The Current Practice Applications of Artificial Intelligence to Improve Traffic Flow During Roadside Construction at Jalan Batu Pahat-Ayer Hitam- Kluang FT050

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Abstract

In a traffic study done in 2020, it was discovered that there was 28,298 traffic in 16 hours and 2,279 traffic between the hours of 5 and 6 pm. Compared to other locations in the same district, the quantity of traffic on Jalan Kluang is the greatest in Batu Pahat. Higher incomes lead to more travel and car ownership, while growing commercial activity adds to service and freight traffic. These trends contribute to widespread traffic congestion, causing increased costs and productivity losses. The research objectives are to investigate current practices of Artificial Intelligence (AI) usage in traffic flow during roadside construction in Jalan Kluang, investigate factors of Artificial Intelligence (AI) usage in traffic flow during road construction in Jalan Kluang, and to determine challenges the adoption of Artificial Intelligence (AI) in traffic flow. In order to collect data for the study, a variety of primary and secondary methods are used, including literature reviews and interviews. Using the Google Meet application, three respondents from various agencies JKR Malaysia, Muda Consult Sdn Bhd and Aktif Unggul Sdn Bhd were interviewed as part of the qualitative approach. The research utilized a content analysis methodology to methodically evaluate the remarks provided by respondents, exposing the current applications of artificial intelligence (AI) for traffic flow management during roadside construction on Jalan Kluang. As a result of the research, respondents demonstrated the effectiveness of AI is in reducing traffic congestion in these kinds of scenarios such as Intelligent Transportation System (ITS) and machine learning and IOT. From the perspectives of these three respondents, it can be concluded that reducing risk, minimize time travel and lessen the traffic congestion are the main factors of artificial intelligence (AI) usage in traffic flow in Jalan Kluang. The study also found the main obstacles to the adoption of Artificial Intelligence (AI) in traffic flow during roadside construction at Jalan Kluang are high cost in installation with maintenance and for a smaller city, it might not practical require huge amounts of data to function effectively.

1. Introduction

Roads serve as crucial communication channels, connecting locations and facilitating traffic flow. Road construction and maintenance activities are necessary to ensure a balance between traffic services and consumer safety. In Malaysia, the Public Work Department is responsible for providing federal roads and bridge infrastructure, aiming to meet the nation's growing demands and ensure proper maintenance, repair, and upgrades for safer usage. Road development in Malaysia predates its independence, with major cities already connected by road systems before 1957. Since independence, the road infrastructure has been consistently improved through careful planning, particularly through the Malaysia Plan introduced every five years. Road construction is primarily the responsibility of the Federal and State Governments, but private corporations have also started building toll roads with government permission to impose tolls as an alternative to existing road systems (Zulkafli, 2015).

1.1 Research Background

Malaysian Federal Route 50, FT050 is a federal route located in Johor, Malaysia. It starts from Batu Pahat to Jemaluang in Mersing district. The Federal Route 50's Kilometre Zero is situated at Batu Pahat, close to Mount Soga, at its intersection with the Federal Route 5, the principal thoroughfare along Peninsular Malaysia's west coast. Based on Special Area Plan (RKK) Bandar Penggaram 2015-2025, the function of three major roads linking the city and the surrounding area, such as Jalan Bakau Condong, Jalan Kluang, and Jalan Bukit Pasir, provides convincing evidence of a hierarchical road system in the studied area. These three roads function as an arterial route that connects to the highway in terms of the system's apparent hierarchical organization of the road network. The demand for urban road traffic is growing as urbanization and development progress, and traffic congestion in major cities is getting worse and worse. It is necessary to increase investment in the development of intelligent transportation systems and create roads that can support urban roads while carefully planning the urban road network using the transportation informatization construction framework, development plan, and technical standards of the transportation department to address the various issues with urban road traffic, especially the problem of road traffic in the old city that is prone to traffic congestion.

1.2 Problem Statements

In a traffic study done in 2020, it was discovered that there was 28,298 traffic in 16 hours and 2,279 traffic between the hours of 5 and 6 pm. Compared to other locations in the same district, the quantity of traffic on this road is the greatest in Batu Pahat. During the road maintenance work, it is typical to only close the lane where work needs to be done and direct moving cars to the open lane. The length of this maintenance may range from a few hours to a few weeks, depending on the nature of the task and the site's circumstances. Reducing the negative impact of work zones on traffic flow and creating a safe environment for employees and motorists is one of the issues encountered by transportation officials and road maintenance contractors regarding work zones. Ineffective traffic operation control in work zone regions can result in long traffic jams, more forced merges, and a higher risk of traffic accidents (Shakouri, 2014). While waiting for roadside places to move, some vehicles must temporarily double park or circle the network of roadways. These behaviours disrupt traffic flow, result in needless obstacles, and endanger the safety of other road users (Ho *et al*., 2019). In concern of intersection with heavy traffic where accident and traffic jams are frequently occurred, basic traffic lights are insufficient to distribute the traffic flow. This persistent problem has a number of recurring causes, including peak-hour traffic congestion. traffic accidents, stopped automobile, roadside work, or poor weather conditions can all cause incidents (Elsahly, 2022). Therefore, this research is conducted to investigate the potential application of Artificial Intelligence (AI) to improve the traffic flow during roadside construction at Jalan Kluang.

1.3 Research Question

These are a few research questions that have been established in accordance with the research statement;

(i)   What are the current practices of Artificial Intelligence (AI) usage in traffic flow during road construction in Jalan Kluang?
(ii) What are the factors of Artificial Intelligence (AI) in traffic flow during road construction in Jalan Kluang?
(iii) What are the challenges related to the adoption of Artificial Intelligence in traffic flow during roadside construction in Jalan Kluang?

1.4 Research Objectives

Objective of this study are:

(i) To investigate current practices of Artificial Intelligence (AI) usage in traffic flow during roadside construction in Jalan Kluang.

(ii) To investigate factors of Artificial Intelligence (AI) usage in traffic flow during road construction in Jalan Kluang.

(iii) To determine challenges to the adoption of Artificial Intelligence (AI) in traffic flow during roadside construction in Jalan Kluang.

1.5 Scope of Study

This study was conducted to enhance traffic flow and driving safety during roadside construction via Artificial Intelligence (AI) at Jalan Kluang, Batu Pahat. The study area has been carried out on Jalan Kluang, Batu Pahat. Three targeted respondents were selected as respondent for this research which are traffic officer from contractor company, senior design engineer from consultant company and road engineer from Malaysian Public Work Department as the client of this project Jalan Kluang FT050 project. The most appropriate individuals to interview for finding out more about potential applications of artificial intelligence for improving traffic flow during roadside construction are senior design engineer, traffic officer, and road engineers. These people are extremely knowledgeable and skilled in managing construction projects and handling the challenges of managing traffic in construction zones (Naser, 2022). Methodology to be used in this study is qualitative method.

1.6 Significance of Study

This study is important for a variety of parties, including institution, the community, the environment, and other relevant stakeholders. In the context of education, it develops research in data analytics, computer vision, machine learning, and AI algorithms while examining new possibilities of AI in the fields of transportation and civil engineering. By facilitating better traffic flow and minimizing disruptions during roadside maintenance, the study's findings can benefit the community by boosting economic activity, raising satisfaction levels, and raising living standards. By reducing traffic, air pollution, and greenhouse gas emissions, AI-driven traffic management can improve the environment. Finally, by putting safety first, contributors can align with community satisfaction, and using data-driven decision-making to accomplish their objective.

2. Literature Review

Roadside construction zones might change the shape of the road, impact traffic volumes and flows, and alter driving conditions by, for instance, reducing visibility or producing abrupt traffic jams due to lane closures (Sofi, 2021). In order to maintain and improve driveway systems across the world, a variety of work zone operations, such as building, maintenance, and rehabilitation, are essential. The particular road conditions of these activities should be provided; however, it can enhance the risk of accidents. For instance, the necessity of lane closure or lane shifting in work zones may increase the frequency of certain collision types. In addition to the indicator factors (such as drivers' traits, road conditions, environmental circumstances, etc.) that have been used to assess injury-severity outside of work zones, specific conditions in work zones may have an impact on the safety of drivers and occupants (Yu, 2020). Therefore, Artificial intelligence (AI) is being widely discussed as a solution for improving various sectors, including traffic management. AI technologies, such as computer vision, can enhance driving safety by preventing crashes and helping vehicles stay in their lanes. Many countries and companies are investing in AI to gain a competitive edge. Implementing AI in traffic management during construction zones can potentially improve road safety and optimize traffic flow (Sarker, 2022).

2.1 Definition

(a) Road Construction

Roadside maintenance refers to the activities and efforts undertaken to ensure the proper upkeep, repair, and management of roadside infrastructure and features, such as roadsides, shoulders, signage, vegetation, drainage systems, and safety barriers. It involves routine inspections, repairs, and improvements to maintain the functionality, safety, and aesthetics of the roadside environment (Singh, 2023).

(b) Traffic Flow

According to Abhishek (2016), traffic flow is defined as the volume of cars passing through a certain highway recording station in a given time period. Prediction of traffic flow is based on traffic data that is gathered from a variety of sensors, including inductive loops, radars, cameras, mobile Global Positioning Systems, and social media in both the past and present. We have reached the era of big data transportation and new coming traffic sensor technologies (Lv, 2014).

(c) Artificial Intelligence

In this big data era, artificial intelligence (AI) is the most significant area in computer science. 50 years after its inception, artificial intelligence (AI) has come a long way and made promising strides, particularly in the fields of machine learning, data mining, computer vision, expert systems, natural language processing, robotics, and related applications (Shi, 2019).

2.2 Artificial Intelligence in Overseas and Malaysia

(a) Artificial Intelligence usage in Overseas

In 2000, U.S. Department of Transportation reported significant socioeconomic impacts of traffic congestion, including 3.6 billion hours of delays and 5.7 billion gallons of lost fuel. The rise of Intelligent Transportation Systems (ITS) integrates sensor and wireless tech for more efficient traffic management. The City of Tampa's Smart Mobility Division, as of 2023, still relies on resources like CCTV networks, news feeds, and telephone systems to monitor traffic accidents. However, with the system's growth, they found it challenging to keep up, leading them to adopt Artificial Intelligence (AI) for more efficient traffic monitoring. According to the Smart Mobility Manager, AI can recognize unreported incidents 60% of the time and respond to emergencies in less than 20 minutes (Leigh, 2023). In 2021, AI sensors were integrated into Vivacity cameras, enabling recognition of diverse road users. These sensors dynamically adjust traffic signal timings based on tracked driver behavior, aiming to reduce congestion and improve air quality. The gathered information informs future initiatives and actions, as highlighted by Neill (2021).

(b)   Artificial Intelligence Usages in Malaysia

In Malaysia, traffic management systems are rapidly using artificial intelligence (AI) to increase productivity, security, and mobility. Here are a few instances of Malaysian traffic control using artificial intelligence which is Intelligent Traffic Signal Control is using data from the current traffic flow, AI is used to optimise the timing of traffic signals. To lessen congestion, cut down on delays, and improve overall traffic flow, AI systems analyse the incoming traffic data from numerous sensors and modify signal timings accordingly (Chai,2019). Intelligent Transportation Systems is use to monitor and control traffic conditions, intelligent transportation systems incorporate diverse technologies such as cameras, sensors, and data analytics. AI algorithms examine the gathered data to give traffic control authority real-time traffic data, route optimisation, and decision support (Zainal,2017).

2.3 Current Practices of Artificial Intelligence (AI) usage in Traffic Flow During Roadside Construction

Based on previous study, there are so many factors that causes artificial usage in traffic congestion. Artificial intelligence research and development is advancing quickly, opening up countless prospects to boost company and industry productivity, particularly in the transportation sector. Advanced computational intelligence is one breakthrough brought forth by artificial intelligence. A technique known as computational intelligence mimics the way the human brain functions. The transportation industry has many difficulties, but the use of artificial intelligence has greatly helped to ease these difficulties. Table 2.2 in appendix B shows factors of Artificial Intelligence (AI) in traffic flow during roadside construction from the previous literature. In 2021s, Chan pointed that, in order to shorten the travel times of vehicles, many hours have been spent investigating strategies to predict traffic congestion and provide drivers a more effective path by using traffic prediction using artificial Intelligence (AI). Long-term construction zones on city streets cause a number of issues, including reduced capacity, increased travel time delays, queue length, fuel consumption, and traffic accidents that result in unreported economic losses as a result, the number of lanes decreases from three in the non-work zone area to two in the work zone to one station work zone area owing to long-term development (Chan,2021).

2.4 Factors of Artificial Intelligence (AI) Usage in Traffic Flow During Roadside Construction

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2.5 Challenges in the adoption of Artificial Intelligence (AI) in Traffic Flow during Roadside Construction

In the Fourth Industrial Revolution (Industry 4.0 or 4IR), artificial intelligence (AI) is a key technology that may incorporate human behaviour and intellect into devices or systems. To create automated, intelligent, and smart systems that meet today's demands, therefore AI-based modeling is essential. Different forms of AI, including analytical, functional, interactive, textual, and visual AI, can be used to improve the intelligence and capabilities of an application to address real-world problems. However, because real-world issues and data are dynamic and variable, creating an effective AI model is a difficult endeavor (Sarker, 2022). From Table 2.3, we can conclude that there are various challenges in the adoption of artificial intelligence in traffic flow during roadside construction. Based on Alsheibani *et al*. (2018) state that three key factors that affect the adoption of AI are technology readiness, organizational readiness, and environmental readiness (environmental conditions including government restrictions). Hiring qualified staff, depending on outside partners, and infrastructure expenditures are possible additional challenges. Therefore, a deeper knowledge of the various processes that influence an organization's ability to adopt AI and subsequently establish an AI competence is necessary. Given that AI necessitates collaboration between workers in various business units to produce AI applications, more research should be done on the socio-technical setup and the procedures involved in creating and implementing AI applications. (2019, Holton).

3. Research Methodology

Figure 3.1 in Appendix B is a form of flowchart that shows the overall research process. This process must be followed in order to do efficient research. In addition, this research stream overview can assist professionals in initiating the process by providing them with the appropriate guidance. The study is organized into five main phases, each of which is essential to the whole investigation process. The first stage of the research process involves defining the problem statement, research objectives, and study parameters. This leads to the development of specific research questions, objectives, and problem statements. In order to build a solid foundation of knowledge on the topic, Stage 2 then comprises a thorough literature study, where academic sources including earlier research, news articles, and books are examined. In Stage 3, the focus is on collecting data carefully using semi-structured interviews. Primary data is collected directly from chosen respondents, while secondary data is gathered from credible websites, books, journals, newspapers, and previous research. In order to thoroughly categorize and classify the data in order to identify patterns, themes, and linkages, the research employs content analysis as a qualitative approach in Stage 4. Stage 5, which concludes the research project, involves summarizing the results, drawing conclusions, and offering suggestions for further study based on the data gathered. In order to provide an in-depth understanding of the state of the field, this step also entails a comparison of the findings with those of previous studies.

3.1 Data Collection

In research tradition, qualitative and quantitative research methodologies are the two most commonly used. When a phenomenon needs to be measured, the theory needs to be tested, and generalization needs to be made, researchers apply quantitative research. When researchers need to work with words and visuals, researchers turn to qualitative research. The utilization of interviews, which enables qualitative researchers to perform in-depth investigations into their subject of inquiry, is the strength of qualitative research (Aborisade, 2013). Primary data for this study will be gathered qualitatively using semi-structured interviews that will be held with respondents to gather information. The survey questions will mostly focus on the objectives of the studySpecific research designs such as description of research methodology selection, research population, research sampling, research instrument, and research flow process need to be explained clearly.

3.2 Data Analysis

Data analysis involves gathering, modelling, and analysing data using a range of statistical and logical techniques. Data should be processed and analysed using an established technique after data collection in order to provide a research design. The unstructured method of research is typically categorized as qualitative research. This strategy offers for flexibility throughout the entire study process. Instead than quantifying a problem, issue, or phenomena, it is preferable to examine its nature (Goundar, 2012).

4. Result and Discussion

The results and discussion section present data and analysis of the study. This section can be organized based on the stated objectives, the chronological timeline, different case groupings, different experimental configurations, or any logical order as deemed appropriate.

4.1 Results

The background details of the respondents who participated in the study through interviews with the researcher is displayed in Table 1. Table 1 layout the respondents' demographics and knowledge. Based on the respondents' job titles, educational backgrounds, and work experiences, it is reasonable to assume that most respondents are knowledgeable with activities related to Jalan Kluang's road construction project. Government and public organizations made up the respondents in this survey.

Table 1 *Background of Respondents*

Number of respondents	Position	Work experience in industry (years)	Work experience in road construction (Years)
Respondent A	Traffic officer	15	3
Respondent B	Engineer	8	4
Respondent C	Senior Design Engineer	8	5

4.2 Part A: Roadside Construction Project in Jalan Kluang

The research's particular population of interest is respondents with direct experience with road construction project in Jalan Kluang. By interviewing those with real-world experience and intimate understanding of the difficulties involved in such construction projects, the aim is to determine the legitimacy and applicability of the questions. The study aims to obtain context-specific and complex information from respondents who have experience with road construction in Jalan Kluang. This approach can improve the overall quality and application of the research findings. Table 4.2 shows that all respondents has worked on roadside construction project at Jalan Kluang FT050.

4.3 Part B: Current Practices of Artificial Intelligence (AI) Usage in Traffic Flow in Jalan Kluang

Based on Table below, Respondent A highlights that the actively utilized AI practice in Malaysia is the implementation of Intelligent Transportation Systems.

"Yes, I'm quite familiar with Artificial Intelligence (AI) usage such as Intelligence Transportation System (ITS) which it aims to improve the sustainability, safety, and efficiency of transportation networks by the full use of new technologies, including artificial intelligence but in Jalan Kluang project we have not implement any artificial intelligence system yet. …" (Respondent A)

On the other hand, Respondent B provides a different response but with a similar meaning by stating:

"Yes, there is no application of artificial intelligence in traffic flow. I do not have any practical experience, but from my point of view Artificial Intelligence (AI) facilitates smooth communication between linked cars and traffic infrastructure in smart cities. Vehicles provide the traffic control system with real-time information about their location and speed as they approach intersections...." (Respondent B)

Respondent C offers a different point of view in their response, offering a departing perspective. Even though they had different opinions, the general idea is in line with the main idea or message.

"For this road, we did not implement any Artificial Intelligence. Even though I may not have experience using AI in traffic flow management. The Intelligent Transportation System (ITMS) data is further enhanced with the addition of Internet of Things (IoT) devices, such as linked cars and smart sensors incorporated into roads. Real-time data on traffic density, vehicle speeds, and environmental conditions can be obtained from these Internet of Things devices...." (Respondent C)

Table 2 *Current Practices of Artificial Intelligence (AI) Usage in Traffic Flow*

Current Practices of Artificial Intelligence (AI)	Explanation	Respondent
Current Practices	• No Implementation of AI	R1
	• Currently using a conventional method	R2
	• AI is still not use in current practices	R3

4.4 Part C: Factors of Artificial Intelligence (AI) usage in Traffic Flow during Roadside Construction in Jalan Kluang

Based on Table 3, respondent A stated that the main factor of main factor of Artificial Intelligence (AI) in traffic flow during roadside construction in Jalan Kluang is to to prioritize the safety of both road users and construction workers.

"In order to prioritize the safety of both road users and construction workers, I think we should integrate artificial intelligence (AI) into traffic flow management during roadside construction. This skill makes it possible to take preventative action, which lowers the hazards that come with construction work on public roads. Some drivers' careless actions are to blame for the accidents that occur when roads are being constructed. These drivers' reckless behaviour, which includes disobeying speed limits, missing marked diversions, and ignoring signage, puts both themselves and the construction workers on the site at serious risk......." (Respondent A)

Respondent B presents an alternative viewpoint in their statement. Despite their divergent viewpoints, the overall concept aligns with the main idea.

"In my opinion, the need to minimize travel time and prevent delays during roadside construction in Jalan Kluang is the main driving force behind the application of artificial intelligence (AI) in traffic flow management. Making traffic flow smoother is the main goal in order to provide a transportation network that is more effective and efficient in terms of time since the road is busy with construction work. By cutting travel times, this strategy not only helps road users but also improves the overall operating effectiveness of transportation networks." (Respondent B)

Respondent C presents an alternative viewpoint in their statement. Despite their divergent viewpoints, the overall concept aligns with the main idea.

"I think the main factors of integrating artificial intelligence (AI) into traffic flow management, from the perspective of a design engineer, is the urgent need to lessen and control traffic congestion in a variety of scenarios. Specifically, the integration of AI becomes especially important in rural regions like Jalan Kluang, where the infrastructure is defined by simplicity, with simple traffic signal systems acting as the base......" (Respondent C)

From the perspectives of these three respondents, it can be concluded that reducing risk, minimize time travel and lessen the traffic congestion are the main factors of artificial intelligence (ai) usage in traffic flow in Jalan Kluang.

Table 3 *Factors of Artificial Intelligence (AI) Usage in Traffic Flow*

Respondent	Factors of Artificial Intelligence Usage	Explanation

		(AI) in Traffic Flow
Respondent A	Main factor	Lower risk such as traffic accident for both vehicles and construction workers
Respondent B		Need to minimize travel time and prevent delays
Respondent C		lessen and control traffic congestion in a variety of scenarios

4.4.2 Enhance Safety and Reduce Risk

Based on Table 4, All respondents are agreed that the adoption of Artificial Intelligence (AI) in traffic flow can enhance safety between road user and roadside construction worker. Respondent A believe that reduce risk as traffic accident for both vehicles and construction workers include variable speed limits and dynamic lane closures is one of the factors of Artificial Intelligence (AI) in traffic flow at Jalan Kluang FT050.

"Yes. artificial intelligence, in my opinion, has a lot to offer in terms of controlling traffic in and around construction areas. It would revolutionize the field. Adaptive strategies that lower risk such as traffic accident for both vehicles and construction workers include variable speed limits and dynamic lane closures. Not only is efficiency important, but road safety is also important when work is still ongoing, I think with Artificial Intelligence (AI), we can avoid any risk during the roadside construction project. From there, we can provide a safer environment for drivers or road user and also road construction workers" (Respondent A)

Table 4 *Respondent's perspectives on enhance safety and reduce risk*

Factors of Artificial Intelligence (AI) Usage In Traffic Flow	Explanation	Respondent
Enhance Safety and Reduce Risk	• Reduce risk as traffic accident for both vehicles and construction workers	R1
	• Increase highway safety for workers	R2
	• Decrease the chance of traffic accidents	R3

4.4.3 Reduce Time Travel and Avoid Delay

In 2021s, Chan pointed out that, to shorten the travel times of vehicles, many hours have been spent investigating strategies to predict traffic congestion and provide drivers with a more effective path by using traffic prediction using Artificial Intelligence (AI). Table 5 below shows the respondent's perspectives on reduce time travel and avoid delay.

"Due to artificial intelligence (AI) dynamic nature, route suggestions, lane layouts, and traffic signals may all be changed in real-time to adapt to changing circumstances. By providing best routes based on current traffic circumstances, AI-driven navigation systems help to reduce delays. Further highlighting AI's contribution to responsive and effective traffic flow are adaptive decision-making, preventive incident management, and effective signal timing. In the end, AI is a potent ally in the fight to reduce travel delays and improve overall transportation efficiency because of its capacity to process and respond to real-time data." (Respondent B)

Table 5 *Respondent's perspectives on reduce time travel and avoid delay*

Factors of Artificial Intelligence (AI) Usage In Traffic Flow	Explanation	Respondent

Reduce Time Travel and Avoid Delay	• To recommend other routes to drivers when congestion is anticipated	R1
	• Shorten the travel times of vehicles	R2
	• Decrease time travel delay	R3

4.4.4 Reduce Air Pollution

In Table 6, Respondent A and B believed that Artificial Intelligence are able to help reducing air pollution during roadside construction while Respondent B has a different point of view by stated that:

"In my opinion, air pollution is not the factor of artificial intelligence (AI) usage in traffic flow during roadside construction. Road construction has small percentage contribute to air pollution, it is possible that adoption of AI is not primarily motivated by concerns about the environment, particularly air quality. Rather, other variables like cost-effectiveness, efficiency, or technological improvements are probably what are driving this domain's concentration on AI, which indicates a prioritization of criteria unrelated to environmental impact..." (Respondent A)

Table 6 *Respondent's perspectives on reduce air pollution*

Factors of Artificial Intelligence (AI) Usage In Traffic Flow	Explanation	Respondent
Reduce air pollution	• Decrease fuel consumption	R1
	• Small percentage contribute to air pollution	R2
	• Reduce carbon emissions and air pollution	R3

4.4.5 Traffic Congestion

AI-based traffic technology is primarily employed to reduce traffic congestion and promote better traffic management. A network of interrelated operations that are carefully created together and have observable effects on one another's operation contribute to smart traffic management. AI enables quicker and simpler coordination, which helps commuters, drivers, and traffic officials better manage their travel routes and time (Isarsoft, 2023). According to Table 7, respondents A and C believe artificial intelligence (AI) components can lessen traffic congestion during roadside construction.

" In my opinion, several essential functions are involved in the application of AI to lessen traffic congestion during roadside construction. The artificial intelligence (AI) system uses predictive algorithms and real-time data analysis to keep an eye on the ever-changing traffic circumstances in and around construction zones. Through the evaluation of variables including traffic volume, degrees of congestion, and construction activities, the artificial intelligence (AI) system acquires an in-depth awareness of the condition of the roads." (Respondent A)

While respondent B presents an alternative viewpoint in their statement. Despite their divergent viewpoints, the overall concept aligns with the main idea.

" .. Artificial intelligence (AI) systems are able to anticipate traffic jams and make proactive adjustments to traffic management tactics by analyzing data from several sources, including cameras, traffic sensors, and historical trends. This makes it possible to design routes more effectively, optimize signal timings, and implement adaptive traffic control, all of which help to ease traffic flow and lessen congestion" (Respondent B)

Table 7 *Respondent's perspectives on reduce traffic congestion*

Factors of Artificial Intelligence (AI) Usage In Traffic Flow	Explanation	Respondent
Traffic Congestion	• Predict traffic congestion	R1
	• Lessen traffic congestion	R2
	• Boost the road network's effectiveness and capacity	R3

4.5 Part D: Challenges in The Adoption of Artificial Intelligence (AI) in Traffic Flow During Roadside Construction in Jalan Kluang

This section aims to investigate the difficulties in implementing Artificial Intelligence (AI) to control traffic during roadside construction. In this research, the challenges that need to be consider in adoption of artificial Intelligence (AI) technologies through a detailed analysis, providing insights into possible barriers and suggestions for improving the efficiency of AI applications specific context.

It is essential to determine the main factors that affect how artificial intelligence (AI) is used to traffic flow management during roadside construction in Jalan Kluang FT050. This is significant because these elements have a big impact on how successful and efficient transportation networks are. Based on Table 4.9 shows that respondent B has a different opinion from respondent A and respondent C which stated that:

"The greatest obstacle to the widespread use of artificial intelligence (AI) in traffic flow management is the high cost of installation and upkeep. The installation of sensors, smart infrastructure, and communication networks necessitates a large upfront expense for the use of AI technology. The strain on resources is further increased by continuing maintenance expenses such as software upgrades, system monitoring, and equipment upkeep......" (Respondent A)

Table 8 *Challenges in the adoption of Artificial Intelligence (AI) usage In Traffic Flow at Jalan Kluang FT050*

Respondent	Challenges in the adoption of Artificial Intelligence (AI)	Explanation
A		High cost in installation and maintenance
B		For smaller cities, it might not practical require huge amounts of data to function effectively
	Main Challenges	
C		The cost of implementation and maintenance is high

While respondent B stated that:

"In my opinion, obtaining large amounts of data for efficient operation is the main obstacle to implementing artificial intelligence (AI) for traffic flow management, especially in smaller cities. It may be more difficult for smaller towns to provide the kind of varied and large-scale datasets that artificial intelligence (AI) systems require for larger urban centres with abundance of data sources...." (Respondent B)

4.5.1 Cost

Based on respondent 's A perspective the major barrier to the application of artificial intelligence (AI) in traffic flow during roadside construction is the expenses that involved for installation and maintenance. This statement was also supported by Respondent B which state that:

"The expenses involved is a major barrier to the application of artificial intelligence (AI) in traffic flow during roadside construction. The application of AI technology in traffic management involves significant costs

associated with the development of complex algorithms, software, and hardware purchases. There are more expenses related to the setup, maintenance, and continuous improvement of the AI systems…." (Respondent A)

While Respondent C stated that*:*

"Adopting artificial intelligence (AI) for traffic control on Jalan Kluang is hampered mostly by the accompanying expenditures, especially the higher costs involved with training. AI solution implementation calls for specific training for those working in data analysis, system maintenance, and operation. The cost of employing qualified personnel and the investment in training programs present a financial hurdle……" (Respondent C)

Table 9 *Respondent's perspectives on cost challenge in the adoption of Artificial Intelligence (AI) Usage in traffic flow*

Challenges in the adoption of Artificial Intelligence (AI)	Explanation	Respondent
Cost	• High expenses for installation and maintenance	R1
	• The cost of implementation and maintenance is high	R2
	• Need extra expenses for training	R3

4.5.2 Time

Based on Alsheibani *et al.* (2018) state that three key factors that affect the adoption of AI are technology readiness, organizational readiness, and environmental readiness (environmental conditions including government restrictions). Hiring qualified staff, depending on outside partners, and infrastructure expenditures are possible additional challenges.

"The workforce needs enough time to complete training programs and develop the necessary skills to comprehend and use AI-driven systems efficiently. Adopting AI can take time, especially when learning about the specifics of the system and getting used to new procedures. In order to overcome these time-related obstacles, a well-organized training program is required..." (Respondent C)

Table 10 *Respondent's perspectives on time challenges in the adoption of Artificial Intelligence (AI) Usage in traffic flow*

Challenges in the adoption of Artificial Intelligence (AI)	Explanation	Respondent
Time	• The planning and integration of AI systems can take a significant amount of time*.*	R1
	• On-site testing is essential	R2
	• Workers need to learn & getting used to new procedures.	R3

4.5.3 Location

Deploying worldwide AI solutions is difficult since different locations have different traffic patterns, infrastructural layouts, and environmental conditions. Thorough data collecting, model training, and fine-tuning are necessary to tailor AI systems to each location's specific characteristics (Ajith Kumar B P *et al.*, 2023).

Consequently, all respondent stated that location-specific considerations are the obstacles to the adoption of artificial intelligence (AI) on Jalan Kluang based on Table 11.

"Differences in infrastructure may be attributed to a wide range of variables including the kinds of roads and their state as well as the existence and effectiveness of public transit networks. Furthermore, the presence and feasibility of substitute routes significantly influence the traffic patterns in a given region…" (Respondent A)

Table 11 *Respondent's perspectives on location challenges in the adoption of Artificial Intelligence (AI) Usage in traffic flow*

Challenges in the adoption of Artificial Intelligence (AI)	Explanation	Respondent
Location	• Inequalities in Infrastructure	R1
	• Inequalities in planning and development for urban	R2
	• Inequalities in Infrastructure	R3

4.6 Discussion

After gathering and analyzing data, the researcher discovered that every research goal aligns with the examination of existing literature. By compiling new journals, each responder enhanced the findings of the prior study. The association between the literature review and the respondent data is displayed in Table 4.15 in Appendix B. According to the research's results, every question and objective could be satisfactorily and totally answered, so the implementation of the study has been considered effective. An interview form instrument is used in this study, which collects data through semi-structured interviews. In all, three respondents took part in this investigation. It may be concluded that respondents to this survey gave thoughtful answers. Every piece of data has been analysed by using the content analysis approach, and the results are presented in the form of tables. The manual review of each respondent's thorough responses to these questions forms the basis for the evaluation.

Based on section C, questions are formulated to achieve the first objective of the study. The results of the study found that the current practice of artificial intelligence usage in traffic flow is widely used such as Intelligent Transportation System (ITS). This finding is supported by Sayed (2023), large cities nowadays have been growing in number and congested in recent decades, there has been an increase in demand for the creation of ITS-based systems for accurate traffic prediction and mobility management. To sum up, the first purpose of the study provides insight into the extensive use of artificial intelligence (AI) in traffic flow management, highlighting the significance of creative solutions in addressing the problems brought about by urbanization and rising traffic needs. The integration of a variety of artificial intelligence technologies illustrates the complexity and flexibility needed to create systems that effectively manage mobility and accurately forecast traffic in the face of urban expansion. From the perspectives of these three respondents, it can be concluded that reducing risk, minimize time travel and lessen the traffic congestion are the main factors of artificial intelligence (AI) usage in traffic flow in Jalan Kluang. Respondent A stated that artificial intelligence (AI) able to lower the risk for road user and construction worker at the construction site. Respondent B highlighted artificial intelligence (AI) system is needed to minimize travel time and prevent delays during roadside construction. While Respondent C emphasized this system is needed to lessen and control traffic congestion in a variety of scenarios. In 2021s, Chan pointed that, in order to shorten the travel times of vehicles, many hours have been spent investigating strategies to predict traffic congestion and provide drivers a more effective path by using traffic prediction using artificial Intelligence (AI). Long-term construction zones on city streets cause a number of issues, including reduced capacity, increased travel time delays, queue length, fuel consumption, and traffic accidents that result in unreported economic losses as a result, the number of lanes decreases from three in the non-work zone area to two in the work zone to one station work zone area owing to long-term development (Chan,2021).

When implementing artificial intelligence users in traffic flow, there are a number of challenges that must be considered. In this section, Respondents agreed that high cost in installation with maintenance and for a smaller city, it might not practical require huge amounts of data to function effectively are the main obstacles to the adoption of artificial intelligence in traffic flow. The application of artificial intelligence (AI) in traffic management involves significant costs associated with the development of complex algorithms, software, and hardware purchases. There are additional expenses related to the setup, maintenance, and ongoing improvement of the AI systems. The associated costs represent a major obstacle to the application of AI in traffic flow during roadside construction. particularly in smaller cities, is acquiring huge volumes of data for effective operation. Smaller communities could find it more challenging to supply the type of large-scale, diverse datasets that artificial intelligence (AI) systems need for more data-rich, bigger metropolitan centers. This finding is supported by Sarker (2022), different forms of AI, including analytical, functional, interactive, textual, and visual AI, can be used to improve the intelligence and capabilities of an application to address real-world problems. However, because real-world issues and data are dynamic and variable, creating an effective AI model is a difficult challenging task.

5. Conclusion

5.1 Conclusion of The Study

5.1.1 Research Objective 1: Investigate current practices of artificial intelligence (ai) usage in traffic flow during roadside construction in Jalan Kluang

Respondents comprehend that certain current applications of artificial intelligence in traffic flow have been effectively recognized. Table 2.1 highlights several applications of artificial intelligence in traffic flow, including machine learning, reinforcement learning, intelligent transportation systems, green link detection, and freeway (Expressway) traffic management systems that can may be apply at Jalan Kluang. This conclusion is further supported by the evidence that the data investigated with the content analysis approach aligns with the existing practice as mentioned in the literature study. Therefore. the first research objective has been accomplished. In conclusion, the research studied the potential positives and negatives of incorporating Artificial Intelligence (AI) in traffic flow during roadside construction on Jalan Kluang. Professionals working on road construction projects made up the respondents, and they offered insightful information on the issues, obstacles, and possible solutions surrounding the application of AI in this particular setting. The respondents reached an agreement about the significant importance of location-specific factors, including the varied traffic patterns, infrastructural configurations, and environmental attributes that define Jalan Kluang. Some respondents were upbeat about AI's potential to improve safety, shorten travel times, and ease traffic congestion, while others voiced worries about the technology's possible imprecision, time commitment, and related expenses.

5.1.2 Research Objective 2: Investigate factors of Artificial Intelligence (AI) usage in traffic flow during roadside construction at Jalan Kluang

Based on table 2.2 shows factors of artificial intelligence (AI) in traffic flow during roadside construction at Jalan Kluang. According to Qureshi (2013), Intelligent Transportation Systems (ITS) one of the artificial intelligence components that can significantly contribute to reducing risks, high accident rates, traffic congestion, carbon emissions, and air pollution, and on the other hand, increasing safety and reliability, travel speeds, traffic flow, and contented travelers for all modes. This finding is supported by Manyard (2020), with the use of artificial intelligence (AI) platform and real-time data analysis, a considerable increase in the number of traffic collisions may be detected, allowing for quicker validation and shorter emergency response times. Other than that, several lines of evidence suggest that the intelligent transportation system (ITS) is a reliable and effective traffic management system that incorporates several cutting-edge technologies and has reduced the problem of traffic congestion. The predictive model, which makes use of traffic data including traffic speed, flow volume, and congestion levels, is an essential part of ITS. It evaluates traffic patterns and forecasts short or long-term traffic situations (Ranchan,2021). Therefore, the evidence from the content analysis technique supports the conclusion and shows that it is in line with the accepted procedures that were noted in the literature study.

5.1.3 Determine challenges to the adoption of Artificial Intelligence (AI) in traffic flow during roadside construction at Jalan Kluang

Based on Table 2.3, challenges to the adoption of Artificial Intelligence (AI) in traffic flow during roadside construction at Jalan Kluang has proven by Ektabani (2013) that stated a fundamental challenge with significant scientific and practical relevance is the development of workable and effective real-time signal control strategies for urban road networks under congested traffic situations. The scientific significance derives from the recent rise in interest in the particular issue as well as from recent, possibly beneficial models and discoveries that might help to improve signal control techniques. This finding also supported by Frackiewicz (2023), that stated the cost of using AI for traffic planning is an additional possible problem. AI systems may not be practical for smaller cities or towns due to their high implementation and maintenance costs. Furthermore, obtaining the large volumes of data that AI systems need to function effectively can be challenging in some regions. In general, cities and towns might benefit greatly from the application of AI for transportation planning. The negative potential must be considered to ensure that any AI system can be operated properly and morally. Additionally, this study has been also validated by the literature on Shahmoradi, (2021) has highlighted several challenges adoption of artificial intelligence such as being able accurately assess the separation from the traffic camera is one of the trickiest issues in traffic engineering. As a result, the content analysis technique's data demonstrates that the conclusion is accurate and consistent with the recognized practices mentioned in the literature review.

5.2 Recommendation of the study

To enhance traffic control during roadside construction on Jalan Kluang, it is recommended to implement a comprehensive strategy incorporating artificial intelligence (AI) technology. This involves forming partnerships with technology and infrastructure businesses to customize artificial intelligence solutions for real-time monitoring, predictive analytics, and adaptive traffic signal control systems. Collaboration with construction equipment manufacturers is advised to integrate artificial intelligence into machinery, improving coordination and efficiency. A proactive approach to workforce development, including specialized training programs in artificial intelligence applications for construction and traffic management, is also crucial. Governmental recommendations include establishing a policy framework to encourage artificial intelligence adoption in construction traffic management, ensuring safety guidelines, and conducting public awareness campaigns. Next, collaboration with research institutions is vital for ongoing policy evaluation. Future research should focus on optimizing artificial intelligence algorithms for dynamic traffic flow in construction zones, assessing ecological effects, ensuring sustainability, and conducting comprehensive cost-benefit analyses to realize artificial intelligence's potential in influencing traffic management during roadside construction on Jalan Kluang.

5.3 Conclusion

In conclusion, the research studied the potential positives and negatives of incorporating Artificial Intelligence (AI) in traffic flow during roadside construction on Jalan Kluang. Professionals working on road construction projects made up the respondents, and they offered insightful information on the issues, obstacles, and possible solutions surrounding the application of AI in this particular setting. The respondents reached an agreement about the significant importance of location-specific factors, including the varied traffic patterns, infrastructural configurations, and environmental attributes that define Jalan Kluang. Some respondents were upbeat about artificial Intelligence's potential to improve safety, shorten travel times, and ease traffic congestion, while others voiced worries about the technology's possible imprecision, time commitment, and related expenses.

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Conflict of Interest

Authors declare that there is no conflict of interests regarding the publication of the paper.

Author Contribution

*The authors confirm contribution to the paper as follows: **study conception and design:** Aida Syakirah Rohaizad, Roshartini Omar; **data collection:** Aida Syakirah Rohaizad; **analysis and interpretation of results:** Aida Syakirah Rohaizad; **draft manuscript preparation:** Aida Syakirah Rohaizad, Roshartini Omar. All authors reviewed the results and approved the final version of the manuscript.*

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