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A Model on Fuzzy Logic Implementation in the Development of Traffic Management in Smart Cities: Artificial Intelligence Approach.

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Abstract

Smart cities have been developing using a combination of new emerging technologies which majorly Include Internet of Things (IoT), Big Data, Block chain, Augmented Reality, and Artificial Intelligence(AI). These technologies have contributed to the development of many fields such as transportation, environmental protection, energy, medical care, and logistics, and have produced many social, economic and ecological benefits Traffic monitoring has become one of the censorious issues in large cities. The Latest traffic light frameworks utilize a fixed time delay for various traffic directions and do follow a specific cycle while changing starting with one sign then onto the next. This makes undesirable blockage during top hours, loss of worker hours, and in the long run decreases profitability. A smart city is one that extraordinarily decreases vehicle traffic and permits individuals and merchandise to be moved without any problem. Wise traffic frameworks are a case of this and the accomplishment of independent vehicle transportation would be a prime case of achievement for a smart city, as this could decrease vehicle-related passing. Every one of these endeavours would lessen contamination, bringing about a more beneficial populace. We propose to you a system that has proven to be smart, intelligent, and capable of solving traffic system issues that offer to be a boon to smart cities and control systems emerging cities of the world.

Keywords

Smart Cities,

Fuzzy Network,

Artificial Intelligence,

Internet of things,

Traffic Management

1. Introduction

With an enumerate of approximately 8 billion as per world meter, the world population is building up thoroughly from day to day [1]. Following these increasing populations is the necessity to scale infrastructure and resources sufficiently to well accommodate the increasing desiderata of communities. Deprivation of a poor management system in such a context would invite a lot of chaos and congestion. One of such requisites that need proper management is road traffic. With the majority of the population residing in urban areas, various authorities and organizations are trying to enhance the traffic management system to reduce congestion [2]. It is unimaginable to anticipate the perception of the cities of the next coming day from that of the future configuration in the field of transportation [3]. Nimble technologies are needed in this scene to ensure that people can be served with the best way of traffic monitoring and surveillance.

Smart-Cities is the name allocated to the framework that encompasses all such technologies that enable communities to enhance the management of such growing needs. Machine-learning, Artificial Intelligence, Image processing, Computer Vision, and Fuzzy Logic are the crucial technologies that this domain would include. Through this paper, we propose a framework model for smart-cities and proceed by elaborating constituent components of this framework and their potential dominance over existing systems. In this proposed model, we follow a modular approach to better describe the work-flow and also observe subtle occurrences that could prove to be crucial at the level of implementation. For Convenience, we do not consider vehicle travel patterns while embedding intelligence into the model as people's travel patterns may change more often than they appear to be. Machine Learning, a subdomain of Artificial Intelligence is a deemed technology that is used to deploy systems that could learn from data and experiences to form insights rather than run on hard-coded algorithms [11]. Artificial Intelligence finds application in enhancing automobiles in several forms. This research paper deals with a few of them such as detecting, analysing, and predicting the traffic volume, incidents, and conditions of traffic, mobility as a service [4]. Hence, Artificial Intelligence would turn out to be a crucial tool and a primary technology in building solutions to hurdles faced due to traffic congestion while still answering questions of safety and environmental issues

In Scenarios, that require a significant ratio representing the likeliness of an entity to be labelled into a category, strict labels or discrete values may not be most useful. This is where Fuzzy systems come into play. Fuzzy Systems run on fuzzy logics which fundamentally deal with discretized ratios between 0 to 1, unlike the traditional Boolean logics which constitute strictly 0 and 1. This approach is much appropriate in real-time scenarios and hence find a lot of prominence in intelligent systems as such [13]. The outcome of the Fuzzy Logic is much more justifiable than that of Boolean logic. For example, if one were to implement a system to monitor the speed of vehicles on a road with a speed limit of 50mph, Boolean logic over a speed of 50.2mph would output a strict label as "Over speeding" which is very inappropriate as per the context. On the other hand, fuzzy logic would assign a ratio that indicates the extent of "over speeding" as 0.2, which would be neglected/considered accordingly. Hence, fuzzy logic would be another crucial aspect involved in the implementation of our model [12].

2. Background study

AI is the solution to complex problems. The complexion arises when there are incidents which are prone to accidents. To predict future incidents the researchers are finding a technological solution through AI. The Distinctive Artificial Intelligence Monitoring System (AIMS), assemble, understand, and transfer the data based on the potency of the traffic on the lane. AIMS will assist the working of traffic congestion, monitoring, and enhance resource management [5]. It also measures the traffic volume on a specific lane and categories them based on the classes of vehicles.

Some sensors should be replaced with the machine-like robot to detect future incidents that would happen based on the speed of the vehicles. The transformation from the car (mobility) to automated driving is where AI is very much implemented. AI approaches can change car mobility from traditional to eco-driving, enhanced safety, energy-saving functions, and best road space allocation. Instead of driving the person can do more productive work [6]. Drivers take easy decisions which may lead to difficult traffic design patterns due to which congestion occurs. Congestion depends on different aspects, like the road network, holidays, weather conditions, abnormal situations, time of day, and any day of the week. Effectively finding and predicting traffic design patterns might bring on to many precise analyzations and predictions of how vehicles might travel on certain roads at a particular time of day [7].

According to the statistics which were analysed in the year 2020, India ranks 2nd by population. It measures up to 1billion plus population. Due to this the present system of traffic couldn't able to meet the rules and regulations, thereby leading to accidents. Through the research of NCBI, traffic cops working in their workplace are getting through traumatic stress, sleep disorders, metabolic syndrome, depression, anxiety, and other health issues. Because of all of this, people are not showing any interest in the traffic field. Hence the manpower is decreasing. "SMART CITIES" is the technology that replaces the above problems [9]. Through the idea of Smart Cities, we can eradicate the severity in the above situation [10]. For 1 year there is electronic surveillance used in the traffic systems that reduced the violation of the norms of the traffic signal. There is a computing-based approach called “FUZZY LOGIC” which always considers the true value. All the comparisons are ranged between the truth value 0 and 1. Our research proposes the implementation of Fuzzy Logic in Smart Cities. Intelligent traffic systems avoid traffic congestion and monitoring which is the critical issue of large cities. We developed a system that has proven to be smart and intelligent and capable of solving traffic system issues and has been the boon of smart cities and control systems in emerging cities of the world.

3. Proposed Model

We are proposing a model to identify the time signal which is to be given to the traffic light such that depending on the category of vehicle it should be moved in the particular lane. To predict the timing signal of a specific lane the density of that specific lane plays a key role. Traffic signals are implemented differently in different regions to match the need of the traffic these aren’t dynamic and less efficient. Indian traffic systems are usually set up in two ways- Manual and Fixed Timed ones. The manual ones are where a human controller keeps controlling the traffic signals according to his point of view. Though this system prevails, manual monitoring surely causes lots of trouble due to the human nature of committing mistakes. Whereas in the Fixed timed ones each lane is allowed to pass the intersection for a particular amount of time according to the daily approximations of the vehicle flow. This could be a better option, but these are extremely static and can’t be changed as per the change of the flow of traffic in real-time. To overcome those problems, we need to have a dynamic intelligent system that could control the traffic efficiently and recreate the human controlling system eliminating the manual errors caused. This is where our model comes into the picture. We use a combination of techniques as in layers to process the data stage-wise and recording the observations to increase the accuracy of the model This model allows the traffic flow to be grouped into categories like “low”, “high”,” med”,” very high” etc. This is where there is a difference to the usual timed (circular) ones where the traffic is only categorized once and implemented. Fuzzy logic is employed to handle the concept of partial truth, where the truth value may range between completely true and completely false contrary to the Boolean logic

3.1. Proposed Architecture

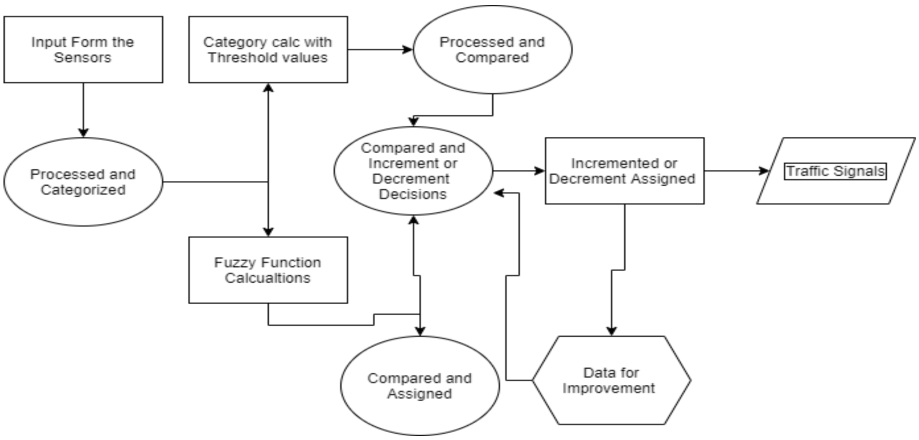

Figure 1:. The architecture of the Proposed Model

The model which we are trying to propose is using the Layered Structure. The traditional classification doesn’t fit in the current system and is thriving for some new changes to be brought in. Multiple Epochs are used for gaining accuracy in transiting from one iteration to another. Firstly, our model uses AI techniques to detect and counts the number of vehicles and later classifies to three different categories:

- Small Vehicles
- Medium Vehicles
- Heavy Vehicles

We already have set some threshold or limiting value to each vehicle category. After the classification and the count of the vehicles, we compare it to the limiting value with its category. If the count of the vehicle is less than the limiting count then the crisp value is displayed as low, high if found greater. This is done to each of the vehicles and we get a result of the combination of all the vehicle categories with different intensity. The result at this stage is either low or high i.e., the received crisp value.

3.2. Implementation Details

Table. 1. Dependency on Number of Vehicles on the Output

Small Vehicles Count	Medium Vehicles Count	Heavy Vehicles Count	Output (P)
low	Low	low	low
low	Low	high	mid
low	Low	high	low
low	High	high	high
high	Low	low	low
high	Low	high	mid
high	High	low	mid
high	High	high	high

Now for instance if the threshold of each of the vehicles is as follows: Small Vehicles-10, Mediums Vehicles -7, Heavy vehicles- 5 and if the count of the arrived vehicles is Small Vehicles- 8, Mediums-8, Heavy Vehicles- 5. After comparing each of the thresholds with the count we receive the crisp value as Small Vehicles-low, Mediums Vehicles - low and Heavy Vehicles- high. Now for this particular example, the end output for the combination of each of the vehicles is- Medium Parallelly we also calculate the fuzzy function values i.e., the degree of the intensity of the vehicles. These values lie between 0 and 1. Now at the second stage, a similar kind of process is followed in which the crisp values are fed into the fuzzy system where they undergo fuzzification and defuzzification to get the crisp output [8]. Thorough collection of data is constantly needed in order to update the recommendations and using an recommendation system to much better increase the accuracy is one of the most important factors since a particular fuzzy network could be manipulated by its calculation, in such case receiving recommendations from previous calls could help in making a much better decision in processing the information [14].

Table. 2. Dependency of the Fuzzy Membership Function on the Output

Small Vehicles Fuzzy Function	Medium Vehicles Fuzzy Function	Heavy Vehicles Fuzzy Function	Output (Q)
low	low	low	low
low	low	high	low

low	low	high	low
low	high	high	high
high	low	low	low
high	low	high	high
high	high	low	high
high	high	high	high

The crisp output here is the result of the whole process and we finally conclude whether the traffic is very high, high, medium, or low. Now for instance if the same example is considered where we received the output as a medium and compare this to the fuzzy values. Let us consider the fuzzy membership function to be 0.8, which is a bit higher therefore medium with 0.8 would give us a signal of high traffic. If the fuzzy value was 0.2 then the signal would've been medium itself [15]

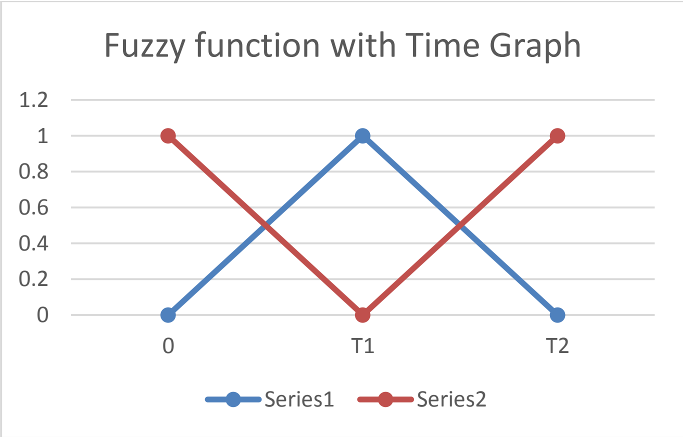

Figure 2:

The graph describes the change in the Fuzzy membership function on the graph concerning the increase of the count of vehicles where T1 is the low threshold value where T2 is the value of high threshold value.

$$\mu(x) = \frac{|x-l|}{l} \quad 0 \leq x \leq l$$

$$\mu(x) = 1 - \frac{|x-l|}{l} \quad 0 \leq x \leq l$$

$$\mu(x) = 1 - \frac{|x-h|}{h-l} \quad l \leq x \leq h$$

$$\mu(x) = \frac{|x-l|}{h-l} \quad l \leq x \leq h$$

$$\mu(x) = 1 \; if \; x > h$$

Formulae concerning the logic and implementation

From the above set of formulae, we understand that μ(x) is the fuzzy membership function which takes the value of the x i.e. count of the vehicles, l is the lower threshold value and h is the higher threshold from which μ(x) = 1.For an example to be considered let x be 7 and l be 5 and h be 10. Now according to the formulae above we get two sets of μ(x) values i.e., 0.4 and 0.6. With this example assumed we understand how effective the fuzzy system is by increasing or decreasing the accuracy values. [16]

Table 3: Table Showing the Implication of P Q Outputs on T Increment of Time

P	Q	Increment in Seconds (T)
low	Low	low
low	High	mid
mid	Low	mid
mid	High	high
high	Low	high
high	High	very high

Here we get the outcome of our proposed model that is by merging vehicle count and the fuzzy variables determined in the form of seconds T producing fuzzy variables “very high”, “high” and “mid” based on the density and the vehicle count.

4. Conclusion

Enactment of smart cities' infrastructure and its services is a long-term process. The proposed model has been favourable to determine the traffic congestion in the city by categorizing the vehicle into different categories namely small vehicles, medium vehicles, and high vehicles. The flexibility in our model links, senses the number of vehicles at the incoming junction. Thereby, it uses fuzzy values that lie between 0 and 1 which determine all the vehicle categories with different intensity and at the end produces a result as either high or low. Through this, anyone can examine traffic congestion. The model offers an uncompromising solution to impediments that ineluctably occur with an increase in populations of communities. Hereby illustrated are the advantages posed by embedding pioneering technologies in superposition with innovations into Smart Systems that could deal with complex and naive day to day tasks in an efficient fashion.

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