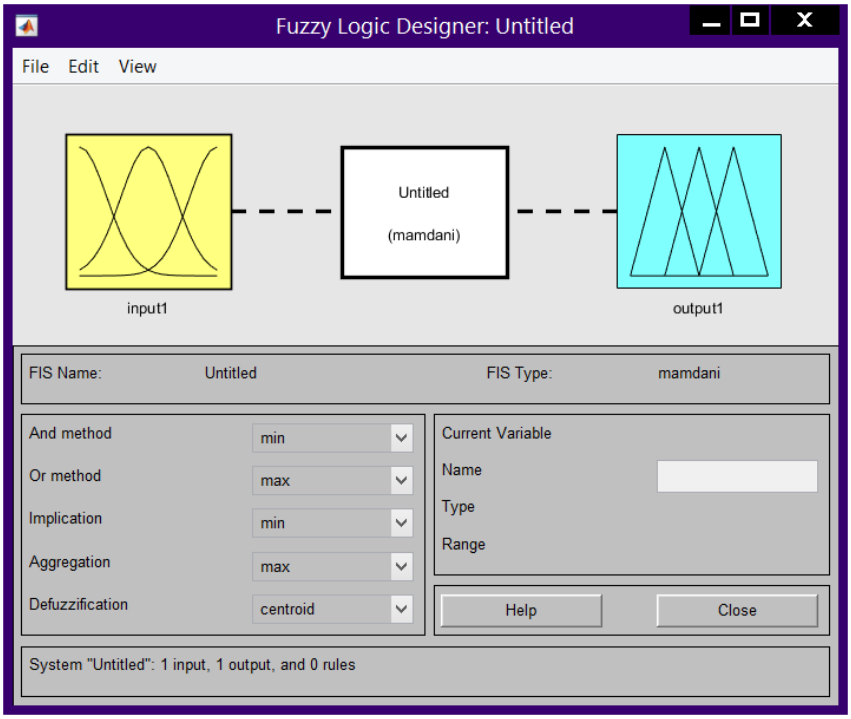
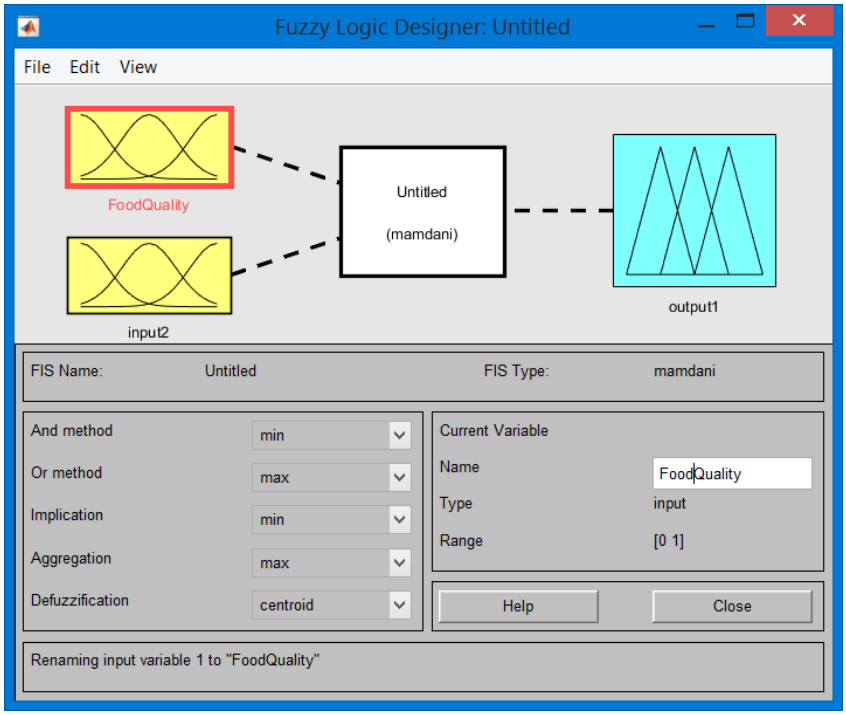
Developing a FIS for the Tipper problem using the Fuzzy Logic Toolbox

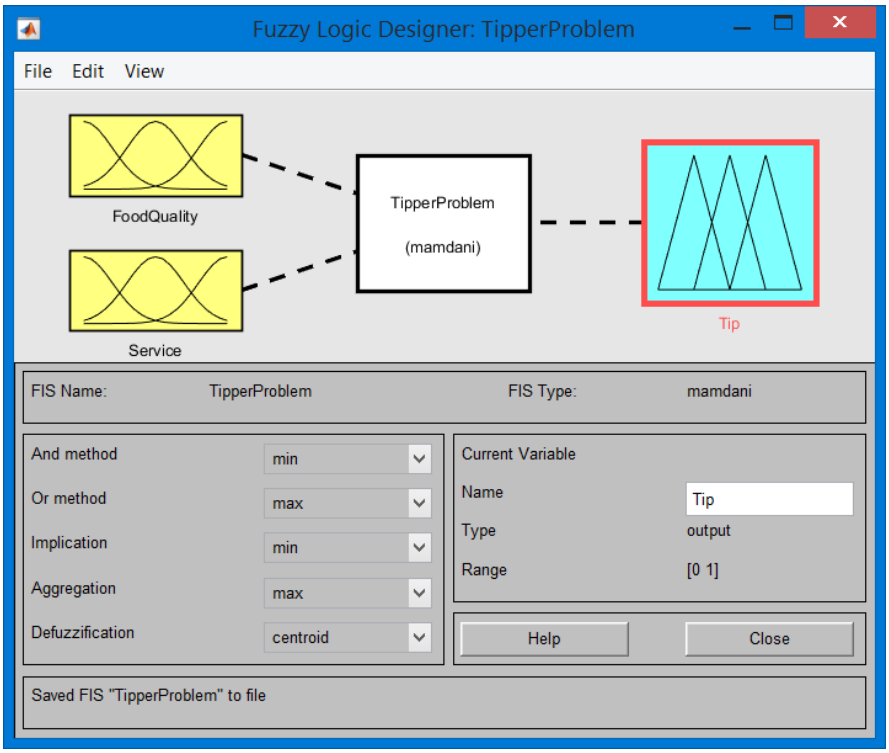
1. Open MATLAB. Go to Apps and look for Fuzzy Logic Designer.
2. The Fuzzy Logic GUI opens with a preset 1-input-1-output system.



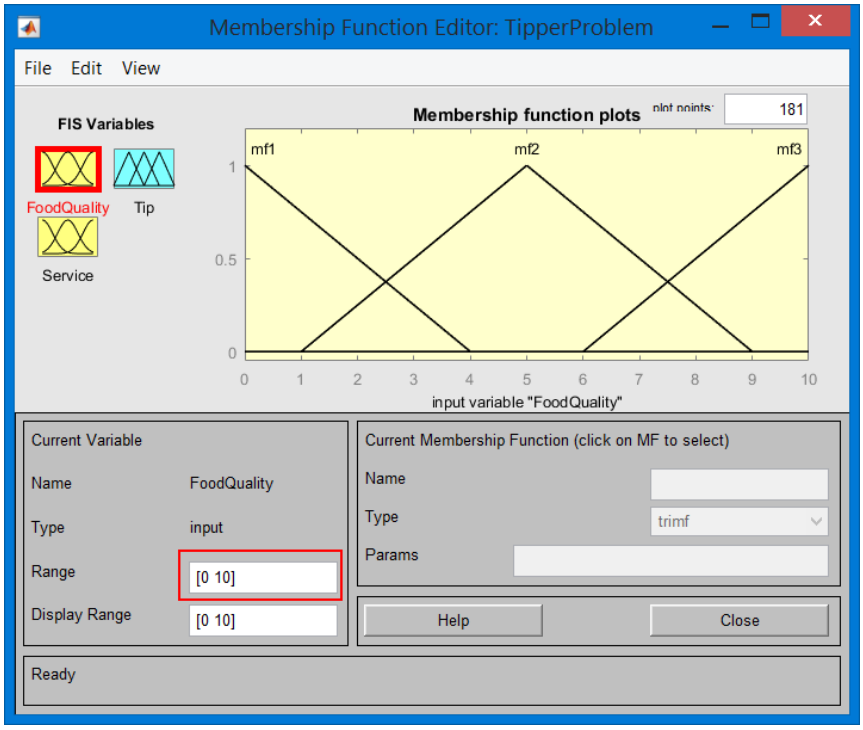
3. The Tipper problem requires a 2-input-1-output FIS. So, we need to add one more input. Go to Edit > Add variable > Input. This adds a second input to the FIS.
4. Modify the variable name “input1” to “FoodQuality” by clicking on the first input and changing the name in the text box.



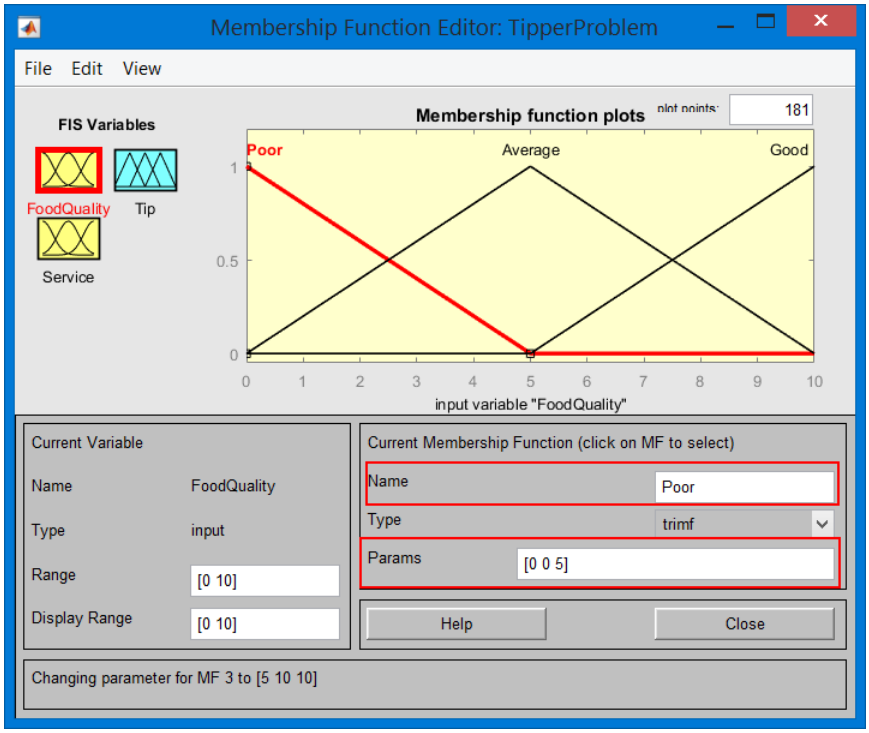
5. Similarly, change the name of input2 and output to Service and Tip, respectively. Save the FIS as TipperProblem.fis.



6. It can be noticed that the And, Or, Implication, Aggregation and Defuzzification methods are preset to their default values. The range of each variable is set as [0 1] by default.
7. Let's set the ranges of each variable to the range we need. Double click input "FoodQuality". This opens up a new window. Set the range to [0 10] as shown below.



8. Similarly, set the range of Service to [0 10] and that of Tip to [0 25].
9. The variables are already defined using 3 triangular membership functions. So, we just have to modify the boundaries of the membership functions.
10. Click on FoodQuality and then on mf1. Change its name to Poor and the params values to [0 0 5].



11. Similarly, change the name and params of the other two membership functions as follows:

Current mf name	New name	Params
mf2	Average	[0 5 10]
mf3	Good	[5 10 10]

12. Redo steps 10 and 11 for input Service.
13. Similarly, modify the names and params of the membership functions associated with output Tip to the following.

Current mf name	New name	Params
mf1	Low	[0 0 12.5]
mf2	Medium	[0 12.5 25]
mf3	High	[12.5 25 25]

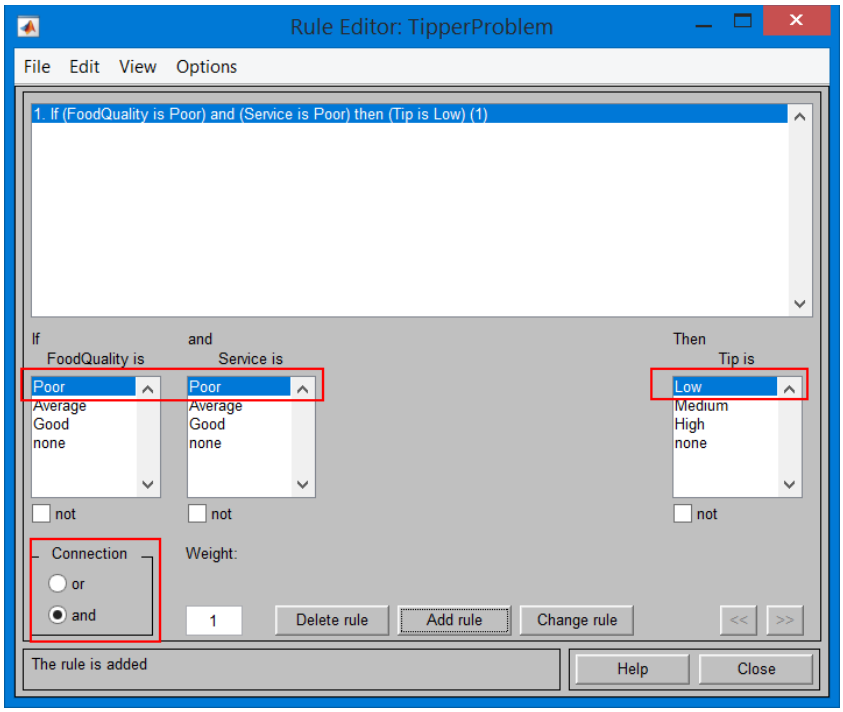
14. Now, we have completely defined the membership functions for all three variables. Close the current window.
15. Let's define the rulebase for our FIS. Go to Edit > Rules.
16. This opens a new window to edit the rules. Currently, the rulebase is empty. We plan on defining the following three rules:

    a. If the FoodQuality is Poor AND the Service is Poor, then the Tip is Low.

    b. If the Service is Average, then the Tip is Medium

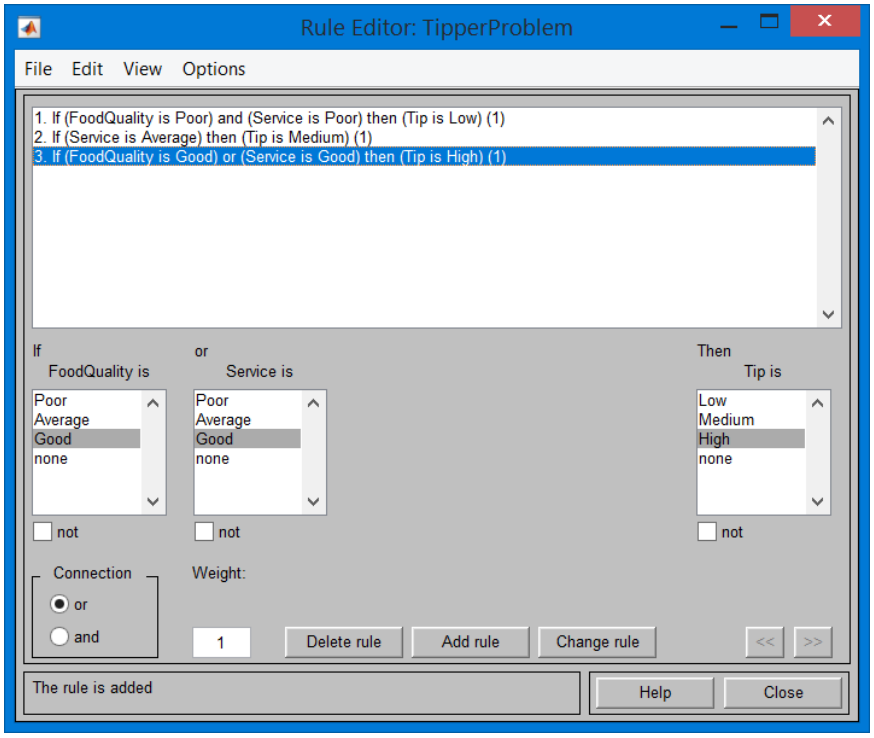
    c. If the FoodQuality is Good OR the Service is Good, then the Tip is High.

17. For rule a, the connection is AND and both the inputs are Poor. So, choose Poor for both inputs and Low for the output Tip. Make sure the connection is set to AND. Then, click Add Rule. This creates rule a.

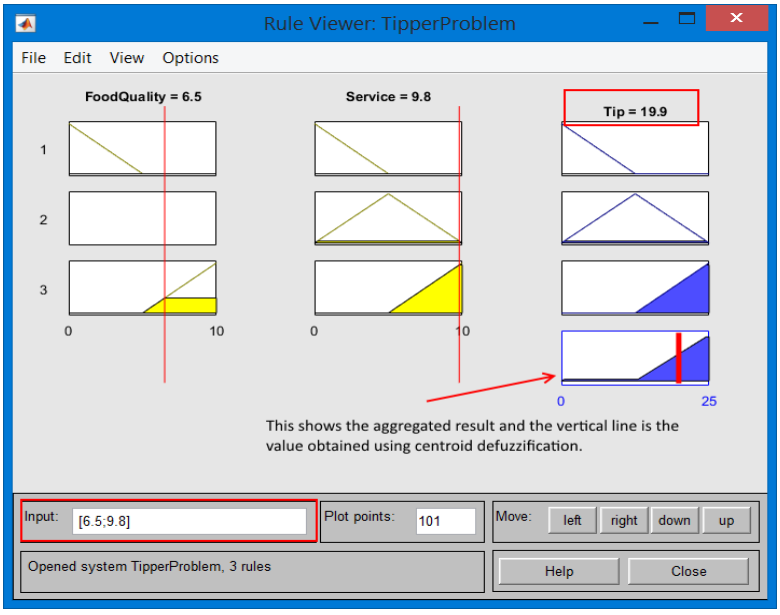


18. Similarly, create rules b and c using the following table:

Rule	FoodQuality	Service	Tip	Connection
b	None	Average	Medium	-
c	Good	Good	High	OR



19. Close the current window. This completes the design of the TipperProblem fis. We defined everything in accordance with the problem we discussed in the previous class.
20. Go to View > Rules. Change the inputs to FoodQuality = 6.5 and Service = 9.8. This should give an output Tip = 19.9.



21. You can also move the red vertical sliders to change the inputs.
22. Go to View > Surface. This provides the surface plot which shows how the output Tip varies with respect to the two inputs. You can drag the plot to get a different view of the surface.
23. Go to the original FIS window. Go to File > Export > To workspace. Put the name as 'fis1'. This exports our TipperProblem as a matlab struct named "fis1".
24. On the command window, use the command ***gensurf(fis1)*** to obtain the fis surface as a matlab plot. Save this as .fig file.
25. Go back to the Fuzzy Logic GUI and change the defuzzification method to mom (mean-of-max).
26. Redo steps 23 and 24 to plot the surface. Save this plot. Compare this with the previous surface that you saved. You will notice that the output has a larger range compared to the centroid defuzzification. It can also be noticed that the mom defuzzification results in a discrete set of values as opposed to centroid defuzzification which is more continuous.
27. Delete the three rules from the rulebase. Instead add the following set of 9 rules using the AND connection. These 9 rules represent all combinations of the input membership functions for the two inputs.

FoodQuality	Service	Tip
Poor	Poor	Low
Poor	Average	Low
Poor	Good	Medium
Average	Poor	Low
Average	Average	Medium
Average	Good	Medium
Good	Poor	Medium
Good	Average	High
Good	Good	High

28. Check the surface plots for both mom and centroid defuzzification methods and compare them to the plots obtained using just the three rules.