

AI-based logistics system overview and a workflow for digital freight forwarding in logistics.

Md Ariful Islam Mozumder*, Rashedul Islam Sumon*, Ziaullah Khan*, Shah Muhammad Imtiyaz Uddin*,
Muhammad Omair Khan* Hee Cheol Kim*

Department of Computer Engineering/Institute of Digital Anti-Aging Healthcare/u-HARC, Inje University, South Korea
arifislamro@gmail.com, sumon39.cst@gmail.com, zkhan.msee19seecs@seecs.edu.pk, imtiyaz.dream@gmail.com,
mumairkhan690@gmail.com, heeki@inje.ac.kr

Abstract— In the realm of global business, logistics stands out as a cornerstone, and the ongoing development of Artificial Intelligence (AI) is shaping logistics into a secure and intelligent domain. The digitization of freight forwarding involves converting traditional logistic procedures into streamlined, digitized processes within the freight forwarding system. This paper provides a concise exploration of AI applications in logistics systems, delving into the transformative impact on supply chain management. Focusing on key components such as machine learning and predictive modeling, it offers a brief overview of AI's role in optimizing logistics processes and enhancing efficiency. Also, we will show a framework for digital freight forwarding in logistics considering AI applications with the explanation.

Keywords— Artificial intelligence, IoT, supply chain, logistics, and digital freight forwarding.

I. INTRODUCTION

In recent years, the synergy between Artificial Intelligence (AI) and logistics systems has propelled the evolution of supply chain management into uncharted territory. The integration of AI technologies, ranging from advanced machine learning algorithms to natural language processing and computer vision, has ushered in a new era of efficiency, adaptability, and precision within the logistics domain [1]. Beyond the technical aspects, we delve into the ethical

considerations inherent in AI adoption within logistics, contemplating issues of data privacy, algorithmic bias, and the imperatives of transparent decision-making [2]. In the dynamic landscape of contemporary logistics, the synergy between Artificial Intelligence (AI) and the pervasive trend of digitalization is catalyzing a profound transformation. The integration of AI in logistics represents a pivotal evolution, offering unprecedented opportunities to enhance efficiency, accuracy, and adaptability across the supply chain. From real-time data analytics to predictive modeling, AI applications permeate every facet of logistics, revolutionizing decision-making processes and ushering in a new era of intelligent logistics systems [3]. Simultaneously, the conceptual framework outlined herein addresses the digital transformation of freight forwarding critical component within the logistics ecosystem. As traditional procedures undergo a paradigm shift towards digital processes, the framework serves as a guiding structure, illuminating the intricate web of technological advancements, connectivity, and streamlined operations that characterize the envisioned future of freight forwarding [4]. There are several benefits for AI-based smart logistics systems, in figure 1 we have shown some core benefits [5].

By weaving together these strands, this overview aspires to furnish researchers, practitioners, and policymakers with a

Benefits of AI based Smart Logistics					
Logistics Data Analysis	Process Automation	Improved Performance	Improved Security	Smart Delivery	Increase Sales & Marketing
- Dynamic Pricing - Automated Documents Processing - Route Analysis	- Damage Detection - Predictive Maintenance - Warehouse Automation	- AI Customer Care - Smart Process Management - Fast Delivery	- Secured Delivery - Uses of IoT Devices - AI-driven Logistics Data Security	- Delivery Tracking - Self-driving Vehicle - Delivery with Drones	- Automated Online Marketing - Sales Analysis - Marketing Analysis

Figure 1. The benefits of smart logistics based on artificial intelligence

comprehensive understanding of the current state and future trajectories of AI-based logistics systems. Through this exploration, we aim to contribute to the ongoing dialogue on the harmonious integration of artificial intelligence into the intricate tapestry of modern supply chain management. This paper embarks on a comprehensive exploration of AI-based logistics systems, seeking to elucidate the transformative influence of AI across the entire logistics spectrum. From the rudimentary components of AI implementation to its sophisticated applications in demand forecasting, route optimization, and inventory management, we dissect the mechanics behind the efficiency gains witnessed in modern logistics. As we traverse the logistics lifecycle, the integration of AI in transportation, warehousing, and last-mile delivery emerges as a critical focal point, reshaping traditional methodologies and mitigating challenges that have long plagued supply chain operations. On the other hand, we will provide a conceptual framework for digital freight forwarding in logistics.

II. AI IN SMART LOGISTICS

Integrating AI into Smart Logistics is propelling a transformative wave across the logistics and supply chain management landscape. Smart Logistics harnesses the power of the Internet of Things (IoT) by embedding sensors and GPS trackers in various logistical elements, including vehicles,

warehouses, and packages. This seamless integration enables the continuous collection of real-time data on location, condition, and environmental factors, forming the bedrock for precise tracking and meticulous inventory management, thereby ensuring goods' quality and timely delivery [6]. The dynamic synergy of AI and machine learning is pivotal in the Smart Logistics ecosystem, where these technologies process the substantial volume of data generated by IoT devices. Through sophisticated analysis, AI optimizes current logistical operations, predicts future demand patterns, refines delivery routes, and enhances stock-level management. This predictive capability becomes a strategic asset, empowering logistics operations to adapt to market changes and meet evolving customer needs with agility and precision [7]. Smart Logistics, therefore, represents more than just optimizing logistics processes; it embodies a paradigm shift toward a holistic, data-driven approach to logistics management. Beyond its operational benefits of enhanced efficiency and cost reduction, Smart Logistics significantly elevates customer satisfaction by providing faster and more reliable delivery services [8]. Below the figure, we have shown the application of AI for logistics with its explanation.

A. AI-based Planning

AI is reshaping the landscape of logistics planning, offering transformative solutions across critical domains. In the realm

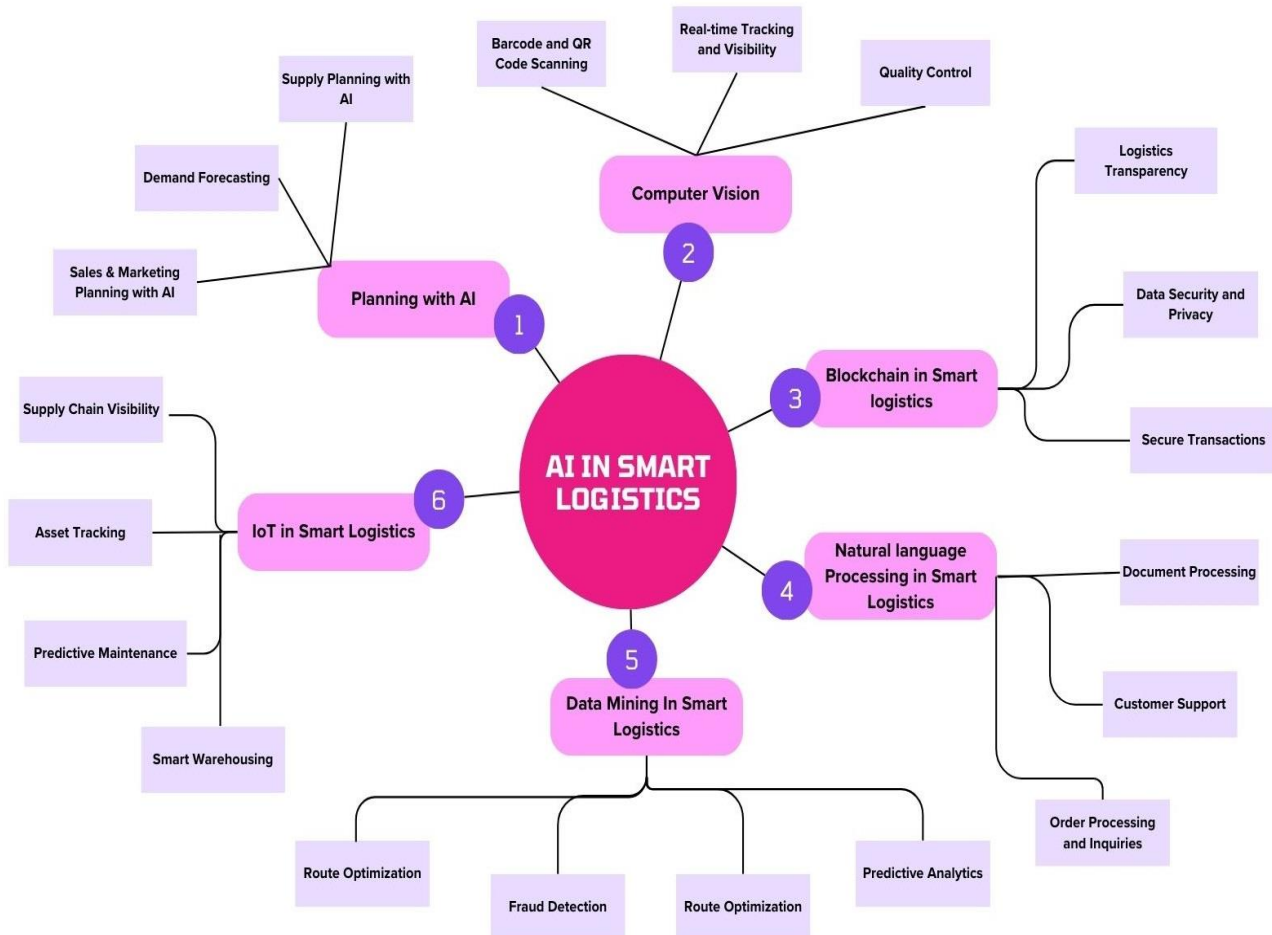


Figure 2. Artificial intelligence application for logistics

of supply planning, AI algorithms analyze historical data, market trends, and supplier behaviors to optimize inventory levels, ensuring a seamless flow of goods. Demand forecasting, another pivotal area, witnesses the power of AI-driven predictive modeling, which anticipates customer needs with unprecedented accuracy, mitigating the risk of overstock or stockouts. Sales and marketing strategies, too, benefit significantly from AI in logistics planning. Through data-driven insights, AI refines sales projections, allowing for dynamic adjustments based on market fluctuations.

B. Computer Vision

Computer Vision is reshaping logistics with precision and speed. Barcode and QR Code Scanning by advanced vision algorithms e.g., Deep Learning-based Image Recognition and Optical Character Recognition, streamline inventory checks, reducing errors and boosting efficiency [9]. Real-time Tracking and Visibility get a significant upgrade with Computer Vision. Automated tracking of shipments and goods provides instant insights, empowering quick decisions and enhancing operational transparency e.g., Light Detection and Ranging, Simultaneous Localization and Mapping. Quality Control becomes meticulous as Computer Vision assesses product quality, identifying defects with accuracy e.g., Hyperspectral Imaging, Texture Analysis, and Pattern Recognition.

C. Blockchain

Supply Chain Transparency gets a boost, providing stakeholders with real-time visibility. Traceability and Provenance ensure accurate tracking of product journeys, instilling trust in the supply chain. Secure Transactions form the backbone of blockchain in logistics, preventing tampering and fraud [10]. This decentralized approach fosters resilience and trust in financial processes. Simultaneously, Data Security and Privacy are prioritized, leveraging cryptographic techniques to safeguard sensitive information, and addressing modern concerns around confidentiality.

D. Natural Language Processing

NLP, a cornerstone in smart logistics, redefines customer-

centric processes. In Supply Customer Support, chatbots driven by NLP ensure swift and precise assistance. Order Processing benefits as NLP deciphers natural language, automating inquiries and improving responsiveness [11]. Meanwhile, Document Processing sees a boost as NLP extracts vital information from unstructured documents, streamlining logistics documentation for increased efficiency.

E. Data Mining

In smart logistics, data mining is the silent efficiency booster. Supply Predictive Analytics leverages data for proactive inventory management. Route Optimization crunches historical and real-time data for cost-effective logistics. Fraud Detection sharpens security by unveiling irregularities in transactions. For Energy Efficiency, data mining identifies optimization opportunities, aiding informed decisions.

F. IoT in smart Logistics

The Internet of Things (IoT) is a vast network of individually identifiable, highly networked items, including mechanical and digital machinery. These devices can send data across a network. IoT devices can sense, collect, and transfer data via the Internet. IoT has completely changed logistics and transportation fields by connecting large objects. IoT has improved transportation and logistics, including condition monitoring, online tracking, traffic control, avoiding traffic jams, effective supply chains, and prompt decision-making [10]. IoT enables real-time tracking of assets, enhancing their visibility and management. IoT sensors anticipate equipment issues, allowing for proactive maintenance and minimizing disruptions. IoT optimizes warehouse operations, automating processes and improving overall efficiency. IoT provides end-to-end visibility, ensuring real-time insights into the entire supply chain.

III. FRAMEWORK FOR DIGITAL FREIGHT FORWARDING IN LOGISTICS

AI-based freight forwarding in logistics involves the application of AI technologies to optimize and automate various aspects of freight forwarding processes. It includes the

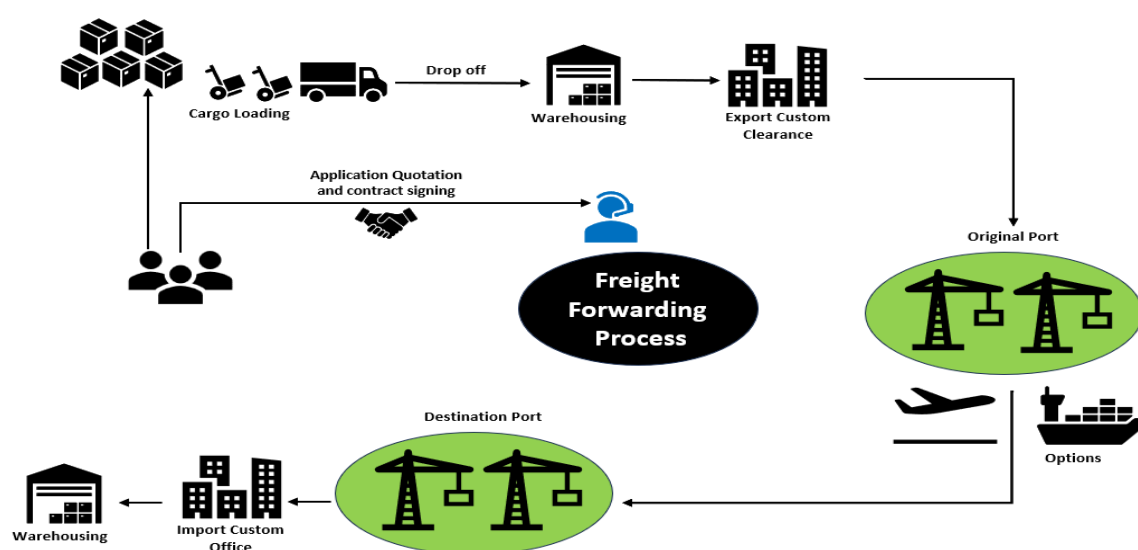


Figure 3. Complete workflow for digital freight forwarding in logistics.

use of AI algorithms for route optimization, demand forecasting, real-time tracking, document processing, and decision-making. AI enhances efficiency, reduces costs, and improves overall operational effectiveness in logistics freight forwarding [12-14]. In Figure 3 we have shown the workflow of AI-based digital freight forwarding.

AI-based automated systems facilitate the loading of goods onto a transport vehicle during the cargo loading phase. Smart tracking algorithms monitor the movement of the truck symbolizing the transportation of loaded cargo to the warehouse. Predictive analytics determine the optimal timing for goods to be ready for shipping, factoring in customs clearance and consolidation needs. Natural Language Processing (NLP) algorithms assist in generating and finalizing quotations and contracts for shipping, ensuring clarity on costs and terms of service. Machine learning models aid in export customs clearance, automatically checking cargo against documentation and ensuring compliance with export regulations. Intelligent data analytics optimize the selection of the original port based on various factors such as transport efficiency and cost-effectiveness. Automation and optimization algorithms drive the freight forwarding process, integrating, and streamlining all preceding steps for efficiency. Predictive modeling anticipates the arrival time and condition of goods at the destination port, facilitating smoother logistics planning. Automated systems assist in import customs clearance by quickly verifying adherence to destination country import regulations upon the goods' arrival. AI-driven logistics planning determines the most suitable warehousing strategy post-clearance, considering delivery timelines and other logistical factors. Decision support systems recommend the optimal mode of transport (air, road, sea) for the final leg based on destination-specific factors and urgency.

IV. CONCLUSIONS

The paper provided a comprehensive overview of AI-based logistics systems and introduced a framework for digital freight forwarding within the logistics domain. The synthesis of AI technologies in logistics showcased their transformative impact on efficiency, transparency, and decision-making. The conceptual framework outlined sets the stage for a more streamlined and responsive logistics ecosystem, emphasizing the pivotal role of AI in shaping the future of freight forwarding. This contribution aims to inspire further exploration and integration of AI in logistics, fostering a progressive and technologically advanced industry.

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Md Ariful Islam Mozumder is pursuing his Ph.D. in the Institute of Digital Anti-Aging Healthcare at Inje University. He has previously worked on multiple real-life projects related to computer vision, data sciences, Smart IoT systems, and text mining. His research interest aligns with Computer Vision, Medical Image Processing, Metaverse, Artificial Intelligence, Sensor Data Analysis, Bio Signal Processing, Algorithms, and Smart Logistics.



Rashedul Islam Sumon is pursuing his Ph.D. in the Institute of Digital Anti-Aging Healthcare at Inje University. His research interest aligns with Computer Vision, Medical Image Processing, Metaverse, Artificial Intelligence, and Bio Signal Processing.



Ziaullah Khan is a Ph.D. student at the Institute of Digital Anti-aging and Healthcare at Inje University. His research interest area Machine Learning and deep Learning, includes Smart Logistics, Metaverse, and Natural Language Processing.



Shah Muhammad Imtiyaj Uddin received his BSc in Computer Science and engineering from the World University of Bangladesh in 2017. Currently, he is pursuing his Master's in the Institute of Digital Anti-Aging Healthcare from Inje University. His research interests include Computer Vision, Machine Learning, and Deep Learning.



Muhammad Omair Khan is a Ph.D. student at the Institute of Digital Anti-aging and Healthcare at Inje University. His research interest's area Machine Learning, Deep Learning, including Image Processing, Logistics, and Natural Language Processing.



Hee-Cheol Kim Ph.D. at Numerical Analysis and Computing Science, at Stockholm University in Sweden. He is a professor and Head of Institute of the Digital Anti-aging Healthcare, Inje University, South Korea. His research interests include Machine learning, Text mining, Bioinformatics, Blockchain, Metaverse, and XAI for Finance.