Programming assignment 02 – Reasoning
CII-2M3 Introduction to Artificial Intelligence
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What is a Fuzzy Logic?
Fuzzy logic is an appropriate way to map an input space into an output space. For very complex systems, the use of fuzzy logic is the one of solution. This system is designed to control a single output from multiple unrelated inputs.

Trivia about Fuzzy Logic:

- The theory of fuzzy sets was first proposed by Lotfi Zadeh in 1965.
- Since the mid-1970s, Japanese researchers have succeeded in applying fuzzy theory to various practical problems.

Problem Statement
We analyze and give the solution to the uncertainty of the input and the parameter of the system.

The Description of the Program Design

- Reading file input
  This program is processing the file input, which is “bengkel.xlsx”.
- Fuzzification
  Transform crisp input into fuzzy values based-on its corresponding Membership Function.
- Inference
  Determine the fuzzy output using predefined rules.
- Defuzzification
  Transform back the output fuzzy value into crisp value.
- Save output to file

The Description of The Decoding Function

- read_excel(path, sheet_target) → to process the ‘Reading file input’ activity.
  How it works:
  1. The program reads the file.
  2. The program returns to the dictionary to make the process easier.

- output_xlsx(data_final, filename) → the process of the ‘Save output to file’ activity. This function will save the final result of the fuzzy result.

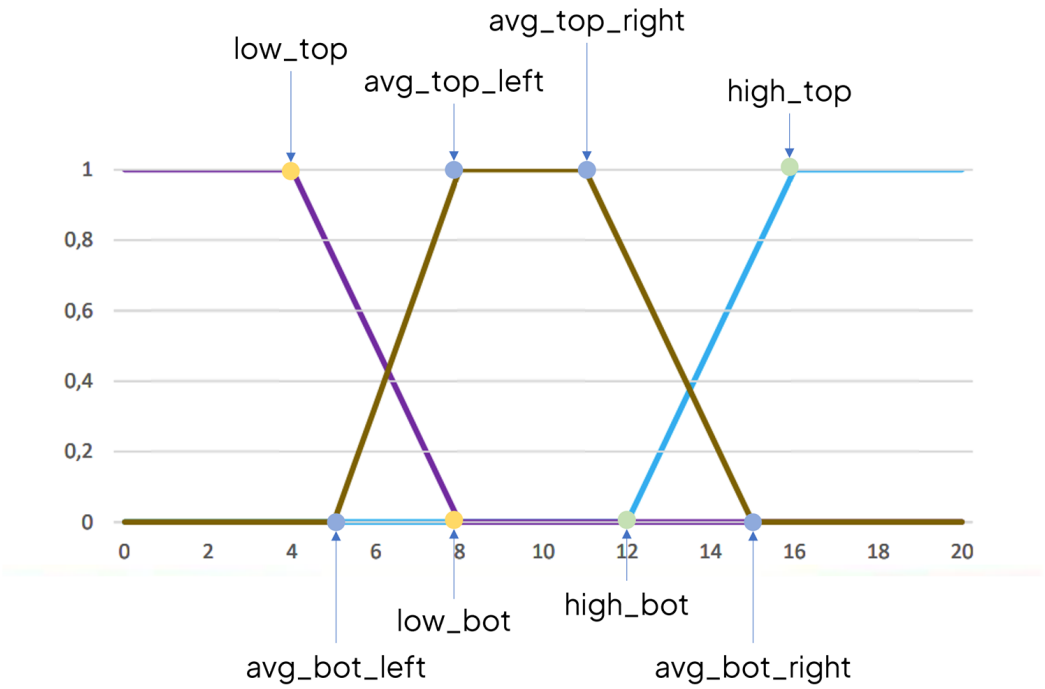
How it works:

We insert the result in the array into the contains of the column “ID” and “Defuzz”, then we insert the contains into a new file excel.

- fuzz(n, data, fuzz_setting) → the process of the Fuzzification activity.

How it works:

1. We choose one category between two columns, which are Service or Price, into a variable choice.
2. We use the if condition.



a. In Low

We compare between choosing variables with low_top value and low_bot.

- If it is higher than low_top and lower than low_bot, then

$$Low\_fuzz = abs(\frac{choose - low\_bot}{low\_top - low\_bot})$$

- If it is lower than low_top, then

$$Low\_fuzz = 1$$

b. In Average

We compare between the choice variable with avg_bot_left also avg_top_left, and avg_bot_right also avg_top_left.

- If it is higher than bot avg_bot_left and lower than avg_top_left, then

$$Avg\_fuzz = abs(\frac{choose - avg\_bot\_left}{avg\_botleft - avg\_top\_left})$$

- If it is higher than avg_top_left and lower than avg_top_right, then
  $$Avg\_fuzz = 1$$
- If it is higher than avg_top_right and lower than avg_bot_right, then
  $$Avg\_fuzz = abs(\frac{choose - avg\_bot\_right}{avg\_bot\_right - avg\_top\_right})$$

c. In High

We compare between choosing variables with high_bot and high_top.

- If it is higher than high_bot and lower than high_top, then
  $$High\_fuzz = abs(\frac{choose - high\_bot}{high\_top - high\_bot})$$
- If it is higher than high_top, then
  $$High\_fuzz = 1$$

3. Then we make a dictionary contains the ID of the service, Low_fuzz value, Avg_fuzz value, and High_fuzz value.

- inference(n, fuzz_service, fuzz_price, inference_setting) → the process of inference.
  How it works:

  We make an inference array by comparing the service fuzzification and price fuzzification value, then the value of that comparization will determine its status and the status will be input to the inference array.

- defuzz(sugeno, inference_data) → the process of defuzzification.
  How it works:

  We calculate the defuzzification of each inference value that is calculated in the inference(n, fuzz_service, fuzz_price, inference_setting) function.

- bestof10(defuzz_data) → the order from 1 until 10 based on the best defuzzification value.
  How it works:
  1. Use sort function.
  2. Return the values.

- savefile(final_data) → the process of saving a new file included the fuzzy logic implementation's value.
  How it works:
  1. We input the file name.
  2. We input how it issorted.

If it is based on ID, then we sort it by ID. Otherwise, if it is based on Defuzzification value, then we sort it by Defuzzification value.

3. We use the 'output_xlsx(data_final, filename)' function.

Ran program.

Service
Low_top: 20
Low_bot: 45
Avg_top_left: 55
Avg_bot left: 30
Avg_top_right: 70
Avg_bot_right: 75
High_top: 80
High_bot: 60

Price
Low_top: 2
Low_bot: 4
Avg_top_left: 5
Avg_bot left: 3
Avg_top_right: 7
Avg_bot_right: 8
High_top: 9
High_bot: 6

Inference setting:

Service/Price	Cheap	Average	Expensive
Low	Rejected	Rejected	Rejected
Average	Considered	Considered	Rejected
High	Accepted	Accepted	Considered

Output of the program.
Sorted by ID.

```
-----The Result-----
{'ID': 3, 'Service': 98, 'Price': 2, 'Defuzz': 79.99999920000002}
{'ID': 13, 'Service': 80, 'Price': 3, 'Defuzz': 79.99999840000002}
{'ID': 15, 'Service': 78, 'Price': 5, 'Defuzz': 79.99999911111111}
{'ID': 16, 'Service': 82, 'Price': 6, 'Defuzz': 79.99999920000002}
{'ID': 17, 'Service': 70, 'Price': 3, 'Defuzz': 79.99999840000002}
{'ID': 34, 'Service': 93, 'Price': 4, 'Defuzz': 79.99999840000002}
{'ID': 52, 'Service': 94, 'Price': 3, 'Defuzz': 79.99999840000002}
{'ID': 60, 'Service': 79, 'Price': 6, 'Defuzz': 79.99999915789475}
{'ID': 91, 'Service': 98, 'Price': 3, 'Defuzz': 79.99999840000002}
{'ID': 92, 'Service': 83, 'Price': 3, 'Defuzz': 79.99999840000002}
Choose filename : ranking
Sort by ID or Defuzz? ID
File saved as : ranking.xlsx
```

Sorted by Defuzzification value.

```
-----The Result-----
{'ID': 13, 'Service': 80, 'Price': 3, 'Defuzz': 79.99999840000002}
{'ID': 17, 'Service': 70, 'Price': 3, 'Defuzz': 79.99999840000002}
{'ID': 34, 'Service': 93, 'Price': 4, 'Defuzz': 79.99999840000002}
{'ID': 52, 'Service': 94, 'Price': 3, 'Defuzz': 79.99999840000002}
{'ID': 91, 'Service': 98, 'Price': 3, 'Defuzz': 79.99999840000002}
{'ID': 92, 'Service': 83, 'Price': 3, 'Defuzz': 79.99999840000002}
{'ID': 15, 'Service': 78, 'Price': 5, 'Defuzz': 79.99999911111111}
{'ID': 60, 'Service': 79, 'Price': 6, 'Defuzz': 79.99999915789475}
{'ID': 3, 'Service': 98, 'Price': 2, 'Defuzz': 79.99999920000002}
{'ID': 16, 'Service': 82, 'Price': 6, 'Defuzz': 79.99999920000002}
Choose filename : ranking
Sort by ID or Defuzz? Defuzz
File saved as : ranking.xlsx
```