THE UNIVERSITY OF CALGARY

DEPARTMENT OF ELECTRICAL AND COMPUTER ENGINEERING

ENEL 525 Machine Learning for Engineers

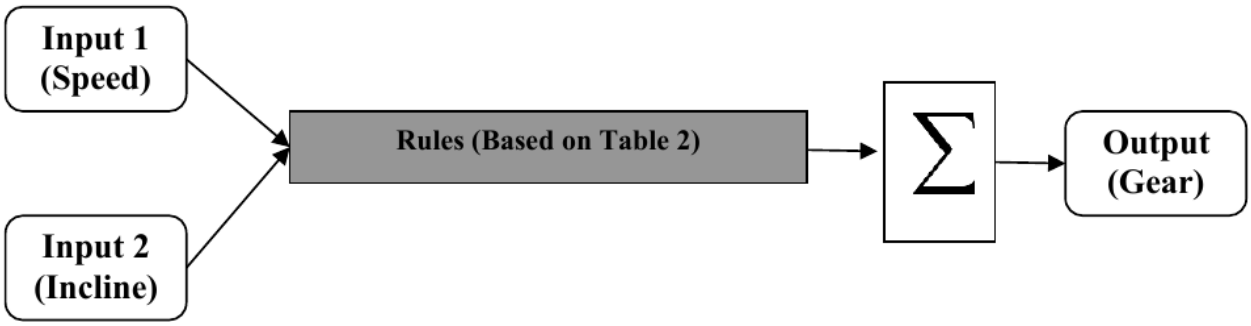
Lab 5 – Fuzzy Inference System

2 December (B02) & 5 December (B01), 2025

Objective: Designing a control system based on fuzzy inference.

Problem: Automatic Gear Selection

Assume a car operates using five (5) gears and the gear selection depends on the instantaneous speed of the car and the incline of the road with reference to the gravitational horizontal. In order to develop the controller responsible for selecting an appropriate gear while the car is in motion, certain standard rules for changing gears have been outlined by an experienced driver. These rules are with reference to a manual car.



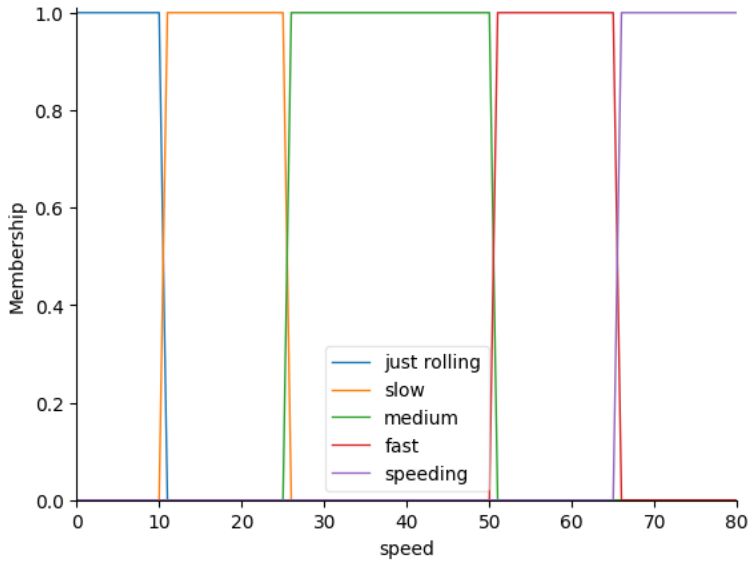
In this lab, you will be exploring the fuzzy inference method using scikit-fuzzy (`skfuzzy`) library to implement the gear selector based on the 2 inputs. For this goal, you need to follow the steps below for membership functions and decision rules definition.

1- Create `skfuzzy.control.Antecedent` object for both inputs (speed and incline) to define their membership functions.
2- Similarly create `skfuzzy.control.Consequent` object for the gear output. Use 'mom' as the defuzzification method argument.
3- Define membership functions for each input using the information in tables below.

Speed (in Km/H)	Just Rolling	[0, 10]
	Slow	[11, 25]
	Medium	[26, 50]
	Fast	[51, 65]
	Speeding	> 66
Range: 0 to 80 Km/H		

Incline (in Deg)	Steep	< -10
	Slope	[-10, -1]
	Flat	0
	Up	[1, 10]
	Climb	> 10
Range: -15 to 15		

An example membership function is shown below. You may use different membership function generators (i.e., 'trapmf', 'trimf', etc.).



4- Define the rules for the gear selector as `skfuzzy.control.Rule` objects based on the table below.

Incline → / Speed ↓	Steep	Slope	Flat	Up	Climb
Just Rolling	2	1	1	1	1
Slow	3	2	2	1	1
Medium	4	4	3	3	2
Fast	5	5	4	4	4
Speeding	5	5	5	4	4

5- Create the control system object using `skfuzzy.control.ControlSystem()` and all the rules in a list as its argument.

6- To simulate your system, create a simulation object of `skfuzzy.ControlSystemSimulation()` using your control system object as its only argument.

7- Finally, to run your simulation, provide input(s) to your simulation object, execute its `compute()` function, and collect its output. An example code snippet is provided below.

```
gear_selector.input['speed'] = 15
gear_selector.input['incline'] = -12
gear_selector.compute()
print(gear_selector.output['gear'])
```

8- You may test your fuzzy inference system using for the sample inputs below. Also, you may want to refer to scikit-fuzzy library's API reference.

Car *speed* (Km/H)	Road *incline* (Deg)
15	-12
80	5
45	0
21	10
75	-3

Marking:

Show the following to the TA during the lab period:

• The outputs for the test cases given in the above table.

• The membership functions for the inputs and outputs of the fuzzy system.

The TA may apply different/additional inputs to your code.