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Machine learning-based traffic management techniques for intelligent transportation system: Review

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Abstract

The increase of congestion in the urban environment has become a major problem. The traditional traffic control methods with poor administration of human resources do not moderate traffic, resulting in increased traffic congestion and road violations. The intelligent transportation system (ITS) can guarantee safety, efficiency, and sustainability for large-scale vehicle traffic issues. In order to ensure the smooth flow of traffic, ITS combines machine learning with the existing traffic control system and provides a real-time strategy. Several researchers have shown great work with different optimization techniques in intelligent traffic police management and deployment. However, it remains necessary to compile such an impressive effort as a whole. In light of these facts, we present a comprehensive review of the state-of-the-art technology for the development of a three-tier solution classification in machine learning. The first tier contains several tools and methods for collecting traffic statistics. The second tier focuses on the accuracy of the machine learning algorithms, forming a pattern for the acquired data, and then provides important data on traffic flow, congestion levels, and so on. Various traffic planning techniques are covered in the third tier, the most essential layer of taxonomy. The proposed review also examines the usage of traffic police schedules which develop the application of this evaluation in different areas. Finally, some of the major challenges are discussed and further improvement is initiated.

Keywords: *intelligent transportation system (ITS), machine learning, reallocation, traffic management, traffic police*

1. Introduction

Recently a significant problem has emerged in metropolitan areas due to the rapidly increasing population and the number of vehicles, traffic obstructions, and overcrowding. Traffic jams and congestion issues affect public regular life on a two-fold basis and increase travel costs directly [1]. Nowadays, the progress of information and communication technology (ICT) and the growth of Artificial Intelligence (AI) applications have prepared the road for ITS evolution [2]. This

development is aimed at providing new road transport services, including mobility control, infrastructure, vehicles, traffic congestion management, etc. This includes mostly wireless sensors and computing technology applied with AI capability [3]. Figure 1 displays classification in the application domains where ITS is utilized. In major smart cities, ITS offers various functions including traffic management and safety. These include automatic road enforcement, emergency vehicle alert systems, changeable speed limits, flexible sequences of traffic lighting, collision early termination systems and pollution controls, parking advice, weather reporting systems, deletion of bridges, and shifting systems leading to smooth vehicle flow [4]. However, the ITS does not have the aspect of human resources and management resources. The traffic police are the core of traffic management for all cities and, thus, their scheduling and reorganization based on the different densities of traffic is primarily necessary to tackle the growing issue of traffic congestion. In this paper, we have reviewed the traffic management system based on machine learning technology, which ensures that human resources, time, money, and fuel are used optimally in order to build sustainable smart cities [5].

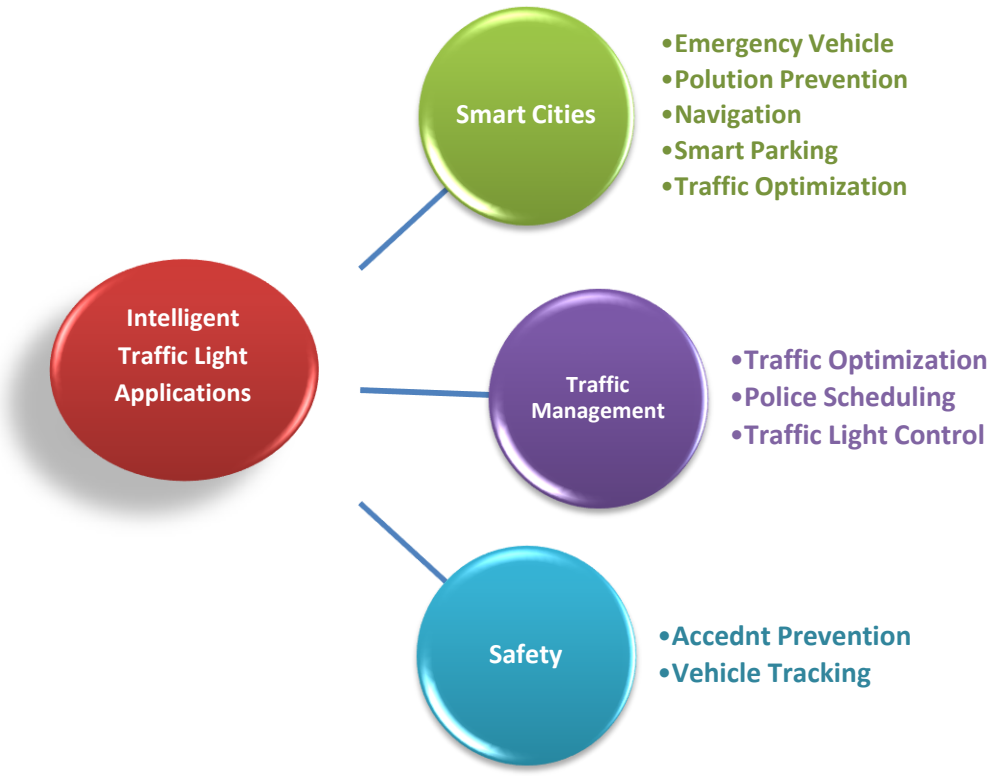

Figure 1. ITS applications

The main reason for this work is to examine the planning and the distribution based on real-time traffic density based on machine learning. Currently, the traffic police are statically allocated, where regions are allocated [6]. But the steady increase of traffic at the crossroads leads to traffic

congestion during early hours of the day or on festivals or at public meetings. In addition, the installation of the traffic signal equipment at the smaller junctions lowers space and even causes expensive maintenance. The necessity of the hour is for effective management and uniform deployment of available traffic police at the intersection before traffic congestion reaches the maximum level. Furthermore, a rise in the number of traffic fines issued by traffic cops lowers the incidence of deadly road accidents [7][8].

The rest of the paper is structured as follows. Section 2 depicts traffic police management for ITS. Section 3 describes the applications of intelligent transportation systems. Section 4 discusses the research challenges and issues, and finally, Section 5 concludes the paper.

2. Traffic Police Management for ITS

The smart cities approach is filled with many concepts which focus largely on saving money and time while keeping a decent health ratio and building a sustainable environment that makes people's lives easier. Unfortunately, traffic congestion problems become a major cause of stress, resentment, and a worsening health situation. The increasing number of cars, lapses such as bad traffic control management, and the lack of infrastructure are drivers for increased congestion. Intelligent planning initiatives rely significantly on techniques for traffic congestion control. It is aimed towards decreasing people's transmutation time and improving safety and comfort [9].

With movement as a major problem, dynamic traffic lighting management, real-time simulated computing, and smart traffic police implementation allow large-scale transport networks to be better regulated. In addition to the growing idea of smart cities, ITS combines these systems and is an important and trendy component [10]. ITS includes machine learning-based collection of data, intelligent applications, analytical techniques, smart and dynamic algorithms of scheduling, and workable protocols These leveraging technologies assist manage the hardware components and human resources accessible through software techniques rather than hardware alterations, given that they demand considerable investments in their installation and maintenance. From now on ITS ideas will assist to solve the traffic congestion problem in managing traffic control equipment, assignment, and scheduling of existing traffic control personnel as per the actual traffic circumstances [11] [12].

As a move toward this intelligent traffic control system, there are several ideas in the following literature. Table 2 describes the previous efforts in the planning of the transport police force and its limits.

Table 2: The previous efforts in the planning of the transport police

Reference	Year	Objective	Contribution	Limitation
The traffic police location and schedule assignment problem [13]	2014	Increase the visibility of traffic police in hotpots and proactive police activities	creates optimum coverage systems for patrol vehicles with halo effects and MAXMIN integer linear problem	The volume of traffic is not real time
A multi-criteria police districting problem for the efficient and effective design of patrol sector [14]	2015	Efficient patrol sector planning to decrease effort, reaction time, etc.	provides rapid patrolling for the crime predicted at a certain place	Policing distribution based exclusively on crime prediction
Genetic algorithm for optimizing routing design and fleet allocation of freeway service overlapping patrol [15]	2018	Minimize the mean response time for incidents	A complete, nonlinear mixed integral coverage and overlap of the patrol design and fleet design pattern based on genetic algorithms	There is no stochastic planning for the Freeway Service Patrol (FSP).
An approach for the police districting problem using artificial intelligence [16]	2018	Responding to real-time monitored events with efficient traffic police location and timetable assignment	Human component assigns priority levels to AI-based traffic police deployment based on real-time events.	Large amounts of data slow down the algorithms and make changes unrecognizable.
Analysing the police patrol routing problem: a review [17]	2020	Discuss possible solutions for interactive police patrols.	Detailed examination of several ways to resolving the problem of police patrol routing	There is a lack of cost-effectiveness and an effective crime preventive impact.

3. Traffic Management Applications

During the sustainable development of the smart city, many applications exist for traffic police planning. There are a few usage scenarios and circumstances that benefit from efficient traffic police scheduling [18]. Figure 2 offers an example of additional areas in which the scheduling of traffic management might be useful. Some of the previous applications are presented in Table 2.

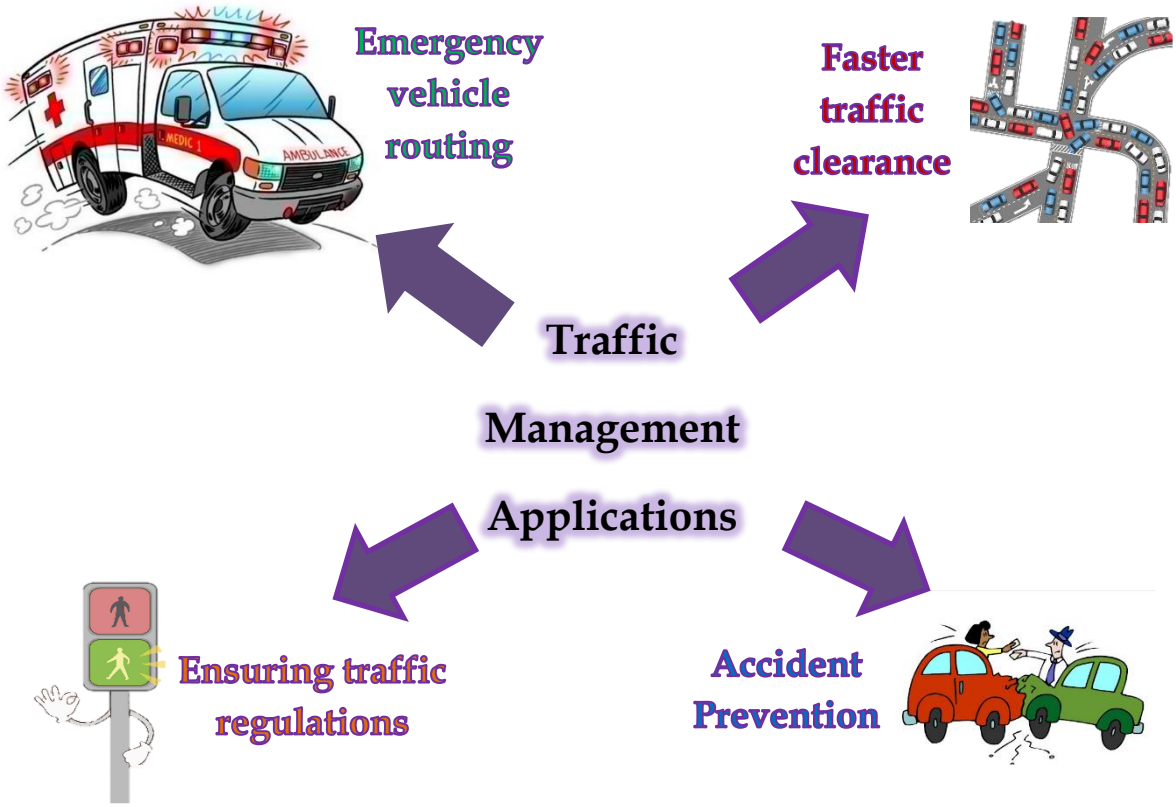

Figure 2: Traffic Management Applications

3.1. Emergency vehicle routing

Ambulances, police vehicles, fire trucks, and other emergency vehicles must be at the scene of the incident within seconds. However, the bulk of underdeveloped countries have no dedicated roads for emergency fleets, and they are caught in huge traffic [19]. The traffic police, therefore, need to contact their colleagues in advance and clear the road in order to understand the best potential route for these emergency vehicles. When faced with unanticipated changes, the following scheduling aid will assist restricted traffic and patrol police platforms in making a rapid and effective routing of the emergency vehicle. The authors in [15] proposed a new concept of boundary based on graph theory, utilizing 0-1 programmatic programming; the Dijkstra algorithm; and the Shortest Path Tree(SPT) setting out the confinement pattern.

3.2. Ensuring traffic regulations

The increase in death rates due to increased deaths from accidents concerns emerging countries. The highway accident mortality rate is mostly driven by ignorance of the

regulations on road safety and the rise in emergency car response times due to congestion problems. In order to decrease road accidents, the government has to introduce severe traffic regulations including frequent vehicle inspections, thorough driving license inspections, and medical fitness of drivers. In order to provide rapid emergency response services during road catastrophes, governments of all nations should develop and upgrade their paved road networks and also effectively control road congestion. The authors in [20] showed the country's wise comparison, together with the advantages and drawbacks of its road traffic control system, of road traffic deaths and their determinants.

3.3. Accident Prevention

One of the main reasons for this increased fatality rate is road accidents. According to government data, more than 1.5 people died from road accidents with the major cause of over-speed, and 5.8 percent of the road deaths included driving on the incorrect side. The usage of mobile phones accounted for 2.4% of fatalities, while 2.8% of dead people were intoxicated driving [21]. One main objective of the intelligent management assistant is to minimize the accident rate through traffic control. According to [22], it would encourage direct interaction of the deployed forces with cars for driving license check, car registration, and road tax clearance to cover maximum nodes or junctions with current deployed patrol elements. Vision contact should be part of the speed control, drink and drive cases of the vehicle, and rash conduction at junctions. Even if it is difficult and inaccurate to eliminate accidents in real practice, it may be reduced by wise use of the traffic force.

3.4. Faster traffic clearance

The sudden traffic congestion situation will be presented by a clever traffic police aid system to inform the police of possible recommendations and a rapid map. In addition, a simple software click would transmit alarm messages to the neighboring traffic forces and clear the traffic lock within seconds instead of hours by its synchronized operations. Due to traffic mismanagement, developed countries' economies suffer enormous monetary losses. A simulation-based traffic management system has been developed by authors in [23] which mitigated damages without modifying the current road infrastructures. Fast congestion clearing saves money, leads to smoother traffic flow, which in the final analysis minimizes mental stress and environmental impacts.

Table 2: Traffic Management Applications

Reference	Year	Objective	Application	Contribution	Limitation
Genetic algorithm for optimizing routing design and fleet allocation of freeway service overlapping patrol [15]	2018	Reduce the average response time of highway patrol vehicles.	Overlapping FSP method for emergency vehicle routing and incident response time reduction	A mixed-integers complete genetic algorithm patrol routing design covering and overlapping	There is no stochastic FSP planning.
Road traffic fatalities and its determinants in high-income countries: a continent-wise comparison [20]	2019	Investigate the relationship between road traffic deaths and the impact of road safety enforcement.	Road Traffic Fatalities (RTFs) reduced by the implementation of traffic regulations	Different approaches for expanding the paved road network and ensuring strong enforcement of traffic regulations in various locations were investigated.	There is no connection between the economic consequences of road traffic deaths and economic growth.
An application of genetic algorithm method for solving patrol manpower deployment problems through fuzzy goal programming in traffic management system: a case study [22]	2012	In a traffic control planning horizon, lower traffic rule violations and accident rates.	Accidents can be avoided by strictly enforcing road safety regulations while being monitored by traffic cops.	A genetic algorithm increased the fugitive objective of programming the correct deployment of patrolling in different metropolitan roads.	Personnel deployment difficulty in dealing with traffic in complicated emergencies
Traffic scheduling simulation: the case of Dhaka City [23]	2017	Optimally improve the traffic control system without modifying the hardware	With the aid of an effective traffic management system, traffic may be cleared faster.	To decrease the expense of traffic congestion, a simulation-based traffic scheduling system has been developed.	Consider the cross-section of a road with the same number of lanes on both sides.

4. Challenges and Issues

The common traffic management strategies suffer from some challenges and issues that need to be tackled. The performance, reliability, precision, and schedule configurations created as a result by the traffic police are immediately affected. Below are some of those common problems.

4.1. Data collection

Data from many sources, such as video cameras, GPS (Global Positioning Systems), OBUs (On-Board Units) and RSUs (Road-Side Units), sensors, and cell towers can be gathered. However, it is difficult to integrate heterogeneous data with these large data to establish standard information. It is extremely difficult to correct the data received from multiple independent systems from the same source into one source. The utilization of this data in a practically centralized vehicle environment is another important problem [24]. In addition,

data from these devices may contain personal ownership information that reveals confidentiality. To secure sensitive information from intrusions during data transfer, a security mechanism is necessary [25]. The inefficient layout of road networks, traveler information systems, and vehicle control systems poor traffic management systems remain important problems for traffic-related data collection.

4.2. Data analysis

A huge volume of data has to be processed in the traffic management system. It is hard to manage this asynchronous data from many sources and merge them into unified traffic conditions. For prediction-based applications, data filtration is an absolute condition since the more relevant traffic data are a better input parameter for algorithms of optimization and prediction. It is also hard to integrate the findings of this estimate to develop a flexible model, which accurately predicts future traffic circumstances and justifies objectives such as time, cost, convenience, environmental pollution, etc.

5. Conclusion

Technical advances in traffic management and the planning of real-time traffic police services will move the policing focus to proactive and eventually minimize wasting money, time, and fuel on long-distance traffic jams by the public. The focus of this study is on the planning and relocation of transport police consistently based on real-time traffic density in large and small roads so that traffic jams may be reduced and traffic flows throughout the entire city can be smooth.

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