

CS 514 – Applied Artificial Intelligence
Project 2
University of Illinois at Chicago
Fall 2017

Project Title:

Fuzzy Rule Based throttle/brake control system for autonomous vehicle

Domain:

Autonomous Driving

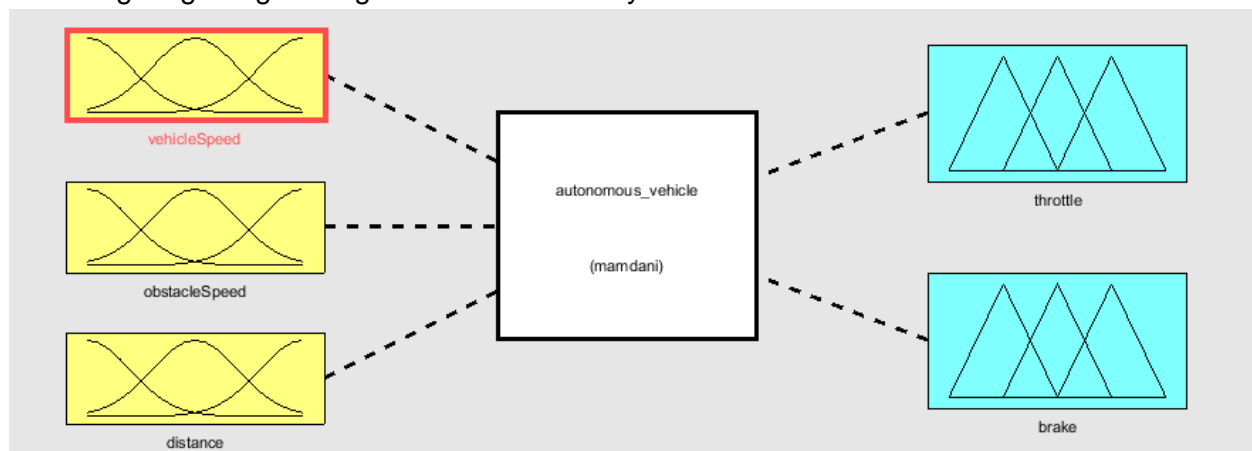
Nickname:

Skynet

Introduction

Moving beyond normal rule based system from project 1, this project includes fuzzy reasoning for throttle and brake control in an autonomous vehicle. Although fuzzy inference can be incorporated in large no. of ways in autonomous driving system, I have selected throttle and brake control based on vehicle speed, obstacle speed and distance between them for this project.

Following diagram gives high level view of the system.



Inputs

The inputs to the system are

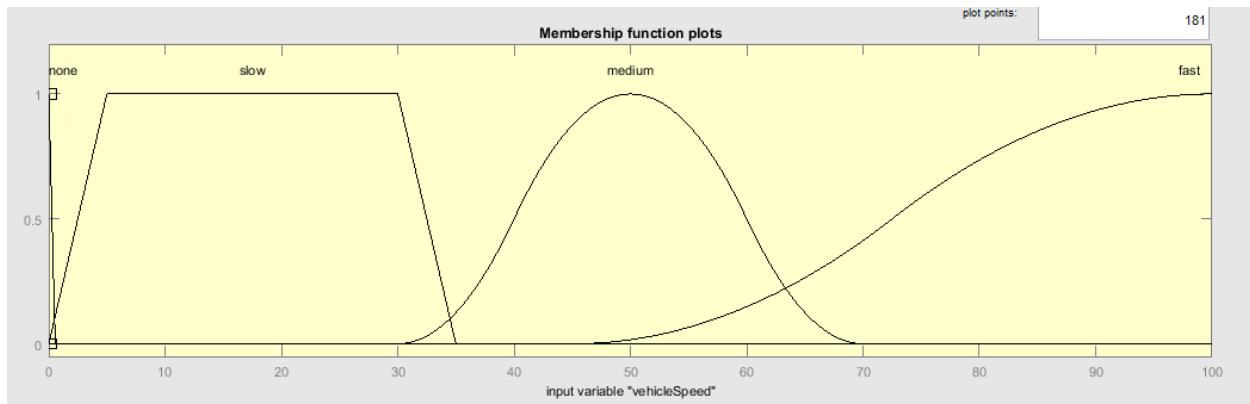
1. Vehicle Speed
2. Obstacle Speed
3. Distance between vehicle and obstacle

```
(defglobal ?*speedFvar* = (new FuzzyVariable "speed" 0.0 100.0 "miles/hour"))  
(defglobal ?*distanceToObstacleFvar* = (new FuzzyVariable "distance to obstacle" 0.0 200.0  
"feet"))
```

Vehicle speed and obstacle speed are based on same fuzzy variable `*speedFvar*`. Its range is from 0 miles to 100 miles per hour. The terms for this fuzzy variable are defined as follows:

```
(?*speedFvar* addTerm "none" (new SingletonFuzzySet 0))  
(?*speedFvar* addTerm "slow" (new TrapezoidFuzzySet 0.0 5.0 30.0 35.0))  
(?*speedFvar* addTerm "medium" (new PIFuzzySet 50 20))  
(?*speedFvar* addTerm "fast" (new SFuzzySet 45 100.0))
```

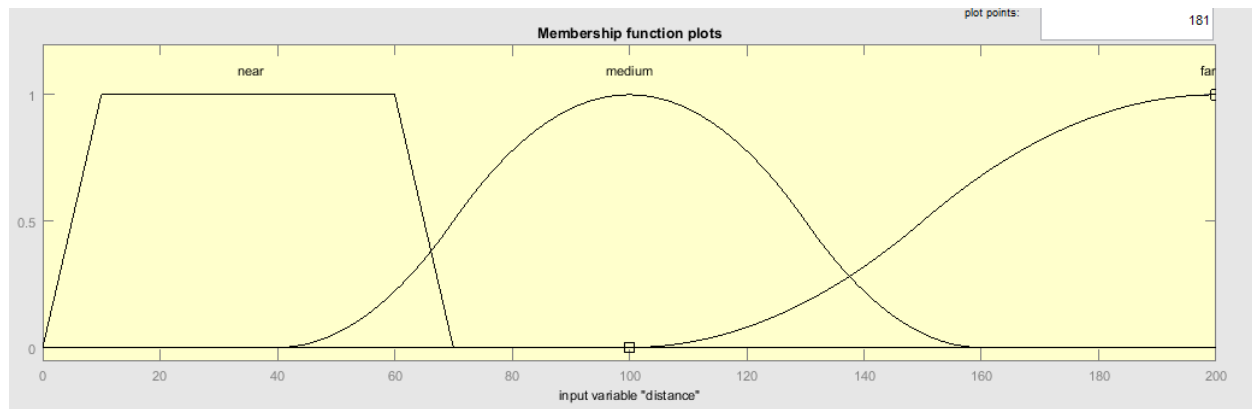
The following diagram shows membership function plots for this variable



The distance to obstacle variable has a range from 0 to 200 feet. The terms for this variable are defined as follows:

```
(?*distanceToObstacleFvar* addTerm "near" (new TrapezoidFuzzySet 0.0 10.0 60.0 70.0))  
(?*distanceToObstacleFvar* addTerm "medium" (new PIFuzzySet 100 60))  
(?*distanceToObstacleFvar* addTerm "far" (new SFuzzySet 100 200.0))
```

The following diagram shows membership function plots for this variable



Outputs

The outputs of the system are throttle and brake press levels

;output

;complete press of throttle/brake denoted by 1.0 and no press of throttle/brake denoted by 0.0

```
(defglobal ?*throttleFvar* = (new FuzzyVariable "throttle press" 0.0 1.0 ""))
```

```
(defglobal ?*brakeFvar* = (new FuzzyVariable "brake press" 0.0 1.0 ""))
```

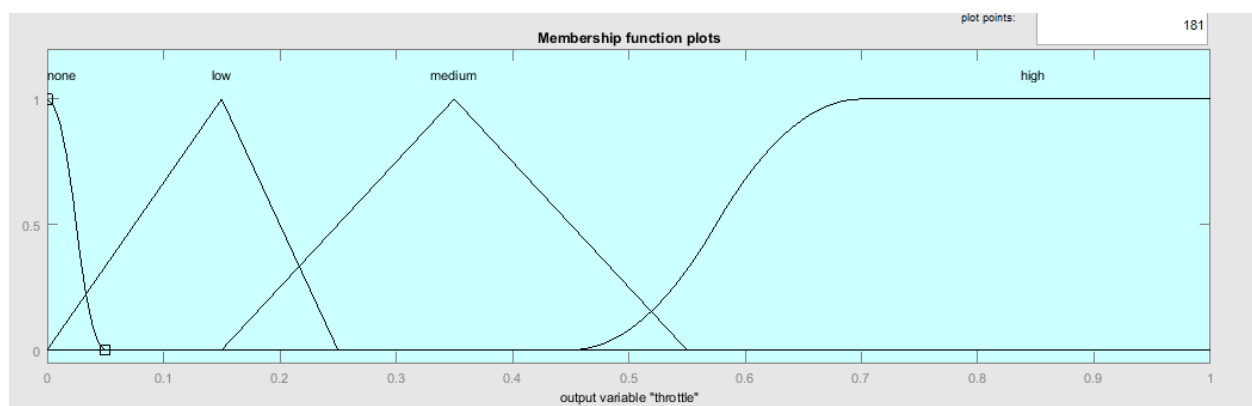
The terms for both the variables are defined in similar manner

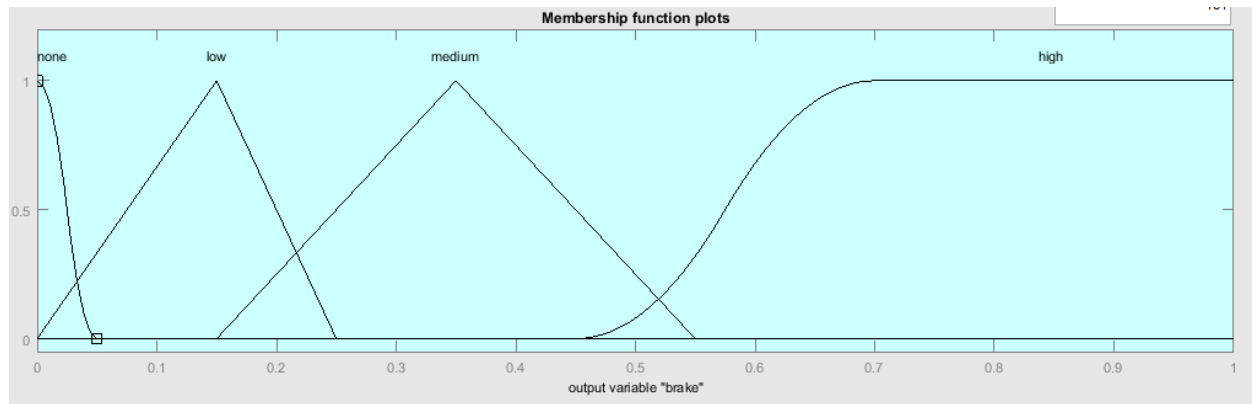
```
(?*throttleFvar* addTerm "none" (new ZFuzzySet 0 0.05 ))
```

```
(?*throttleFvar* addTerm "low" (new TriangleFuzzySet 0.0 .15 .25))
```

```
(?*throttleFvar* addTerm "medium" (new TriangleFuzzySet .15 .35 .55))
```

```
(?*throttleFvar* addTerm "high" (new SFuzzySet .45 .7))
```





Rules

Rule #	My speed	Obstacle Speed	distance	decision
1	slow	slow	close	Do nothing
2	medium	slow	close	Press brake low
3	fast	slow	close	Press brake high
4	slow	medium	close	Press throttle low
5	medium	medium	close	Do nothing
6	fast	medium	close	Press brake medium
7	slow	fast	close	Press throttle low
8	medium	fast	close	Press throttle low
9	fast	fast	close	Do nothing
10	slow	slow	Medium	Press throttle low
11	medium	slow	Medium	Press brake low

12	fast	slow	medium	Press brake high
13	slow	medium	Medium	Press throttle low
14	medium	medium	Medium	Do nothing
15	fast	medium	Medium	Press brake medium
16	slow	fast	Medium	Press throttle high
17	medium	fast	Medium	Press throttle medium
18	fast	fast	Medium	Do nothing
19	slow	slow	Far	Press throttle high
20	medium	slow	Far	Do nothing
21	fast	slow	Far	Press brake medium
22	slow	medium	Far	Press throttle high
23	medium	medium	Far	Press throttle low
24	fast	medium	Far	Press throttle low
25	slow	fast	Far	Press throttle high
26	medium	fast	Far	Press throttle high
27	fast	fast	far	Press throttle low

The fuzzy rules are defined from lines 317 to 723 in the .clp file

Sample Outputs

The speed of our vehicle is set to “fast” . You can change this in following code present in line 202.

```
(modify ?cur_vehicle(speed(new FuzzyValue ?*speedFvar* "fast")))
```

The speed of obstacle and distance are read as input from user. The crisp input values are converted to fuzzy inputs by adding a small correction factor.

```
(printout t "Enter speed of obstacle")  
(bind ?speed-value (float (readline t)))
```

```
(printout t "Enter distance between vehicle and obstacle")  
(bind ?distance-value (float (readline t)))
```

```
(assert(obstacle  
  (speed (new FuzzyValue ?*speedFvar* (new TriangleFuzzySet (- ?speed-value 0.25)  
    ?speed-value (+ ?speed-value 0.25))))  
  (distance(new FuzzyValue ?*distanceToObstacleFvar* (new TriangleFuzzySet (- ?distance-  
    value 0.5) ?distance-value (+ ?distance-value 0.5))))  
))
```

Sample Output #1

When our speed is fast and speed of obstacle is provided as 20 (slow) and distance as 70 (has membership to both slow near and medium), it sets the brake to 0.65 (high pressure)

```
)  
Enter speed of obstacle20  
Enter distance between vehicle and obstacle70  
The destination chicago is reachable  
The car is in running condition, getting out of garage  
The car is running  
vehicle-medium-obstacle-slow-medium rule triggered  
vehicle-medium-obstacle-slow-near rule triggered  
vehicle-fast-obstacle-slow-medium rule triggered  
vehicle-fast-obstacle-slow-near rule triggered  
throttle set to: 0.01730060812763281  
brake set to: 0.6510432985023381
```

Sample Output #2

When both our speed and speed of obstacle is fast , even if distance is close, around same speed is maintained.

```
Enter speed of obstacle70
Enter distance between vehicle and obstacle20
The destination chicago is reachable
The car is in running condition, getting out of garage
The car is running
vehicle-medium-obstacle-medium-near rule triggered
vehicle-fast-obstacle-fast-near rule triggered
vehicle-medium-obstacle-fast-near rule triggered
vehicle-fast-obstacle-medium-near rule triggered
throttle set to: 0.10956349809729739
brake set to: 0.06540272789200262
```

Sample Output #3

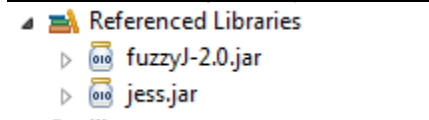
When our speed is fast, speed of obstacle is slow and distance is large, medium pressure is applied on brake.

```
Enter speed of obstacle25
Enter distance between vehicle and obstacle180
The destination chicago is reachable
The car is in running condition, getting out of garage
The car is running
vehicle-medium-obstacle-slow-far rule triggered
vehicle-fast-obstacle-fast-far rule triggered
throttle set to: 0.014960450997562682
brake set to: 0.3354852582191081
```

You can test for different scenarios providing value between 0.25 to 99.75 for obstacle speed and 0.5 to 199.5 for distance.

Running the project

Make sure fuzzyJ-2.0.jar is included in build path



Jess main class should be defined as following in run configuration



After running the project you are prompted to enter obstacle speed and distance between obstacle and your vehicle. Fuzzy rules are fired and output is displayed based on the inputs.