AI Enabled Intelligent Traffic Management and Adaptive Transportation Systems for Congestion Reduction and Efficiency

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Abstract

This chapter explores the transformative potential of Artificial Intelligence (AI) in revolutionizing urban mobility through the integration of multimodal transport systems. As cities face escalating challenges of congestion, inefficiency, and limited accessibility, AI-driven solutions, such as predictive analytics, demand-responsive transport (DRT), and intelligent traffic management, offer innovative pathways for enhancing the efficiency and sustainability of urban transportation networks. The chapter delves into the role of AI in optimizing route planning, improving traffic flow, and enabling seamless mobility across various transport modes. Furthermore, the integration of autonomous vehicles, human-driven cars, and alternative transport services is examined within the framework of AI-enhanced traffic signal control and real-time decision-making. Key topics such as AI-powered Mobility as a Service (MaaS) platforms, real-time data analysis, and the role of predictive models in demand forecasting are discussed in depth. By addressing challenges like data privacy, system interoperability, and equitable access, this chapter outlines a roadmap for creating smart, adaptive transportation systems that are efficient, inclusive, and resilient to future urban mobility demands.

Keywords: Artificial Intelligence, Multimodal Transport, Demand-Responsive Transport, Mobility as a Service, Predictive Analytics, Intelligent Traffic Management

Introduction

Urban mobility has become one of the most pressing issues facing modern cities, as rapid population growth, economic development, and environmental concerns converge to strain existing transportation infrastructure [1]. Traffic congestion, inefficient public transit systems, and the inability to provide equitable access to mobility have significant social, economic, and environmental impacts [2]. In response, Artificial Intelligence (AI) has emerged as a key enabler of smart transportation systems, providing advanced solutions for enhancing efficiency, accessibility, and sustainability [3]. AI technologies such as predictive analytics, machine learning

algorithms, and real-time data processing are transforming how cities manage traffic, optimize routes, and integrate various modes of transport [4]. This chapter explores the application of AI in the development of adaptive, multimodal transportation networks designed to tackle urban mobility challenges while improving service delivery and overall system performance [5].

The rise of AI-driven systems within urban transport networks enables a more dynamic and responsive approach to traffic management [6]. Traditional transportation models, which rely on fixed schedules and rigid routing, are increasingly becoming outdated due to their inability to adapt to real-time changes in demand and environmental conditions [7]. AI, on the other hand, uses vast amounts of data from multiple sources—such as sensors, GPS devices, and connected vehicles to enable real-time adjustments in traffic flow, route planning, and service delivery [8]. Through predictive analytics, AI can forecast traffic patterns, detect congestion before it occurs, and recommend optimal routes for users, thereby reducing delays and improving overall efficiency [9]. By incorporating machine learning algorithms that continuously learn from new data, AI systems are becoming more adept at managing urban traffic in a manner that is both proactive and adaptive [10].

One of the most promising applications of AI in urban mobility is the integration of Mobility as a Service (MaaS) platforms, which provide users with a seamless, multimodal travel experience [11]. MaaS platforms combine various transport options, such as public transit, ride-hailing, bike-sharing, and even autonomous vehicles, into a single interface that offers personalized travel recommendations [12]. AI plays a crucial role in this integration by analyzing users' preferences, real-time travel conditions, and available modes of transport to suggest the most efficient and cost-effective travel routes [13]. These platforms enable users to plan, book, and pay for their journeys across different modes, all within one ecosystem, while AI continuously adapts to changing traffic conditions and personal needs [14]. This level of integration and personalization enhances convenience for commuters while reducing the environmental footprint of urban transport by promoting shared mobility solutions and reducing single-occupancy vehicle use [15].