

Application of Artificial Intelligence for Development of Intelligent Transport System in Smart Cities

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Abstract

This study presents basic concepts and applications of Artificial Intelligence System (AIS) for development of intelligent transport systems in smart cities in India. With growing urbanization the government has now realized the need for developing smart cities that can cope with the challenges of urban living and also be magnets for investment in India. Transport system in smart cities should be accessible, safe, environmentally friendly, faster, comfortable and affordable without compromising the future needs. The Indian cities largely lacks of Intelligent Transport System in India and there are various problems such as inefficient public transport system, severe congestion, increasing incidence of road accidents, inadequate parking spaces and a rapidly increasing energy cost etc. Therefore, development of Intelligent Transportation System is essential for smart cities due to concerns regarding the environmental, economic, and social equity. Artificial Intelligence is a key technology to resolve these issues. Therefore, there is an urgent need to adopt Artificial Intelligence system for development of Intelligent Transport System to better understand and control its operations in smart cities. Hence, the main objective of this study is to present some basic concepts of Artificial Intelligence and its applications for development of Intelligent Transport System in smart cities in India. This study concludes that Artificial Intelligence system needs to be adopted to develop smart public transport system, intelligent traffic management and control, smart traveller information system, smart parking management and safe mobility & emergency system in smart cities. It is expected that this study will pave the way for development of Intelligent Transport System in smart cities in India.

Keywords: Artificial intelligence, smart city, intelligent transport system

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INTRODUCTION

A 'smart city' is an urban region that is highly advanced in terms of overall system, safe mobility, sustainable real estate, communications and market viability. The smart-city management system handles information and controls across the different types of system needed by a city^[1]. The United Nations estimates that the urban population of emerging economies across the world, the stride of migration from rural to urban areas is

increasing. In 2050, about 70 per cent of the population will be living in urban areas, and India is no exception^[2]. With growing urbanization the government has now realized the need for smart cities in urban area that can cope with the challenges of urban living and also be magnets for investment in India announcement of '100 smart cities' falls in line with this vision^[1]. Intelligent transportation system play an essential role in today's world and are a vital extension

for development of a smart city due to concerns regarding the environmental, economic, and social equity^[3]. Intelligent transport system move people and freight by emphasizing accessible, environmentally friendly, comfortable, affordable and accessible with integrated various transport modes which is safe and operates at suitable speeds without compromising the future needs. However, at present there are various problems involved in Indian cities such as severe congestion, deteriorating air quality, increasing incidence of road accidents and a rapidly increasing energy cost due to present traffic management, the city largely lacks of Intelligent Transport System in India. As the number of vehicles increased everyday on Indian roads, the average motorists spend hours in traffic jam due to lack of urban planning, traffic mismanagement, and parking control which leads to billions of rupees wasted every year in major cities of India.

Most of the major cities in India, due to lack of Intelligent Transport System faces various problems like accidents, environmental degradation, congestion; overcrowding and parking space etc. Today India leads the world in traffic accidents and also has the highest fatality rate of traffic accidents in the world. Hence there is urgent need to develop intelligent transport systems in smart cities proposed to be developed in India for traffic control management and to tackle the rising menace of road accidents and fatalities. Artificial Intelligence is a key technology for development of Intelligent Transport System in smart cities to better understand and control its operations and optimize the use of limited resources in smart cities. Table 1 represents the requirement of Intelligent Transport System in smart cities in India and need for application of Artificial Intelligence system for developing such system.

Table1: *Requirements of Intelligent Transportation Systems in Smart Cities.*

S. No.	Requirements of Intelligent Transport System in Smart Cities	Need for Application of Artificial Intelligence System
1.	Accessible in most of the area of smart cities.	Need to develop multi-modal integrated public transport system
2	Minimum travelling time	Need to develop intelligent traffic control and management system to reduce congestion.
3	Real time information system for safe and efficient movement	Need to develop smart traffic information system
4	Affordable by all section of the society.	Need to develop economical public transport system
5	Environmental friendly and energy efficient.	Need to develop intelligent traffic control and management system
6	Redesign and management of street as per the requirements of different transport modes.	Need to develop smart pavement management system
7	Sufficient spaces for parking of vehicles in different areas of smart cities	Need to develop of smart parking management system
8	Faster service to reach different areas quickly.	Need to develop intelligent traffic control and management system
9	Safe mobility of public and vehicles in smart cities.	Need to development safety management and emergency system
10	Congestion free route for faster service and safe mobility.	Need to develop intelligent traffic control and management system
11	Rapid intervention in an emergency situation.	Need to develop smart emergency system
12	Efficient fare collection service.	Need to develop electronic pricing system
13	Better facilities to users during waiting at stops, travelling and transferring.	Need to develop user friendly & comfortable public transport system

Hence, the main objective of this study is to present some basic concepts of Artificial Intelligence and its applications for development of Intelligent Transport System in smart cities in India. This study presents applications of Artificial Intelligence system in developing smart public transport system, intelligent traffic management and control, smart traveller information system, smart parking management and safe mobility & emergency system in smart cities.

Artificial Intelligent system is a key technology for improvement of traffic management & control, traveller information system i.e. real-time traffic information provision route navigation systems, parking information etc. It maximizes the capacity of transport system applying real time traffic data. Traffic signal lights can improve traffic flow significantly, reducing the need to build additional highway capacity, reducing stops by as much as 40%, reducing travel time by 25%, decreasing fuel consumption by 10% and thereby reducing the carbon emission^[4]. This study will be useful for engineers and planners to develop efficient transport system in smart cities in India.

This paper consists of four sections of which this is the first one. The first section introduces the study. The second section highlighted the basic concepts, challenges and advantages of artificial intelligent for development of intelligent transport system. Third section briefly presents an application of artificial intelligent system for development of intelligent transport system in smart cities. The last section presents the important conclusions drawn from this study.

Artificial Intelligence System

Artificial Intelligence (AI) is the science of making machines or systems do things that would require intelligence if done by men^[5]. The main objective of the Artificial

Intelligence system is to create intelligent machines and through this, to understand the principles of intelligence. Artificial Intelligence system is suitable when a direct mathematical relationship cannot be established between cause and effect. Artificial intelligence system models capture the uncertainty between real-life cause and effect scenarios by incorporating available knowledge with probabilities and probability inference computations^[6]. Artificial Intelligence system is dealing with both qualitative as well as quantitative data. Artificial Intelligence system may be categorised in two types (i) Symbolic which focuses on development of Knowledge Based system (ii) Computer intelligence which includes methods such as neural network, fuzzy system and evolutionary computing^[7].

Knowledge Based system (KBS)

KBS is a computer system capable of giving advice in a particular domain using the knowledge provided by a knowledge base which has data provided from past events in similar domains and feedbacks by a human expert. In this system, the knowledge is represented in several ways such as rules, frames, or cases, and the inference engine or algorithm^[7] wherever needed the domain expert intervenes to arrive at appropriate decisions. In order to arrive at more reliable and satisfactory results, the introduction of an expert to intervene and assist in judging on actual performance in arriving at solutions based on his knowledge and experience in the relevant field is considered appropriate and this is the basis on which Expert systems, including KBS function^[7].

KBS differs from conventional programs in the following ways^[7]

1. It simulates human reasoning about a domain,
2. It performs reasoning over representation of human knowledge, in addition to doing numerical computations or data revival;

3. It solves problems by heuristic or approximate methods.

KBS deals with subject matters of realistic complexity, and therefore must exhibit high performance in terms of speed and

reliability in order to be a useful tool and it must also be capable of explaining and justifying the solutions to convince the user that its reasoning is correct^[7, 8]. Table 2 presents major components of knowledge based system.

Table 2: Major Components of Knowledge Based system (KBS).

S. No.	Component	Application
1	User Interface	It Converts user queries into an internal representation to be processed by the system and converts system's solutions and explanations into a language which the user can understand.
2	Knowledge Base	It contains an expert's knowledge about a narrow domain of application. The knowledge is represented in several ways such as rules, frames, or cases, and the inference engine or algorithm. The domain expert intervenes to arrive at appropriate decisions
3	Inference Engine	It manipulates the knowledge base, to give answers to user's queries.
4	Explanation Generator	It provides explanations to the user about how the system arrives at a conclusion so that the user can be convinced (sometimes it is also considered a part of Inference Generator).

Computational Intelligence (CI)

Computational Intelligence (CI) techniques provide superior analysis of complex real-time data sets that arise within transport systems. According to literature, improved use of existing transport infrastructures can accomplish

positive sustainable outcomes, decreasing congestion, improving air quality, providing real-time travel information and supporting low carbon vehicles^[8]. Table 3 represents the various methods of computational intelligence of Artificial Intelligence System.

Table 3: Methods of Computational Intelligence.

S. No.	Methods	Remark
1	Neural Network (NN)	NNs can be trained to approximate virtually any nonlinear function to a required degree of accuracy and are provided with a set of input and output examples. A learning algorithm is then used to adjust the weights in the network so that the network would give the required output.
2	Fuzzy System (FS)	Deal with the ambiguity associated with real-world problems. Classic set theory defines sharp boundaries between sets and an object can only be a member of a given set. Fuzzy set functions allow gradual transitions between sets and also varying degree of membership of a given set. The use of Fuzzy set theory, though not necessarily minimises uncertainty relating to problem objectives or input values, provides a standard way to systematically capture and define ambiguity.
3	Genetic Algorithm (GA)	GA would yield a near optimum solution.

Some of the advantages of the Artificial Intelligence in developing transport system may be summarised as follows:

1. Artificial Intelligent is useful solution for design, construction, maintenance,

and time scheduling of transport system.

2. It can be used better and faster models for solving complex problems of transport system involving huge volume of data such as airways, roadways, railway and waterways.
3. It can be formulated and adopted to ensure proper use of available resources.
4. It helps to converting traffic sensors into intelligent agents that can automatically detect and report traffic accidents or predict traffic conditions.
5. It is more reliable system for assessing and predicting traffic conditions,
6. It can be used to review and evaluation of transport technology.
7. It can be used to analysis of traffic demands and analysis & simulations of pedestrian and herd behaviour.

However, there are a number of challenges involved in developing and deploying Artificial Intelligence in smart cities in India. Artificial Intelligence System face a range of challenges, including system interdependency, network effect, scale, funding, political, institutional and other challenges^[9]. Some of the challenges in

implementing Artificial Intelligence System in India are as follows:

1. Artificial Intelligence System challenges include a lack of expertise within local and regional transportation agencies with regard to the technologies underlying intelligent transportation systems and their implementation.
2. A lack of technical standards for Artificial Intelligence technologies makes it difficult to ensure that systems purchased by different localities can be integrated.
3. Establishing Artificial Intelligence System standards and comprehensive data collection system for applicable throughout the urban and rural sections of India.
4. Designing an Artificial Intelligence System that encompasses the heterogeneous vehicle population.
5. Government setting up rules and regulations of traffic that will aid in Artificial Intelligence System implementation.
6. Setting up active interaction between academia, industries and governmental agencies.

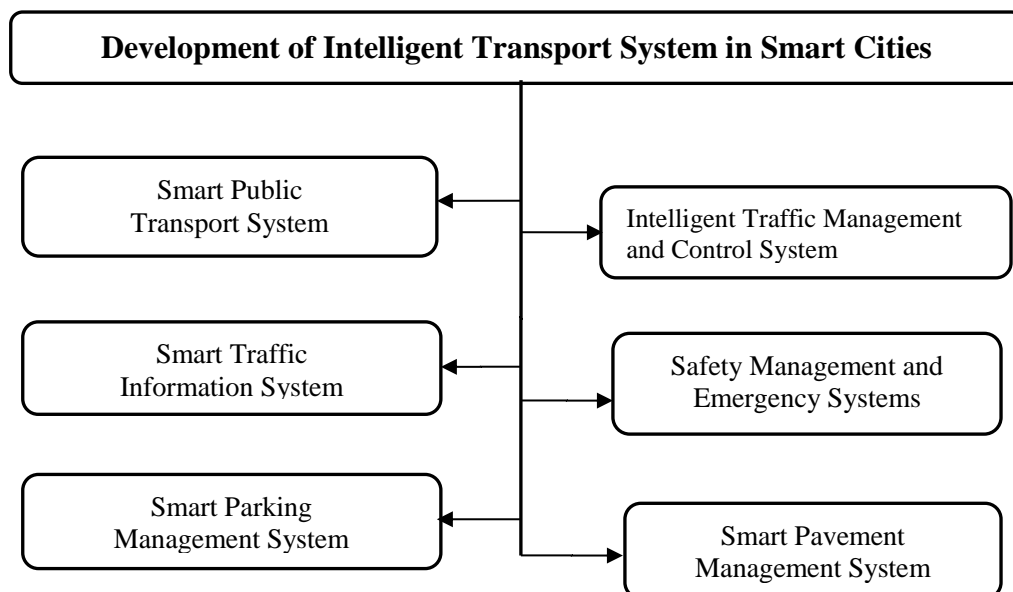


Fig1: Various Sub-Systems for Development of Intelligent Transport System.

Application of Artificial Intelligence System in Smart Cities

Most of the major cities in India due to lack of intelligent transport system faces various problems like accidents, environmental degradation, congestion; overcrowding and parking spaces etc.^[3]. Artificial Intelligence is a most recognized technology which dealing with both qualitative as well as quantitative data to resolving these issues. Figure 1 presents various sub-systems that need to be developed for providing intelligent transport system in smart cities.

Some of the applications of Artificial Intelligence for development of various system of Intelligent Transport System in

smart cities are summarised in the following sub sections.

Application for Development of Smart Public Transportation System

Artificial Intelligence system include applications for development of smart public transport system such as en-route public transit information, automatic vehicle location, smart travel security and smart revenue management which enable transit vehicles, to report their current location, making it possible for traffic operations and revenue management to construct a real-time view. Figure 2 presents sub components of smart public transport system in smart cities.

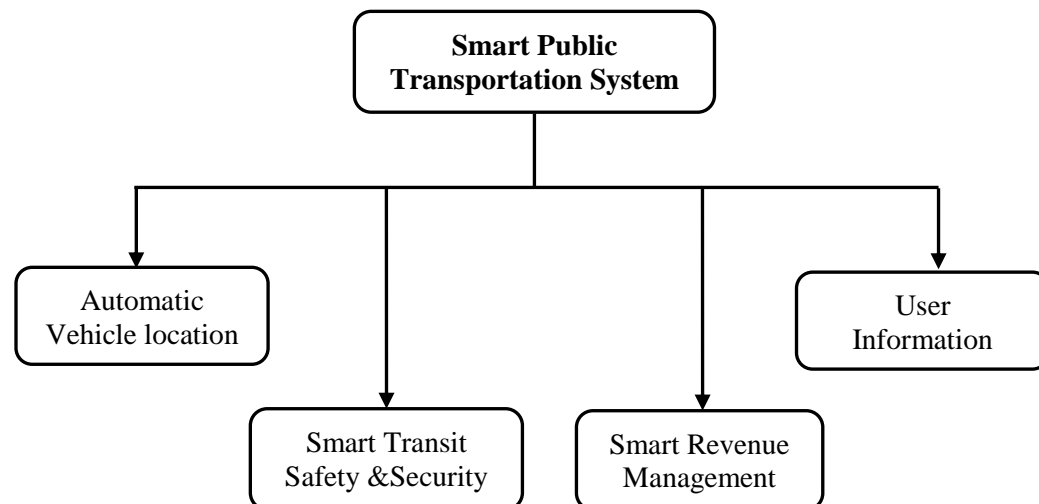


Fig 2: Sub Component for Development of Smart Public Transport System.

Application of Artificial Intelligence for development of smart public transportation systems in smart cities are summarised as follows:

1. Artificial Intelligence system include applications such as automatic vehicle location which enable transit vehicles, to report their current location, making it possible for traffic operations managers to construct a real-time view of the status of all assets in the public transportation system.
2. It can be used for monitoring the vehicles which will be useful to reduce traffic congestion and thus, saving the travelling time.
3. It can be used to provide commuters and operators with current information so they can avoid congested routes.
4. It can be used to provide commuters with arrival and departure information of transit vehicles.
5. It can be used to make public transport system more attractive

option for commuters by giving them enhanced visibility.

6. It can be used to represent an emerging new infrastructure system, from which new products and services are likely to emerge.
7. It can be helpful for transit network operators to take decision, for choosing the route when to travel.
8. To deploy and enable a communications infrastructure that supports vehicle to infrastructure as well as vehicle to vehicle.

Application for Development of Intelligent Traffic Management and Control System

Artificial intelligence system includes various applications in traffic control, traffic demand management, emission testing and mitigation, electronic payment management and incident management for development of intelligent traffic management and control system. Figure 3 presents sub component for development of intelligent traffic management and control system in smart cities.

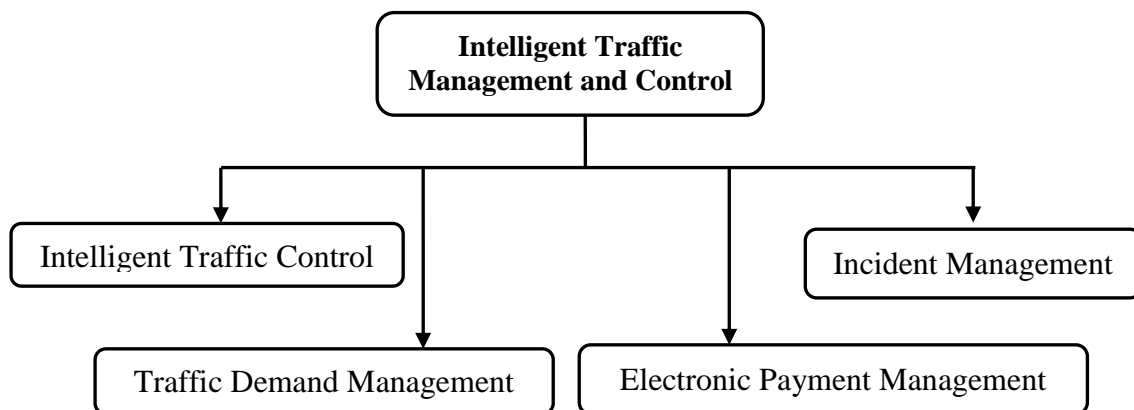


Fig 3: Sub Component for Development of Intelligent Traffic Management & Control System.

Traffic management and control system is the planning, monitoring and control or influencing of traffic. Some of the applications of Artificial Intelligence for development of intelligent traffic management and control system in smart cities are summarized as follows:

1. Artificial Intelligence system helps to make intelligent traffic control devices that provide drivers real time messaging about traffic or highway status.
2. It helps for traffic planning, traffic information, and traffic management which are essential for interurban traffic, urban traffic, and for parking of vehicles. .
3. It maximise the effectiveness of the use of existing infrastructure.
4. To ensure reliable and safe operation of traffic.
5. It can be used to maximize the operational performance of the transportation network.
6. It can also use to move towards performance based funding for transportation systems.
7. To optimize traffic signals where to build new roadways.
8. It can be used to manage the incidents which include crashes, breakdowns, and other random events that occur on highway system. Incident management systems contain basic components such as incident detection, incident verification, response to the incidents, clearance of the incidents, and traffic management at the incident locations.

9. In many locations, incident data are archived on a regular basis to identify locations of high incident frequency. These locations can be used in planning the responders' routes on the highway and for the identification of reasons for causation of incident to improve the existing roadway characteristics to avoid future incidents at the same location.
10. The most common application of artificial intelligent system is electronic payment collection through which operators and commuters can pay automatically. Implementation of electronic payment collection can help to generate needed resources to fund investments in public transport infrastructures and to reduce traffic congestion and environmental impact of vehicles.

Application for Development of Smart Traffic Information System

Artificial Intelligence system includes various applications in pre- trip travel information, en route travel information, route guidance and archived data function for development of smart traffic information system. Some of the applications of Artificial Intelligence for development of smart traffic information system in smart cities are summarised as follows:

1. Artificial Intelligence system can be provide real-time travel and traffic information such as transit routes and schedules, navigation directions, and information about delays due to congestion, accidents, weather conditions, or road repair work.
2. It can be used to inform driver's precise location, current traffic on roadways and empower them with optimal navigation instructions and route selection.
3. It can be used to make parking easier and indicate to drivers where vacant spaces can be found in the city, and

even allow drivers to reserve spaces in for parking.

Application for Development of Safety Management and Emergency System

The traffic accident patterns word wide indicated that it is not enough to have the safest vehicle and road technology to ensure safe mobility but the city structure, modal share split, and exposure of motorists and pedestrians also have a significant role in ensuring safe mobility. Artificial Intelligence plays an important role for reducing the traffic accidents and increases the safe mobility in smart cities. Some applications of the Artificial intelligence for development of Safety management and emergency system in smart cities are summarized as follows:

1. Artificial intelligence used to develop a comprehensive and reliable computerised accident data base which can provide necessary data for analysis of trends of accidents required for safe mobility.
2. Artificial Intelligence system can be used to provide facilitates rapid intervention in an emergency situation which can safeguard the health and safety of the people involved.
3. The main objective of Artificial intelligence system for development of emergency system are to improve the safety of travel, to increase the efficiency of the emergency service by reducing travel time, to optimize trip planning from the emergency vehicle station to final destination and to reset ordinary traffic conditions as soon as the emergency has ceased.

Application for Development of Smart Parking Management

Most of the metro cities of India every third driver is looking for a parking space. This does not necessarily have anything to do with a shortage of parking spaces, but with a lack of information about the location and number of available spaces^[4]. Every city is different and unique due its

traffic structures, topography and financial possibilities. Smart parking management systems provide customized solutions of parking problems. Artificial Intelligence is a most recognized technology for development of smart parking management in smart cities. Some applications of the Artificial Intelligence system for development of smart parking management systems in smart cities are summarized as follows:

1. Dynamic displays guide the driver to parking spaces and to multi-storey car parks.
2. In the multi-storey car park, every space can be monitored by ultrasound sensors.
3. All information is monitored "online" in the management centre, which relieves the driver of finding a parking space.
4. Optimum use of multi-storey car park capacities,
5. It boosts demand and high customer satisfaction and
6. Reduces carbon emissions by minimizing the number of drivers searching for a parking space.

Application for Development of Smart Pavement Management System

Some applications of the Artificial Intelligence for development of smart pavement management system in smart cities are summarized as follows:

1. Artificial Intelligence system is best solution for collection and analysis of very large volume of data for evaluation of existing condition of the pavement both structurally and functionally.
2. It helps pavement preservation by maintaining it to the desired level without resorting to restoration spending huge amount of money.
3. It can be used to develop project level analysis tools based on economic principles to arrive at maintenance standards and maintenance strategies

and to optimize the use of funds allocated for pavement maintenance and rehabilitation.

4. It is used to develop expert systems for pavement management i.e. PAVEMENT EXPERT, PAVER, SEVADER and ORAGE which can be used to manage roads, incidence, severity, streets, parking lots and airfield and the extent of range of distress for each road section.

The computer engineers can develop appropriate models using his knowledge in Artificial Intelligence and combining them with transport expert's to evolve realistic solution for developing transport systems in smart cities. Though the computer engineer could handle computer part of the Artificial Intelligence System, it will not be appropriate to expect him to deal with transport specific problems and hence the need arises for him to work jointly with transport expert. Similarly, the transport expert is also not expected to have so much exposure to computer applications as to independently handle all the nuances of Artificial Intelligence Systems in solving the complex problems of developing transportation infrastructure in smart cities. The application of Artificial Intelligence in developing transport Systems will therefore involve a joint effort of transportation experts and computer engineers. The application of Artificial Intelligence in developing transport Systems will therefore involve a joint effort of transportation experts and computer engineers.

CONCLUSIONS

The important conclusions based on this study are summarized as follows:

1. There is an urgent need for developing smart cities in India that can cope with the challenges of urban living.
2. Transport system in smart cities should be accessible, safe, environmentally friendly, faster, comfortable and

affordable without compromising the future needs. The Indian cities largely lacks of intelligent transport system and there are various problems such as inefficient public transport system, severe congestion, increasing incidence of road accidents, inadequate parking spaces and a rapidly increasing energy cost etc. Therefore, development of intelligent transportation system is essential for smart cities due to concerns regarding the environmental, economic, and social equity. Artificial intelligence system is a key technology to resolve these issues. Therefore, there is an urgent need to adopt artificial intelligence system for development of intelligent transport systems to better understand and control its operations in smart cities.

3. This study reviews the basic concepts of Artificial Intelligence. This study also identifies various sub-systems of Intelligent Transport System i.e. smart public transport system, intelligent traffic management and control system, smart traffic information system, safety management & emergency system, smart parking management and smart pavement management system in smart cities. This study also presents application of Artificial Intelligence for development of intelligent transport systems in smart cities in India.
4. There is an urgent need to develop smart public transport system for smart cities in India. This study identifies various sub components for developing such a system. These components are en-route public transit information, automatic vehicle location, smart travel security and smart revenue management which enable transit vehicles to construct a real-time view.
5. There is an urgent need to develop intelligent traffic control and management system for smart cities in India. This study identifies various sub

components for developing such a system. These components are intelligent traffic control, traffic demand management, emission testing and mitigation, electronic payment management and incident management for effectiveness of the use of existing infrastructure.

6. There is an urgent need to develop smart traffic information system for smart cities in India. This study identifies various sub components for developing such a system. These components are pre- trip travel information, en-route travel information, and route guidance to provide real-time travel and traffic information such as transit routes and schedules, navigation directions, and information about delays due to congestion, accidents, weather conditions and road repair.
7. There is an urgent need to develop a smart parking management system for identification of vacant spaces for parking and even allow drivers to reserve spaces in for parking for smart cities in India.
8. There is an urgent need to develop safety management and emergency system for smart cities in India to increase the efficiency of service in an emergency situation and to improve the safety of travel.
9. There is an urgent need to develop smart pavement management system for redesign and management of street as per the requirements of different transport modes in smart cities.

The application of Artificial Intelligence in developing intelligent transport system in smart cities will involve a joint effort of transportation experts and computer engineers. It is expected that this study will be useful for planners and engineers so that AI system can be formulated for development of intelligent transport system in smart cities in India.

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