

**CIS-445 MACHINE LEARNING**  
**MatLab Fuzzy Logic Toolbox – Individual Tutorial #4**  
**100 points**

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Due: See Blackboard

**Goal:** Get familiar with the MatLab Fuzzy Logic Toolbox.

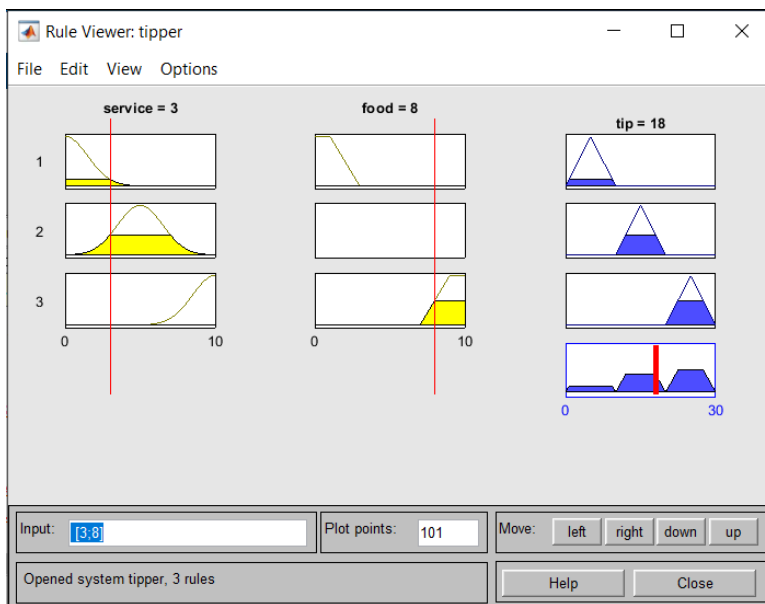
Machine learning falls under the umbrella of computational intelligence, while fuzzy logic is a component of the broader field known as soft computing or computing with words.

Like Weka, MatLab Fuzzy Logic Toolbox software is installed on VMWare on Instant\_ MBA/MSBA pool. The toolbox is one of the many software products embedded in MatLab R2024b software package represented by an icon on the virtual desktop.

**First read pp. 1-1 through 1-20 and 2-1 through 2-38** from the document titled *Fuzzy Logic Toolbox - R2013a.pdf*. (To see and read the sticky note on p. 2-51, you may need to open the above Tutorial file in [Adobe Acrobat](#).) Though the tutorial was written for the previous version of Matlab R2013a, it should work the same with the newest version of MatLab R2024b. The screen shots included in the tutorial and steps to perform may vary slightly from what you will actually see on your computer screen. The content of the tutorial represents essentially the same material which we covered in class. This material provides the foundations on fuzzy logic and introduces the reader to the tutorial named *Tipper*.

Now, open the MatLab software (double click on the icon) and work the GUI-based tutorial on pp. 2-38 through 2-61. The tutorial actually starts with the command *fuzzy* which you type from the MatLab command prompt. The command opens the toolbox.

Follow the tutorial. After completing it, **run the fuzzy logic tipping system using the values for Service and Food specified in the table**. Record the results for *Tip [%]* and indicate which of the three rules fired for both the original OR version and the modified AND version of the logical operators linking the antecedents in the rules. In other words, **run it for the OR version, then replace the OR operator with the AND operator in the rules, and run it again for the AND version**. Note that 1, 2, or 3 rules can fire simultaneously depending on the values for *Service* and *Food* inputted in the *Rule Viewer*. Specifically, rule 1, rule 2, rule 3, rules 1 & 2, rules 1 & 3, rules 2 & 3, or rules 1, 2 & 3 may fire. If 2 or 3 rules fire, each of them will contribute to the tip to a different degree. For example, if *Service* = 3 and *Food* = 8, Rules 1, 2 & 3 fire, resulting in an 18% tip. (See the screenshot below). The truncated portion of the triangles for *Tip* in the attached screenshot below illustrates the degree to which the 3 rules (rule 1, rule 2, and rule 3) contribute to the value of the tip. Rule 3 contributes the most, followed by rule 2, with rule 1 contributing the least.



#### Tutorial 4 Submission Instructions:

##### (1) Complete the Table with Actual Results

Fill in the table below with the actual results for both the OR version and the AND version. By "actual results," indicate:

- Which rules fired for each of the eight combinations of *Service* and *Food* (choose from: 1, 2, 3, 1&2, 1&3, 2&3, or 1&2&3). (See the Rule Viewer and the screenshot on page 1.)
- The corresponding *Tip* amount for each combination.

Case #	Service	Food	OR Version (Rules Fired)	OR Version (Tip)	AND Version (Rules Fired)	AND Version (Tip)
1	5	5	2	15	2	15
2	1	1	1	5.54	1	5.56
3	10	10	3	24.9	3	24.9
4	3	5	1&2	12.2	1&2	15
5	7	3	2&3	17.8	2&3	15
6	5	9	2&3	19.9	2&3	15.1
7	1	8	1&3	13.8	1&3	15
8	3	8	1&2&3	18	1&2&3	15

#### OR Rules:

- If (service is poor) OR (food is rancid) then (tip is cheap)
- If (service is good) then (tip is average)
- If (service is excellent) OR (food is delicious) then (tip is generous)

#### AND Rules:

- If (service is poor) AND (food is rancid) then (tip is cheap)
- If (service is good) then (tip is average)
- If (service is excellent) AND (food is delicious) then (tip is generous)

##### (2) Summary and Discussion

Below write a short summary discussing your results. Address the following points:

- Which system do you think is better: the one using the OR operator or the one using the AND operator to link rules?

I think the OR operator is better as it better represents the real-world. In the United States, tipping is expected, while other countries don't have the same tipping culture. The tips we provide are the wages that a server earns as their livable income, and thus we feel more pressure as the consumer to tip. If you get terrible service but amazing food, most people would still leave a decent tip as the food compensated. On the other hand, if the food was awful but the server did phenomenal, you'd likely still tip. The OR operator allows one strong factor to outweigh the negative one. Using AND, if service is awful (1) and food is delicious (8), a tip of 15 doesn't seem as likely as a tip of 13.8.

- Which version (OR or AND) generates a higher tip?

The OR operator generated a higher tip. OR statements take the max operator, meaning a single antecedent can have full weight. On the other hand, AND takes the min operator, so one low value can bottleneck the results.

- Briefly reflect on your overall experience with the tutorial.

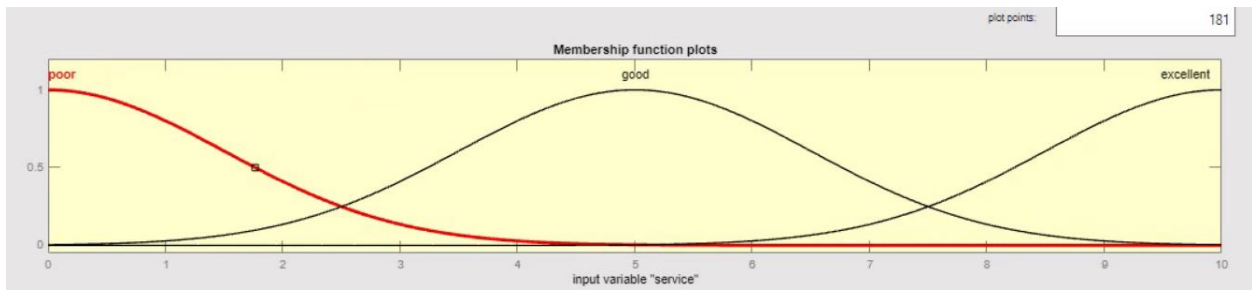
This tutorial helped see fuzzy logic in practice with something we've all experienced – tipping – which can also make us a domain expert when it comes to using common sense to build our system. Being able to create the rules and membership functions ourselves made the learning much more fulfilling than just loading 'fuzzy tipper.' You deal with the ranges hands-on and see where membership function domains change. A single logical operator change seems like a small difference, but it makes a great difference in the final output. In this case, many tips were lowered as a result of using the AND operator.

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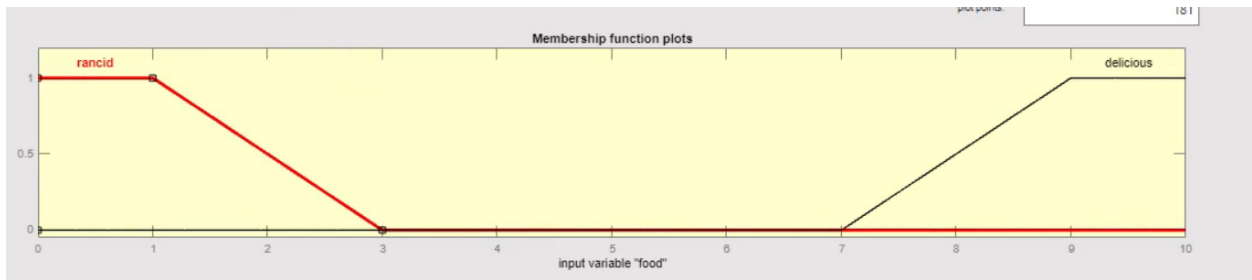
### (3) Membership Function Plots

Copy and paste below the membership function plots for the two input variables (*Service* and *Food*) and the output variable (*Tip*).

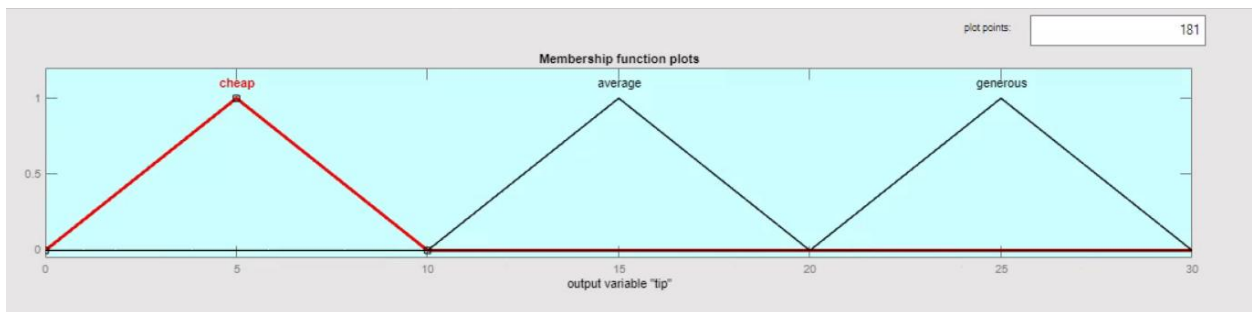
#### Service



## Food



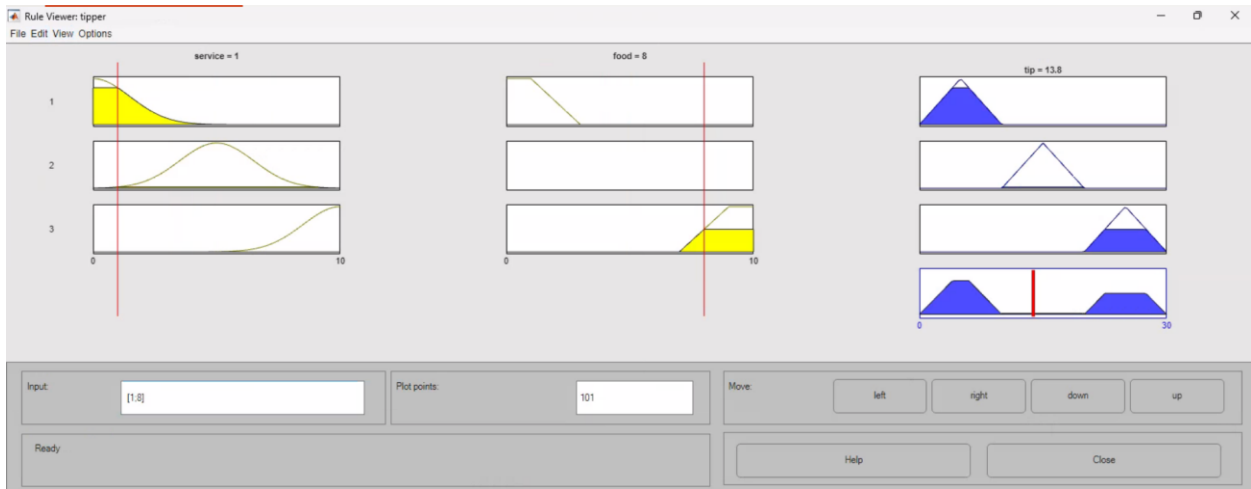
## Tip



### (4) Fuzzy Rules

Copy and paste below the fuzzy rules for both versions:

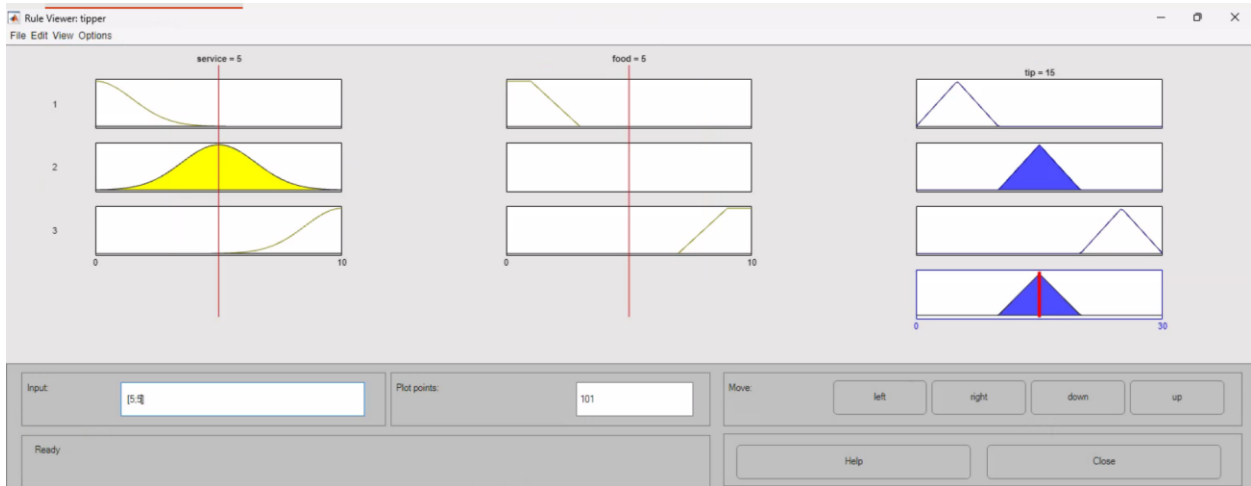
- **Rules linked with the OR operator**



Rule Editor: tipper  
File Edit View Options

1. If (service is poor) or (food is rancid) then (tip is cheap) (1)
2. If (service is good) then (tip is average) (1)
3. If (service is excellent) or (food is delicious) then (tip is generous) (1)

- Rules linked with the AND operator



Rule Editor: tipper  
File Edit View Options

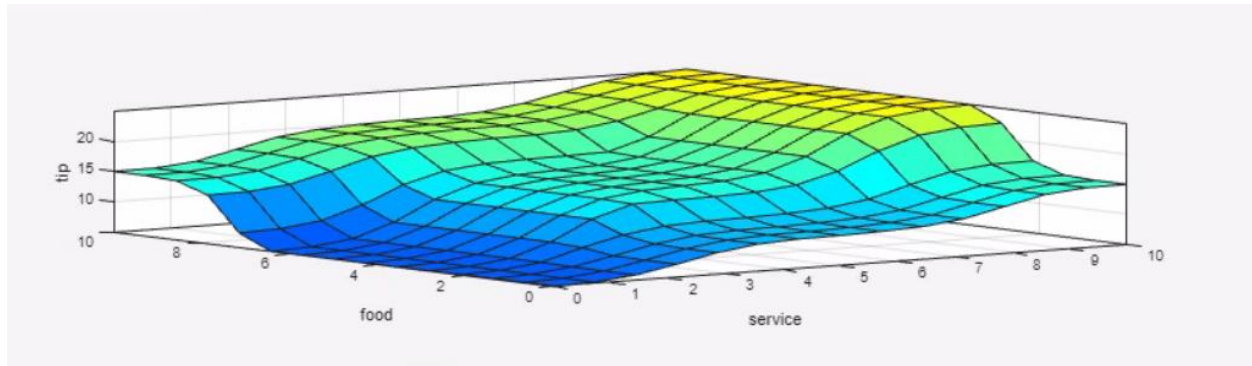
1. If (service is poor) and (food is rancid) then (tip is cheap) (1)
2. If (service is good) then (tip is average) (1)
3. If (service is excellent) and (food is delicious) then (tip is generous) (1)

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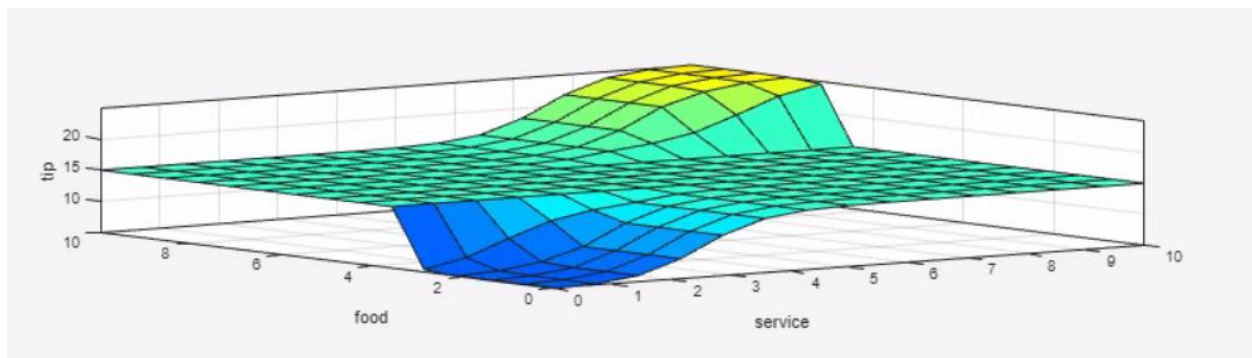
(5) Control Surface Plots

Copy and paste the control surface plots for both versions:

- **Control surface for the OR version**



- **Control surface for the AND version**



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Submission Instructions:

Merge sections 1–5 into a single PDF or Word file.

Save the file as: Your\_FirstName\_LastName\_Tutorial4.pdf.

Submit the file via Blackboard under Assignments → Tutorials folder by the due date.