Republic of Tunisia Ministry of Higher Education and Scientific Research General Directorate of Technological Studies Higher Institute of Technological Studies of Bizerte
Department of Electrical Engineering

Title of the project

Automatic Brake System using Fuzzy Logic

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Contents

1. What is Julia ?

Julia is an exciting and relatively new programming language designed to be the ideal language for scientific computing, machine learning, and data mining. Released in 2012, Julia has rapidly become a favorite among experienced data practitioners.

Designed to possess the speed of C, the general programming ability of Python, and the statistical power of R, Julia is a powerful language that is reasonably simple to learn compared to other languages.

2. Intro

Human judgment error may cause serious accidents due to inaccurate reaction time and time consumes to perform full braking. In many such cases, the main cause of such accidents is the distraction through driving and failure to react in such enough time. Moreover, the fully intelligent vehicle, which is called driverless car, will totally automate without any human interaction. Each vehicle will utilize both its speed sensor which measures the wheel speed and distance sensor which is based on ultrasonic waves to compute the safety distance between the vehicle and its neighbours by controlling the brake pressure force on the brake pedal.

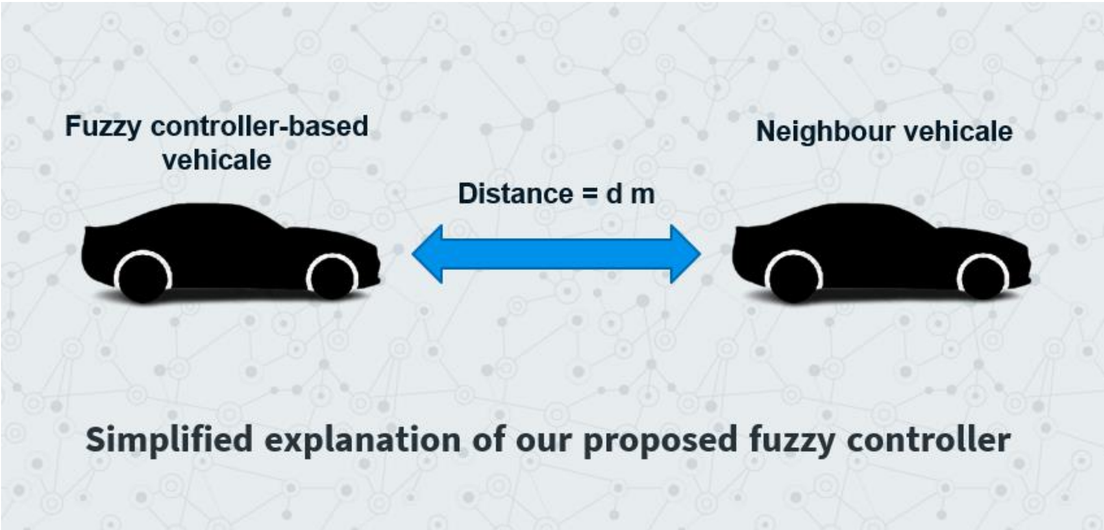
The automatic brake system, which make the driving journey safer, has developed from 25 years ago, in recent years (Aras 2013), it is developed significantly utilizing the artificial intelligent methods and algorithms, which increase the accuracy and response time. In this project, we proposed fuzzy controller with two inputs, vehicle speed and inter-vehicle distance, and one output, brake force, to create a safety distance between vehicles under different circumstances which waves from too fast speed to too low speed and from a too close distance to far distance.

The main problem of this project is as follows:

• Human driving, which involves reaction times, delays, and judgment errors is not enough to avoid emergency braking or road accidents.

• Moreover, and in many such cases, the cause of the accident is driver distraction and failure to react in time.

• So, in this project, we design human free brake system that maintains both the vehicle speed and inter-vehicle distance, to automatically decelerate the vehicle on urgent demands by controlling the brake force pressure.



3. Inputs and outputs of fuzzy logic system

We have two inputs and one output, the inter-distance is based on ultra-sonic sensor and speed is based on Hall effect principle. The output of our fuzzy proposed controller is brake force pressure. For measuring purposes of the distance between two consequence vehicles, usually **ultra-sonic sensor**.

The speed sensor is based on Hall effect principle which generate an electrical signal when a magnetic field moves near a metal, these pulses are transferred to an engine electronic control unit (ECU) which compute the relative speed of the vehicle depending on the transferring pulse frequency. Higher frequency means high speed and low frequency means low speed,

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Figure 1: ultra-sonic sensor for car

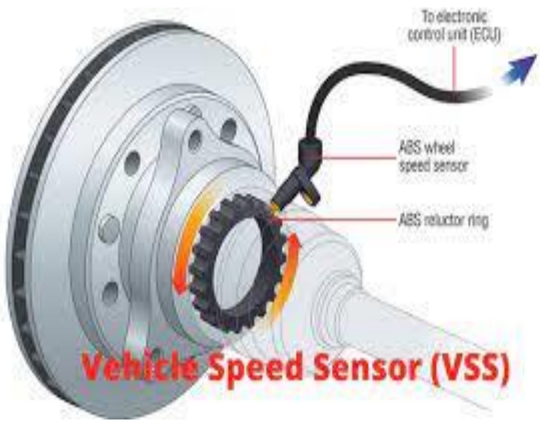
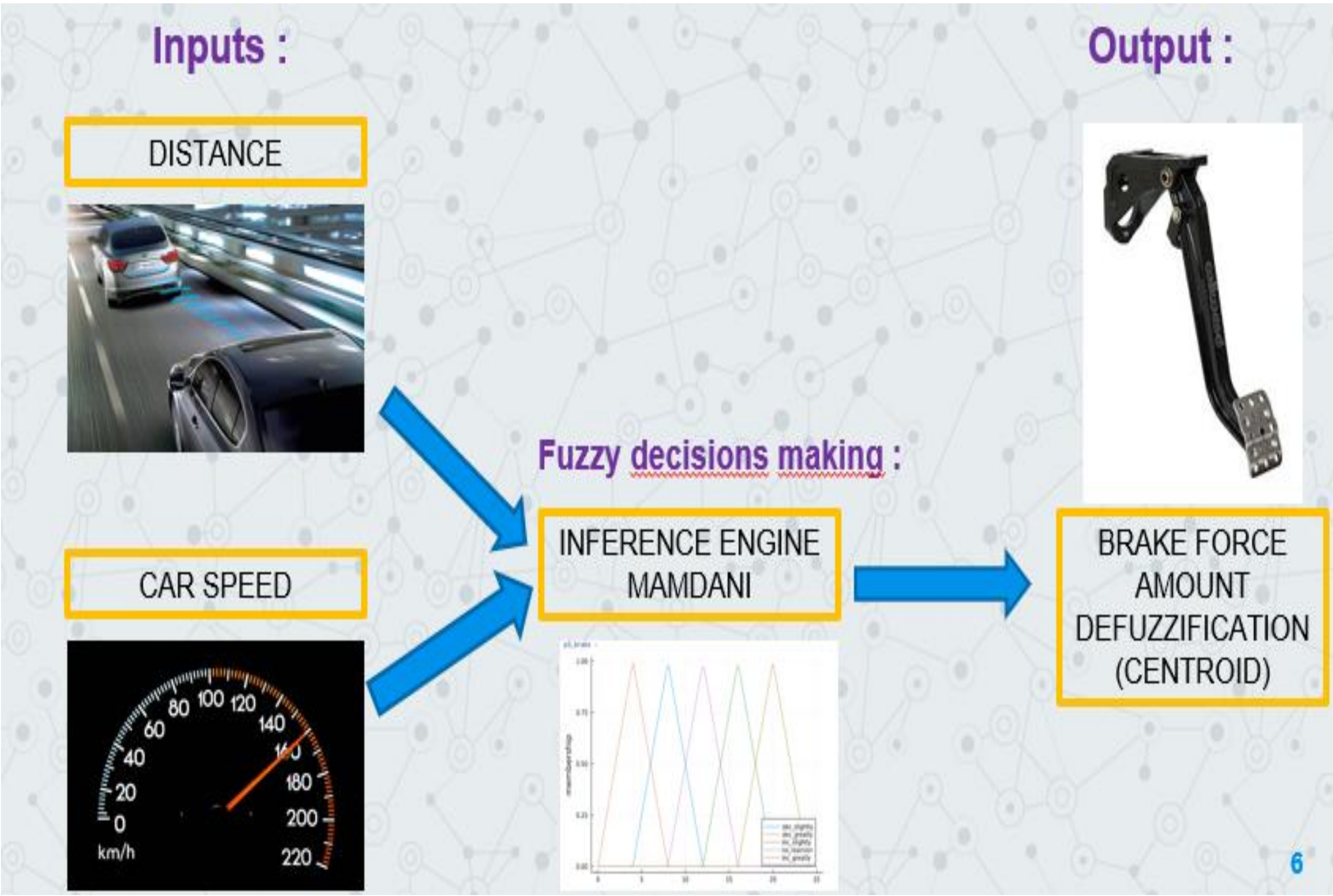


Figure 2: speed sensor for car

4. Design structure

Our fuzzy logic design is consisting of inputs, output, and Mamdani-Fuzzy inference engine. The output is the brake force and is defuzzied using the centroid method. The block diagram below depicts that.



5. Fuzzification

We divide the distance range from 0-10 m to three sub ranges, very close(V_cls), close, and far. The inter-vehicle distance is classified as follows:

- Very close distance (0-5 m), Triangular.
- Close distance (2-8 m), Triangular.
- Far distance (5-10 m), Triangular.

We have chosen triangle membership function since as the vehicle become close, the value of the crisp input (V_cls) increase dramatically, at the middle membership, there are marginal space starts from 4 and ends at 6m, after that, the distance considers far.

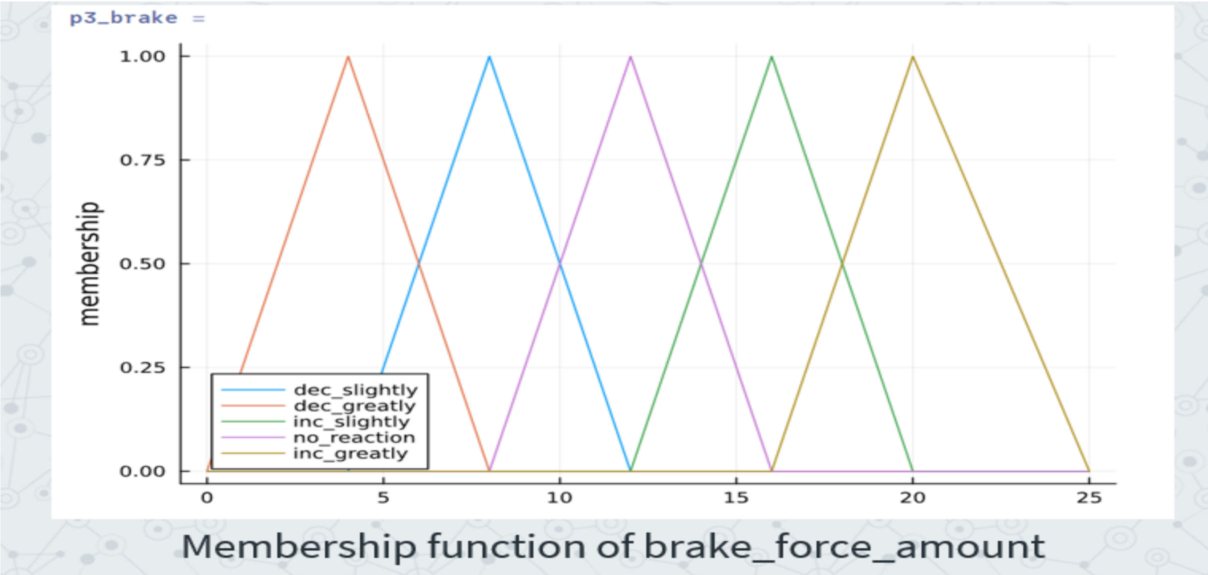
Then, we divide the vehicle speed from 0 to 25m/s to 5 different ranges as follows:

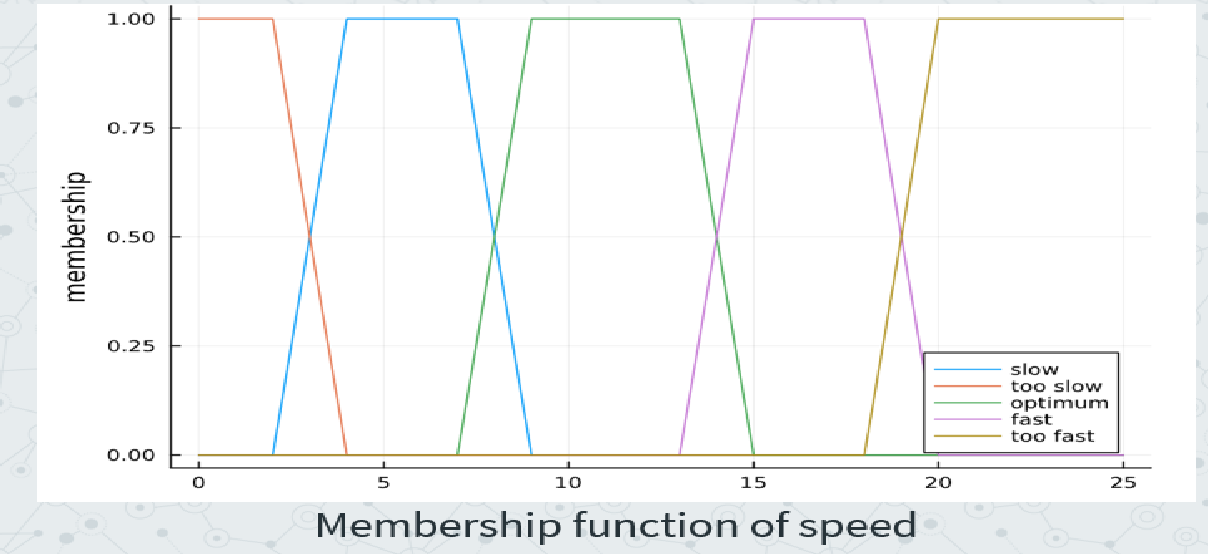
- Too slow (0-4 m/s), Trapezoidal.
- Slow (2-9 m/s), Trapezoidal.
- Optimum (7-15 m/s), Trapezoidal.
- Fast (13-20 m/s), Trapezoidal.
- Too Fast (18-25 m/s), Trapezoidal.

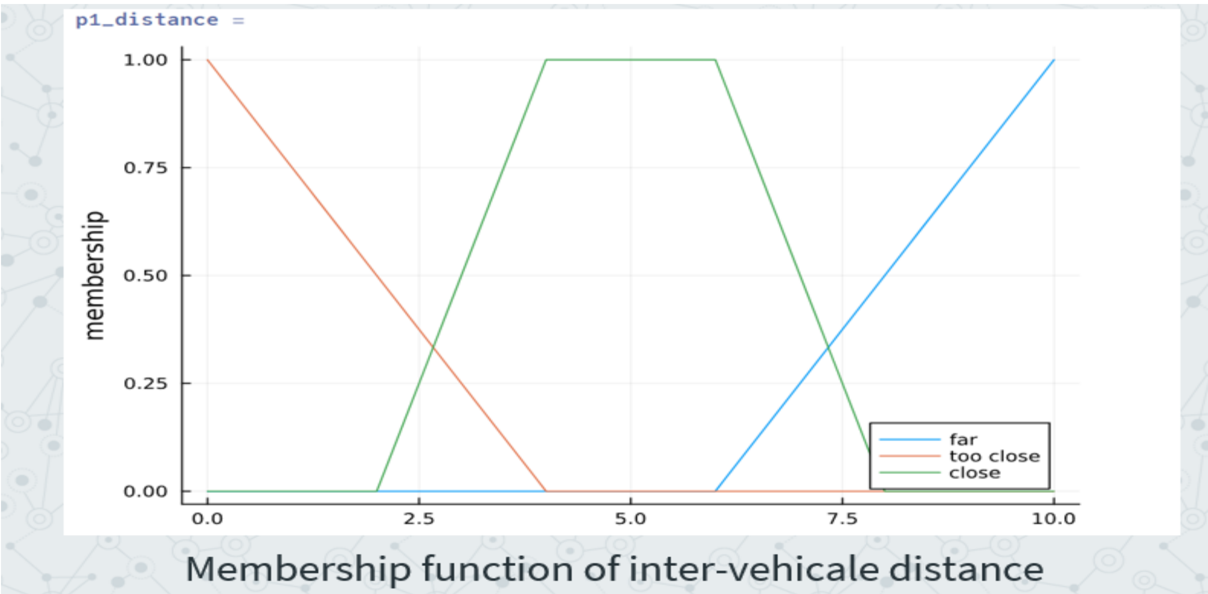
For the speed since its relative and couldn't rely on a specific value, we select trapezoidal membership function. The trapezoidal shape makes the values wave with reset range. The output of our fuzzy system is the amount of brake force and is classified as follows:

- Decrease brake force greatly (0-8 N)
- Decrease brake force slightly (4-12 N)
- No brake reaction (8-16 N)
- Increase brake force slightly (12-20 N)
- Increase brake force greatly (16 -24 N)

The output membership function consists of 5 members, triangle membership is the best choice, since for each division range, the value increase sharply until the middle then decrease to interfere with the adjutant membership. Figures below depicts the input and output membership function







6. Rule base and inference engine

If				Then
	Too close		→	Increase greatly
Close	And	Too fast	→	Increase greatly
Close	And	Fast	→	Increase slightly
Close	And	Optimum	→	Increase slightly
Close	And	Slow	→	Increase slightly
Close	And	Too slow	→	No reaction
Far	And	Too fast	→	Increase slightly
Far	And	Fast	→	No reaction
Far	And	Optimum	→	No reaction
Far	And	Slow	→	Decrease slightly
Far	And	Too slow	→	Decrease greatly

7. Defuzzification

We used Mamadni inference engine which is the simplest one and to extract the crisp output we used a centroid method.

8. Code Julia

https://github.com/hamoudaattia/auto_brake_system_FL/blob/main/auto_brakesystem.jl