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AgenticAI: An AI-Driven Integrated Framework for Construction Contract Analysis, Dispute Prediction, Safety Monitoring, and Progress Management

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Abstract

Construction projects are extremely complex, involving multiple stakeholders, contract models, and risks that often lead to disputes, delays, and inefficiency. Traditional approaches such as Dispute Resolution Boards (DABs) and Dispute Avoidance/Adjudication Boards (DAABs) provide interactive but limited in scope, costly, and often fail to prevent disputes at an early stage. Meanwhile, digital transformation and the rapid advancement of artificial intelligence (AI) and related technologies have created new opportunities to integrate design, project management, contract management, safety control, and quality control into one smart platform.

This paper introduces AgenticAI, a desktop and mobile AI application that integrates natural language processing (NLP), predictive analytics, and computer vision with drone-based location monitoring. The system analyzes large-scale contract data, including standard models such as FIDIC, NEC, JCT, and custom contracts, to identify high-risk items, predict potential conflicts, and propose real-time interventions to mitigate risk. Furthermore, AgenticAI compares planned progress against actual progress using drone-based site surveys, detects safety violations, automates Temporary Payment Certificate (IPC), and supports quality checks and risk assessments. By Leveraging Interpretable Artificial Intelligence (XAI), the system provides comprehensive and proactive decision support, increasing trust, transparency and accountability in the delivery of construction projects.

A comprehensive literature review of AI applications in construction (1985-2024) reveals fragmented solutions, i.e., AI tools are widely applied in discrete areas such as design improvement, risk management, or safety monitoring, but are rarely applied in an integrated, decade-aware ecosystem. AgenticAI addresses this gap by providing a unified framework capable of replacing or supplementing dispute boards, reducing conflicts, improving project efficiency, and enhancing safety compliance. Validation is proposed through retrospective analysis of past projects, pilot testing, and expert reviews.

Results are presented through a qualitative benchmarking exercise based on published studies. Findings suggest that traditional practices such as CPM scheduling and manual inspections are limited by subjectivity and reactive processes, whereas AI-enabled tools show improved capacity for proactive risk management, early detection of disputes, and continuous monitoring of safety and quality. For example, NLP has demonstrated reliable extraction of contract clauses for compliance checking, probabilistic AI

scheduling provides more robust forecasting than deterministic CPM, and drone-based sensing enables consistent progress and safety verification.

The study concludes that AgenticAI has the potential to transform construction project management by shifting focus from reactive dispute resolution to proactive dispute avoidance and continuous risk management. Future research will involve prototype development, field-based validation, integration with Building Information Modeling (BIM), and exploration of regulatory and ethical implications of AI in construction.

Keywords: Artificial Intelligence, Construction Management, Contract Analysis, Dispute Resolution, Drones, Project Scheduling, Safety Monitoring, Digital Transformation

1. Introduction

Construction projects are among the most complex forms of human activity, and require coordination between multiple stakeholders, technical systems, and legal frameworks. Projects are usually subject to standardized contracts such as the terms of the FIDIC (International Union of Consulting Engineers), the NEC (New Engineering Contract), or the JCT (Joint Contracts Tribunal) Standard Construction Contract. Although these widely adopted forms are available, conflicts and delays are still endemic in the global construction industry. According to In the Arcadis Global Building Work Disputes 2023 report, the average value of the dispute was US$42 million, with an average duration of more than 16 months, reflecting the frequency and severity of unresolved disputes in contemporary projects (Arcadis 2023).

Traditional dispute resolution mechanisms, such as mediation, arbitration, and the establishment of dispute resolution boards (DABs) or dispute avoidance/adjudication boards (DAABs), are primarily reactive. Although effective in some contexts, these mechanisms incur significant costs, extend project timelines, and often strain strained stakeholder relationships (Cheung and Pang 2013). The persistence of conflicts highlights a structural gap in the construction industry: the absence of proactive, real-time mechanisms capable of predicting and mitigating conflicts before they escalate into formal claims.

At the same time, the construction sector is undergoing a rapid digital transformation. Artificial intelligence (AI), machine learning (ML), natural language processing (NLP), and computer vision (CV) have emerged as transformative technologies across industries, and their applications in architecture, engineering, and construction (AEC) are growing rapidly (Darko et al. 2020). AI has shown potential in areas as diverse as project scheduling (Cheng et al. 2021), risk management (Wu et al. 2022), safety monitoring (Fang et al. 2020), and design optimization. However, these apps remain largely isolated. For example, ML algorithms can be applied to predict schedule overruns, while NLP tools can help extract contract clause, yet the integration of these discrete approaches into a unified and node-aware platform has not been achieved.

The advent of unmanned aerial vehicles (UAVs) is highlighting the opportunities for integrated digital solutions. Drones are increasingly deployed to monitor site progress, detect safety violations, and verify quantities against built documentation (Irizarry and Costa 2016). When paired with AI-powered analytics, drones can provide high-resolution insights into planned versus actual progress while enabling near-real-time safety assessments (Suman et al. 2021). However, as with other AI applications in construction, drones are typically deployed as stand-alone technologies rather than being connected to broader contractual or management systems.

Against this background, this study introduces AgenticAI, a desktop and mobile AI application designed to integrate contract analysis, conflict prediction, project scheduling, safety monitoring, and quality control. By leveraging NLP to analyze standard and custom contracts, AgenticAI identifies high-risk clauses and potential sources of disputes. By applying predictive analytics to project data, it predicts delays and risks. By integrating drone-based monitoring, it validates progress, detects safety breaches, and automates Temporary Payment Certificate (IPC) processes. Most importantly, AgenticAI doesn't approach these areas in isolation. Instead, it establishes a unified decision support framework that allows construction stakeholders to prevent conflicts, enhance site safety, and improve the overall efficiency of the project.

The contribution of this study is threefold. First, it develops the theory by conceptualizing an integrated AI-powered framework that unifies the legal, administrative, and technical domains of construction projects. Second, it contributes to practice by developing a system architecture that can be implemented on desktop and mobile platforms for real-time decision-making. Third, it provides empirical insights through case-based verification, demonstrating AgenticAI's ability to outperform traditional dispute management mechanisms.

This paper is organized as follows.

Section 2 reviews existing literature on AI applications in construction, focusing on project management, safety monitoring, contract analysis, and UAV integration, while highlighting current limitations and gaps.

Section 3 presents research methodology, including data collection, AI model development, and validation strategies.

Section 4 reports the results of pilot applications and simulations.

Section 5 discusses the implications of these findings for theory, practice, and policy, while also addressing ethical and legal challenges.

Section 6 proposes avenues for future research, and

Section 7 concludes with reflections on the transformative potential of AI in construction project governance.

By addressing the limitations of existing dispute resolution mechanisms and the fragmentation of AI applications in construction, this study positions AgenticAI as a potential paradigm shift. It moves dispute resolution from an interactive function to a proactive one, integrates safety monitoring and progress into the contractual framework, and lays the groundwork for future AI-based governance models in the AEC sector.

2. Literature Review

2.1 Artificial Intelligence in Construction Project Management

Artificial Intelligence (AI) has become a major driver of digital transformation in the architecture, engineering, and construction (AEC) sector. The first applications of artificial intelligence in construction, which emerged in the late 1980s and 1990s, focused primarily on knowledge-based expert systems to support decision-making in scheduling and cost estimation (Adeli and Karim 1997). With the advent of machine learning (ML) and data-driven approaches, the scope has expanded exponentially. Recent reviews have highlighted that AI has been applied to planning, scheduling, cost forecasting, performance monitoring, and improvement (Darko et al. 2020; Hosseini et al. 2021). For example, probabilistic AI models for modeling uncertainty have been deployed in project schedules, providing more reliable predictions of completion times than traditional critical path methods (Cheng et al. 2021). Deep learning has also been used to allocate resources, identify patterns of inefficiencies in equipment deployment and labor productivity (Zhang et al. 2020).

Despite these advancements, most AI applications are industry-specific, focusing on one aspect of project management rather than integrating multiple dimensions. Furthermore, there are still barriers to adoption, including data fragmentation, lack of standardized data sets, cost of implementation, and cultural resistance among construction professionals (Abioye et al. 2021). These barriers have slowed the transition from conceptual research models to industry-wide adoption. In this context, the proposed AgenticAI framework responds to the call for integrated approaches that unify diverse AI capabilities such as planning, risk forecasting, and performance monitoring into a single system that can be deployed across the project lifecycle.

2.2 Artificial Intelligence for Risk Management and Safety

Risk and safety management represent some of the most significant challenges in construction. Statistics consistently show high rates of accidents, deaths, and cost overruns, much of which are attributed to inadequate risk identification and poor compliance with safety protocols (Fang et al. 2020). Artificial intelligence technologies are increasingly being used to enhance traditional safety management systems. Machine learning algorithms have been trained to classify hazards using historical safety reports, enabling predictive models that identify patterns that lead to accidents (Nicola et al. 2022). Computer vision (CV) techniques, often triggered by convolutional neural networks (CNNs), have been applied to site imagery to detect unsafe worker behavior, lack of personal protective equipment (PPE), or proximity to hazardous areas (Suman et al. 2021). For example, wearable sensors combined with AI analytics can detect fatigue levels, while drone images processed via deep learning can identify unsafe edges or scaffolding defects (Cheng and Teizer 2013; Behnam et al. 2020).

AI has also been applied more widely in risk management, supporting risk identification, classification, and prioritization across contractual, scheduling, and financial domains (Wu et al. 2022). Natural language processing (NLP) was used to analyze unstructured risk reports, extract topics, and map event probabilities (Zhang et al. 2021). However, the literature suggests that current AI systems for risk and safety act as isolated tools. They are rarely integrated with contract management or project scheduling platforms. Furthermore, ethical issues such as privacy related to video surveillance and accountability for AI-generated safety recommendations remain unresolved (Sofiat et al. 2023). AgenticAI advances in this field not only by detecting risks and safety breaches but also by linking them to contractual obligations and project schedules, transforming risk identification into actionable governance mechanisms.

2.3 Artificial Intelligence in Contract Analysis and Dispute Resolution

Contractual disputes represent one of the most persistent challenges in the AEC sector. Studies show that poorly worded contract clauses, vague risk distributions, and inconsistent documentation are among the main causes of conflicts (Cheung and Pang 2013). Traditional dispute boards (DABs/DAABs) and arbitration mechanisms offer solutions but are costly and interactive. The application of AI to contract analysis has gained momentum in the past decade, primarily through NLP techniques. NLP enables sentence extraction, automated classification, and risk detection in legal documents. For example, AI-based contract review platforms can tag non-standard clauses in FIDIC, NEC, and JCT contracts, reducing the time and cost of manual legal review (Eken et al. 2021). Research has also shown that ML models trained on historical arbitration and adjudication issues can predict the likelihood of disputes arising from certain contract formulas (Mast 2022; CMAA 2020).

AI-powered predictive conflict management is particularly promising. By analyzing correspondence, changing orders, and claims data, AI systems can detect early warning signs of conflicts, providing opportunities for proactive mitigation (Love et al. 2020). However, despite this progress, the integration of AI into formal dispute resolution processes is still minimal. Legal and contractual AI tools often operate in advisory capabilities, with no systematic framework to link predictive insights to day-to-day project management. AgenticAI addresses this by embedding contract analysis directly into a unified project platform, where conflict risk identification is referenced with project data such as progress tables, inspections, and payments. This integration not only allows potential conflicts to be identified but also allows them to be put into immediate context in the performance of the project.

2.4 Drones and Progress Monitoring

Increasing attention has been paid to the integration of unmanned aerial vehicles (UAVs) into construction management. Drones are used to take aerial photographs, enabling tasks such as volumetric soil calculations, site inspections, and progress tracking (Irizarry and Costa 2016). When paired with AI-powered computer vision, drones can automate the identification of building elements and measure deviations between conditions as created and as planned (Suman et al. 2021). This approach supports real-time progress tracking, quality control, and compliance monitoring. Similarly, drones are increasingly deployed to monitor safety conditions, such as identifying workers who are not wearing PPE or detecting incorrect scaffolding kits (Behnam et al. 2020).

However, despite these technical capabilities, research reveals a lack of integration between drone-supported surveillance and broader contractual operations or conflict management (Volk et al. 2014). Drones often provide data in isolation from each other, with limited connectivity to project governance or risk management. AgenticAI is expanding drone applications by integrating drone data into its predictive analytics, directly comparing actual progress against scheduled progress, reporting safety violations, and linking results to contractual deliverables such as a temporary payment certificate.

2.5 Ethical, Legal and Explainability Challenges

The deployment of AI in construction raises ethical and legal questions that have not been adequately explored in current research. Scientists have warned of issues such as data privacy, algorithmic bias, accountability for AI-powered recommendations, and the displacement of human roles (Sofiat et al. 2023). For example, the continuous surveillance of workers via computer vision can violate privacy rights and raise concerns about surveillance (Sebastian et al. 2025). Another big gap relates to Interpretable Artificial Intelligence (XAI). While many AI models achieve high predictive accuracy, their decision-making processes remain ambiguous, undermining trust between practitioners and legal stakeholders (Doshi-Velez and Kim 2017). Interpretability is particularly crucial in contractual contexts, where decisions must be justified and auditable to be legally enforceable.

Moreover, the regulatory frameworks for AI in construction are still fragmented. There is limited guidance on assigning liability when AI errors contribute to contractual disputes or safety violations (Miriam et al. 2023). By integrating XAI technologies and emphasizing transparent reporting, AgenticAI responds directly to these concerns. It ensures that predictions and recommendations can be understood, verified, and defended in legal or administrative contexts, thus facilitating wider stakeholder acceptance.

Synthesis of literature and research gaps

The literature reflects the rapid progress in applying AI to discrete areas of construction management:

project planning, risk identification, contract analysis, and drone-enabled monitoring. However, the field is still fragmented, with most applications operating as standalone solutions. Furthermore, critical challenges such as interpretability, legal enforcement, and ethical governance have not been resolved, highlighting a clear research gap: the lack of an integrated AI-powered framework that unifies contractual analysis, conflict prediction, project scheduling, safety monitoring, and progress validation. AgenticAI proposes to address this gap by combining NLP, machine learning, resume, and drone technologies into a single platform.

3. Methodology

This section introduces the adopted methodological framework for AgenticAI system visualization, design, and validation. The methodology has been developed to meet the complex and multifaceted requirements of construction management, ranging from contract management and dispute resolution to safety monitoring and progress tracking. To address these diverse challenges, the approach integrates three key pillars: (1) an AI-powered architecture that enables real-time data ingestion, interpretation, and analysis. (2) Machine learning models for contract interpretation, schedule forecasting, and safety risk detection. and (3) verification protocols that measure system performance against current industry practices. The following subsections detail the proposed structure, AI model design, data sources, and validation strategies.

3.1 AgenticAI System Architecture

AgenticAI was conceived as a hybrid platform available on both desktop and mobile interfaces. The system architecture follows a modular design, ensuring scalability, interoperability, and adaptability across projects of different sizes and contract types. The structure consists of four interconnected layers:

1. Data acquisition layer: This layer is responsible for collecting structured and unstructured data from multiple sources. Structured data includes project schedules, interim payment certificates, inspection reports, and risk registers, while unstructured data includes contract documents (FIDIC, NEC, JCT, and custom contracts), site images, drone surveys, and correspondence records. Natural Language Processing (NLP) pipelines are used to analyze contract lines and project logs, while computer vision algorithms process drone images and videos.
2. Data processing and storage layer: Pre-collected data is processed and stored in a cloud-based environment. The data processing phase includes text cleaning, coding, item classification for contracts, image segmentation for drone surveys, and normalization timeline for project timelines. The relational database stores structured project data, while the document database manages unstructured records.
3. Artificial Intelligence and Analytics Layer: This layer hosts machine learning and deep learning models designed to provide real-time predictions, recommendations, and alerts. Key models include:

- NLP-based legal interpretation models trained on international contract standards for the detection of conflict-prone clauses.
- Predictive scheduling models based on recursive neural networks to predict potential delays.
- Computer vision models of drone images that identify progress deviations, safety violations, and physical non-compliance.
- Risk assessment models that combine contract interpretation with project performance data to provide probabilistic predictions of disputes, claims, and safety incidents.

4. User engagement layer: This layer provides insights across dashboards that can be accessed through desktop and mobile platforms. The dashboard provides real-time visualizations, automated node alerts, hazard heat maps, safety breach notifications, and progress vs. plan comparisons. Interactive features allow project managers to query the system, simulate alternative scenarios, and generate automated reports for stakeholders.

The modular design allows AgenticAI to operate as a stand-alone tool or integrate with existing project management systems such as Primavera P6, MS Job, and Building Information Modeling (BIM) platforms.

3.2 AI Model Design

The AI models embedded in AgenticAI are designed for specific aspects of construction project management.

3.2.1 Contract Interpretation and Dispute Prediction Natural Language processing is used to analyze contract documents and correspondence. Standards and specifications are fed and fine-tuned to identify key contractual clauses, obligations and risk allocation mechanisms. These models categorize contract sections into categories such as pay, difference, time extension, and dispute resolution. By applying supervised learning to annotated datasets of previous contract disputes, the system is trained to predict items with a high probability of conflict.

3.2.2 Schedule Delay Prediction Project scheduling data is modeled using time series learning techniques. Decision trees (DT) are used to analyze the significance of features, while long-term memory short-term (LSTM) networks are used to model temporal dependencies in activity progression. The models predict potential delays by analyzing actual progress data, temporary milestones, resource allocation, and historical delay patterns. Probabilistic outputs provide stakeholders with confidence periods in delay predictions.

3.2.3 Monitor progress and analyze drone-enabled safety Images and videos of drones are processed via artificial intelligence for object detection and semantic segmentation. These models automatically identify construction elements such as scaffolding, machinery, workers, and protective equipment. Safety violations are reported by detecting conditions such as workers without helmets or scaffolding without guardrails. Progress monitoring models compare the physical elements detected with BIM or scheduling data to assess deviations from planned progress.

3.2.4 The outputs of integrated risk management from contract interpretation, schedule forecasting, and drone-based monitoring are grouped into a risk matrix. The network model aggregates this information to estimate the likelihood of conflicts, schedule overlaps, and safety incidents. This integration enables proactive recommendations, such as renegotiation alerts, reallocation of resources, or additional safety training.

3.3 Data sources

The development and validation of AgenticAI is based on diverse data sources representing structured and unstructured information.

- Contractual Documents: Standard forms such as the FIDIC Red Book, NEC4, JCT Design and Build, and custom project contracts.
- Project management records: Primavera and MS Job tables, Gantt charts, progress reports, and resource allocation records.

- Inspection reports: Work inspection reports, material approvals, and temporary payment certificates.
- History of Dispute Cases: Publicly Available Case Law and Arbitral Awards Relating to Construction Disputes.
- Drone Data: High-resolution images and video streams collected from commercial drones during site surveys.
- Safety Records: Records of safety incidents, imminent errors, and compliance audits.

The data is anonymized and standardized to ensure confidentiality and comparability across projects.

3.4 Validation Approach

AgenticAI system validation involves a combination of retrospective analysis, experimental testing, and expert review.

1. Retrospective verification: Historical data from completed projects is used to test the accuracy of AI models. For instance, timeline predictions are validated against actual project delays, while dispute predictions are compared to documented arbitration outcomes.
2. Pilot Project Testing: The system will be deployed in live projects in a pilot phase, with drone surveys conducted weekly and contract documentation ingested at the beginning of the project. Performance metrics will include prediction accuracy, early warning timeout, and reduced conflict incidents.
3. Expert Review: Committees of contract managers, project managers, and safety officers will review the recommendations generated by AgenticAI. Structured interviews and Delphi Method surveys will be used to assess practical relevance and usefulness of insights.
4. Benchmark: AgenticAI's results will be measured against traditional dispute resolution boards and standard project management controls. Key indicators include the frequency of disputes, the average time needed to resolve disputes, reducing delays, reducing safety incidents, and saving costs.

3.5 Ethical and practical considerations

The use of AI in construction raises ethical concerns regarding data privacy, bias in model predictions, and the potential displacement of human experience. To address these concerns, AgenticAI incorporates transparent and interpretable AI mechanisms, anonymity protocols, and human-in-loop design that allows experts to bypass system recommendations when necessary. Practical implementation considerations include training project personnel, ensuring regulatory compliance for drone operations, and establishing interoperability with existing enterprise software systems.

3.6 Summary

AgenticAI's methodology integrates advanced AI models with drone-based data collection to create a comprehensive, proactive, and proactive platform for managing construction projects. By structuring the system into modular layers, designing models for specialized tasks, obtaining varied, high-quality data, and validating through retrospective and direct testing, the methodology ensures both technical robustness and practicality.

4. Results and Discussion

4.1 Overview of Simulated Findings

The evaluation of AgenticAI is based on a combination of simulated scenarios and comparison with published literature on AI applications in construction. The finding relies strictly on the conclusions reported in peer-reviewed studies.

4.2 Contract Administration and Dispute Avoidance

Cheung and Pang (2013) and Chan and Suen (2005) note that disputes often arise due to ambiguities in contract language and late recognition of claims. AgenticAI's NLP models can process contract clauses automatically and flag ambiguous areas. While exact predictive accuracy rates cannot yet be validated without live pilot projects, prior research has shown that NLP models for legal and regulatory text extraction (Zhang and El-Gohary, 2013) achieve reliable performance in identifying compliance-related clauses. This provides confidence that similar models applied to FIDIC, NEC, and JCT contracts would deliver early warnings to project managers.

4.3 Project Scheduling and Delay Prediction

Traditional methods such as CPM and PERT often struggle with uncertainty (Assaf and Al-Hejji, 2006). AI models such as gradient boosting and recurrent neural networks have shown promise in improving predictive power. For example, Ahiaga-Dagbui and Smith (2014) demonstrated that data-driven models could better account for cost overruns compared to deterministic approaches. Cheng et al. (2021) showed that probabilistic AI scheduling models provide improved reliability in forecasted completion times. Based on these studies, AgenticAI's predictive scheduling module has the potential to outperform traditional CPM by offering dynamic and continuously updated forecasts rather than static timelines.

4.4 Safety and Quality Monitoring

Teizer et al. (2013) and Lin and Golparvar-Fard (2021) emphasize the limitations of manual safety inspections, noting that human observation is prone to fatigue and inconsistency. Automated sensing and computer vision techniques have been shown to detect hazards and unsafe conditions more consistently. For example, Liu et al. (2021) successfully applied computer vision for detecting unsafe worker actions, reporting high levels of reliability under controlled conditions. Turkan et al. (2012) demonstrated that 4D schedule-linked automated progress tracking can significantly enhance objectivity in reporting compared with manual site reports. These findings suggest that AgenticAI's integration of drone imagery and AI-driven vision systems could support more continuous and objective safety and quality monitoring.

4.5 Benchmarking AgenticAI against Traditional Methods

Table 1: Benchmarking of AgenticAI against Traditional Methods (Qualitative Assessment)

Domain	Traditional Method Performance	AgenticAI Potential (Based on Literature)
Contract Dispute Detection	Manual reviews often identify issues late; disputes escalate to DAB/DAAB for resolution (Cheung and Pang, 2013; Chan and Suen, 2005).	NLP models can analyze contracts and flag ambiguous clauses early (Zhang and El-Gohary, 2013).
Delay Prediction	CPM/PERT are deterministic and handle uncertainty poorly (Assaf and Al-Hejji, 2006).	AI models provide probabilistic forecasting and dynamic updates (Cheng et al., 2021).
Progress Verification	Manual progress reports are subjective and prone to bias (Turkan et al., 2012).	Automated sensing, drones, and BIM integration improve objectivity and reliability.

Safety Breach Detection	Human inspections are inconsistent, prone to fatigue, and miss hazards (Teizer et al., 2013).	Computer vision consistently detects unsafe actions and conditions (Liu et al., 2021).
Quality Defect Detection	Periodic manual checks catch issues late and inconsistently.	AI-driven vision systems enable continuous, real-time defect detection (Lin and Golparvar-Fard, 2023).

The benchmarking clearly shows that while traditional methods rely heavily on human judgment and retrospective recognition of problems, AI-assisted methods improve objectivity, consistency, and timeliness. However, full validation of AgenticAI's integrated capabilities requires field-based pilot testing.

4.6 Implications for Construction Practice

AI-driven systems like AgenticAI could shift the industry from reactive dispute resolution to proactive dispute avoidance. Predictive scheduling, combined with real-time drone monitoring, creates adaptive planning processes. Safety and quality monitoring become continuous and data-driven rather than periodic and manual. However, adoption depends on stakeholder trust, regulatory alignment, and integration with existing systems such as BIM.

4.7 Limitations of the Simulation

The main limitation of this study is that results are based on simulations and secondary data from literature rather than live deployments. Environmental conditions, data quality, and jurisdictional variations in contracts may affect system performance in practice. Ethical and legal questions also remain, especially around liability and privacy when AI is applied to site monitoring and contract interpretation.

4.8 Future Directions

Future research should include prototype development, field testing on live projects, and cross-project learning. Integration with BIM and IoT will expand functionality. Regulatory frameworks for AI in construction must be studied in parallel to ensure adoption is legally sound and ethically responsible.

5. Conclusion and future research

5.1 Conclusion

The construction industry is at a critical juncture as traditional practices have become increasingly inadequate to meet the requirements of complex, large-scale, and highly regulated projects. Ongoing issues such as contract disputes, cost overruns, delays, safety breaches, and fragmented project communications continue to impact productivity and results across the globe. This study was presented AgenticAI, a conceptual framework for an integrated AI platform designed to address these challenges by unifying contract analysis, predictive scheduling, risk management, conflict avoidance, safety monitoring, and quality control within a single ecosystem.

The contribution of this research lies in the holistic design approach. Unlike current tools that focus on discrete tasks such as scheduling optimization or drone-based progress tracking, AgenticAI integrates multiple dimensions of construction management. Leveraging natural language processing (NLP) for contract analysis, machine learning to model predictive risk, and computer vision with drone-based imagery for safety and progress monitoring, the platform provides periodic and real-time recommendations. This integration enables construction stakeholders to proactively mitigate risks, avoid conflicts, and improve safety and quality performance.

The benchmarking exercise, grounded in literature, highlighted the limitations of traditional methods. Manual contract reviews often detect risks late (Cheung and Pang, 2013; Chan and Suen, 2005), CPM schedules inadequately capture uncertainty (Assaf and Al-Hejji, 2006), and manual inspections are prone to fatigue and inconsistency (Teizer et al., 2013). In contrast, AI-enabled approaches such as NLP for clause extraction (Zhang and El-Gohary, 2013), probabilistic AI scheduling (Cheng et al., 2021), and computer vision for hazard detection (Liu et al., 2021) show clear potential for improved reliability and timeliness.

From a management point of view, the adoption of AgenticAI contributes to enhanced collaboration between stakeholders by integrating data flows into a unified interface to support the decision. Owners benefit from improved oversight and reduced litigation risk, contractors receive actionable intelligence to allocate and schedule resources, and consultants can make more accurate and timely recommendations.

5.2 Limitations

First, the proposed system has not yet been tested on live projects, limiting the framework's ability to validate real-world complexities such as incomplete data, human error in documentation, and unpredictable site conditions. Second, developing robust NLP models for contract interpretation remains a technical challenge due to context-specific jurisdiction-dependent construction contract language. Third, relying on drones for location data imposes operational constraints, such as regulatory restrictions on unmanned aerial vehicles (UAVs), weather dependence, and the need for skilled operators. In addition, consolidating heterogeneous data streams of contracts, timelines, inspection reports, and drone imagery into a unified platform presents challenges for interoperability and data standardization.

5.3 Future Research Trends

The results of this research open several avenues for future exploration. To advance AgenticAI from concept to practice, several detailed research directions have been proposed:

- Prototype Development and Field Testing: The most urgent step is to create a functional prototype for AgenticAI. This should include the development of modular components for contract analysis, scheduling forecasting, and drone-based monitoring. The pilot implementation of real construction projects across various contractual scales and frameworks will be critical to validating the platform's accuracy, usability, and cost-benefit outcomes.
- Advancing NLP for Legal Contracts: Future work should focus on designing NLP models to interpret construction contracts across multiple jurisdictions. This includes the development of industry-specific training datasets from FIDIC, NEC, JCT and custom contract forms. Collaboration with legal experts will be essential to ensure that AI-generated recommendations are technically robust and legally defensible.
- Integration with Building Information Modeling (BIM): AgenticAI's integration with BIM systems represents a promising research path. Linking AI-powered contract interpretation and schedule forecasting with BIM-enabled digital plans can provide real-time visualization of risks, conflicts, and project performance. This integration can enhance collaboration and decision-making by embedding AI insights directly into the project's digital model.

- Expansion of UAV and sensor applications: While drones offer significant opportunities for location monitoring, future studies could explore the use of complementary technologies such as IoT sensors, LiDAR, and robotics to improve data capture. The combination of these technologies and AI analytics can enable more accurate progress tracking, safety assessments, and predictive maintenance planning.
- Cross-project learning and predictive benchmarking: By aggregating data across multiple projects, AgenticAI can evolve into a predictive measurement tool capable of identifying recurring patterns of disputes, delays, and safety violations. This will allow stakeholders to compare their projects to industry-wide performance baselines and adopt preventive strategies early in the project lifecycle.
- Scalability and cost analysis: Further studies should examine AgenticAI's scalability across small, medium, and large enterprises, as well as in different geographies with varying levels of technological infrastructure. Cost-benefit analyses will be critical in demonstrating value to stakeholders, especially in regions where upfront investment in digital technologies remains a barrier.

5.4 Concluding Remarks

The research presented in this paper contributes to the growing body of knowledge about AI-powered construction management by proposing a new and integrated framework. While limitations are there, AgenticAI's conceptual development illustrates a path toward proactive conflict avoidance, improved safety monitoring, and improved project performance. The combination of contract interpretation, predictive analytics, and drone-based monitoring has the potential to transform construction practices by replacing reactive dispute resolution mechanisms with proactive risk management strategies. Future R&D efforts should focus on addressing specific limitations, building a prototype, and conducting pilot studies that will provide empirical evidence of the system's effectiveness. If successfully implemented, AgenticAI can play an important role in the digital transformation of construction, aligning with broader industry trends and contributing to a safer, more efficient, and more resilient built environment.

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