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"A Review of Artificial Intelligence (Ai) Based Transportation System"

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ABSTRACT

Due to the progressive increase in the population and the complexity of their mobility needs, the evolution of transportation systems to solve advanced mobility problems has been necessary. Additionally, there are many situations where the application of traditional solutions is not entirely effective, e.g., when the processing of large amounts of data collected from in-vehicle sensors and network devices is required.

To overcome these issues, several Artificial Intelligence-based techniques have been applied to different areas related to the transportation environment. In this paper, we present a study of the diverse Artificial Intelligence (AI) techniques which have been implemented to improve Intelligent Transportation Systems ITS). In particular, we grouped them into three main areas depending on the main field where they were applied: (i) Vehicle control, (ii) Traffic control and prediction, as well as (iii) Road safety and accident prediction. The results of this study reveal that the combination of different AI techniques seems to be very promising, especially to manage and analyze the massive amount of data generated in transportation.

Keywords **—Intelligent Transportation Systems, Artificial Intelligence, Artificial Neural Networks, Genetic Algorithms**.

1.INTRODUCTION

Transportation systems have become an essential part of daily human life. It is estimated that an average of 40% of the world population spends at least one hour on the road every day [1]. Intelligent Transportation Systems (ITS) are those systems which integrate both advanced control systems and wireless communication technologies to provide innovative solutions in transport and traffic management [2]. In the last years, mainly due to the progressive increase

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of the population and the complexity of their mobility needs [3], ITS have incorporated different Artificial Intelligence (AI) [4] techniques to provide new services. These services usually involve managing a significant amount of data generated by vehicles and drivers [5], [6]. In particular, modern ITS seek to overall improving traffic safety and sustainability, while additionally introducing a positive impact on people living [7], [8]. In fact, the use of AI has extended to many areas and disciplines in real life, and transportation systems are no exception since multiple applications using AI techniques and methodologies, with the aim of improving ITS, can be carried out In this paper, we perform a thorough study of existing literature related to the application of AI techniques in ITS. More specifically, we determine the most used techniques and analyze their advantages and drawbacks when they are applied to different areas of transportation. Particularly, we grouped all the proposals into four techniques:
(i) Artificial Neural Networks (ANNs), (ii) Genetic Algorithms (GAs), (iii) Fuzzy Logic (FL), and (iv) Expert Systems (ESs) (see Figure 1). Next, we present a brief description of the selected AI techniques.

Artificial Neural Networks are based on the mathematical model of neuron proposed by McCulloch and Pitts in 1943 [9], and they can be considered as a processing paradigm that works similarly to the human brain. ANNs present some features, such as adaptive learning, self organization, and fault tolerance, and they are usually implemented to solve problems related to pattern recognition, data coding, optimization, and data mining

- Genetic Algorithms are heuristic search methods applied to find solutions to problems using evolutionary biology and natural selection strategies [10]. GAs are often used for searching large and complex datasets, and they are highly capable of solving optimization problems in many fields such as robotics, telecommunications, medicine, and transportation
- Fuzzy Logic techniques emulate the human reasoning capacity to make rational decisions in an environment of uncertainty and imprecision [11]. FL is usually applied to solve many problems, such as complex industrial processes, recognition of handwritten symbols, driving comfort, and prediction systems [12].
- Expert Systems are rule-based approaches based on predefined knowledge [13]. They are commonly applied to decision-making through logical deduction. ESs emulate the behavior of human experts solving problems. More specifically, they store knowledge

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about a given field and can solve problems by using logical deduction about that knowledge. ESs are usually used in telecommunications, medicine, accounting, and transportation

Once we have introduced the different AI techniques which have been commonly used in ITS, now we present the main areas related to transportation in which the AI techniques described before have been widely applied with promising results. They are:

1) Vehicle control. In the literature, we find several proposals implemented to develop new control systems for vehicles. Examples include autonomous driving, antilock braking systems, vehicles' consumption management, and emission control systems

2) Traffic control and prediction, where developed systems aim at reducing traffic congestion or even predicting traffic jams in advance

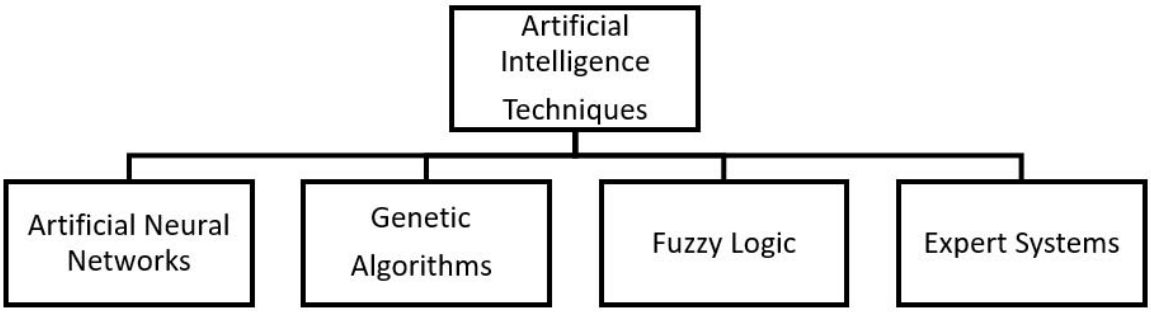


Fig. 1. Artificial Intelligence-based techniques mainly used in ITS.

3) Road safety and accident prediction.Wu15 Finally, other contributions focus on increasing the road safety, avoiding or preventing possible accidents by incorporating systems that autonomously anticipate accidents, or at least mitigate their consequences.

2. LITERATURE REVIEW

Wang Ya-jun Zhang Zhi-jun (2009) Transportation system security efficiency is an important aspect which evaluates the developing level of transportation system. Analyzing and evaluating urban transportation security efficiency exactly is not only the requirement of urban transportation planning, but also the basis of the urban construction planning. The developing course of developed country shows that the developing of the transportation security has its internal disciplinarian; it not only depends on the quantity of vehicle retaining and the mileage

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of open to traffic, but also depends on the other factors, such as economic developing condition of country and society, civil culture and tradition, moral quality, legal ideal, living custom. Therefore, traffic security efficiency evaluation is a synthetic problem, it relates to people, vehicle, road, humanistic environment and management. At the same time, because of multi-layers and dynamic of urban transportation system, it contains lots of uncertain, uncompleted, subjective, fuzzy information; so general qualitative evaluation method can not solve the problem of security efficiency evaluation exactly. Fuzzy synthetic evaluation is the effective method to realize ration evaluation for qualitative problem [1].

Danish Fayaz (2015) India, the second most populated country after China is achieving its heights regarding transportation engineering. With the increase in population, migration from rural to urban and sudden strong economic rise has unambiguously put gigantic pressure on the basic facilities, services and installations needed for the functioning of transportation system. Moreover there will be increase in the number of vehicles. Shoot up in the number of vehicles, traffic problems always exist. The transportation facilities like current unmanaged transient signal priority system make it difficult to control the travel time, collisions at intersections and efficient schedule adherence. Inefficiency in car parking makes it difficult to adjust and arrange the increasing number of vehicles in a proper, acceptable and convenient manner. Inaccurate management in the position of motorists, following the congested route even when there are alternate routes aims at vehicle jamming and time travel increment. So it is necessary to have a management system which should tackle all the above problems in an efficient manner. This study is aimed at reviewing an Intelligent Transportation System (ITS) and technologies associated with transportation system. Implementing this system earmarks available parking space to a driver to park their vehicle and renews the availability of parking space when car leaves. This system also helps to avoid or abstain from collisions at intersections, accidents, impairs the vehicle jamming. This paper reviews discussed wide applications of ITS, used technologies and its usage in different areas respectively. This paper tackles the different Intelligent Parking Services used for parking guidance, parking facility management and gives an insight into such projects [2].

Thirumalaisamy Ragunathan et al. (2015) investigated the structure and design for an ITTS system and discussed the practicable details of the model system developed by them. This system plans to enhance the intelligent tour schedule of the system and install the system in the

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web for public use. Ling Sun et al. (2016) [3] presented the intelligent co-operative system in which two vehicles are dependent to each other and the two motorists (drivers/travellers) interact with each other to exchange their dynamic data by the use of internet. Each component in co-operative intelligent transport system has a core (a core in each roadside system, central system, vehicle system, personal system) that is interconnected to each other. Vehicles exchange data, control mechanisms and stay interconnected during the travel time [3].

Sergei Korjagin (2017) presented the study that deals with intelligent transport security systems. He discussed the use of intelligent transport security systems that intended to lower traffic accidents and threats, increase the traffic capacity of road network, diminish the delays in traffic flow and ameliorate traffic safety. This paper also ensured continuous flow of land urban passenger transport in Klachek and Korjagin (2015). The studies of Russian and European experience showed the application of ITS that enabled to reduce roads and traffic authority (RTA) level by 30%. The work presents a biocybernetical traffic management assumptions based on ITS. The set of assumptions was planned to combine large traffic control at road and transport conditions with fine adjustment at the small level of physiological and intellectual actions taken by driver [4].

Firas Alrawi (2017) proposed whether or not ITS are related to air quality improvement. Studies portray that the use of such systems in transportation system reduced travel time and frequency. e.g. variable message signs reduces the interruptions by 53% and enhanced travel time by 44% (AL-Jarallah, 2012). SCOOT technique for traffic network monitor management in urban areas reduced traffic congestion by 20% (William, 2008). The study revealed the ITS increased reliability of traffic transport and reduced fuel rate consumption which lead to the reduction of emission rate. The main aim of ITS was ton save minimum of one billion of gasoline each year and to lower emissions at least in proportion to this fuel saving (ITS America, 2002)[5].

Rusul Abduljabbar, Hussein Dia (2019) The rapid pace of developments in Artificial Intelligence (AI) is providing unprecedented opportunities to enhance the performance of different industries and businesses, including the transport sector. The innovations introduced by AI include highly advanced computational methods that mimic the way the human brain works. The application of AI in the transport field is aimed at overcoming the challenges of an

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increasing travel demand, CO2 emissions, safety concerns, and environmental degradation. In light of the availability of a huge amount of quantitative and qualitative data and AI in this digital age, addressing these concerns in a more efficient and effective fashion has become more plausible. Examples of AI methods that are finding their way to the transport field include Artificial Neural Networks (ANN), Genetic algorithms (GA), Simulated Annealing (SA), Artificial Immune system (AIS), Ant Colony Optimiser (ACO) and Bee Colony Optimization (BCO) and Fuzzy Logic Model (FLM).[6].

Adaptive Route Selection for Dynamic Route Guidance System Based on Fuzzy-Neural Approaches The objective of this work is to develop a driver's behavior by selecting the optimum route from origin to destination (O/D). One function of a vehicle navigation is the route planning. An effective driver decision making in selecting the optimum route The research focus on optimum route search function in a typical in-car navigation system or dynamic route guidance (DRG). In this work, using the driver's preference we need to emphasize the need to orientate the route selection method. Each feasible route has a set of attributes. To provide a route ranking to the driver we used fuzzy neuro (FN) approach to represent the correlation of attributes with the driver's route selection. Based on a training of the FN net on the driver's choice, the route selection function can be made adaptive to the decision making of the driver[7].

Real-Time Bus Arrival Time Prediction: Case Study for Jinan, China – to enhance to competitiveness and to improve the service quality of a transit system among other transportation one of the key factor is providing real-time bus arrival information. Based on historical global positioning system (GPS) data and automatic fare collection (AFC) system data using two artificial neural network (ANN) the study proposed a real-time bus arrival prediction in city of Jinan, China. The study is subdivided into clusters because of the difficulties in capturing the traffic fluctuations over different time periods and account for signalized intersection impact. Each cluster are develop using Sub- ANN model and further integration of hierarchical ANN model. Six scenarios with respect to different time periods and route lengths are tested to validate the results. The results reveal that both proposed ANN models can outperform the Kalman filter model. Particularly, with several selected performance indices, it has been found that the hierarchical ANN model clearly outperforms the other two models in most scenarios.[8].

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In particular, Chiou used ANNs to develop an accident appraisal Expert System specially designed for the evaluation of traffic accidents. In addition, two ANNs models (i.e., partybased and case-based) were trained and validated using the cross-validation method. Tseng et al. [36] proposed an Expert System, which uses a Radial Basis Function (RBF) Neural Network, to analyze the relationship between vehicles speed and the length of their skid marks. Azim et al. [37] presented a Fuzzy Expert System (FES) that classifies the level of alertness of drivers, as part of a system able to detect drivers' fatigue, by analyzing cockpit videos [9].

3. ANALYSIS OF THE USE OF AI TECHNIQUES IN ITS APPLICATIONS

To analyze the most frequently Artificial Intelligence techniques used in Intelligent Transportation Systems, we made a thorough search of the existing papers in the literature that combine those fields, (i.e., AI and ITS). As previously commented, we grouped AI techniques into four different categories (i.e., Artificial Neural Networks, Genetic Algorithms, Fuzzy Logic, and Expert Systems). Table I summarizes all the proposals studied in this work. In particular, we accounted for the papers that include any AI technique when proposing new applications and services in the transportation environment. As shown, the most used technique in ITS-related approaches is ANNs (twenty-four times), closely followed by the use of FL (twenty-one times), and GAs (eighteen times).

It is noteworthy that Expert Systems are the least technique implemented in ITS (only used in six of the proposals), in spite of representing one of the most consolidated AI techniques in other fields, such as medicine or accounting. Due to the excellent results obtained in other domains [14], it seems appropriate to extend their application to the transportation environment, especially in those services that require the manipulation of large volumes of data. Additionally, it is necessary to mention that in the majority of the proposals, the authors combined two AI techniques to obtain better results

4.Applications of AI in Transport

In many cases, it is hard to fully understand the relationships between the characteristics of the transportation system; therefore, AI methods can be presented as a smart solution for such complex systems that can't be managed using traditional methods. Many researchers have

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demonstrated the advantages of AI in transport. An example of that includes transforming the traffic sensors on the road into a smart agent that detects accidents automatically and predicts future traffic conditions . Also, there are many AI methods used in transport such as ANNs. ANNs can be used for road planning ,public transport Traffic Incident Detection and predicting traffic conditions It is classified into supervised and unsupervised learning methods. Supervised methods include Support Vector Machine (SVM), Probabilistic Neural Network (PNN), Radial Basis Network (RBN), K-Nearest Neighbors and Decision Tree, etc. while unsupervised NNs include greedy layer-wise and cluster analysis.

5. CONCLUSION

we presented a thorough study of existing works where Artificial Intelligence techniques were applied to propose new applications and services, or mitigate problems in
Intelligent Transportation Systems. In particular, we focused our analysis on ITS areas, such as vehicle control, traffic control and prediction, and road safety. We observed how some AI techniques have emerged over the others to address some specific issues.

• Genetic Algorithms have been widely used in vehicle control systems, especially when optimizing all the parameters involved. As expected, they are suitable for multi-objective optimization

• Regarding traffic control and prediction services, most of the authors implemented Artificial Neural Networks. More specifically, they are used to make predictions or classifications

• As for road traffic and accident prediction, both Fuzzy Logic and ANNs have usually been applied. FL seems to be more suitable for introducing the human factor to estimate accidents frequency, whereas neural networks are implemented to predict injury severity in traffic accidents.

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