction Engineering and Management	2	2016	4
		2017	3
Sustainability	2	2018	5
Other Journals -related PM	10	2019	6
Other Journals -related Computing	4	2020	8
Other Journals -related legal Informatics	2	2021	17
Total	62	Total	62

3. SYSTEMATIC LITERATURE REVIEW ANALYSIS

In order to clearly understand the structure of literature data, keyword network analysis was performed to observe the approximate topic and keyword relationship status. This keyword network analysis was analyzed based on the quantitative data on the co-occurrence frequency and trend of keywords. The results are shown in Figure 2.
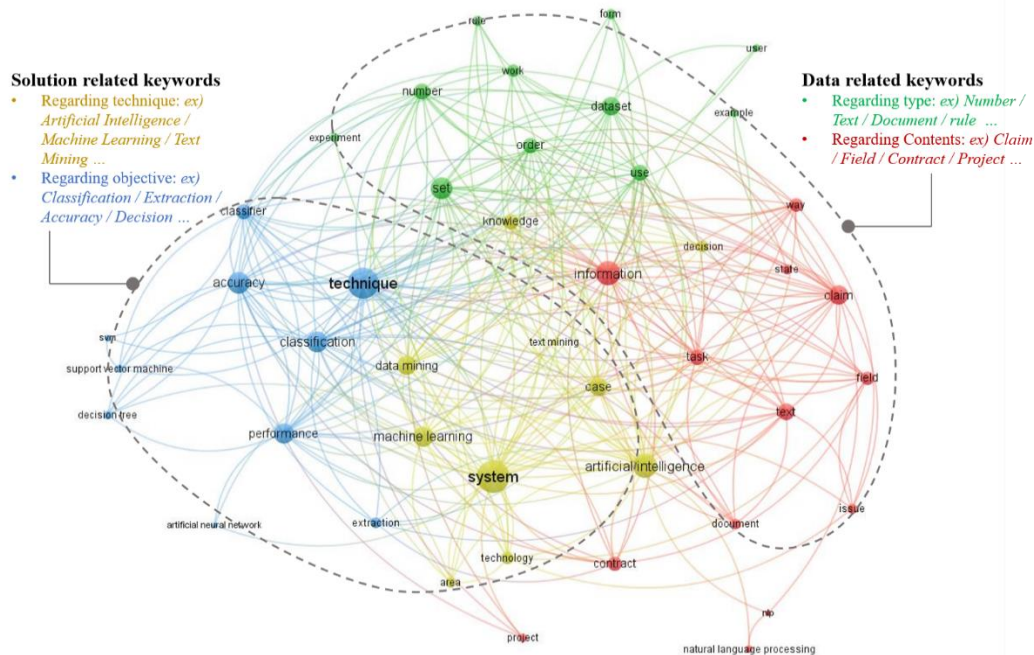
Figure 2. Data keyword network (minimum occurrence: 10)

The co-occurrence network in Figure 2 was created by using a Bibliometric analysis tool, VOS viewer. As shown in the figure, keywords can be classified into two categories: data-related and solution-related. With this result, the current research status would be reviewed by the classification in terms of data source type and solution type. Through the qualitative discussion regarding this data classification analysis, the benefits and challenges of previous research studies will be summarized and a future research direction will be suggested.

Classification analysis by data source

Table 2 shows the result of paper review by data source type. The data source most commonly used in the claim management research was the case data for judgement related to disputes through resolution process such as arbitration or litiagation. It is probably because of the fact that this type of data is publicly available. The second frequently used data type was the project progress data. In this case, numeric data such as project schedule or cost and field document data were used. However, most of the studies using this type of data reported that the restricted data scope is one limitation. Since it is difficult to collect the integrated data from multiple companies, those studies discussed that the inferred research results are not yet suitable for general application. This also infers that the biggest challenge of the studies investigating claims is to secure data properly as data related to claims are generally private and confidential. Except the previous research that was based on the literature review, the least common sources of data were claim documents such as transaction letters and substantiated documents. For such studies, data limitations were also often mentioned [23], [28], [29].

Table 2. Classification by data source

Data source	Description	Reference
Contract documents	Contract conditions, Bidding documents,	Agrawal et al. 2021; Al-Qady and Kandil 2010; Assaad et al. 2020; Hamie and Abdul-Malak 2018; Hassan and Le 2020; Iyer et al. 2008; Lee et al. 2019; Lee et al. 2020; Marzouk and Enaba 2019;

Data source	Description	Reference
	Specification, Regulatory codes, etc.	Niu and Issa 2015; Son and Lee 2019; Zhang and El-gohany 2016; Zou et al. 2017
Project progress data	Numeric progress data(Schedule, Cost), Field Records	Abdel-Khalek et al. 2019; Al-Qady and Kandil 2014; Bektas et al. 2021; Caldas and Soibelman 2003; li et al. 2021; Nedeljković and Kovačević 2017; Pradeep et al. 2021; Shahhosseini and Hajarolasvadi 2021; Sharafi et al. 2018; sharafi et al. 2021; Sheng et al. 2020; Wang et al. 2018; Yousefi et al. 2016; Zhang and El-gohany 2017
Claim document	Transaction letters, Substantiation documents, etc.	Ahn et al. 2020; Al-Qady and Kandil 2013; Ayhan et al. 2021; Chaphalkar and Patil 2012; Chau 2007; Cheng et al. 2009; Chou et al. 2013; Chou et al. 2014; Chou et al. 2016; Jalal Moharreri 2020; Parikh et al. 2019; Zhang et al. 2021;
Historical legal case	Dispute arbitration awards, Court litigation cases	Arditi and Pulket 2005; Arditi and Pulket 2010; Bagherian-Marandi et al. 2021; Chan et al. 2021; Chaphalkar et al. 2015; Chen and Hsu 2007; Fan and Li 2013; Iyer et al. 2018; Jallan et al 2019; Jang and Kim 2021; Lee et al. 2021; Mahfouz et al. 2016; Pulket and Arditi 2009; Saygili et al. 2021; Zheng et al. 2021
Previous research	Academic publication	Ali et al. 2020; Çevikbaş and Işık 2021; Hassan et al. 2021; Marzouk et al. 2011; Mohammed et al. 2021

Classification analysis by solution type

Table 3 summarizes the result of paper review by purpose of solution. The table also shows the expected performance improvement. The purpose of solution was divided into three categories: identification of contract documents, improvement of project claim management, and dispute resolution management. Under each major category, expected effects were classified into three sub-categories.

Table 3. Classification by Purpose of solution

Purpose	Expected effect	Reference
Identification of contract documents	Project risk identification	Ahn et al. 2020; Ayhan et al. 2021; Chan et al. 2021; Chou et al. 2016; Lee et al. 2019; Lee et al. 2020; Parikh et al. 2019; Son and Lee 2019; Yousefi et al. 2016; Jang and Kim 2021
	Extraction of important clauses in the contract documents	Agrawal et al. 2021; Lee et al. 2021; Marzouk and Enaba 2019; Nedeljković and Kovačević 2017; Niu and Issa 2015; Zhang and El-gohany 2016; Zhang and El-gohany 2017

Purpose	Expected effect	Reference
Improvement of project claim management	Ease of contract scope review	Al-Qady and Kandil 2010; Assaad et al. 2020; Hamie and Abdul-Malak 2018; Hassan and Le 2020; Saseendran et al. 2020
	Establishment of information schema	Caldas and Soibelman 2003; Çevikbaş and Işık 2021; Cheung and Pang 2013; Hassan et al. 2021; Iyer et al. 2008
	Improvement of existing management systems	Abdel-Khalek et al. 2019; Ali et al. 2020; li et al. 2021; Pradeep et al. 2021; Saygili et al. 2021; Shahhosseini and Hajarolasvadi 2021; Wang et al. 2018
	Work process improvement	Al-Qady and Kandil 2013; Barakat et al. 2018; Chaphalkar and Patil 2012; Marzouk et al. 2011; Mohammed et al. 2021
Dispute resolution management	Organizing decision-influencing factors	Chaphalkar et al. 2015; Chen and Hsu 2007;-Iyer et al. 2018; Jallan et al 2019; Mahfouz et al. 2016; Zhang et al. 2021
	Prediction of arbitration/litigation outcome	Arditi and Pulket 2005; Arditi and Pulket 2010; Bektas et al. 2021; Chau 2007; Chou et al. 2013; Pulket and Arditi 2009; Sharafi et al. 2018; sharafi et al. 2021; Zheng et al. 2021
	Dispute avoidance decision support	Bagherian-Marandi et al. 2021; Cheng et al. 2009; Chou et al. 2014; Fan and Li 2013; Jalal Moharreri 2020; Sheng et al. 2020; Zou et al. 2017

In the identification of contract documents category, there were three expected effect types. The project risk identification includes the studies analyzing the causes of claims to explore the most potential causal factors of claims. Extraction of important clauses in the contract documents includes the studies automatically deriving major clauses or requirements on the contract or bidding documents. Ease of contract scope review includes the studies that summarize the contract scope and facilitate the contract review process for project execution.

The second major category is the improvement of project claim management, and this category is also divided into three sub-categories as per each expected effect. The extablishment of information schema contains the studies organizing the classification or hierarchical system to systematize the claim management information. The second sub-category is an application study that links claim management to the information systems such as BIM and project management information system. Lastly, a number of work process simulation studies were conducted to improve the claim management process.

The final purpose category, dispute resolution management, includes applications to the dispute resolution process from the submission of a claim to the resolution process within a project. This category was classified into sub-categories such as organizing decision-influencing factors, prediction of arbitration/litigation outcome, and dispute avoidance decision support through automatic prediction of whether a dispute will occur. Several pilot tools have been developed to crawl case data and facilitate content analysis.

4. DISCUSSION

This paper presents a review of 62 AI-applied claim management papers published over the past 20 years. Focusing on the data source, applied solution, expected performance, and limitation of the papers, a systematic review analysis was performed in this study. Specifically, keywords and main topics were extracted from the papers collected by the quantitative analysis with bibliometric software. After that, qualitative analysis was performed to review the trends of research studies investigating claims and disputes that applied the AI.

For the first research question, this study conducted the keyword network analysis. Through this quantification process, it was found that data source type and purpose of solutions can be used as the main criteria for classifying and examining the major trend of research.

In terms of data source, most studies used public data such as arbitration/litigation precedents. Most of these studies used the award case data from publicly opened legal platform. However, for the studies such as case law or contract analysis, it was found that a model with high performance can be designed only when the knowledge of the legal domain and the construction-based domain are properly fused. Meanwhile, there were some studies using the project claim documents or field documents. These studies mentioned that generalizability is one limitation because data being used were from a project or projects from one company. This tendency is probably due to the private nature of claim management data for each company or project. To overcome this limitation, AI application research should use integrated data.

In terms of the purpose type, studies were classified into identification of contract documents, improvement of project claim management, and dispute resolution management. The most common limitation observed in these studies is that there were very few studies where the outcome of the study is applied and empirically verified in the real field. There can be two possible reasons for this limitation: existing domain knowledge of the construction industry was not properly reflected in applying the existing AI system algorithm or data for developing and verifying the outcome was insufficient.

Accordingly, based on the review of previous studies, future research areas can be proposed as follows. First, in the field of AI applied claim management, there are not many empirical applications based on integrated data in general. Two presumable reasons for this are the lack of data or segregated data. For the lack of data, it means that information is not available or not collected properly. For this case, research studies about record keeping and improvement of work process for collecting information are recommended. For the segregated data, this may be related to the fact that information from multiple companies are not integrated to each other due to the privacy. For this case, studies that try to develop an integrated information platform can be recommended.

The main contribution of this study is that the trends of the AI applied studies for claim management were systematically examined and the limitations and knowledge gaps from these studies were summarized. This study also expands the scope of the review including the project management and legal areas as well as construction domain. These can contribute to developing a extensive knowledge system for claim management. These research results also can be helpful for resaerchers when designing studies applying the AI in claim management in the future.

ACKNOWLEGEMENTS

REFERENCES

[1]   P. Love, P. Davis, J. Ellis, and S. O. Cheung, "Dispute causation: Identification of pathogenic influences in construction," *Engineering, Construction and Architectural Management*, vol. 17, no. 4, pp. 404–423, 2010.

[2]   P. I. Cakmak and E. Cakmak, "An Analysis of Causes of Disputes in the Construction Industry Using Analytical Hierarchy Process (AHP)," in *Aei 2013*, 2013, pp. 94–102.

[3]   V. Yousefi, S. H. Yakhchali, M. Khanzadi, E. Mehrabanfar, and J. Šaparauskas, "Proposing a neural network model to predict time and cost claims in construction projects," *Journal of Civil Engineering and Management*, vol. 22, no. 7, pp. 967–978, 2016.

[4]   Arcadis, "2021 Global construction disputes report," *Arcadis Annual report*, 2021. [Online]. Available: https://www.arcadis.com/en-gb/knowledge-hub/perspectives/global/global-construction-disputes-report. [Accessed: 18-Jan-2022].

[5]   S. O. Cheung, T. W. Yiu, and S. F. Yeung, "A Study of Styles and Outcomes in Construction Dispute Negotiation," *Journal of Construction Engineering and Management*, vol. 132, no. 8, pp. 805–814, 2006.

[6]   H. Y. Chong, B. Balamuralithara, and S. C. Chong, "Construction contract administration in Malaysia using DFD: A conceptual model," *Industrial Management and Data Systems*, vol. 111, no. 9, pp. 1449–1464, 2011.

[7]   A. Enshassi, R. M. Choudhry, and S. El-ghandour, "Contractors' perception towards causes of claims in construction projects," *International Journal of Construction Management*, vol. 9, no. 1, pp. 79–92, 2009.

[8]   P. E. D. Love, P. R. Davis, S. O. Cheung, and Z. Irani, "Causal discovery and inference of project disputes," *IEEE Transactions on Engineering Management*, vol. 58, no. 3, pp. 400–411, 2011.

[9]   M. Marzouk and M. Enaba, "Text analytics to analyze and monitor construction project contract and correspondence," *Automation in Construction*, vol. 98, no. November 2018, pp. 265–274, 2019.

[10]   H. Wang, J. Park, and J. Choi, "Developing a Project Management Information System for Construction Claims," *Korean journal of construction engineering and management*, vol. 19, no. 4, pp. 70–81, 2018.

[11]   M. A. U. Abdul-Malak, M. M. H. El-Saadi, and M. G. Abou-Zeid, "Process Model for Administrating Construction Claims," *Journal of Management in Engineering*, vol. 18, no. 2, pp. 84–94, 2002.

[12]   M. Barakat, H. Khoury, and M. A. Abdul-Malak, "Evaluation of simulation techniques for modeling progression of construction claims," *Proceedings of International Structural Engineering and Construction*, vol. 5, no. 1, pp. 1–6, 2018.

[13]   J. Niu and R. R. A. Issa, "Developing taxonomy for the domain ontology of construction contractual semantics: A case study on the AIA A201 document," *Advanced Engineering Informatics*, vol. 29, no. 3, pp. 472–482, 2015.

[14]   M. Al Qady and A. Kandil, "Document Discourse for Managing Construction Project Documents," *Journal of Computing in Civil Engineering*, vol. 27, no. 5, pp. 466–475, 2013.

[15]   J. Lee, Y. Ham, and J. S. Yi, "Construction disputes and associated contractual knowledge discovery using unstructured text-heavy data: Legal cases in the United Kingdom," *Sustainability (Switzerland)*, vol. 13, no. 16, 2021.

[16] T. Mahfouz, S. Davlyatov, and A. Kandil, "Analysis of Differing Site Condition (DSC) Litigation Reasoning Through Statistical Modeling," *International Journal of Construction Education and Research*, vol. 12, no. 4, pp. 285–302, 2016.

[17] K. C. Iyer, N. B. Chaphalkar, and S. K. Patil, "Intrinsic Factors Influencing Decision making of Arbitrators in Dispute Resolution of variation Claims," *Journal of The Institution of Engineers (India): Series A*, vol. 99, no. 2, pp. 287–293, 2018.

[18] R. Y. M. Li, H. C. Y. Li, B. Tang, and W. C. Au, "Fast AI classification for analyzing construction accidents claims," in *Proceedings of the 2020 Artificial Intelligence and Complex Systems(AICS) Conference*, 2020, pp. 1–4.

[19] N. Bagherian-Marandi, M. Ravanshadnia, and M. R. Akbarzadeh-T, *Two-layered fuzzy logic-based model for predicting court decisions in construction contract disputes*, vol. 29, no. 4. Springer Netherlands, 2021.

[20] B. G. McCulloueh and P. Gunn, "Construction field data acquisition iwth pen-based computers," *Journal of Construction Engineering and Management*, vol. 119, no. 2, pp. 374–384, 1993.

[21] J. S. Yoon, "A Study of Efficiency of Construction Claim cost," *Korea Real Estate Academy Review 81*, vol. 21, no. 146, pp. 76–86, 2020.

[22] F. ul Hassan, T. Le, and X. Lv, "Addressing Legal and Contractual Matters in Construction Using Natural Language Processing: A Critical Review," *Journal of Construction Engineering and Management*, vol. 147, no. 9, p. 03121004, 2021.

[23] M. Ayhan, I. Dikmen, and M. Talat Birgonul, "Predicting the Occurrence of Construction Disputes Using Machine Learning Techniques," *Journal of Construction Engineering and Management*, vol. 147, no. 4, p. 04021022, 2021.

[24] S. R. Jang and H. S. Kim, "A Study on the Development of Construction Dispute Predictive Analytics Model - Based on Decision Tree," *Korean Journal of Construction Engineering and Management*, vol. 22, no. 6, pp. 76–86, 2021.

[25] J. Mason, "Intelligent Contracts and the Construction Industry," *Journal of Legal Affairs and Dispute Resolution in Engineering and Construction*, vol. 9, no. 3, p. 04517012, 2017.

[26] E. P. Ermakova and E. E. Frolova, *Using Artificial Intelligence in Dispute Resolution*, vol. 254. Springer Singapore, 2022.

[27] B. Kitchenham and S. Charters, "Guidelines for performing Systematic Literature Reviews in Software Engineering," Durham, UK, 2007.

[28] D. Parikh, G. J. Joshi, and D. A. Patel, "Development of Prediction Models for Claim Cause Analyses in Highway Projects," *Journal of Legal Affairs and Dispute Resolution in Engineering and Construction*, vol. 11, no. 4, p. 04519018, 2019.

[29] J. Zhang, T. Wang, and L. Zhang, "Legal Risk Assessment Framework for International PPP Projects Based on Metanetwork," *Journal of Construction Engineering and Management*, vol. 147, no. 8, p. 04021090, 2021.