



REVIEW ON AUTONOMOUS RESOURCE ALLOCATION IN CONSTRUCTION PROJECTS

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ABSTRACT:

This extensive literature study explores advancements in autonomous resource allocation, RFID technologies, IoT-driven machinery management, and labour management within construction and industrial environments. The study examines innovative approaches such as decentralized resource management systems, the integration of deep reinforcement learning for project optimization, and RFID for efficient materials tracking. Emphasis is placed on the challenges and solutions across these domains, including scalability, interoperability, and the adoption of emerging technologies to enhance productivity. The findings underline the transformative potential of digital tools and intelligent systems in addressing inefficiencies and promoting sustainable practices in construction and related industries.

KEYWORDS: Autonomous resource allocation, RFID technology, IoT, machine learning, materials management, deep reinforcement learning.

INTRODUCTION:

In today's fast-paced and technology-driven world, industries like construction are under constant pressure to improve efficiency, reduce costs, and maintain high-quality standards. One of the biggest challenges is managing resources, materials, and labor effectively, especially in complex projects that demand quick decision-making and accurate tracking. Traditional methods, while functional, often fall short when it comes to handling large-scale or multi-layered projects. This review explores how innovative technologies such as Artificial Intelligence (AI), the Internet of Things (IoT), and Radio Frequency Identification (RFID) are transforming these practices. These tools offer solutions like better tracking of materials, smarter resource allocation, and improved communication among teams. By analyzing current research and technological advancements, this paper sheds light on the potential of these tools to revolutionize industries. It also highlights the challenges that need to be addressed, such as the costs of implementation, resistance to change, and technical limitations, while suggesting ways to overcome them. The aim is to present a comprehensive view of how these technologies are reshaping the future of resource and labor management in industries.

LITERATURE REVIEW:

REVIEW ON AUTONOMOUS RESOURCE ALLOCATION

- **Ivica Draganjac et.al (2016)** addresses the challenges of decentralized control in autonomous guided vehicles operating in complex environments, emphasizing the need for effective path planning and motion coordination. Traditional centralized control methods, while effective, often struggle with scalability and flexibility, as they rely on a single unit to manage all vehicles, which can lead to inefficiencies and bottlenecks. In contrast, the proposed decentralized approach allows each vehicle to autonomously plan its path while negotiating priorities with neighbouring vehicles only when conflicts arise, thus enhancing system performance and scalability. The introduction of private zones for conflict resolution is a significant innovation, ensuring that vehicles can safely execute avoidance manoeuvres without the need for path replanning. The effectiveness of the proposed algorithms has been validated through simulations and experiments on various robotic platforms, demonstrating their applicability in real-world scenarios.
- **Jingyun Feng et.al (2017)** addresses the growing computational challenges in vehicular environments, especially for high-performance applications like Augmented Reality that surpass the capabilities of on-board systems. It points out that traditional cloud computing, limited by high latency and unstable connections, hampers user experience in mobile scenarios. The use of parked vehicles as content caching nodes and decentralized communication to relieve roadside units are also examined. The proposed framework stands out by focusing on generic computation offloading with moving vehicle resources, compared to prior studies tailored to specific applications.
- **Hao Ye et.al (2019)** explores resource allocation challenges in vehicular networks, emphasizing the need for efficient unicast and broadcast communication methods. It underlines the critical role of vehicle-to-vehicle communications for safety, where unicast methods may be inadequate due to non-specific message destinations, prompting a shift to broadcasting while addressing broadcast storm issues. The authors introduce a deep reinforcement learning-based scheme for optimal resource management that meets the strict latency and reliability needs of

vehicle-to-vehicle links, unlike the less demanding requirements of typical cellular traffic. Building on prior research involving algorithms and distributed methods for vehicle-to-vehicle communication, the paper presents a unified framework that integrates unicast and broadcast scenarios for comprehensive resource management in vehicular networks.

- **Thomas et.al (2019)** highlights the necessity of interoperability, survivability, and manageability in blockchain systems, paralleling the successful design principles of the Internet. It argues that for blockchain technology to serve as a fundamental part of a global distributed network, it must embrace goals such as scalability and resilience. The authors introduce the concept of blockchain gateways, akin to Internet routing gateways, to enable connectivity across different blockchain networks. They also address challenges like the need for standardized blockchain components to lower development costs and improve reusability. By reinterpreting Internet architecture challenges within the blockchain context, the paper proposes a design philosophy that prioritizes interoperability as vital for the effective operation of blockchain systems, laying the groundwork for future development.
- **Maryam et.al (2022)** highlights that Resource allocation is very important in construction. Most current methods focus on managing resources for single projects, which is not enough for larger construction companies that need a broader approach. New technology, especially Deep Reinforcement Learning (DRL), can help solve these problems by using data from Internet of Things (IoT) devices placed at construction sites to make quick and smart decisions. The proposed method includes two main parts: Data Harvesting (DH), which collects information about resources, and Coverage Resource Allocation (CRA), which uses that information to decide how to allocate resources effectively. This new system, called Autonomous Resource Management (ARM), can adapt to different situations without needing extra training when project conditions change, which is very useful for companies with various projects.
- **Mazen et.al (2024)** highlights in this paper that examines the integration of artificial intelligence (AI) and machine learning (ML) in autonomous construction project scheduling. It highlights the potential of these technologies to enhance scheduling accuracy and efficiency, particularly using building information modelling (BIM) and natural language processing (NLP). The review discusses the capabilities of models like ChatGPT in generating resource- loaded schedules, noting that while promising, they require specific training for effective application. Additionally, it emphasizes the importance of a design science research (DSR) methodology in developing a comprehensive scheduling system that includes components such as a project analyzer and schedule analyzer. This approach aims to improve project performance through proactive planning and risk management, addressing the challenges faced in construction scheduling.
- **Maryam et.al (2024)** discusses about ARM in construction involves optimizing labor, equipment, and materials. Current methods primarily focus on individual projects, lacking integrated planning and optimization across multiple projects within a construction company. The paper introduces a Deep Reinforcement Learning-based Project Integration Model to address the challenges of resource allocation in construction projects. Resource allocation is crucial for managing cost, time, and quality in construction projects. The system collects resource data from IoT sensors. The Autonomous Resource Allocation (ARA) system then optimizes resource use. The results show that DRL can successfully perform ARA by capturing the complex interactions among resource allocation features.

REVIEW ON RFID TAG USAGE IN CONSTRUCTION AND MATERIAL MANAGEMENT

- **Z. Ren et.al (2009)** discusses the challenges in construction materials management (CMM), highlighting issues like poor planning and data flow that lead to delays and cost overruns. It emphasizes the advantages of RFID technology over traditional methods, such as improved tracking and efficiency. Previous research has shown that while RFID can enhance material management, many systems lack proper integration with existing processes. The case study in a water-supply project illustrates the potential of RFID-CMM to improve material handling, although user acceptance varied, with some embracing the technology while others preferred traditional methods due to the additional workload involved.
- **Javad Majrouhi Sardroud (2012)** discuss in the paper emphasizes the inefficiencies of traditional construction material management methods, which are labour-intensive and error-prone, leading to significant project costs. It highlights the necessity for automation through technologies like RFID, GPS, and GPRS to provide real-time tracking and identification of materials, thereby improving accuracy and efficiency in construction projects. Previous research has established the critical role of effective materials management, with RFID technology being a focal point due to its ability to uniquely identify items and operate in challenging environments. The survey also addresses existing challenges, such as the lack of international standards and issues with certain materials, setting the groundwork for the proposed RFID-based system to enhance construction material management.
- **Ali Montaser et.al (2013)** discusses about RFID technology for indoor location identification emphasizes its importance in construction projects, especially where GPS is ineffective. Many studies have shown that RFID is more cost-effective and easier to implement compared to other technologies like UWB and infrared systems, which often require direct line-of-sight and complex setups. Most research has focused on active RFID tags, which are expensive and have limited battery life. However, this paper highlights the benefits of using passive RFID tags, which, while needing more units, are more affordable and suitable for dynamic construction environments. The methodology presented in this study utilizes a two- step algorithm based on Received Signal Strength Indicator (RSSI) for real-time location estimation and material tracking, enhancing efficiency on construction sites.
- **Narimah et.al (2019)** highlights the critical role of effective materials management in construction, noting that materials account for a significant portion of project costs. It identifies challenges in current practices, particularly the reliance on manual tracking methods and excessive paper-based systems, which complicate the tracking process and hinder real-time information access. The literature review emphasizes the potential of Information and Communication Technologies (ICT), especially RFID, to automate materials tracking and improve efficiency, yet notes that many Malaysian construction projects still utilize manual methods due to cost concerns and a lack of technology adoption. The findings underscore the urgent need for the industry to transition to automated systems to enhance project management and align with Industry 4.0 advancements.

- **Prasad et.al (2021)** discuss on RFID technology in construction material management highlights its advantages over traditional methods, such as real-time inventory tracking and reduced human error. Studies, including those by S. Prakash Chandar et al. (2016), propose integrated RFID-GPS systems to enhance automation in inventory management, demonstrating that materials like precast members can be managed without human interference. Historical context shows that RFID has been utilized in construction since the 1990s, with ongoing developments indicating a favourable benefit-to-cost ratio. Additionally, global case studies reveal that while RFID applications are effective, their implementation in construction is less widespread compared to other industries like manufacturing.
- **Ahsan et.al (2023)** discuss about the passive radio frequency identification (P-RFID) in construction highlights its potential to enhance sustainability and efficiency in project management. It identifies significant barriers to implementation, including technical challenges, cultural resistance, privacy concerns, and resource limitations that must be addressed for successful adoption in small construction projects. The study utilizes structural equation modeling (SEM) to analyze these barriers and their interrelationships, providing a framework for future research. Engaging stakeholders is emphasized as crucial for overcoming these challenges and promoting P-RFID integration. Overall, addressing these barriers is essential for leveraging P-RFID technology to improve construction practices and project outcomes.
- **Maad et.al (2023)** discuss about the significant role of RFID technology in civil engineering, emphasizing its integration with IoT for sustainable building practices. It highlights various applications of RFID, such as monitoring stress and corrosion in reinforced concrete and inspecting building materials, which enhance efficiency and safety on construction sites. The technology allows for real-time monitoring, providing critical data that can prevent structural failures. Additionally, it addresses the limitations of traditional stress measurement methods, advocating for RFID as a more reliable solution. Future research is expected to focus on advancing these technologies to further improve construction practices and structural integrity.
- **Khyomesh et.al (2011)** highlights the construction materials management emphasizes its critical role in enhancing project efficiency and controlling costs, as materials can constitute 60 to 70 percent of total project expenses. Effective management involves systematic purchasing, issuing, and storage of materials, as outlined by experts like Ninad Shah and Manish Dave. Proper procedures ensure that materials are available as needed, while guidelines such as IS: 4082 helps to prevent damage during storage. Additionally, benchmarking processes are essential for comparing estimated and actual material usage, which aids in minimizing waste and improving overall project performance.
- **Narimah et.al (2013)** discuss on materials management in construction emphasizes its critical role in enhancing project productivity, as poor management can lead to delays and budget issues. Many projects still use manual, paper-based tracking methods, which are inefficient and error-prone. Emerging technologies like RFID are highlighted as underutilized solutions that can improve accuracy and efficiency in materials tracking. The study identifies a need for more sophisticated materials management solutions, particularly the integration of RFID technology to enhance on-site tracking and inventory management.
- **Carlos et.al (2015)** discusses on Materials management is essential for improving project efficiency in construction, where materials account for 50- 60% of costs and influence 80% of schedules. Poor management leads to delays and cost overruns, yet construction firms invest only 0.15% in this area, compared to 1% in manufacturing. Studies highlight the need for modern practices like global procurement and early supplier involvement. Recent surveys show progress, with materials management teams increasingly included early in planning, underscoring its role in reducing costs and enhancing safety and outcomes.
- **N.B. Kasim et.al (2015)** discuss on materials management in fast-track construction projects highlights the critical need for effective management practices to mitigate delays caused by material supply issues and organizational deficiencies. It emphasizes the importance of integrating materials management from the design phase to enhance efficiency and reduce project durations. Current practices often rely on outdated methods, but there is a growing recognition of the potential for ICT tools and technologies, such as RFID, to streamline processes and improve productivity. The paper proposes a research framework aimed at developing advanced materials management solutions tailored for fast-track projects, addressing the inefficiencies observed in the industry.
- **Vikram et.al (2017)** highlighted the Effective materials management is key to construction project success, reducing costs and boosting efficiency and that a robust system supports cash flow and limits excess inventory costs. Kasim adds that proper materials handling from design through construction prevents deterioration and theft, while poor management can lead to costly delays and impact time, budget, quality, and productivity. Many small and medium firms lack dedicated materials management, causing inefficiencies. The literature recommends integrating materials management into company policies and using software tools to reduce errors and improve communication.
- **Argaw Tarekegn Gurm (2018)** discusses the importance of construction materials management practices in enhancing labour productivity within multi-storey building projects in Victoria State, Australia. It highlights that the construction industry significantly contributes to the economy but struggles with low productivity growth, necessitating effective management practices to improve output. The study identifies a gap in existing research regarding the applicability of previously established materials management practices to the Australian context, suggesting that local conditions may require tailored approaches. The research employs a two-phase mixed-methods design, starting with qualitative interviews to identify key practices and followed by a quantitative survey to prioritize these practices, thereby addressing the specific needs of the local construction industry.
- **Pham et.al (2021)** highlights the limitations of traditional Economic Order Quantity (EOQ) models in construction logistics, which often fail to address the dynamic nature of material demand and storage constraints. It introduces the Construction Logistics Planning (CLP) model as a more adaptable alternative, optimizing material ordering and warehouse size based on project needs. Additionally, the paper discusses the effectiveness of Genetic Algorithms (GA) and Particle Swarm Optimization (PSO) in solving optimization problems, while proposing a hybrid approach that combines the Dragonfly Algorithm (DA) with PSO to enhance search capabilities and achieve better results in managing construction material costs. The use of Material Requirements Planning (MRP) is also emphasized as a method to control material costs effectively by estimating required quantities and delivery times.

REVIEW ON IOT USE IN MACHINERY MANAGEMENT

- **Prasanth Kumar et.al (2019)** highlighted the importance of equipment management in construction, especially regarding breakdowns and their effects on timelines and costs. It highlights how countries like Australia and Norway have innovatively avoided the "resource curse" in resource-based sectors, leveraging knowledge creation for competitive advantages. The review also identifies gaps in research on equipment failures, particularly in concreting equipment like batching plants and pumps, emphasizing the need to understand downtime factors site, equipment, and crew related. Analysis of repair histories shows risks, with frequent electrical issues in batching plants and blockages in concrete pumps. This establishes a basis for exploring equipment management's impact on project efficiency.
- **Wei Zhang et.al (2019)** provides a comprehensive overview of hybrid construction machinery (HCM) and its energy management strategies. It highlights the evolution of hybrid technologies from the automotive industry to construction machinery, noting that HCM research began relatively late but has accelerated in the past decade due to increased interest from researchers and manufacturers. The literature review categorizes existing studies on HCM systems, focusing on their structural characteristics and energy storage systems. It emphasizes the lack of a systematic overview of energy management strategies specific to HCM, which is crucial for addressing the unique operational challenges of construction machinery, such as lower travel speeds and complex load changes.
- **Behnam et.al (2020)** highlights the presents a thorough literature survey on automated activity recognition methods in construction. It categorizes these methods into kinematic- based, vision-based, and audio-based techniques, each with distinct advantages and limitations. For instance, audio-based methods require less computational power and can function without a line of sight, while vision-based methods are more sensitive to environmental conditions. The review emphasizes the need for effective implementation factors such as cost, accuracy, and computational time, and highlights the current gaps in research, suggesting future directions to enhance the applicability and precision of these systems in real-world construction scenarios.
- **Kaustubh et.al (2020)** highlights various studies related to equipment downtime in the construction industry. Notably, Melissa De Iuliis et al. (2018) focused on estimating downtime using fuzzy logic, categorizing it into three components: downtime due to actual damage, irrational delays, and other factors. The survey aims to gather insights from both local tradesmen and educated contractors regarding equipment usage and maintenance, as well as their perceptions of the economic aspects of equipment management. Additionally, the research identifies a gap in the literature concerning the impact of equipment management on productivity in Pune's construction sector, which is crucial given the city's ongoing multimillion projects. The study will employ personalized interviews and a structured questionnaire to collect data, ensuring that the survey process is clear and minimizes errors. Overall, the literature review need for effective downtime analysis and management strategies to enhance productivity and reduce costs in the construction industry.
- **B. Indhu et.al (2021)** highlights in this paper emphasizes the significant issue of construction delays caused by inappropriate construction equipment, highlighting a research gap in this area. While many studies address overall construction delays, few focus specifically on equipment-related issues. Insights from focus group interviews with procurement managers informed the development of a questionnaire to gather data on these delays. The analysis utilized statistical methods, including Pearson correlation coefficients and Structural Equation Modeling (SEM), to validate the relationships between delay factors and their impact on firms' reputations. The findings led to practical recommendations aimed at improving equipment selection and usage in construction projects.
- **Kleopatra et.al (2021)** highlights the paper employs a two-step process to explore factors affecting construction equipment operators' performance. Initially, a scient metric analysis is conducted to connect operator performance with equipment productivity, utilizing the VOS Viewer application to visualize relationships among 263 relevant publications. This analysis reveals a gap in existing research, as no studies have systematically summarized the interdependencies between operator performance and project outcomes. The second step involves justifying the selection of criteria based on past studies, leading to a comprehensive list of factors that influence operator performance, which are essential for the Analytical Hierarchy Process (AHP) decision model. The review highlights the increasing interest in this area over the past five years, particularly regarding the impact of technological evolution on performance.
- **Meng et.al (2021)** highlights the challenges of manual data collection in construction, which is labour intensive and prone to errors. It discusses the advancements in technologies like RFID, GPS, and computer vision that aim to automate resource tracking, thereby improving efficiency and safety on construction sites. The integration of chatbots is emphasized to enhance user experience by providing real-time information through intuitive interfaces, addressing the complexities of existing systems. Overall, the survey underscores the need for automation and user-friendly solutions in construction management to streamline processes and reduce errors.

REVIEW ON LABOUR MANAGEMENT IN CONSTRUCTION

- **Argaw Tarekegn Gurmu (2018)** discuss and indicates that the construction industry in Australia struggles with low productivity growth, particularly in labour productivity, which is crucial for overall performance. Previous research highlights the importance of advanced management practices and construction materials management in enhancing productivity, yet there is a notable lack of studies focused on multi-storey building projects in Australia. This paper aims to address this gap by identifying and prioritizing effective construction materials management practices that can improve labour productivity specifically in the context of Victoria State, Australia.
- **Dasari et.al (2019)** discuss about the masonry labour productivity highlights various factors influencing performance in construction projects. Studies from different regions, including Trinidad and Tobago, Malaysia, and the Middle East, have identified critical issues such as material shortages and management practices that adversely affect productivity. Research has utilized the Relative Importance Index (RII) method to rank these factors, revealing that workforce-related issues are often the most significant contributors to productivity challenges.
- **Mohammed et.al (2019)** highlights about existing research on Construction Labour Productivity (CLP) to identify key factors influencing productivity in construction projects. A total of 88 relevant papers were analyzed, employing a systematic approach that included a

comprehensive literature review and the use of the Jenks classification method to rank the identified factors by importance. The findings highlight a significant gap in research regarding labourers' perspectives on productivity, despite their substantial role in project costs and team composition. The study emphasizes the need for further exploration of labour opinions and the impact of geographical factors on CLP, ultimately providing recommendations for better management practices in the construction industry.

- **Benjamin et.al (2020)** highlights the critical role of skilled labour in construction, noting that its shortage adversely affects project delivery and economic growth, as evidenced by a 7.2% GDP growth in the sector in 2018 that could be enhanced with a skilled workforce. The study identifies specific trades facing shortages, such as painters and electricians, attributing these issues to socio-economic conditions, job attractiveness, and personal factors. A survey methodology was employed, gathering data from project managers and engineers, revealing a significant need for improved training and workforce development to address these challenges.
- **Kesavan et.al (2020)** discuss about the paper which reveals that various factors influence labour performance in the Sri Lankan construction industry, highlighting issues such as low motivation, inadequate experience, and poor performance evaluation practices. It emphasizes the need for localized studies due to the unique social, cultural, and economic conditions in Sri Lanka, which differ from global contexts. The review identifies 113 factors affecting productivity, including skill shortages and supervision challenges, and underscores the necessity for improved practices to enhance overall labour performance in construction projects.
- **Mohd Ashraf et.al (2022)** highlights the significant challenges faced by the Malaysian construction industry, particularly the shortage of skilled local labour. It notes that while the industry has seen rapid growth and a high demand for labour, the reliance on foreign workers, who are often unskilled, has led to issues such as low productivity and poor quality of work. The review discusses various factors contributing to the lack of local skilled labour, including unattractive working conditions, low salaries, and a negative perception of the construction industry among locals. Additionally, it points out that many trained local workers leave the industry after receiving training, further exacerbating the problem. The paper aims to investigate the current participation levels of local skilled labour, identify the causes of their poor participation, and recommend initiatives to enhance their involvement in the construction sector.
- **Kesavan et.al (2024)** discuss about site supervisory attributes in construction highlights significant challenges related to skills gaps and inefficiencies in labour management, particularly in developing countries like Sri Lanka. It emphasizes the need for systematic skill development and effective training models to enhance site supervision and productivity. Various studies suggest that integrating modern technological tools and competency frameworks can improve supervisory practices, yet many emerging industries face barriers in implementation due to resource constraints. Furthermore, ethical conduct and strong communication skills among supervisors are linked to better job satisfaction and performance outcomes, underscoring the critical role of effective supervision in achieving national economic goals and improving construction productivity overall.

CONCLUSION:

This review shows how smart technologies are changing the way resources, materials, and workers are managed in industries like construction. Tools like AI and IoT can make projects run smoother, while RFID makes tracking materials more accurate. Although some challenges like cost and resistance to new ideas remain, these technologies have the power to save time, cut costs, and make work more efficient. Moving forward, it's important to focus on making these tools easier to use and more widely available.

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