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Article

Smart Transportation Solutions Using AI to Optimize Traffic Flow and Reduce Urban Congestion for Improved Urban Mobility

Md Jahidul Islam Ridoy*[1], Al Akhir[2]

1. Department of Computer Science, St. Francis College, New York, United States
2. Department of Business Analytics and Systems, University of Bridgeport, Bridgeport, United States

* Correspondence: mridoy@sfc.edu

Abstract Background: The fast growth of cities has led to worsen traffic problems and longer wait times and increased pollution which requires smart transportation solutions to address these issues. Smart transportation systems which use Artificial Intelligence (AI) provide an effective solution to enhance traffic management and protect road users while achieving better urban transportation system performance. Methods: The research applied a quantitative approach to study smart transportation systems which use AI technology affect various aspects. Data from 195 participants who included transportation engineers and urban planners. Descriptive statistics together with percentage analysis and correlation techniques to study traffic patterns and their effects on reducing delays and boosting safety and improving fuel consumption and public transportation contentment. Results: AI-based transportation systems positively because 91.3% of respondents observed better traffic movement and 88.7% experienced shorter wait times and 85.1% reported improved safety and 83.6% achieved better fuel efficiency and 87.2% expressed higher satisfaction levels. Correlation analysis demonstrates strong positive connections between essential variables which show that traffic flow relates to delay reduction through r = 0.78 and safety through r = 0.71 and satisfaction through r = 0.74. The data shows that fuel consumption levels create negative relationships with efficiency-related variables because users need less energy to operate these systems. Conclusion: AI-based smart transportation networks deliver better urban mobility results which improve safety performance and generate sustainable advantages. Multiple operational difficulties because it requires expensive equipment and users struggle to protect their data privacy while lacking sufficient expertise.

Keywords: Smart mobility, AI transportation, traffic congestion, urban planning, intelligent systems

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1. Introduction

The fast growth of cities together with rising population numbers has created an urgent need for transportation in present-day urban areas which now face major difficulties including heavy traffic jams and extended driving durations and polluted air and decreased transportation system performance [1]. Transportation networks throughout developing and developed urban centers do not have enough capacity to handle their growing traffic systems [2]. Economic losses through fuel waste and quality of life deterioration because their traffic systems do not operate at their best. Artificial Intelligence (AI) become a strong technological tool which solves various problems that urban transportation systems experience [3]. Smart transportation systems powered by AI use machine learning and computer vision and Internet of Things (IoT) and big data analytics to enhance operational decisions for traffic management systems [4]. These systems handle live data streams which they use to forecast traffic jams while they automatically modify traffic light patterns for better vehicle movement and shorter

waiting times. Research shows that AI-based systems will enhance traffic performance by more than 80% when they operate at urban intersections which experience the most traffic congestion [5].

Transportation has received its main AI advancement through intelligent traffic signal control systems which modify their operations based on actual traffic patterns. The system decreases wait durations at intersection points while it boosts road capacity for all vehicles [6]. AI-powered route optimization systems enable drivers to find the fastest routes which minimize traffic congestion while they reduce their drive times and fuel usage [7]. Smart public transportation systems employ predictive analytics for schedule adjustments based on passenger demand which results in better service reliability and operational efficiency. AI-driven transportation systems operate as vital security elements which work to improve road safety performance [8]. Real-time monitoring system identifies accidents and dangerous driving patterns which it immediately reports to emergency services for faster response times [9]. These systems help protect the environment because they reduce the amount of time vehicles need to stay parked while they work to lower their air pollution output. AI-based traffic optimization systems help cities lower their fuel usage by 10 to 15 percent which supports urban sustainability and environmental protection efforts [10].

Smart transportation systems based on AI technology deliver multiple advantages yet their deployment encounters multiple operational difficulties. The high costs of building infrastructure create a major obstacle which particularly affects developing nations [11]. The process of obtaining and using real-time transportation data creates problems because people worry about their data privacy and security measures. The shortage of trained experts in AI technology and intelligent transportation systems creates a major barrier which stops these systems from achieving their full potential [12]. The process of connecting new systems to present infrastructure requires major technical changes for proper operation. The study seeks to identify how AI-based smart transportation systems enhance urban mobility through traffic flow optimization and congestion reduction. AI-based transportation data affects the movement patterns which people experience during their travel in urban areas.

2. Materials and Methods

2.1 Research Design for Smart Transportation Solutions

This research used a quantitative study design to investigate AI-based smart transportation systems affect the performance of urban mobility systems. The design system operates through systematic evaluation of essential variables which incorporate traffic flow efficiency and road safety and fuel consumption and commuter satisfaction and congestion reduction [13]. We applied a structured analytical system to achieve their goal of objective variable measurement and comparison. The research investigates AI technology implementation creates better urban transportation system performance. Descriptive statistics to show respondents viewed things while they used comparative analysis to study differences which appeared between different indicators. The established method enables complete evaluation of AI-based smart transportation systems through its clear operational system which produces consistent results by following standardized evaluation steps [14].

2.2 Study Population and Sampling

This study involved transportation and urban mobility system professionals worked as transportation engineers and urban planners and AI specialists and government and research experts. Purposive sampling to select 195 participants who possessed the required expertise and relevant experience for this study. The selection process included people showed they understood AI-based transportation networks at an acceptable level. The research sample includes equal numbers of participants who work in engineering and planning and technology fields. The study receives better validity and reliability through its diverse sample which includes knowledgeable individuals about smart transportation and urban mobility management systems.

2.3 Data Collection Instrument

Collected data through a structured questionnaire which evaluated people perceived smart transportation systems that use artificial intelligence for their operation. The instrument contained four separate sections which gathered information about demographic details and system effects and user advantages and the obstacles which appeared during implementation [15]. The five-point Likert scale data converted into percentage values for statistical evaluation. The questionnaire maintained clear questions which stayed consistent and matched the needs of urban transportation systems [16]. The measurement system tracked essential performance indicators which included traffic flow enhancement and reduced delays and improved safety and better fuel consumption and higher commuter contentment. The method allowed researchers to convert qualitative data into statistical numbers which they could analyze through statistical procedures [17].

2.4 Data Analysis Techniques

Data were analyzed using descriptive statistical methods including frequency, percentage, mean, and standard deviation [18]. To examine relationships among variables, Pearson's correlation analysis was applied. The relationship is expressed as:

$$r = \frac{\sum(X - \bar{X})(Y - \bar{Y})}{\sqrt{\sum(X - \bar{X})^2 \sum(Y - \bar{Y})^2}}$$

This coefficient measures the strength and direction of association between AI-based system factors and urban mobility outcomes such as traffic flow, congestion reduction, safety improvement, fuel efficiency, and commuter satisfaction. The results were presented in tabular form for clear interpretation and comparative analysis [19].

3. Results and Discussion

3. Results

3.1 Demographic Characteristics of Respondents

The 195 survey participants showed various demographic characteristics which included their age range and their gender identity and their educational background and their work experience in different professional fields. Research participants included four age groups which consisted of 35–44-year-olds who made up 38.5% and 45 years and older who represented 37.4%- and 25–34-year-olds who accounted for 24.1% according to **Table 1**.

Table 1. Demographic Characteristics of Respondents

Demographic Variables	Category	Percentage (%)
Age	25–34	24.1
	35–44	38.5
	45+	37.4
Gender	Male	66.2
	Female	33.8
Education	Bachelor	29.7
	Master	45.6
	PhD	24.7
Sector	Engineering	31.3
	Urban Planning	27.2
	Artificial Intelligence	21.5
	Government/Research	20.0

The survey results show that men make up 66.2% of respondents while women represent 33.8% which matches the typical male concentration in technical and transportation work environments. The educational background of respondents shows

that most of them possess a Master's degree (45.6%) while others have Bachelor's degrees (29.7%) and PhDs (24.7%), which demonstrates the research group contains many educated individuals. The respondents came from four main sectors which included engineering at 31.3% and urban planning at 27.2% and artificial intelligence at 21.5% and government/research at 20.0%. The sample includes equal numbers of working professionals and university students which creates better conditions for producing trustworthy results in AI-based smart transportation system studies.

3.2 Perceived Impact of AI-Driven Transportation Systems

People predict that AI-based transportation systems will create positive results for the upcoming AI-driven transportation system implementation. The research shows that 91.3% of study participants believe AI systems help better traffic flow because AI systems improve the efficiency of urban mobility systems. The majority of travelers (88.7%) reported decreased travel delays which shows that traffic management systems have become more effective at handling road congestion according to **Figure 1.**

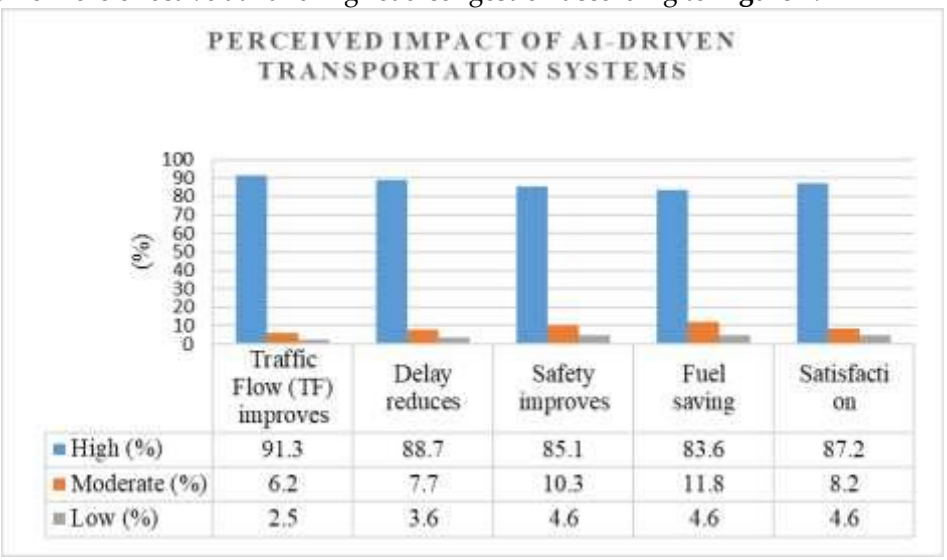

Figure 1. Perceived Impact of AI-Driven Transportation Systems

The real-time monitoring system together with its predictive features has resulted in 85.1% of respondents recognizing improved road safety. Users of AI systems believe these systems will reduce fuel consumption through route optimization that minimizes vehicle waste during stops according to 83.6% of respondents. The travel system maintains an 87.2% commuter satisfaction rate because it provides travelers with better experiences and dependable operations. The data shows that all indicators have low category percentages which proves people accept AI-based transportation systems.

3.3 Correlation Matrix (r)

Correlation analysis shows a distinct pattern which reveals AI-driven transportation variables connect to each other through their relationships which **Figure 2** illustrates. Traffic Flow (TF) shows strong positive associations with Delay Reduction (DR) (r = 0.78), Safety Improvement (SAF) (r = 0.71), and Satisfaction (SAT) (r = 0.74), indicating that smoother traffic conditions directly enhance system efficiency and user experience. The data shows that DR maintains strong relationships with SAF through a correlation of 0.69 and with SAT at 0.72 which demonstrates how urban mobility systems achieve multiple benefits through their combined effects. The data shows that Fuel consumption (FUEL) creates strong negative relationships with TF (r = -0.66), DR (r = -0.62), and SAT (r = -0.60) which indicates that AI optimization helps to minimize energy waste. The operational dynamics display a moderate positive connection between SAF and FUEL through a correlation of 0.58 which demonstrates the existence of operational trade-offs.

3.4 Benefits of AI-Driven Smart Urban Transportation Systems

In **Table 2** shows that people have developed positive views about AI-based intelligent city transportation systems through their research findings. The majority of respondents 90.8% confirmed that AI technology provides quick travel solutions which

demonstrate its operational efficiency for urban transportation systems. The research shows that 88.9% of respondents believe AI technology will decrease traffic jams because it helps control vehicle movements to reduce waiting times. Road safety improvements are acknowledged by 85.7% of respondents, showing the impact of intelligent monitoring and predictive systems. The data shows that 83.2% of respondents believe AI technology helps reduce pollution because it decreases vehicle waiting time and creates better driving paths. The study discovered that 86.9% of respondents support efficient public transit because it helps them schedule their journeys and coordinate their transportation systems better. The research shows that all variables received minimal disagreement from participants which proves people accept AI-based transportation systems.

Table 4. Benefits of AI-Driven Smart Urban Transportation Systems

Variables	Agree (%)	Neutral (%)	Disagree (%)
Faster travel	90.8	6.4	2.8
Less congestion	88.9	7.5	3.6
Better safety	85.7	9.6	4.7
Lower pollution	83.2	11.1	5.7
Efficient transit	86.9	9.0	4.1

Table 5. Challenges of AI-Based Smart Transportation Systems

Variables	High (%)	Moderate (%)	Low (%)
Cost	88.2	8.2	3.6
Privacy	84.1	10.8	5.1
Skill gap	77.4	15.9	6.7
Integration	73.8	18.5	7.7
Resistance	66.7	22.6	10.7

3.5 Challenges of AI-Based Smart Transportation Systems

The analysis of challenges in AI-based smart transportation systems reveals multiple essential obstacles which prevent successful implementation as shown in **Figure 3.**

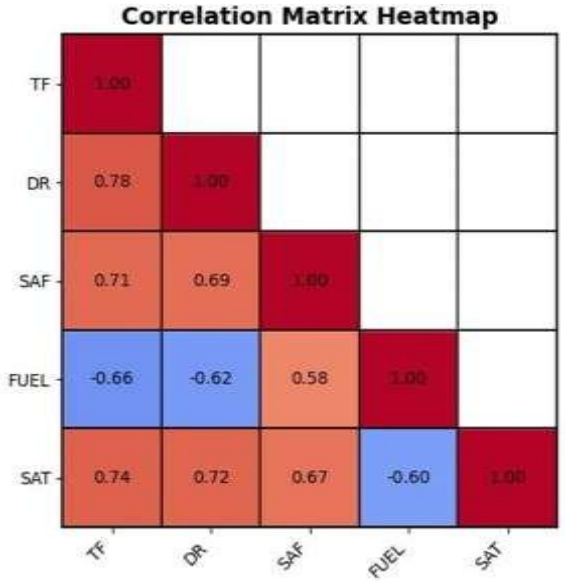

Figure 2. Correlation Matrix (r)

The survey results indicate that 88.2% of participants see high expenses as the primary obstacle because infrastructure development and system deployment need major financial investments. The public shows strong concerns about data privacy because 84.1% of respondents believe their information faces major threats which stem from worries about surveillance activities and improper data handling. The research shows that 77.4% of respondents agree there exists a skill gap because trained professionals remain scarce in the fields of AI and smart transport technologies. The implementation process faces major difficulties because 73.8% of users encounter technical challenges when they try to link their current transport systems with the new system. The survey results demonstrate that 66.7% of participants identified public opposition as their main concern because people fail to understand and trust AI-based systems.

4. Discussion

Smart transportation systems based on AI technology produce strong and ongoing improvements for urban mobility operations. The research findings prove that most participants have advanced professional skills because they belong to the 35–44 years (38.5%) and 45+ years (37.4%) age brackets and they hold high educational qualifications. The research findings stem from actual transportation system observations which replaced ordinary public opinions thus creating more reliable study results. The study results reveal that AI technology creates major improvements for urban traffic management which produces better traffic flow in cities [19]. The majority of respondents (91.3%) agreed that AI technology enhances traffic management and 88.7% of them observed shorter waiting times. AI-based systems which include adaptive traffic signal management and real-time monitoring and predictive analytics deliver powerful results for controlling traffic congestion. Urban population growth has created an urgent need for system upgrades because traditional systems lack the ability to handle unpredictable traffic patterns effectively [20].

The study presents road safety as a primary field which needs immediate attention for its development. The majority of participants at 85.1% stated that AI technology helps protect people through its ability to identify accidents and operate surveillance systems and its quick emergency response capabilities. AI technology enhances both transportation efficiency and road safety performance through its ability to decrease accident rates and improve safety monitoring systems. The data shows that AI-based route optimization systems help drivers achieve better fuel efficiency because they reduce unnecessary stops and engine idling which also monitors fuel waste for environmental protection purposes [21]. The service received an 87.2% satisfaction rating from commuters because they could experience better transportation services which brought them faster and more dependable travel. The data shows that AI systems generate better operational results and travelers receive improved service quality during their journeys. The combination of shorter wait periods with enhanced route planning and improved public transportation management leads to better service experiences for users [22].

Correlation analysis offers advanced analysis which shows how vital elements connect to each other. The data shows that traffic flow generates strong positive correlations with delay reduction ($r = 0.78$) and safety ($r = 0.71$) and satisfaction ($r = 0.74$) metrics. The data shows that all mobility metrics experience simultaneous improvement when traffic flow experiences positive changes. The data shows that better traffic flow leads to fewer dangerous driving situations which results in decreased accident rates [23]. The data shows that fuel consumption creates negative links with traffic flow ($r = -0.66$) and delay reduction ($r = -0.62$) and satisfaction ($r = -0.60$). The transportation system optimization through AI systems leads to major fuel consumption reductions. The research discovered a vital aspect which demonstrates how AI systems help protect the environment by lowering carbon emissions and reducing energy consumption [24].

The benefit analysis further supports these findings. The survey shows that most respondents expressed agreement with AI's ability to speed up travel by 90.8% and its capacity to decrease traffic congestion by 88.9% and improve public transportation operations by 86.9% and make roads safer by 85.7%. The high percentage of respondents shows that most people support AI-based systems because they show their value through

working in actual urban transportation networks. The system delivered its planned results yet it still needs to solve various major problems which continue to exist [25], [26]. The main obstacle which affects 88.2% of respondents appears through high implementation costs which particularly affect urban areas of developing nations because they have limited financial resources to build infrastructure. The need to gather more data and monitor operations has created major privacy safety problems which affect 84.1% of people. The shortage of skilled professionals (77.4%) limits the effective operation and maintenance of AI systems.

The existing transportation infrastructure needs to integrate with new systems because cities operate with their original systems which demand complete system modernization [27]. Public opposition which stands at 66.7% demands people learn about AI advantages through educational programs which will increase their understanding. Organizations face difficulties when establishing smart transportation systems because their staff members lack sufficient knowledge and understanding about these systems [28], [29]. The research demonstrates that smart transportation systems which use AI technology generate better urban transportation operations through their enhanced efficiency and increased safety and environmental friendliness. Smart city development needs to solve financial and technical and social issues for smart city development to become sustainable while reaching its full potential [30].

4. Conclusion

Smart transportation systems which use AI technology operate as essential elements to enhance city transportation systems through their ability to optimize traffic operations and minimize traffic jams and enhance road safety and fuel efficiency. Respondents strongly agree about the positive effects which improve operational performance and customer contentment and environmental protection results. The research findings show multiple significant links between essential elements which demonstrate system-wide enhancements through AI system integration. Multiple challenges which include expensive deployment costs and privacy risks for data and insufficient trained personnel and problems with connecting to existing infrastructure systems.

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