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# Intelligent Transportation Systems: An Overview of Current Trends and Limitations

Mohamed Shahraz[1], Muneeba Ahmed[2]

[1]*Graduate, Civil Engineer, Jamia Millia Islamia, New Delhi, India*
[2]*Systems Engineer, Infosys Limited, India*

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**Abstract** - Artificial intelligence (AI) is developing at a rapid rate, opening up previously unimaginable prospects to improve the performance of various industries and enterprises, including the transportation sector. AI is being used in the transportation sector to address issues such as rising travel demand, $CO_2$ emissions, safety problems, and environmental damage. . In this digital age, it is more feasible to handle these challenges in a more effective and efficient manner due to the abundance of quantitative and qualitative data. A thorough understanding of the interactions between AI and data on the one hand, and the characteristics and factors of the transportation system on the other, is necessary for the successful use of AI. This article is a compendium of many problems affecting the transportation sector that are categorised as Intelligent Transportation Systems problems. Some of the sub-systems from Intelligent Transportation Systems that are taken into consideration are related to Traffic Management, Public Transport, Safety Management, and Manufacturing & Logistics. Finally, the overview discusses the limitations of AI applications in transportation.

***Keywords- Artificial Intelligence, Machine Learning, Intelligent transportation systems, Transport management systems, Traffic management, Public transport, Safety management, Manufacturing & Logistics***

## 1. Introduction

A key component of ensuring our daily existence is the transportation sector. The transport industry has significantly aided in the transportation of people and goods between different geographical areas. In a supply chain management system where commodities are moved from one location to another, it is crucial. In a logistics chain, the industry is essential to the transfer of goods to the appropriate location at the appropriate time. In the past, technologies have helped organisations tackle problems in a variety of industries, including retail, finance, insurance, healthcare, and even sports.

Some of these ideas have altered how companies are conducted by lowering operating costs, increasing efficiency, and enhancing efficiency. One of the newest industries where cutting-edge technology has been successfully used is transportation, which is hampered by problems with traffic congestion, unforeseen delays, and routing that cause firms to lose money. Governments and companies have leveraged technology like machine learning, artificial intelligence, and the internet of things among others to fully profit from commercial investments.

### A. Artificial Intelligence (AI)

Artificial intelligence (AI) is a vast field of computer science that aims to make machines behave like human brains. AI is also defined as a machine's ability to fulfil cognitive functions of a person with ease. Due to the availability of massive volumes of data created by numerous devices, as well as effective hardware, software, and network infrastructure, this six-decade-old concept of AI has recently gained popularity. Automation of business processes has been made possible by the development of AI [1]. AI reduces uncertainty in the decision-making process while offering dependable and affordable solutions. Process automation has enabled firms to make decisions more quickly since modern algorithms can handle complex data [2]. As environmental concerns increase, artificial intelligence (AI) has emerged as a provider of climate change and water challenges by revolutionising the conventional sectors and systems. These qualities have assisted governments in creating sustainable cities that support the preservation of wildlife and the welfare of people [3].

### B. Transport and AI

The majority of the world's major cities struggle with transportation, traffic, and logistics-related difficulties. This is brought on by both the rapidly expanding human population and the rise in the number of automobiles on the road. Technology could be a huge help in designing and running a sustainable transportation system. Urban regions struggle with traffic congestion, but artificial intelligence (AI) technologies have arisen that allow traffic management to receive real-time information from moving vehicles and employ mobility on demand for trip planning through a single user interface. Other options for effective traffic management include the secure integration of AI-based decision-making, routing, transportation network services, and other mobility optimization technologies [4]. The World Economic Forum lists AI as one of the developing technologies. Artificial Neural Networks (ANN), Genetic Algorithms (GA), Simulated Annealing (SA), Fuzzy Logic Model (FLM), and Ant Colony Optimizer (ACO) are some AI techniques that assist in transportation. The purpose of implementing these strategies in transport management is to reduce congestion, increase commuters' confidence in their trip times, and enhance the system's economics and productivity [5]. To address problems in the transportation

sector, numerous research have been carried out globally. The results of the research projects conducted in this sector with the use of AI technology have raised hopes for this important area of development.

## 2. Intelligent Transportation System

Intelligent Transportation Systems, also known as ITS, are advanced software programmes that aim to offer cutting-edge services relating to various modes of transportation and traffic management and facilitate users to be more knowledgeable and make safer, more organized, and smarter use of transportation networks. With the aid of progressive innovations like GSM, Wi-Fi, Cellular Data, GPS, and GPRS, the Intelligent Transport Systems offer transportation businesses a centralised way to schedule and monitor vehicles. Better public transportation services are made possible by the Intelligent Transport System by taking into account bus revenue, public safety, and protection [6]. Extreme traffic congestion, lengthy commutes, parking troubles, a high concentration of $CO_2$ emissions, and other challenges include urban transportation challenges. Emerging ITSs are anticipated to significantly contribute to better traffic flow, which will maximise fuel efficiency, cut down on delays, and improve the entire driving experience [7, 8]. Digital video cameras, along with unique video signal processing and transmission cards, are the key components of the system that gathers data from video cameras and are located in the proper road segments and crossroads. Digital video camera signals are sent in their entirety to central systems that assess traffic patterns [9]. The statistical data is gathered in the actual operational items wherein video cameras having software support that can identify cars and their licence plates are attached. As more and more technological gadgets proliferate around the globe and are subsequently monitored remotely by professionals, the modern technology has outgrown many aspects of itself [10]. The decision makers or the government then use different applications to deal with situations in the real world to guarantee efficient transport [4].

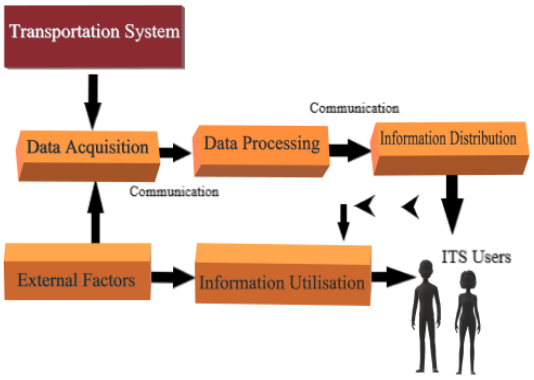


**Fig.1**: A simple representation of ITSs information chain

The information chain for ITSs demonstrate that future inventions and system ideas in the field of ITSs include the exchange of information and the synchronization of decisions involving various centres. The gathering of data and its integration with the road infrastructure, communication with fresh private-sector organisations, and communication with organization outside the transportation industry come next. [9] ITSs can be found in both infrastructure (such as dynamic signalling, infraction control mechanisms, etc.) and vehicles (such as communication systems and intelligent vehicles) [9]. Intelligent Manufacturing & Logistics System, Intelligent Safety Management System, Intelligent Public Transport System, and Intelligent Traffic Management System are some of the subsystems that make up ITS and each serves a specific purpose. To improve the planning of the transportation process, a few of these systems have expanded the processing of data [8]. The goal of ITMSs is to use algorithmic machine learning to anticipate the best routes based on factors like vehicle classification, accident frequency, and traffic mobilisation patterns [11]. IPTSs are designed to manage public transportation networks, keep them working efficiently, and give consumers the most recent information on travels and network operating problems [12]. ISMSs guarantee the security of people, things, and vehicles on the road [10]. IMLSs make sure that technology is incorporated into the production of automobiles and the movement of products [10]. Artificial intelligence-powered technologies will soon make Indian roads safer to travel on, lowering the probability of accidents occurring. The Indian government stated that "The Project 'Intelligent Solutions for Road Safety through Technology and Engineering' (iRASTE) at Nagpur will identify potential accident causing scenarios while driving a vehicle and alert drivers about the same with the assistance of the Advance Driver Assistance System (ADAS)". Additionally, it is claimed that this initiative will locate "grey spots," i.e., by doing mobility analysis and data analysis while continuously keeping an eye on dynamic dangers across the complete transport network [13]. The initiative iRASTE seeks to reduce Nagpur's yearly road crashes by up to 50% through a variety of collision mitigation strategies [14].

TMS, or traffic management systems, are a subset of transportation management that are particularly applicable to transportation operations. These systems' main goals are to use data to implement efficient route planning, load efficiency, increased flexibility, and accountability. For proper management, a city's transportation plans are connected to an information system that focuses on collecting, processing, transferring, and managing the resulting data. TMS, which are systems created to address transportation-related problems utilising various technologies, are a blessing. Route planning, outbound/inbound logistic operations, route scheduling, freight forwarders, service agents, transport monitoring, and bulk handling of route planning & transportation scheduling are some of the main responsibilities of TMS [10]. TMS are involved in the movement of products. In order to make precise predictions, TMS are enhanced with AI and machine learning.

A. How data is acquired?

1) Roads

There are three categories of traffic data: link traffic data, single vehicle characteristics, and point traffic flows data. Vehicle counting and speed measurements can be done using single or double loop detectors, respectively. On occasion, overhead gantries are equipped with ultrasonic, radar, and infrared traffic sensors that serve as single-zone traffic detectors. One of the most recent technologies to be used for traffic detection to determine vehicle speed, size, lane flow rate, etc. is video image detectors (VID) using image analysis. One processing unit can be used to connect multiple cameras for comprehensive coverage. Making timely decisions in challenging traffic circumstances is made easier with the use of live video images. It has been quicker to use surveillance techniques like weigh-in-motion (WIM), and ITS system based on load cell, bending panel, piezoelectric, or similar concepts designed to detect overweight trucks [9].

2) Vehicle

Information about the vehicle is necessary to find any stolen or problematic vehicles as well as any vehicles presumed of transporting suspicious materials. When the exact location of a vehicle is known on a link at two different times, the journey time on the link could be calculated. Additionally, the data might be used to lessen congestion. A probe vehicle or a floating vehicle is a vehicle utilized for this purpose. Automatic Vehicle Identification (AVI)-based vehicle probes necessitate the deployment of the necessary hardware on the infrastructure. Using Automatic Vehicle Location (AVL), a GNSS-based method, the idea of vehicle probe technology may also be used without any equipment on the side of the road and is thus available anywhere in the world [9].

## 3. Influence of AI in transportation sector

AI has made a significant and widespread impact to the transportation business. The solutions include autonomous vehicles, traffic control, optimal routing, and logistics, all of which contribute to vehicle and driver safety. ITSs are produced from data generated by devices mounted in vehicles via AI technologies.

Table 1 show that AI can help with transportation concerns by recommending alternate routes and tracking traffic lights in real time during traffic jams. This aids in the efficient management of traffic, ultimately contributing to the reduction of environmental pollution and the construction of sustainable cities.

**Table – 1**: Traffic Management [10]

| Source of data | Issues | Role of AI | Benefit |
|---|---|---|---|
| **Vehicles with Intelligent systems** | Increased cost due to traffic congestion | Machine learning tools to predict traffic pile up | Better fuel saving capability and lesser pollution to environment |
| **Data from smart phones** | Routing | Alternative route suggestions | Time saving |
| **Intelligent transport systems** | Unpredictable traffic congestion | Identification of polluting substances in air | Curbing of environmental pollution |
| **Traffic lights and vehicles** | Peak hour traffic management | Real time tracking of congestion and algorithms in traffic lights | Control of higher and lower traffic patterns |
| **Data from Vehicles** | Increase in the number of vehicles on the road | Pattern identification | Better observation and decision making |

According to Table 2, AI provides solutions for anticipating weather and traffic patterns, road management, and alert generating for police on duty. These technologies assist drivers, commuters, and pedestrians before to the start of their journey. It is critical to have technological support to establish an effective public transportation system that aids in planning and decision-making.

**Table – 2**: Public Transports [10]

| Source of data | Issues | Role of AI | Benefit |
|---|---|---|---|
| **Vehicles with Intelligent systems** | Increased cost due to traffic congestion | Machine learning tools to predict traffic pile up | Better fuel saving capability and lesser pollution to environment |
| **Data from smart phones** | Routing | Alternative route suggestions | Time saving |
| **Intelligent transport systems** | Unpredictable traffic congestion | Identification of polluting substances in air | Curbing of environmental pollution |
| **Traffic lights and vehicles** | Peak hour traffic management | Real time tracking of congestion and algorithms in traffic lights | Control of higher and lower traffic patterns |
| **Data from Vehicles** | Increase in the number of vehicles on the road | Pattern identification | Better observation and decision making |

**Table – 3**: Safety Management [10]

| Source of data | Issues | Role of AI | Benefit |
|---|---|---|---|
| **Vehicles with Intelligent systems** | Increased cost due to traffic congestion | Machine learning tools to predict traffic pile up | Better fuel saving capability and lesser pollution to environment |
| **Data from smart phones** | Routing | Alternative route suggestions | Time saving |
| **Intelligent transport systems** | Unpredictable traffic congestion | Identification of polluting substances in air | Curbing of environmental pollution |
| **Traffic lights and vehicles** | Peak hour traffic management | Real time tracking of congestion and algorithms in traffic lights | Control of higher and lower traffic patterns |
| **Data from Vehicles** | Increase in the number of vehicles on the road | Pattern identification | Better observation and decision making |

Table 3 shows that AI has reduced the number of road accidents, forecasts accidents based on road conditions, alerts drivers to road safety, and so on. When the transportation business is efficient, the economy operates smoothly. It is critical to accomplish this by constructing a safe transportation system using AI technology.

According to Table 4, the automotive industry benefits from AI technologies during the vehicle manufacturing process. Sensors, cameras, and other technology have all played a role in this industry's advancement. Some of the built-in AI solutions in automobiles have become crucial components in both the passenger and commercial vehicle segments.

**Table – 4**: Manufacturing & Logistics [10]

| Source of data | Issues | Role of AI | Benefit |
|---|---|---|---|
| **Vehicles with Intelligent systems** | Increased cost due to traffic congestion | Machine learning tools to predict traffic pile up | Better fuel saving capability and lesser pollution to environment |
| **Data from smart phones** | Routing | Alternative route suggestions | Time saving |
| **Intelligent transport systems** | Unpredictable traffic congestion | Identification of polluting substances in air | Curbing of environmental pollution |
| **Traffic lights and vehicles** | Peak hour traffic management | Real time tracking of congestion and algorithms in traffic lights | Control of higher and lower traffic patterns |
| **Data from Vehicles** | Increase in the number of vehicles on the road | Pattern identification | Better observation and decision making |

## 4. Limitations of AI methods in Transportation sector

AI's first drawback is that it treats ANNs as a mysterious black box. Any artificial intelligence systems whose feeds and functions are hidden from the operator or another relevant persons is referred to as a "black box," or an impenetrable system. The constraint noted above is thought to be resolved by combining neural networks with other conventional techniques and other AI technologies as a hybrid cloud environment to solve this issue. Despite the fact that hybridization is essential to enhance performance, particularly in multi-scenarios, it is regarded as a hindrance [5]. Only particular ITS applications, such as data processing and projections of future mobility, can use AI in the transportation sector. The accuracy and on-time forecasts are unreliable when AI techniques collect data from conventional methods like loop detectors, sensors, actuators, etc. Reaching the best possible solution for the raster algorithms AI tools is another restriction. In contrast to applying AI raster algorithms, mathematical calculation approaches can give a true grasp of the inherent structure of the problem and the nature of the answer. To find the best answers and gain greater understanding of the issue, the parameters and assumptions must be changed and the model must be run more than once. Short- and long-term traffic flow forecasting under unforeseen occurrences and unfavourable weather conditions is not possible with the current AI algorithms. Most AI methods, like NN in time series transport applications, hardly ever include any testing of the errors and model specification, which also is regarded as a drawback [5].

## 5. Conclusion

In today's world, ITSs are one of the most important technologies to identify potential issues related to the transport industry. This is needed to make important real life decisions to mitigate the current challenges involved in the transportation field. Developed countries have already started to adopt these systems using Artificial Intelligence. However, it is easier said than done as huge amounts of data are needed as an input from vehicles and users for the AI systems to analyse texts, videos, photographs, and audio to make an appropriate decision. Intelligent Transportation Systems may not completely eradicate the accidents but can reduce the huge number to be in a limit. Overall, transportation systems using AI will surely help us to have an efficient and safe journey, minimising traffic and accidents. This article has attempted to give an overview about the current transportation systems and some possible limitations that can possibly be resolved in future.

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