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Road Traffic Management with Fuzzy Logic Approach

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ROAD TRAFFIC MANAGEMENT WITH FUZZY LOGIC APPROACH.

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1.ABSTRACT.

The objective of this research work presented in this article is to establish an intelligent traffic management system based on the fuzzy logic theory allowing to organize the traffic of vehicles in the road and highway networks in order to reduce the number of accidents and the impact of congestion on the traffic. In other words, to increase the fluidity of traffic while respecting road safety. This system controls variable message traffic management panels that will be installed along all roads whose role is to indicate the length not to be exceeded for vehicles. Thus, warning the users for a possible change of their itineraries if necessary. This displayed value of the length of the vehicles depends on several parameters that will feed our system, namely: the time, the dimension of the road and its degree of importance, these parameters are the input variables of our intelligent traffic management system.

Keywords: Traffic management, Road and highway networks, Congestion, Fuzzy logic, decision-making support.

2. INTRODUCTION.

« Congestion in a road network is a condition in which an increase in vehicle traffic causes an overall slowdown in the network. The term congestion refers to the degradation of service quality as the number of users increases. This phenomenon is characterized by the occurrence of delays and even bottlenecks during periods of heavy traffic. As each vehicle occupies a certain length of lane, the length of the queue will only increase in proportion to the number of vehicles in the queue. The above shows that congestion is an evolving phenomenon, both in time and space, which makes the goal of ensuring the smooth flow of traffic on the roads a delicate matter»1 «Especially since the centers in charge of it are now facing large-scale developments and are not always well equipped to respond to them»2. Therefore, while it is inevitable that public authorities promote «the deployment of intelligent traffic management systems and traffic information services to allow users before their departure to choose their route to avoid difficulties and possibly modify their route»3.

Picture : Congestion issue « 4 ».

In order to face the problem of congestion and to ensure the fluidity of the traffic while respecting the road safety, we established an intelligent system of traffic management based on the theory of the fuzzy logic makes it possible to define the maximum length not to exceed for the vehicles. The originality of this system is that it is slaved with variable message traffic management panels that will be implanted along all the roads and that will display as a value the length not to be exceeded, and this value will be broadcasted by the traffic information service either on platforms or on traffic control sites.

First, we describe the approach and we define the major parameters acting on the value of the length not to be exceeded of vehicles. Second, we present the modeling of these factors by membership functions; then we develop the decision rules. Finally, we analyze the results obtained.

3. THE PROPOSED APPROACH.

3.1/. THE FUZZY MODEL.

«Fuzzy logic is an approach to computing based on "degrees of truth" rather than the usual Boolean "true or false" (1 or 0) logic on which modern computing is based. Fuzzy logic understands 0 and 1 as extreme cases of truth (or "state of affairs" or a "fact"), but also the various states of that truth in between»5.

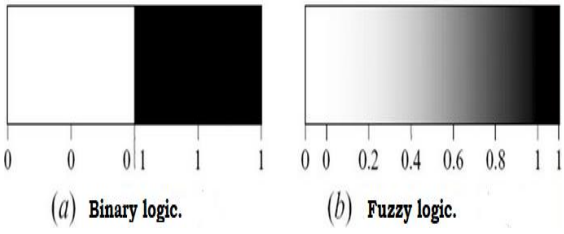

Figure 1. Range of logical values in Binary and Fuzzy logic.

«The theoretical foundations of fuzzy logic were established in the early 1965s by Professor Zadeh of the University of California at Berkeley.This technique combines the notions of "fuzzy subset" and "possibility theory".

It is an approach based on human reasoning rather than on rigid calculations; for ill-defined problems, the human being is irreplaceable.

Indeed, the fuzzy logic reasoning mode is more intuitive than classical logic. It allows designers to better understand imprecise and difficult-to-model phenomena by relying on the definition of rules and membership functions of sets called "fuzzy sets"»6.

The traffic management model established in this research work is mainly based on the fuzzy logic approach. This model makes it possible to obtain an effective control law, without having to call upon important theoretical developments. This law resides in the determination of the length of the vehicles that can use a road in order to avoid congestion. This proposed model has the interest of taking into account the experiences acquired

The parameters presentation.

The value of the length not to be exceeded represents the final result to be achieved, but to find it we must first determine all the actors who participate and influence the traffic and the circulation on the roads constituting the inputs that will feed our system, including :

The time: the schedule is a major parameter in our traffic management system since the traffic density depends on it, in fact this density is not constant in time, there are moments when the traffic is dense and others when it is light. In the dense moments as in the rush hours the vehicles of great length constitute an obstacle and provoke a congestion and a supplementary slowing down where from the necessity to fix the length of the vehicles authorized to use the roads.

Road size: this indicator is reflected by the number of lanes on a road. The greater the number of lanes, the less congestion there is and the greater the width of vehicles allowed to use the road and vice versa.

Road type: we mean by the type of the road its degree of importance which varies between primary, secondary... so, it is necessary to take into consideration this parameter before fixing the authorized width of the vehicles, indeed for a primary road, the width must be relatively tolerated compared to a secondary road, since its degree of importance is big

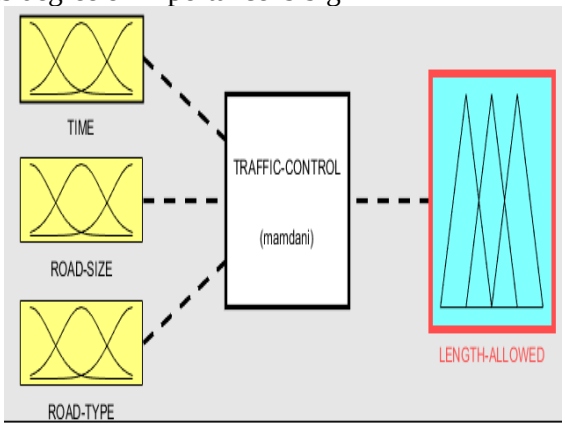

Figure 2. The Fuzzy model.

Step 1: Fuzzification of numerical values into fuzzy values.

Fuzzification consists in defining and slicing the input variables according to membership functions. "Instead of belonging to the "true" set or the "false" set of traditional binary logic, fuzzy logic admits degrees of membership to a given set. The degree of membership to a fuzzy set is materialized by a number between 0 and 1. A precise value of the membership function linked to a value of the variable is noted µ and called "membership factor".

The membership functions can theoretically take any form. However, they are often defined by line segments, and « are called "piecewise linear" Very used because they are simple and include zones where the notion is true, and zones where it is false, which simplifies the collection of expertise»6.

By defining for each variable a function, and for a function subsets (classes).

The figure below shows the quality membership function µ (quality) to a universe of discourse with subsets < Low, High> using Mamdani as the inference type.

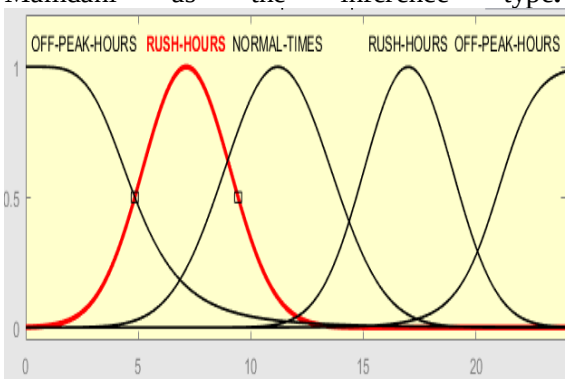

Figure 3. Membership function for "TIME".

The other indicators are modeled by the same principle by triangular and trapezoidal membership functions using linguistic terms appropriate to each indicator

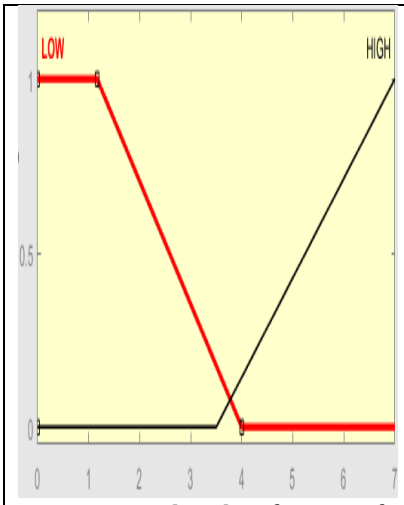

Figure 4. Membership function for "ROAD SIZE".

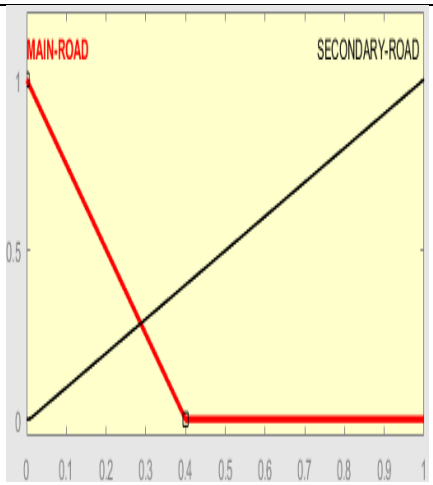

Figure 5. Membership function for "ROAD TYPE".

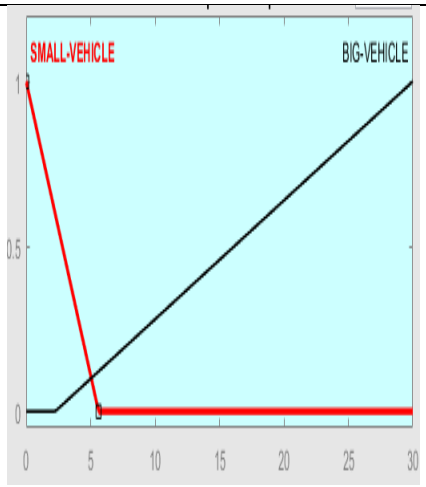

Figure 6. Membership function for "LENGTH ALLOWED".

Step 2: The inference engine

Our «linguistic variables are linked together by rules and allow us to draw inferences»6. Thus, the inference engine is a step consisting of defining the decision rules <If. Then> established by the experts to the input variables using the fuzzy operators <OR> or <AND> or both.

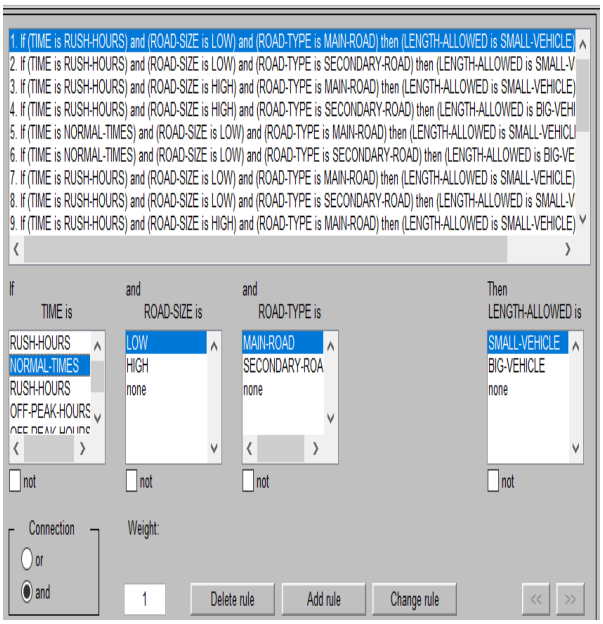

Figure 7. Rules editor.

Step 3: Defuzzification

«Inference methods provide a resulting membership function µR of the output variable xR. It is therefore fuzzy information. This fuzzy information must be transformed into a specified value that will be applied to the process control interface. This transformation is called defuzzification. The most commonly used defuzzification method is the determination of the center of gravity»6.

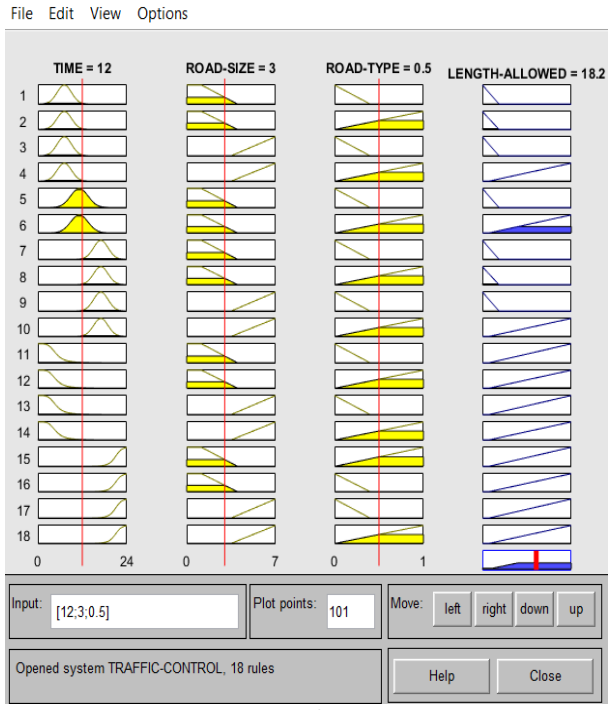

Figure 8. Visualization of decision rules.

Graphically, the following figure shows the defuzzification step, which consists in transforming the fuzzy set associated to the inputs: Cost, Quality and Delay into a net value by applying the center of gravity method.

4. RESULTS AND DISCUSSIONS.

4.1/ Surface Viewer.

The surfaces simulated below reflect the dependency relationship between the input indicators and the output indicator. Nevertheless, the weighting of these inputs is not the same, among which, there is one more influential than the others.

To analyze the surfaces we work with only 2 inputs and we fix the third one on a constant value (abscissa axis) and we visualize the result of the output on the coordinate axis.

Cas N°1 : (Med, Y, Z)

In this case the time indicator is set as a medium

Med: The time indicator.

Y: The indicator of the dimension of the road.

Z: Indicator of the type of road..

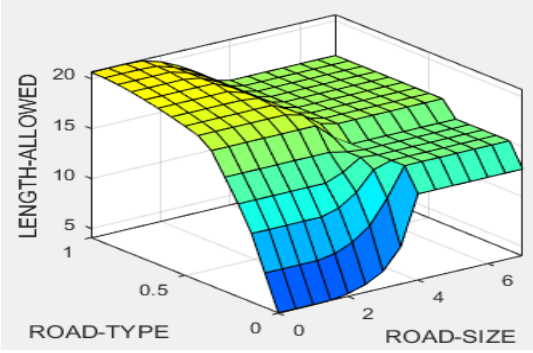

Figure 9. The curve of the case N°1: (Med, Y, Z) result.

The surface shows that the length allowed to vehicles is small when the road is secondary and its dimension is small or medium. However, the allowed length is medium when the road is secondary and its dimension is large. On the other hand, the length of vehicles will be large when the road is primary despite its size.

Cas N°2 : (X, Y, Med).

Dans ce cas l'indicateur du Cout est fixé en moyen

X : Time indicator.

Y: Indicator of the size of the road.

Med : Indicator of the type of road

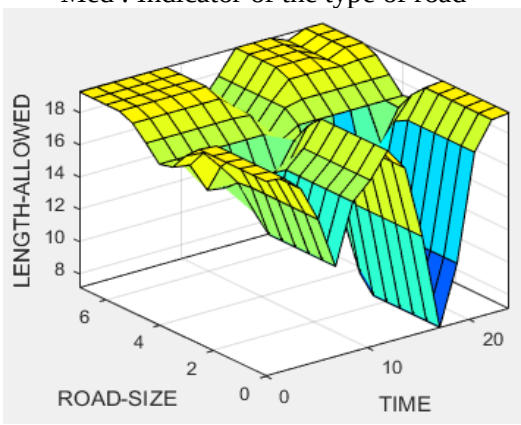

Figure 10. The curve of the case N°2:(X, Y, Med). *result.*

The displayed area shows that the length allowed for vehicles to use the road is small when the transit time coincides with the evening rush hour and the road size is small. It is medium during the morning rush hour and the road size is small. On the other hand, the length allowed to vehicles is large in the case of the latter.

The results obtained are not found in binary logic where the output value will be null if only one of the input parameters is null, hence the advantage of fuzzy logic

Cas N°3 : (X, Med, Z).

In this case the size of the road indicator is set as an Medium

X : Time indicator.

Med: Indicator of the size of the road.

Z: Indicator of the type of road

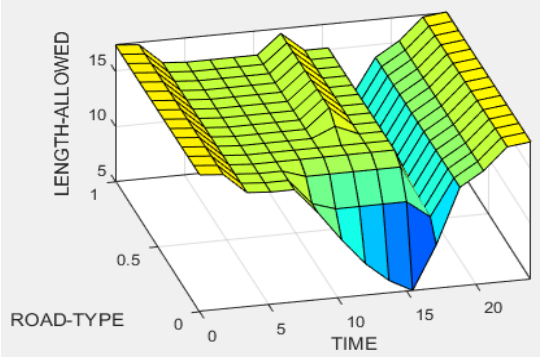

Figure 11. The curve of the case N°3: (X, Med, Z) result.

The displayed area shows that the length allowed to vehicles to use the road is small when the transit time coincides with the evening rush hour on a secondary road. It is medium during the evening rush hours but in a main road. On the other hand, the length allowed to vehicles is large in the later cases.

This simulation is a direct projection to the decision rules set up by the experts, hence the usefulness of modifying these rules when necessary by restoring the rules and allocating the appropriate membership functions to each input variable.

4.2/Result simulation with " Matlab Simulink ".

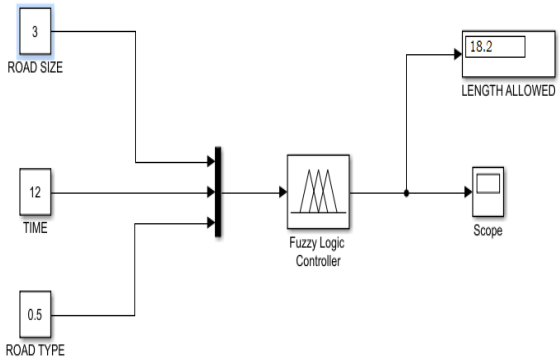

Figure 1. Result simulation.

The figure above is a simulation of our model, as it is displayed it is enough to type the inputs that are the time, the dimension of the road and its type so that the model gives as a result the maximum length allowed for the vehicles to pass. The originality of this model is that the information obtained will be broadcasted via satellites in real time as it is shown in the figure below in order to allow drivers to anticipate and foresee possible changes of itinerary.

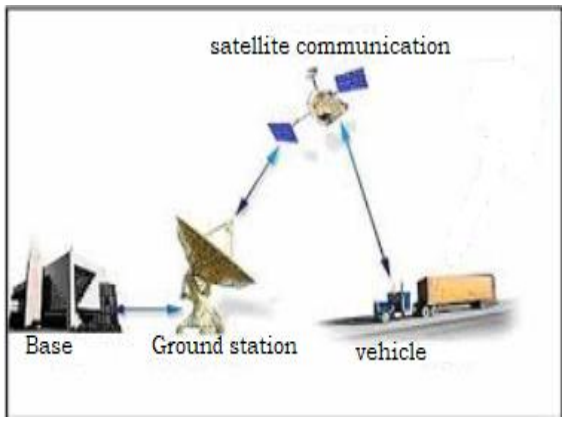

Figure 14. Information sharing and broadcasting.

5. CONCLUSION.

In this article, we have demonstrated the feasibility of implementing an artificial intelligence model based on the fuzzy logic theory, which allows road authorities to better manage vehicle traffic and minimize congestion on roads and highways through the determination of the length allowed for vehicles. Moreover, this model allows drivers to consult on the platforms controlled by this model in order to anticipate and change their itineraries when necessary, which will bring with it a saving of time and money, as well as a preservation of the environment by minimizing pollution.

The originality of this model is that the road authorities responsible for traffic management can model and adapt it to their requirements through the weighting of the decision criteria which is a direct projection to the decision rules. Thus, developing a unique model according to the influential criteria.

Our main objective is to exploit the expert knowledge to establish the decision rules and the artificial intelligence to use them and to implement a model based on fuzzy logic to define the authorized length of vehicles to use the roads that will participate greatly in the management of the road infrastructure. So, minimizing congestion

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