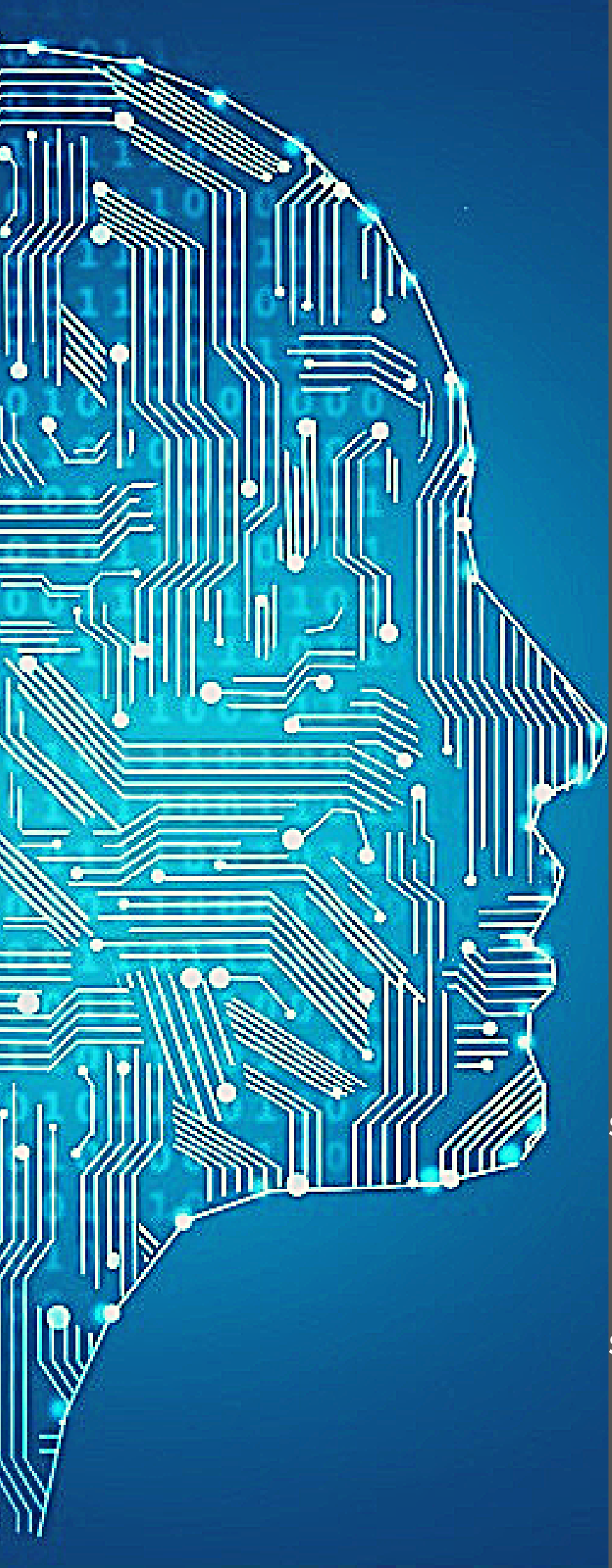

# INTELLIGENT SYSTEM LAB-MCT-452L

## LAB REPORTS


SUBMITTED BY:

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**2015-MC-167**

SUBMITTED TO:

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# List of Experiments

**Lab 1:**

- Introduction to fuzzy logic toolbox in MATLAB

**Lab 2:**

- Intelligent control of a motor using Fuzzy logic.

**Lab 3:**

- Introduction to fuzzy logic operations in MATLAB basic tipping problem.
- Create a fuzzy logic between two inputs (Service & Food Quality) and output (Tip) for a restaurant.

**Lab 4:**

- Introduction to Intelligent Washing Machine.
- Create a fuzzy logic between three inputs (Cloth, Dirt & Dirtiness) and output (Wasing-Time) for an Intelligent Washing Machine.

**Lab 5:**

- Intelligent Air Conditioning System**.**

**Lab 6:**

- Fuzzy Rule Based Diagnostic System For Detecting The Lung Cancer Disease.

**Lab 7:**

- Toyota Corolla fuel consumption.

**Lab 8:**

- Introduction to Artificial Neural Networks and Activation functions.

**Lab 9:**

- Create Artificial Neural Networks in MATLAB.

**Lab 10:**

- Neural Networks for patter classification.

**Lab 11:**

- Implementing backpropagation algorithm in Neural Network.

**Lab 12:**

- Introduction to Genetic algorithm in MATLAB.

# Lab # 1

## Objectives:

1) Introduction to fuzzy logic toolbox in MATLAB

## Introduction:

Fuzzy logic is an approach to computing based on "degrees of truth" rather than the usual "true or false" (1 or 0) Boolean logic on which the modern computer is based. Fuzzy logic includes 0 and 1 as extreme cases of truth (or "the state of matters" or "fact") but also includes the various states of truth in between so that, for example, the result of a comparison between two things could be not "tall" or "short" but ".38 of tallness."

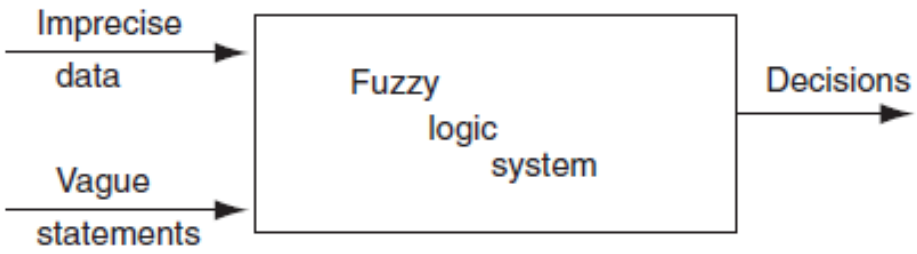



**Figure 1:** A fuzzy logic system which accepts imprecise data and vague statements such as low, medium, high and provides decisions

The Fuzzy Logic Toolbox for use with MATLAB is a tool for solving problems with fuzzy logic. Fuzzy logic is a fascinating area of research because it does a good job of trading off between significance and precision — something that humans have been managing for a very long time.

There are five primary GUI tools for building, editing, and observing fuzzy inference systems in the Fuzzy Logic Toolbox: the Fuzzy Inference System or **FIS Editor**, the **Membership Function Editor**, the **Rule Editor**, the **Rule Viewer**, and the **Surface Viewer**. These GUIs are dynamically linked, in that changes you make to the FIS using one of them, can affect what you see on any of the other open GUIs. You can have any or all of them open for any given system.

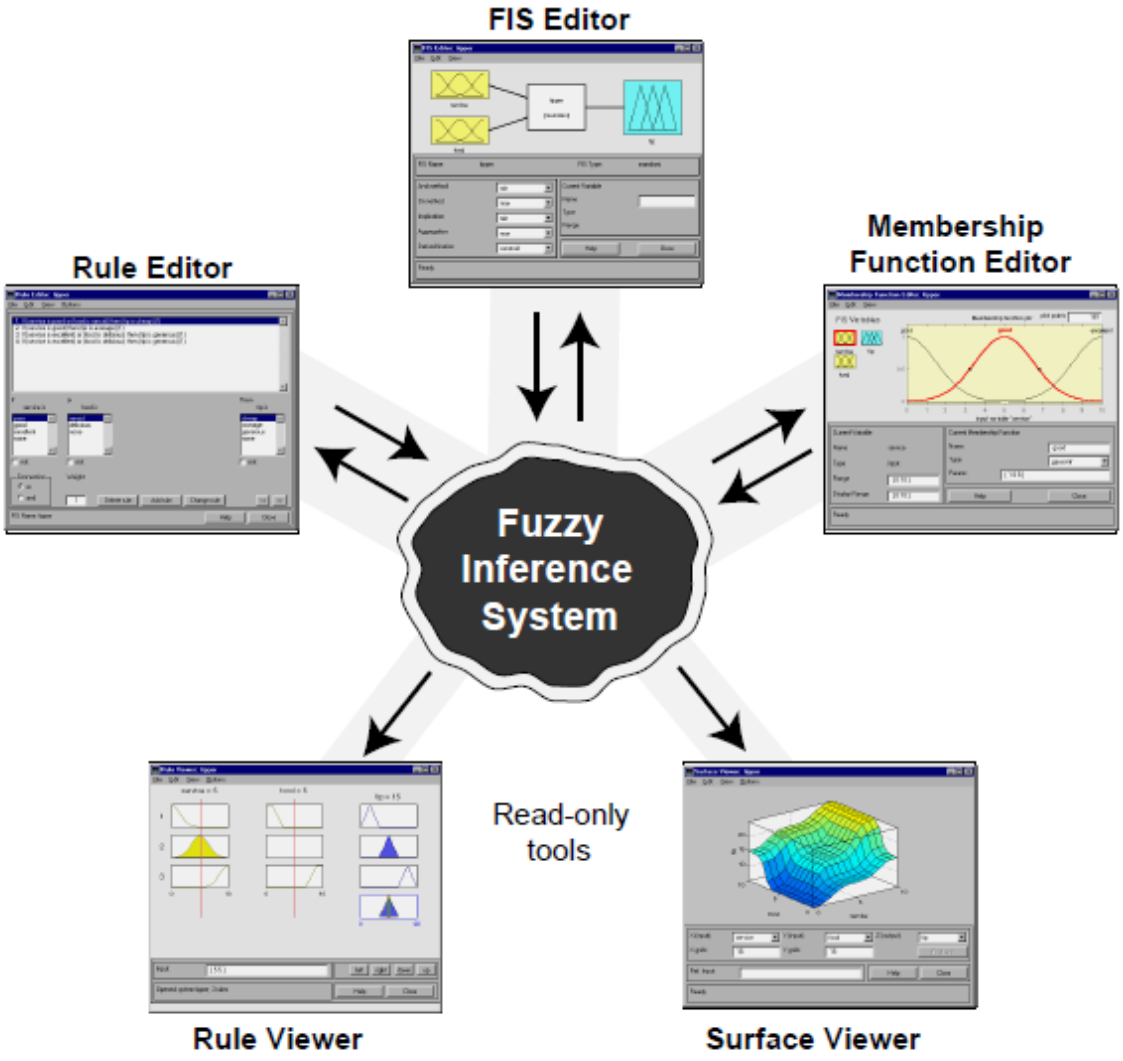



**Figure 2:** Fuzzy Inference System

## The Fuzzy Editor:

Typing fuzzy in MATLAB command prompt

>> fuzzy

This will load the FIS Editor. The FIS Editor displays general information about a fuzzy inference system. There's a simple diagram (**Figure 3**) that shows the names of each input variable on the left, and those of each output variable on the right. The sample membership functions shown in the boxes are just icons and do not depict the actual shapes of the membership functions. Below the diagram is the name of the system and the type of inference used.

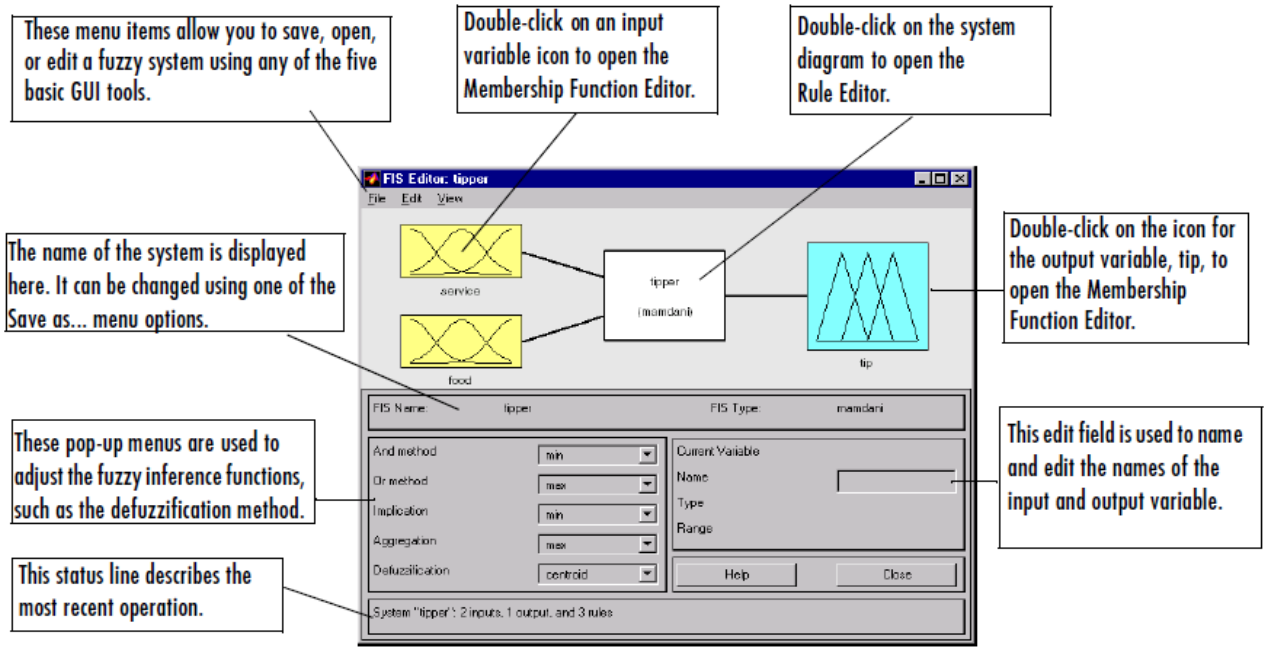



**Figure 3:** The FIS Editor

## Rule:

Rules define the desire relationship between the input and the output. Shortcut key (**ctrl+3**).

## Rule Viewer:

Getting values from input and give net output (defuzzification). Shortcut key (**ctrl+5**).

## Surface Viewer:

Graphical relationship input and output. Shortcut key (**ctrl+6**).

# Lab # 2

## Objectives:

1) Intelligent control of a motor using Fuzzy logic.

## Introduction:

Fuzzy logic is an approach to computing based on "degrees of truth" rather than the usual "true or false" (1 or 0) Boolean logic on which the modern computer is based. Fuzzy logic includes 0 and 1 as extreme cases of truth (or "the state of matters" or "fact") but also includes the various states of truth in between so that, for example, the result of a comparison between two things could be not "tall" or "short" but ".38 of tallness."

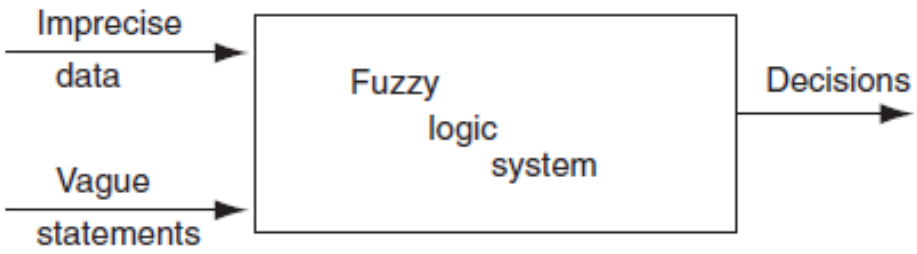



**Figure 1:** A fuzzy logic system which accepts imprecise data and vague statements such as low, medium, high and provides decisions

The Fuzzy Logic Toolbox for use with MATLAB is a tool for solving problems with fuzzy logic. Fuzzy logic is a fascinating area of research because it does a good job of trading off between significance and precision — something that humans have been managing for a very long time.

Intelligent motor means changed the voltage according to RPM of motor without human interference.

## Lab Activity

## Procedure:

- Typed fuzzy in command prompt.
  >>fuzzy
- Fuzzy logic designer: Untitled opened and exported file by "**Lab2_accurate**".
- Changed the name of input1 by **RPM-Of-Motor** and output1 by **Voltage.**
- Chose defuzzification **lom.**

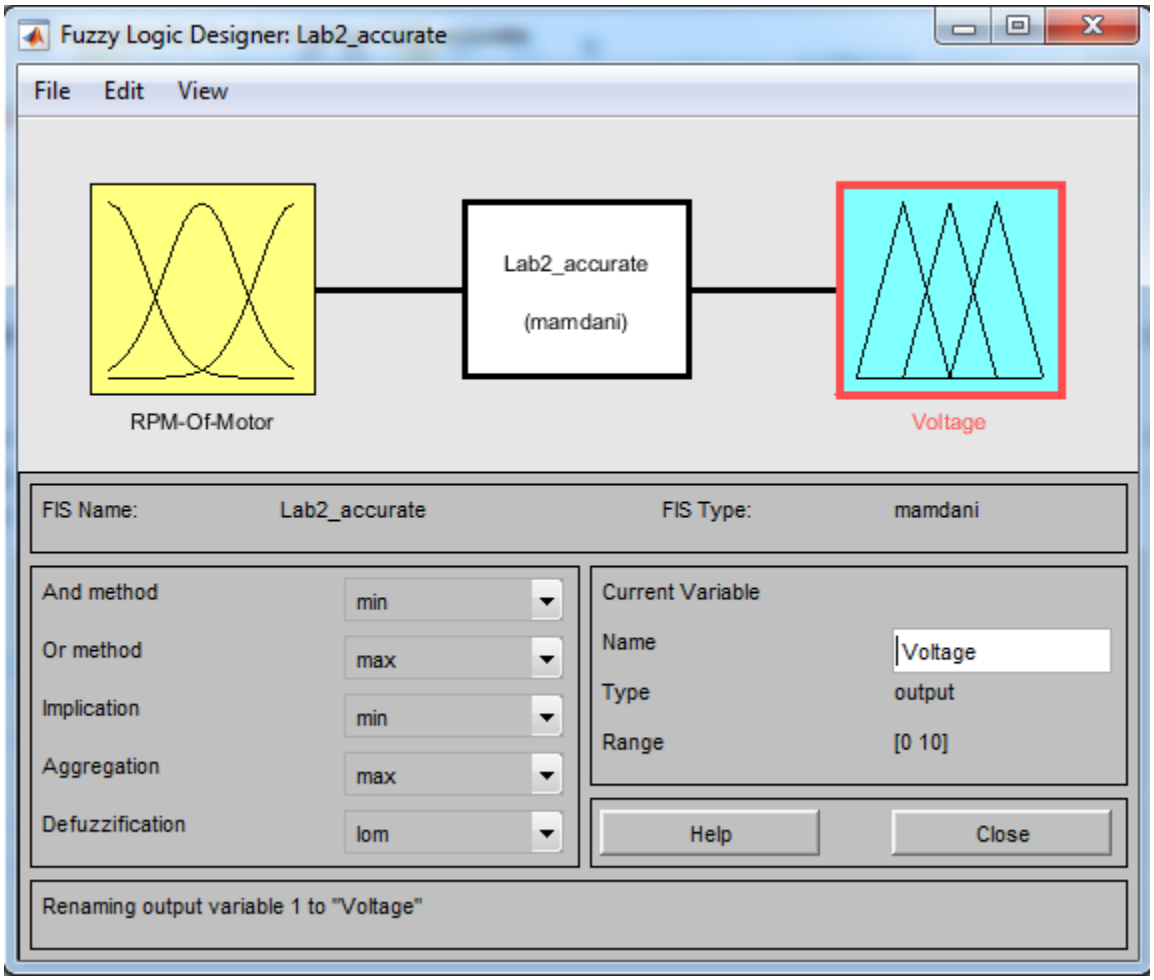



**Figure 2:** Fuzzy logic designer

- Double clicked on the input box and added 3 member functions (MFs) as shown in figure 3; also, changed the range of Input from [0 1] to [0 200].
- Low MF range lied in between 0 to 90, Middle MF between 90 to 110 and High 100 to 200.

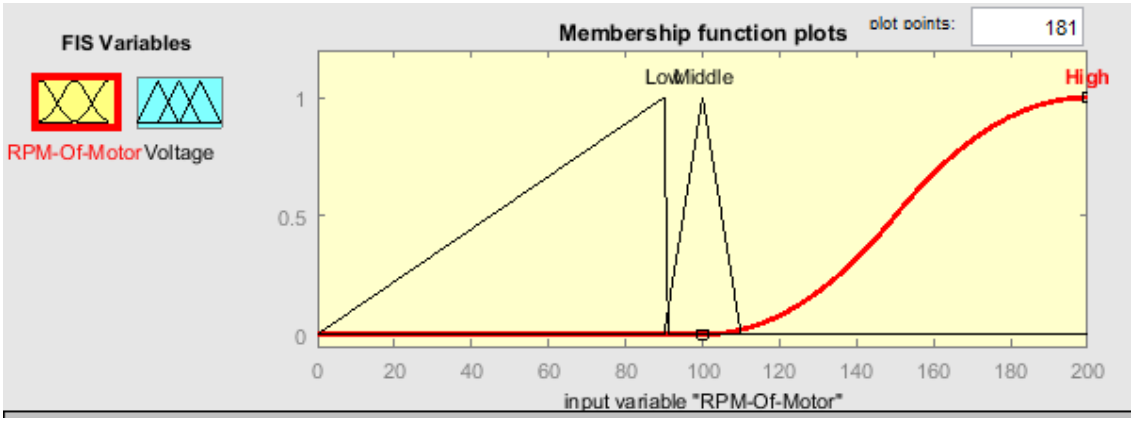



**Figure 3:** Input's MFs

- Then added the MFs of output and changed its range [0 1] to [0 10].
- Low MF range lied in between 6 to 10, Middle MF between 4 to 6 and High 0 to 4.

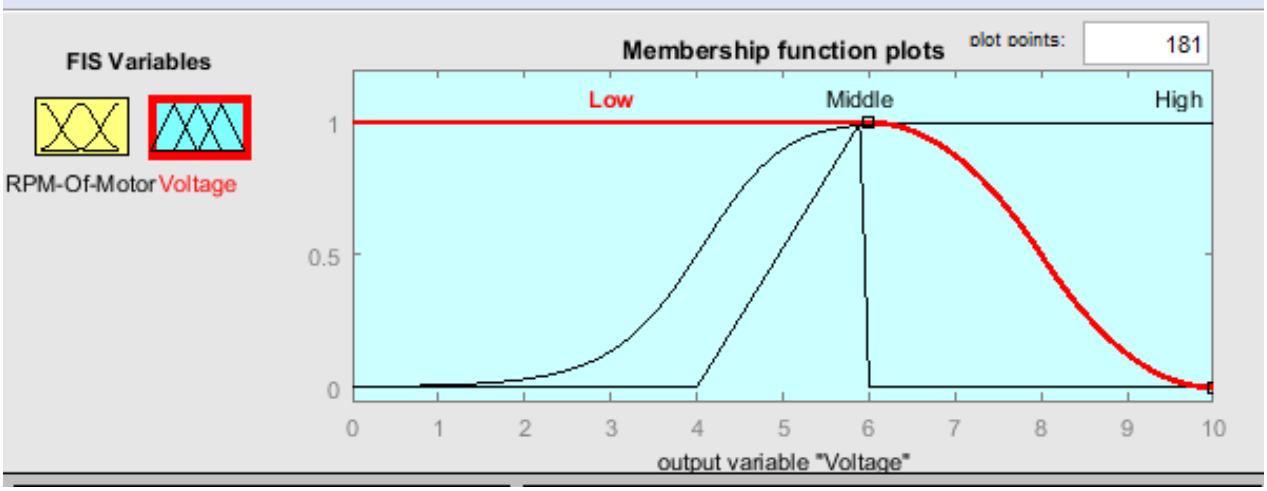



**Figure 4:** Output's MFs

## Rules:

1. Input voltage increased when rpm of motor is less.
2. Input voltage remained constant when rpm of motor was in middle range.
3. Input voltage decreased when rpm of motor is high.

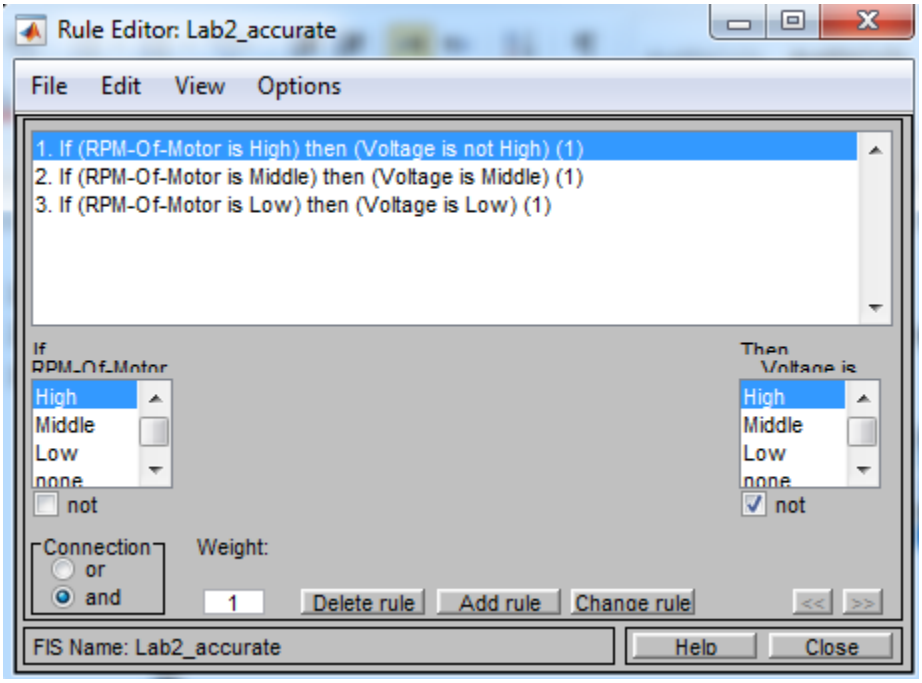



**Figure 5:** Rule Editor: Lab2_accurate

## Results:

- Rule 3 applied according to our desire, Input less, output more as shown below

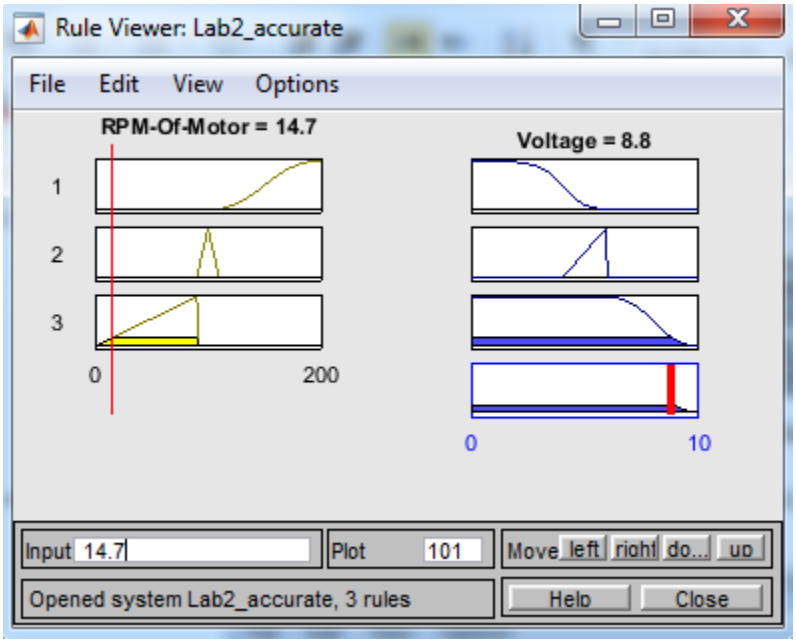



**Figure 6:** Rule Viewer: Lab2_accurate (Rule 3)

- Rule 2 applied according to our desire, Input average, output average as shown below

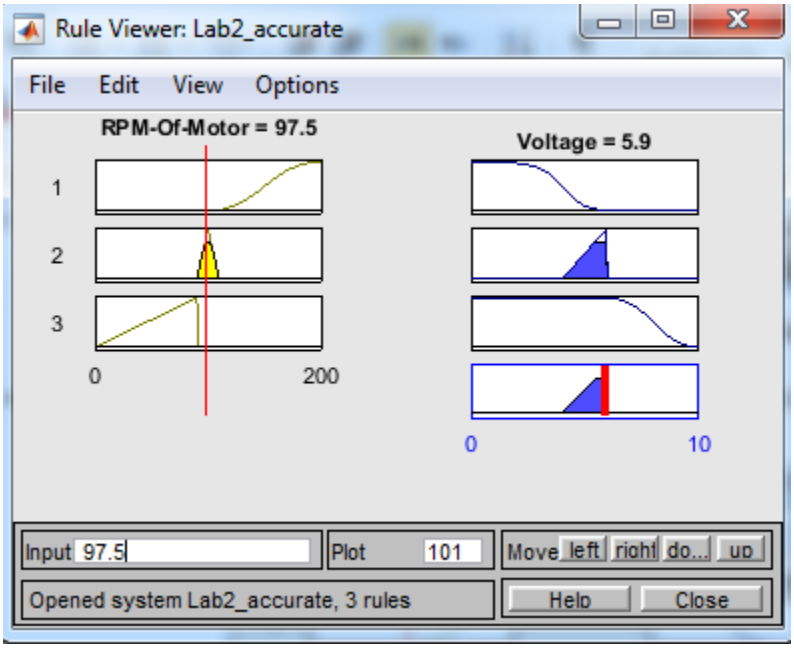



**Figure 7:** Rule Viewer: Lab2_accurate (Rule 3)

- Rule 1 applied according to our desire, Input high, output low as shown below

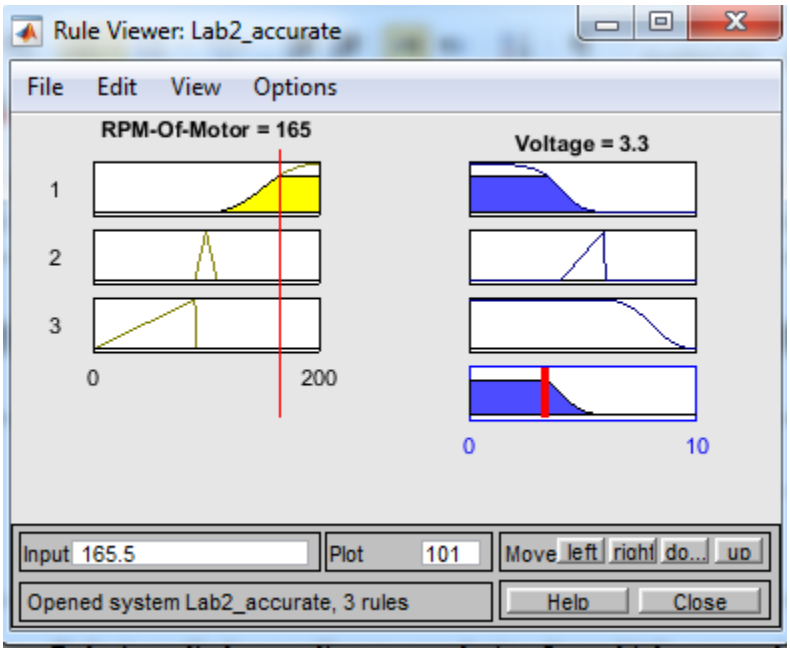



**Figure 8:** Rule Viewer: Lab2_accurate (Rule 1)

- Overall, Input (RPM of Motor) and output (Voltage) relation

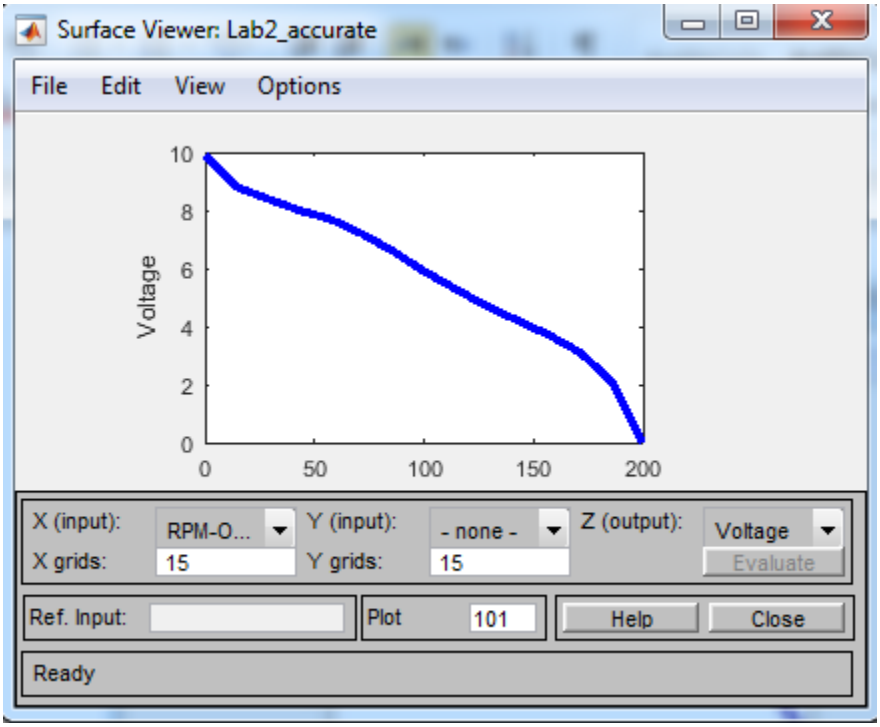



**Figure 9:** Surface Viewer: Lab2_accurate

# Lab # 3

## Objectives:

1) Introduction to fuzzy logic operations in MATLAB basic tipping problem.
2) Create a fuzzy logic between two inputs (Service & Food Quality) and output (Tip) for a restaurant.

## Introduction:

Consider the tipping problem: what is the "right" amount to tip your waitperson? Here is a clear statement of the problem.

**The Basic Tipping Problem.** Given a number between 0 and 10 that represents the service & quality of food at a restaurant (where 10 is excellent), what should the tip be?

Tip is depended on service and quality of food. If both are good, tip will be generous.

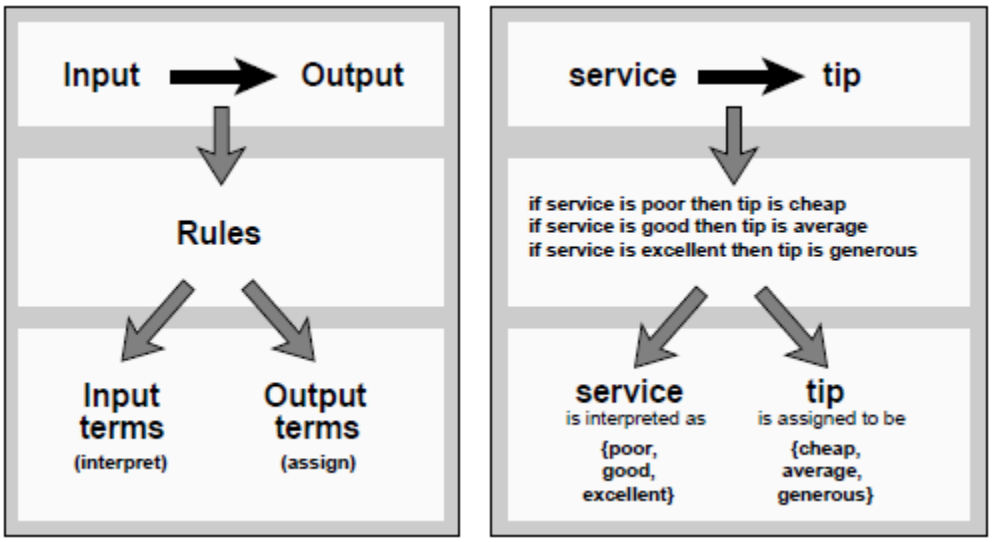



**Figure I:** General and Tipping Case

## Lab Activity

## Procedure:

- Typed fuzzy in command prompt.
  >>fuzzy
- Fuzzy logic designer: Untitled opened and exported file by "**Tipping_Problem**".
- Changed the name of input1 by **Service,** input2 by **Food** and output1 by **Tip.**
- Chose defuzzification **Centriod.**

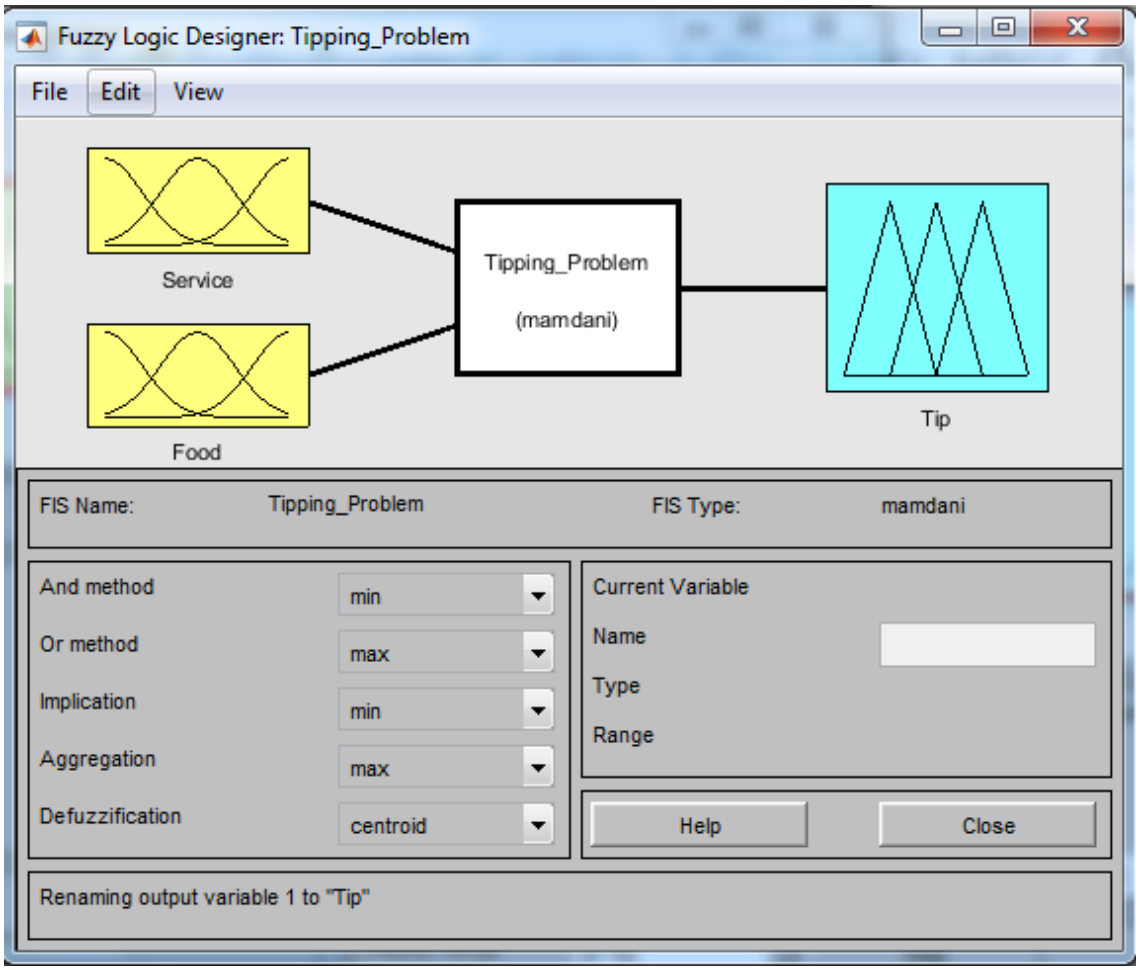



**Figure 2:** Fuzzy logic designer

- Double clicked on the Service box and added 3 member functions (MFs) as shown in figure 3; also, changed the range of Input from [0 1] to [0 10].
- Poor MF range lied in between 0 to 4, Good MF between 4 to 6 and excellent 6 to 10.

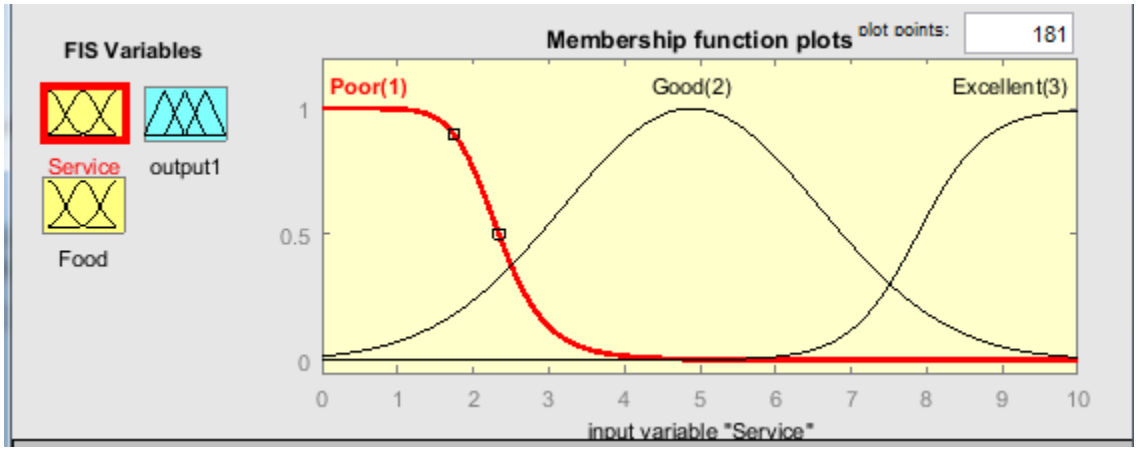



**Figure 3:** Service's MFs

- Then added the MFs of Food and changed its range [0 1] to [0 10].
- Rancid MF range lied in between 0 to 3.5 and Delicious.

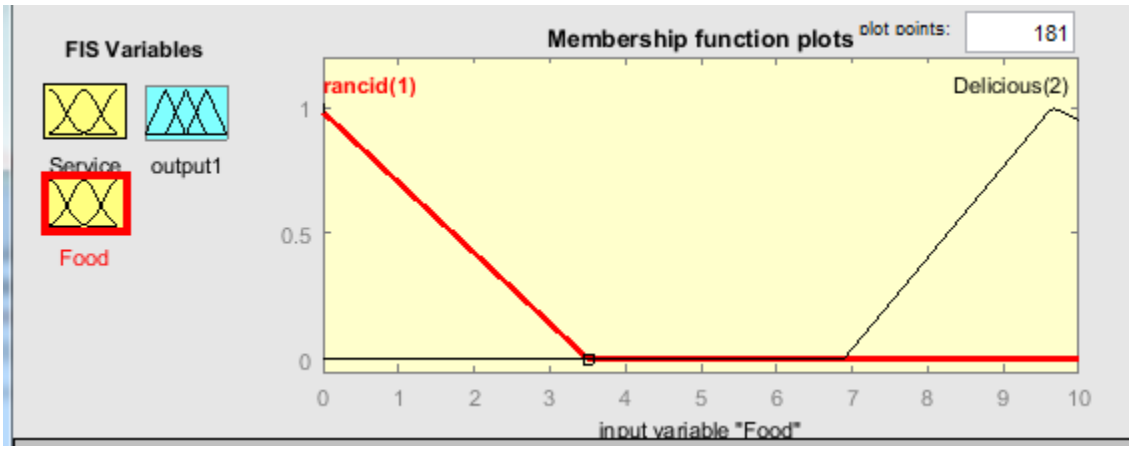



**Figure 4:** Food's MFs

- Then added the MFs of Tip and changed its range [0 1] to [0 10].
- Cheap MF range lied in between 0 to 2.5, Average MF between 1.5 to 6 and High 6 to 10.

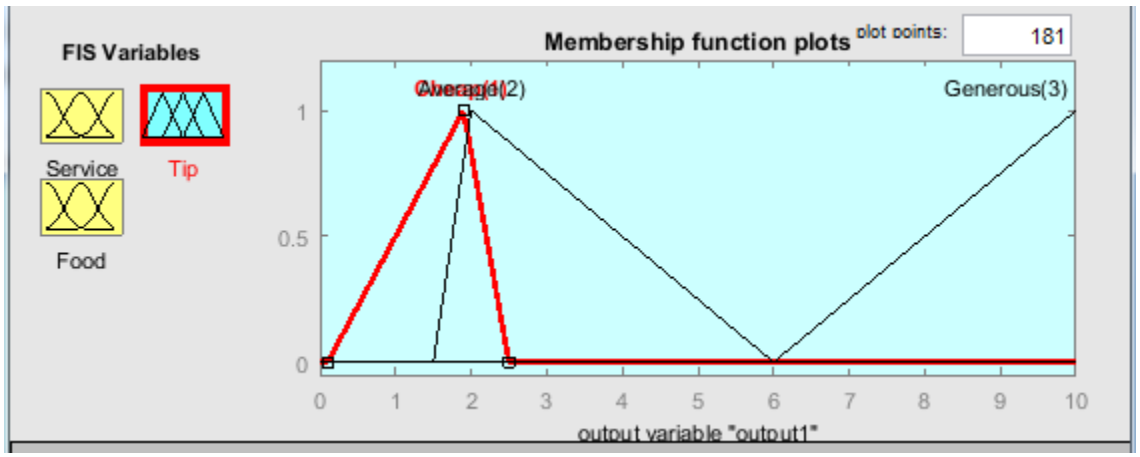



**Figure 5:** Tip's MFs

## Rules:

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

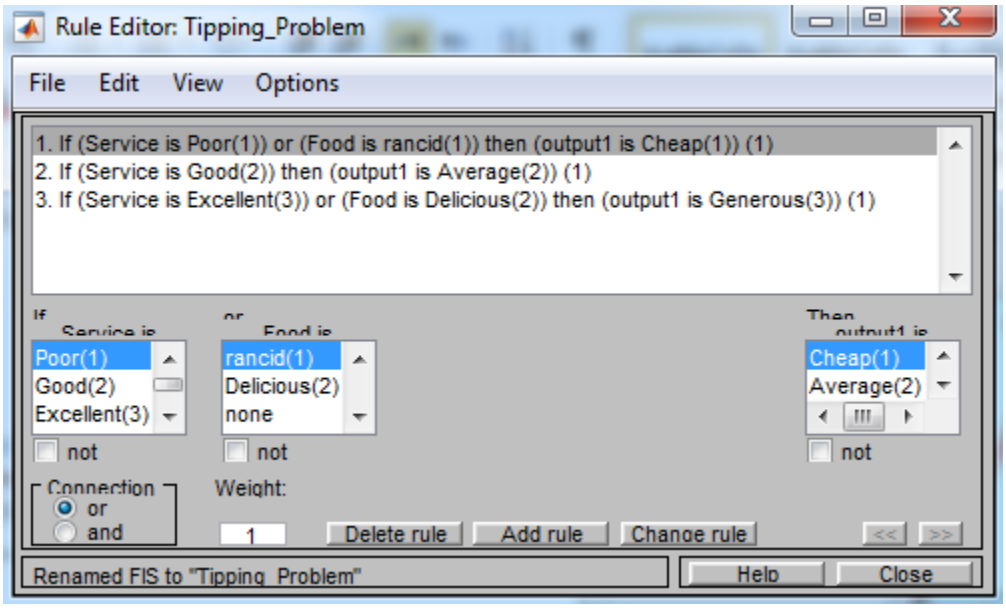



**Figure 6:** Rule Editor: Tipping_Problem

## Results:

- Rule 1 applied according to our desire as shown below

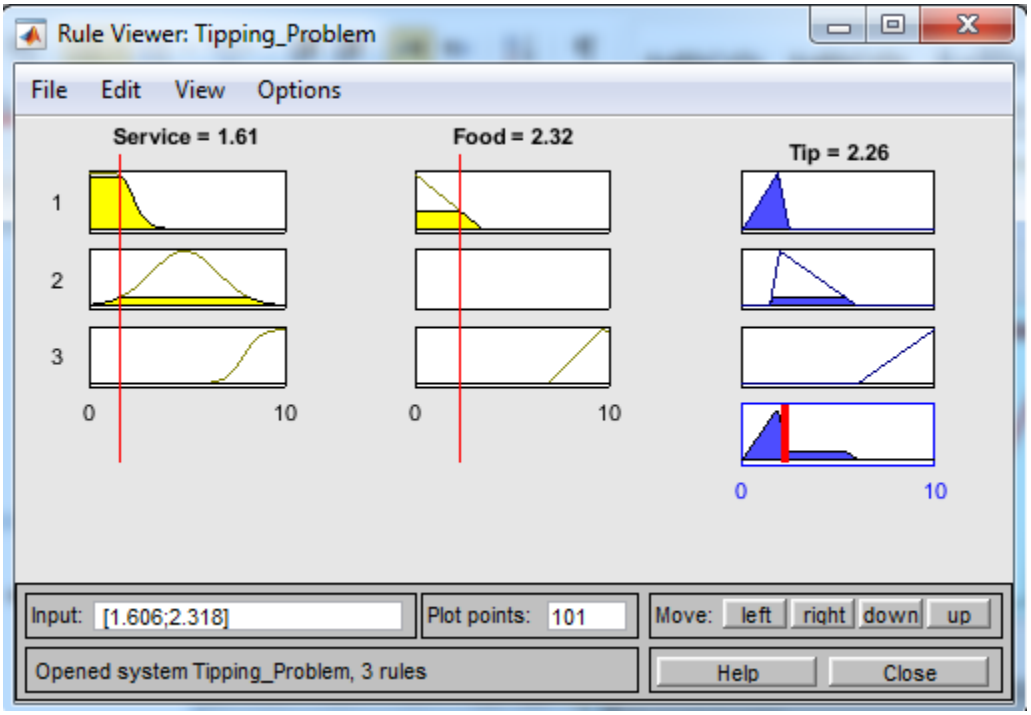



**Figure 7:** Rule Viewer: Tipping_Problem (Rule 1)

- Rule 2 applied according to our desire as shown below

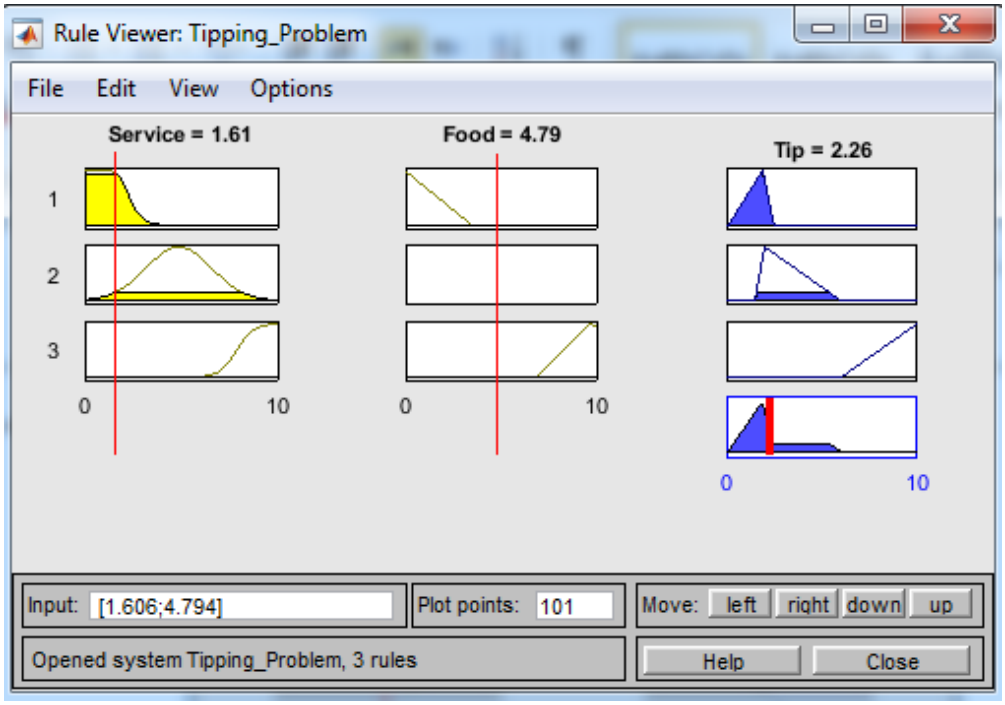



**Figure 8:** Rule Viewer: Tipping_Problem (Rule 2)

- Rule 3 applied according to our desire as shown below

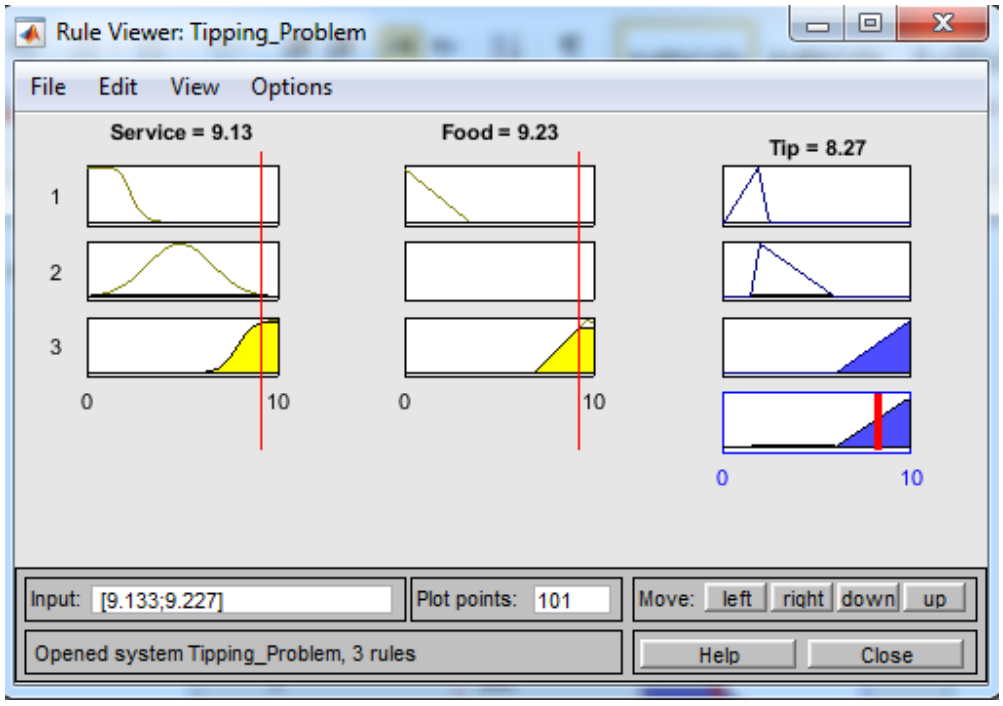



**Figure 9:** Rule Viewer: Tipping_Problem (Rule 3)

- Overall, Input (Service,Food) and output (Tip) relation

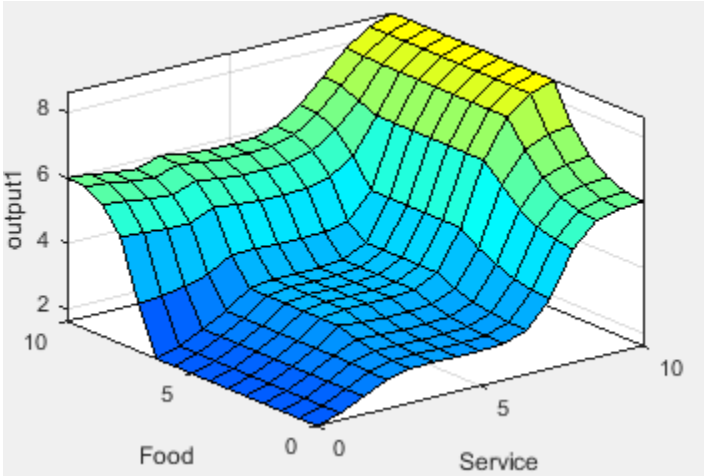



**Figure 10:** Surface Viewer: Tipping_Problem

- Overall, Input (Food, Service) and output (Tip) relation

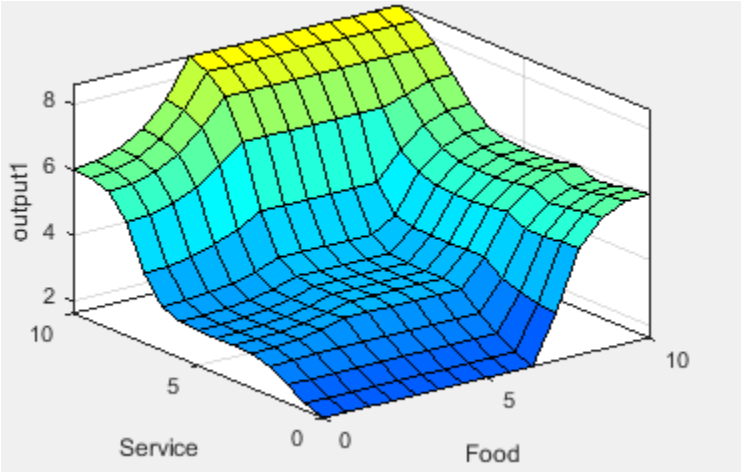



**Figure 11:** Surface Viewer: Tipping_Problem

# Lab # 4

## Objectives:

1) Introduction to Intelligent Washing Machine.
2) Create a fuzzy logic between three inputs (Cloth, Dirt & Dirtiness) and output (Wasing-Time) for an Intelligent Washing Machine.

## Introduction:

Washing machines are common house hold items and to have a washing machine that efficiently controls the wash time is vital. Conventional, proportional, integral and differential [PID] controllers have proven to be less capable in such control situations. In recent years there has been a growing interest in applying Fuzzy logic for control.

This experiment aims at presenting the idea of controlling the washing time using fuzzy logic control. The experiment describes the procedure that can be used to get suitable washing time for different types of cloths, type of dirt and dirtiness of clothes. The process is based entirely on the principle of taking non-precise inputs from sensors, subjecting them to fuzzy arithmetic and obtaining a crisp value of the washing time. It is quite clear that from the experiment itself that this method can be used in practice to further automate the washing machines.

When one uses a washing machine, the person generally select the length of wash time based on the amount of clothes he/she wish to wash and the type and degree of dirt cloths have. Unfortunately, there is no easy way to formulate a precise mathematical relationship between type of clothes and dirt and the length of wash time required.

Consequently, this problem has remained unsolved until very recently. Conventionally, people simply set wash times by hand and from personal trial and error experience. Washing machines were not as automatic as they could be. The users of washing machines have been facing the problem of selecting the length of wash time based on the type of clothes, type of dirt, dirtiness of clothes and amount of clothes. Most of the people find it very difficult to decide that which cloth needs what amount of washing time. To overcome these problems, Fuzzy based washing machine have the sensor based program which checks for the extents of dirt and grease, amount of detergent and water to add which accordingly adjust the wash time. In this experiment, we have introduced three input variables and one output fuzzy logic controller to get correct wash time.

## Lab Activity

## Procedure:

- Typed fuzzy in command prompt.
  >>fuzzy
- Fuzzy logic designer: Untitled opened and exported file by "**Wash_achieved**".

- Changed the name of input1 by **Cloth,** input2 by **Dirt**, input3 by **Dirtiness** and output1 by **Washing-Time**.
- Chose defuzzification **Centriod.**

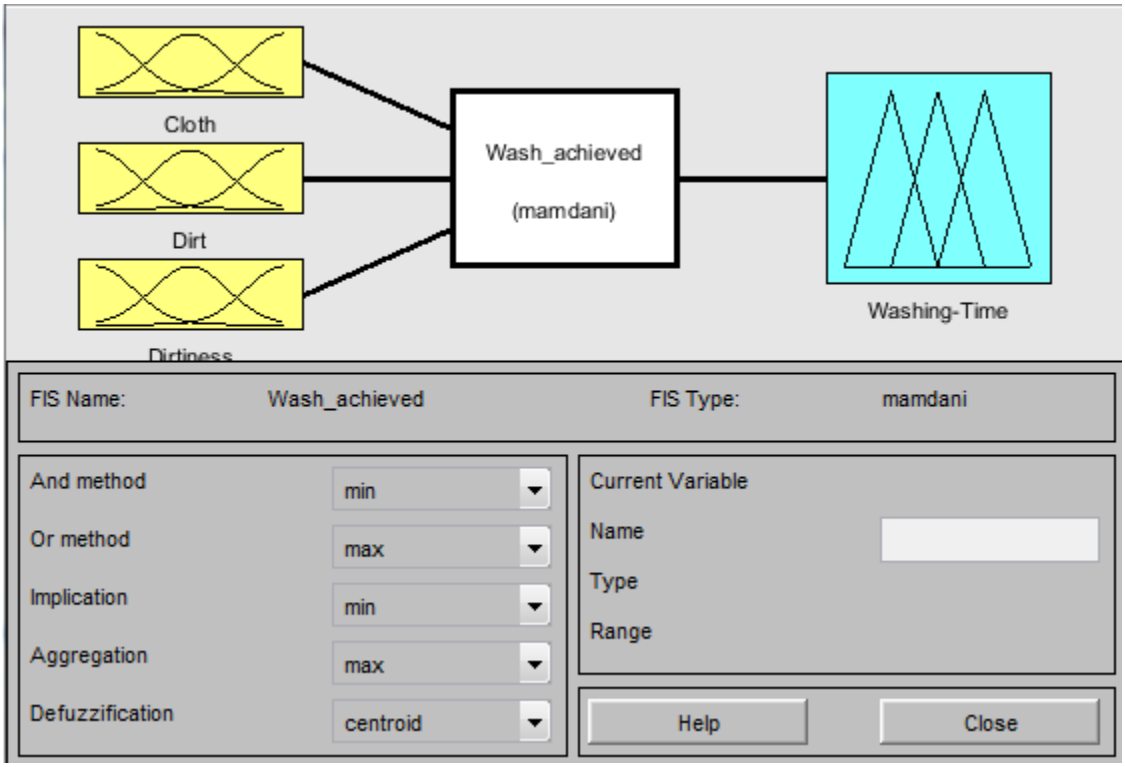



**Figure 1:** Fuzzy logic designer

- Double clicked on the Cloth and added 3 member functions (MFs) as shown in figure 2; also, changed the range of Input from [0  1] to [0 10].

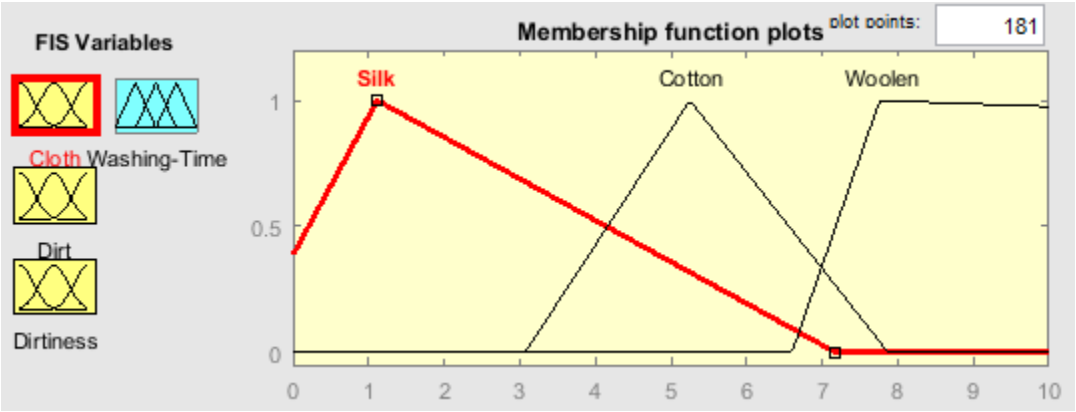



**Figure 2:** Cloth's MFs

- Then added the MFs of Dirt and changed its range [0 1] to [0 10].

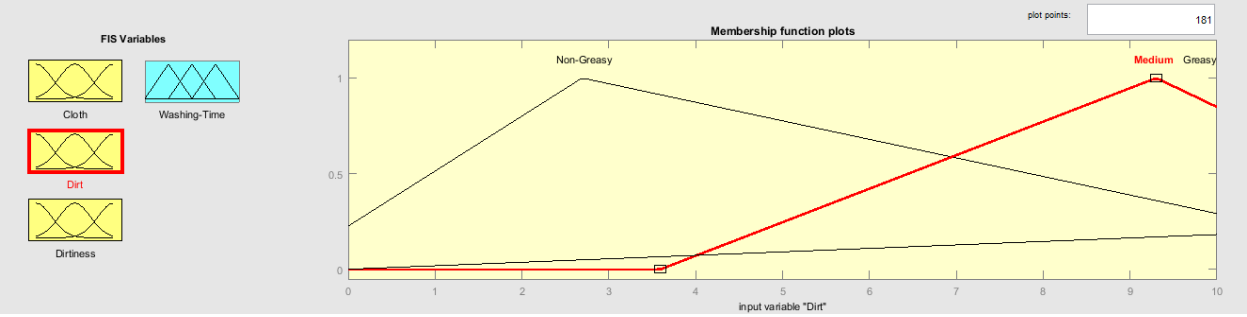



**Figure 3:** Dirt's MFs

- Then added the MFs of Dirt and changed its range [0 1] to [0 10].

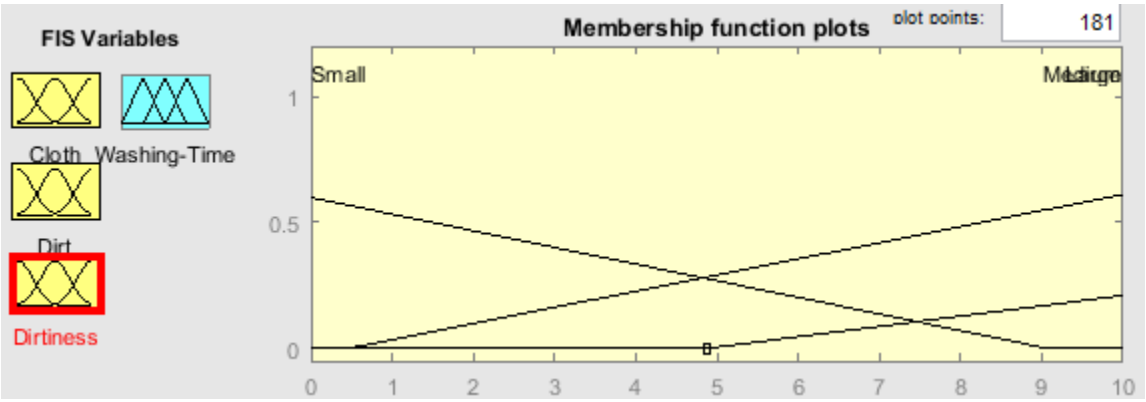



**Figure 4:** Dirtness's MFs

- Then added the 5 MFs of Washing-Time and changed its range [0 1] to [0 100].

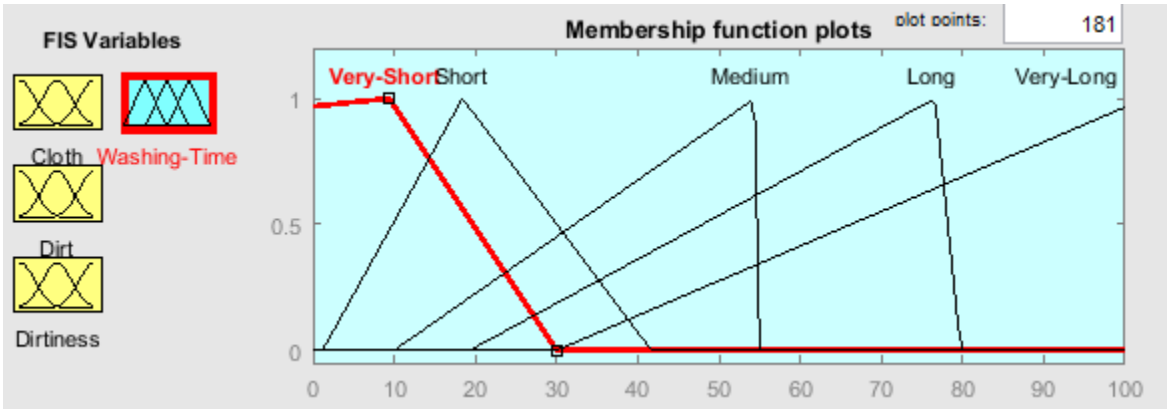



**Figure 5:** Washing-Time's MFs

## Rules:

1. If (Cloth is Silk) and (Dirt is Non-Greasy) and (Dirtiness is Small) then (Washing-Time is Very-Short) (1)
2. If (Cloth is Silk) and (Dirt is Non-Greasy) and (Dirtiness is Medium) then (Washing-Time is Short) (1)
3. If (Cloth is Silk) and (Dirt is Non-Greasy) and (Dirtiness is Large) then (Washing-Time is Medium) (1)
4. If (Cloth is Silk) and (Dirt is Medium) and (Dirtiness is Small) then (Washing-Time is Short) (1)

5. If (Cloth is Silk) and (Dirt is Medium) and (Dirtiness is Medium) then (Washing-Time is Medium) (1)
6. If (Cloth is Silk) and (Dirt is Medium) and (Dirtiness is Large) then (Washing-Time is Medium) (1)
7. If (Cloth is Silk) and (Dirt is Greasy) and (Dirtiness is Small) then (Washing-Time is Medium) (1)
8. If (Cloth is Silk) and (Dirt is Greasy) and (Dirtiness is Medium) then (Washing-Time is Medium) (1)
9. If (Cloth is Silk) and (Dirt is Greasy) and (Dirtiness is Large) then (Washing-Time is Long) (1)
10. If (Cloth is Cotton) and (Dirt is Non-Greasy) and (Dirtiness is Small) then (Washing-Time is Short) (1)
11. If (Cloth is Cotton) and (Dirt is Non-Greasy) and (Dirtiness is Medium) then (Washing-Time is Short) (1)
12. If (Cloth is Cotton) and (Dirt is Non-Greasy) and (Dirtiness is Large) then (Washing-Time is Medium) (1)
13. If (Cloth is Cotton) and (Dirt is Medium) and (Dirtiness is Small) then (Washing-Time is Medium) (1)
14. If (Cloth is Cotton) and (Dirt is Medium) and (Dirtiness is Medium) then (Washing-Time is Medium) (1)
15. If (Cloth is Cotton) and (Dirt is Medium) and (Dirtiness is Large) then (Washing-Time is Long) (1)
16. If (Cloth is Cotton) and (Dirt is Greasy) and (Dirtiness is Small) then (Washing-Time is Medium) (1)
17. If (Cloth is Cotton) and (Dirt is Greasy) and (Dirtiness is Medium) then (Washing-Time is Long) (1)
18. If (Cloth is Cotton) and (Dirt is Greasy) and (Dirtiness is Large) then (Washing-Time is Very-Long) (1)
19. If (Cloth is Woolen) and (Dirt is Non-Greasy) and (Dirtiness is Small) then (Washing-Time is Short) (1)
20. If (Cloth is Woolen) and (Dirt is Non-Greasy) and (Dirtiness is Medium) then (Washing-Time is Medium) (1)
21. If (Cloth is Woolen) and (Dirt is Non-Greasy) and (Dirtiness is Large) then (Washing-Time is Medium) (1)
22. If (Cloth is Woolen) and (Dirt is Medium) and (Dirtiness is Small) then (Washing-Time is Medium) (1)
23. If (Cloth is Woolen) and (Dirt is Medium) and (Dirtiness is Medium) then (Washing-Time is Medium) (1)
24. If (Cloth is Woolen) and (Dirt is Medium) and (Dirtiness is Large) then (Washing-Time is Long) (1)
25. If (Cloth is Woolen) and (Dirt is Greasy) and (Dirtiness is Small) then (Washing-Time is Medium) (1)
26. If (Cloth is Woolen) and (Dirt is Greasy) and (Dirtiness is Medium) then (Washing-Time is Long) (1)
27. If (Cloth is Woolen) and (Dirt is Greasy) and (Dirtiness is Large) then (Washing-Time is Very-Long) (1)

**Figure 6:** Rule Editor: Wash_achieved

## Results:

Change the values for testing purpose as shown below;

- First set value of cloth, dirt and dirtiness = 5, then our output washing-time = 32.

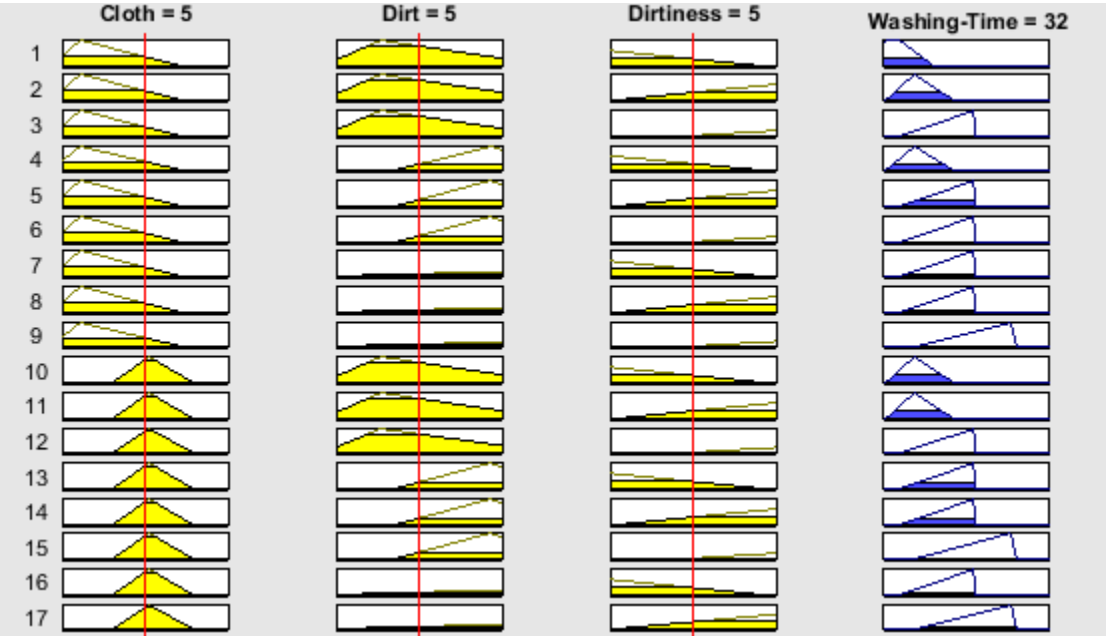



**Figure 7:** Rule Viewer: Wash_achieved

- First set value of cloth = 1.75 dirt = 1.75 and dirtiness = 3.06, then our output washing-time = 17.2.

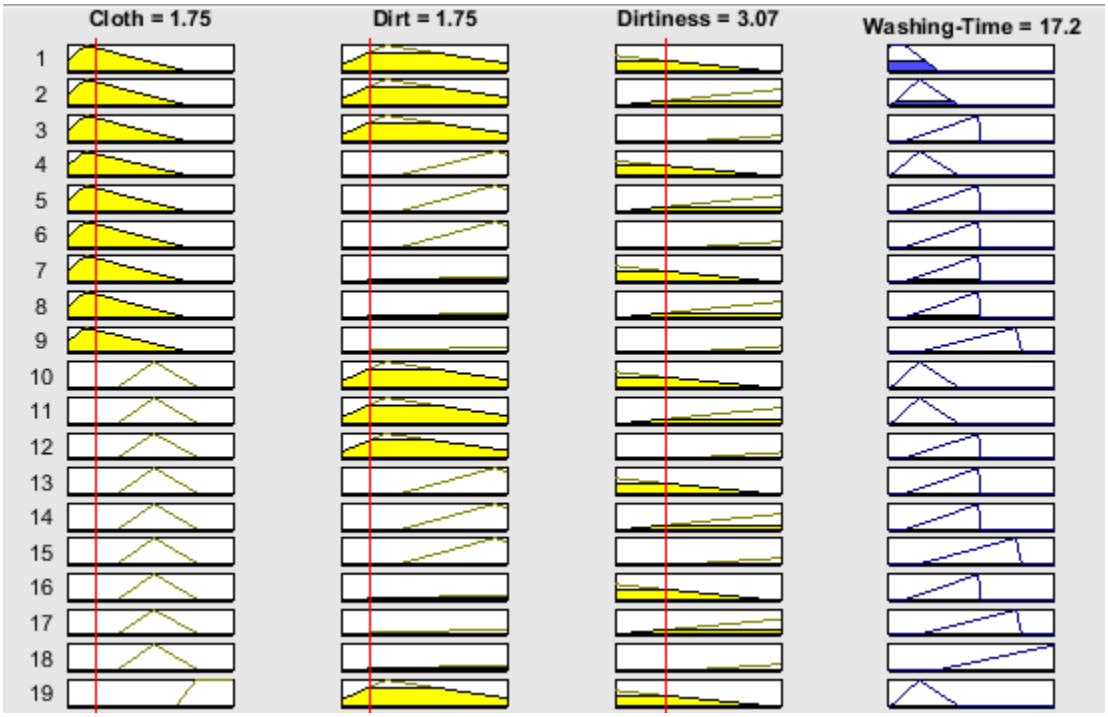



**Figure 8:** Rule Viewer: Wash_achieved

- Overall, Input (Clot, Dirt) and output (Washing-Time) relation.

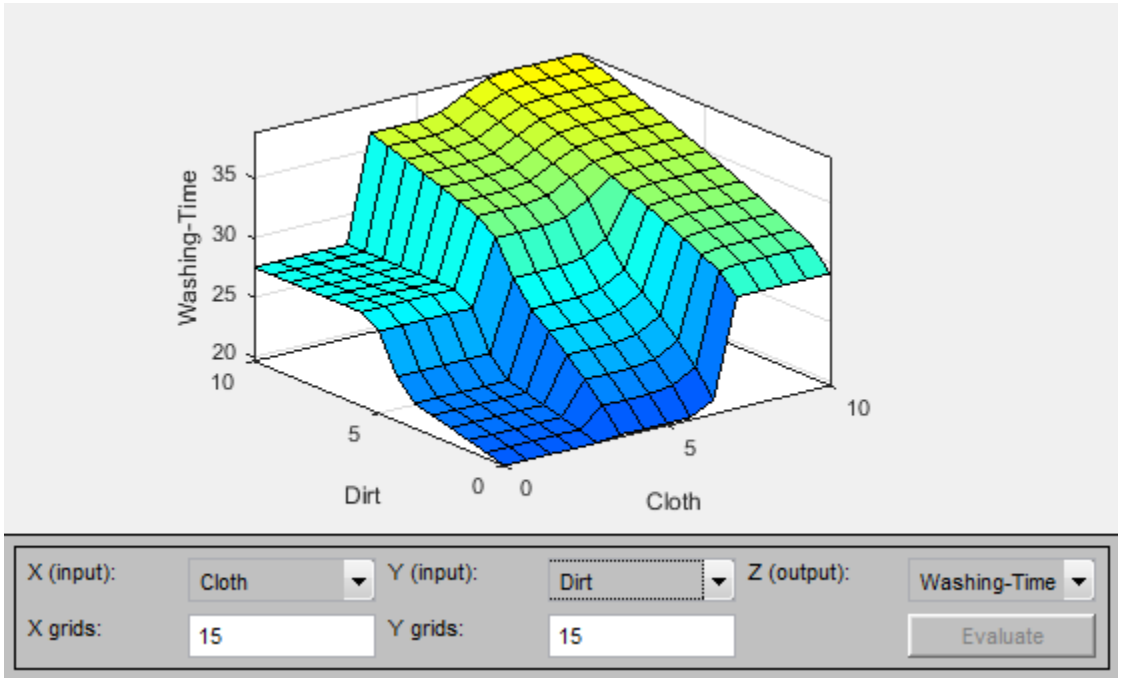



**Figure 9:** Surface Viewer: Wash_achieved

- Overall, Input (Food, Dirtiness) and output (Washing-Time) relation.

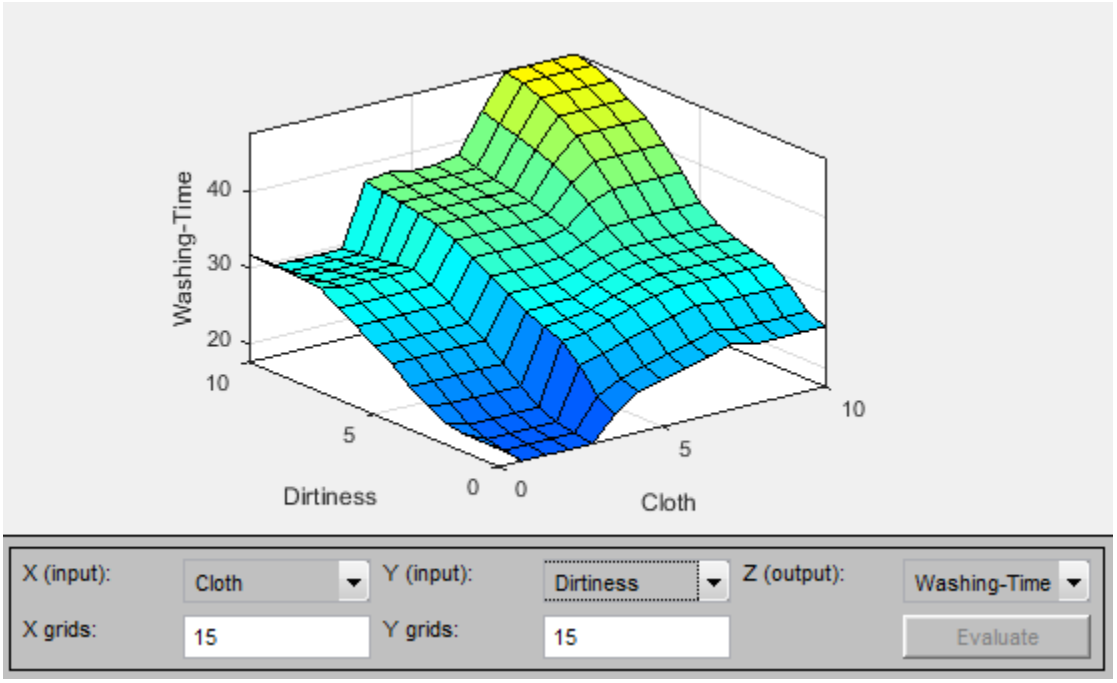



**Figure 10:** Surface Viewer: Wash_achieved

- Relationship of cloth with washing-time.

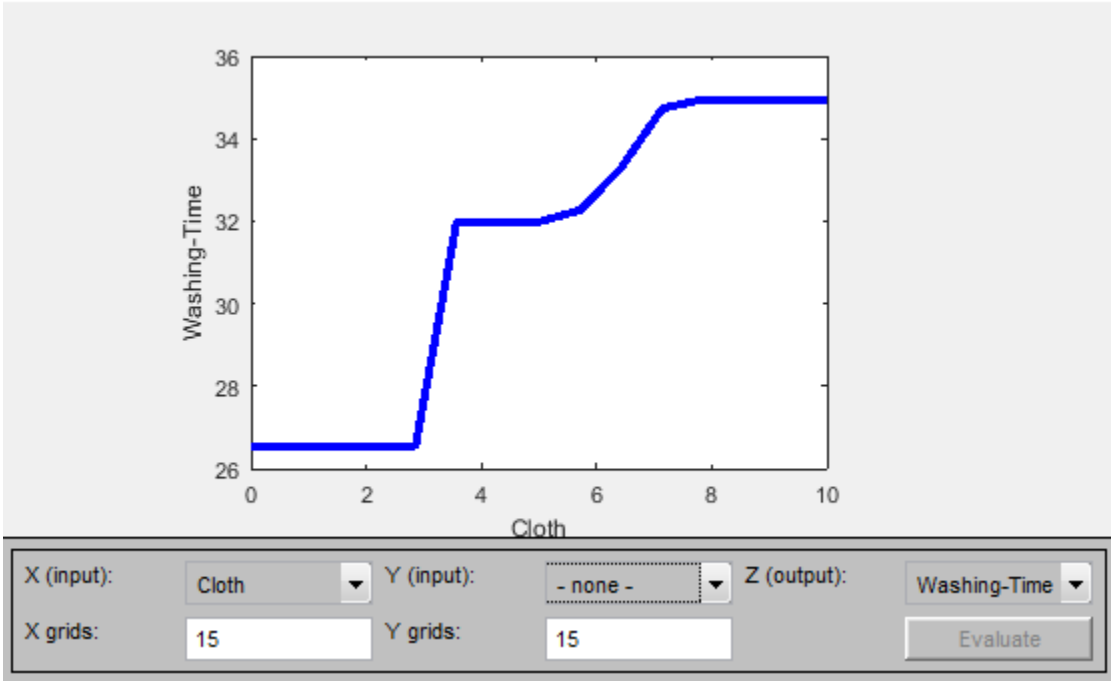



**Figure 11:** Surface Viewer: Wash_achieved

- Relationship of dirt with washing-time.

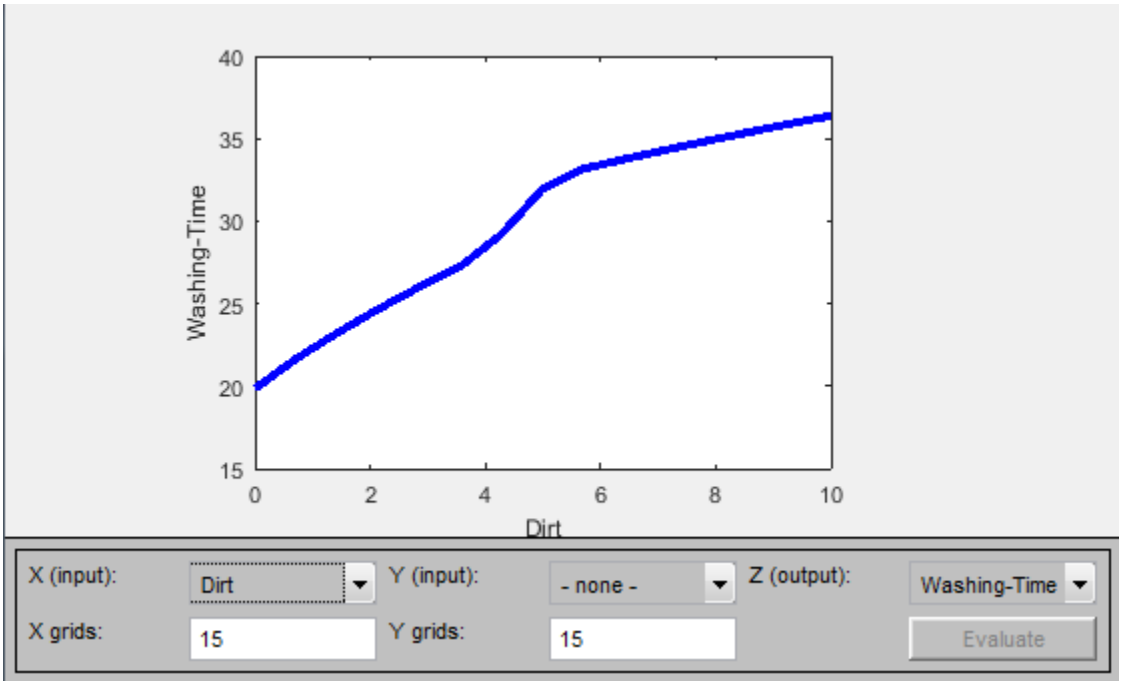



**Figure 12:** Surface Viewer: Wash_achieved

- Relationship of dirtiness with washing-time.

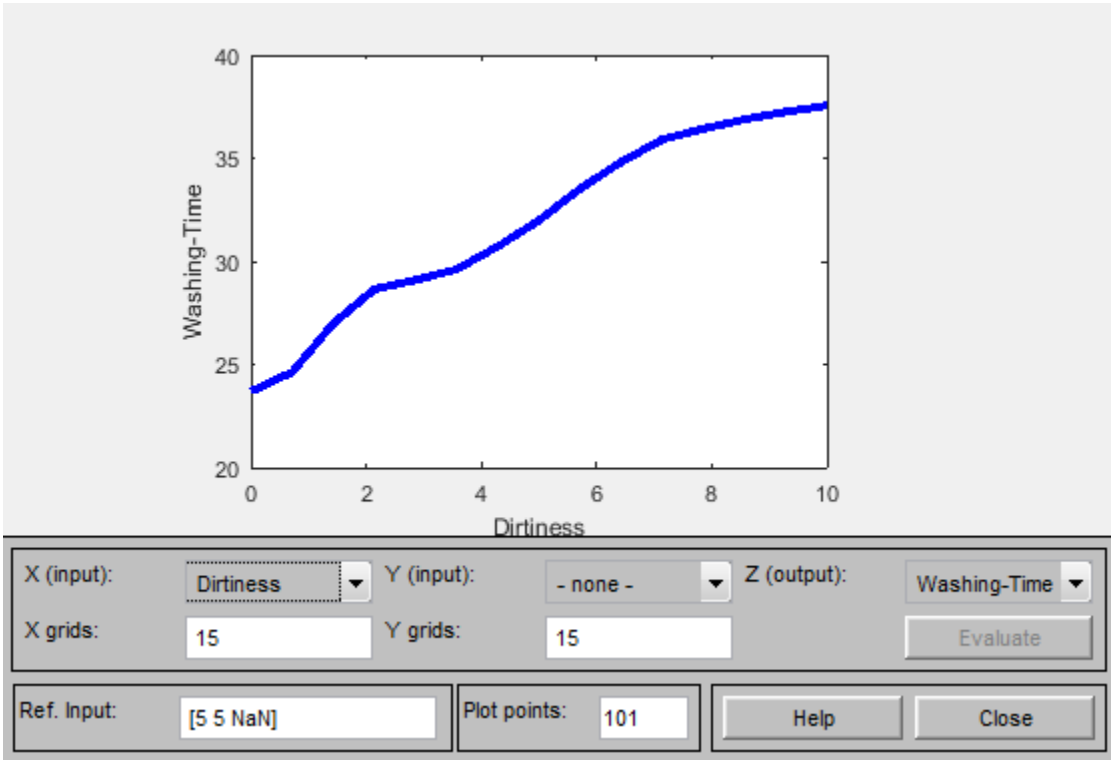



**Figure 13:** Surface Viewer: Wash_achieved

# Lab # 5

## Objectives:

Intelligent Air Conditioning System

## Introduction:

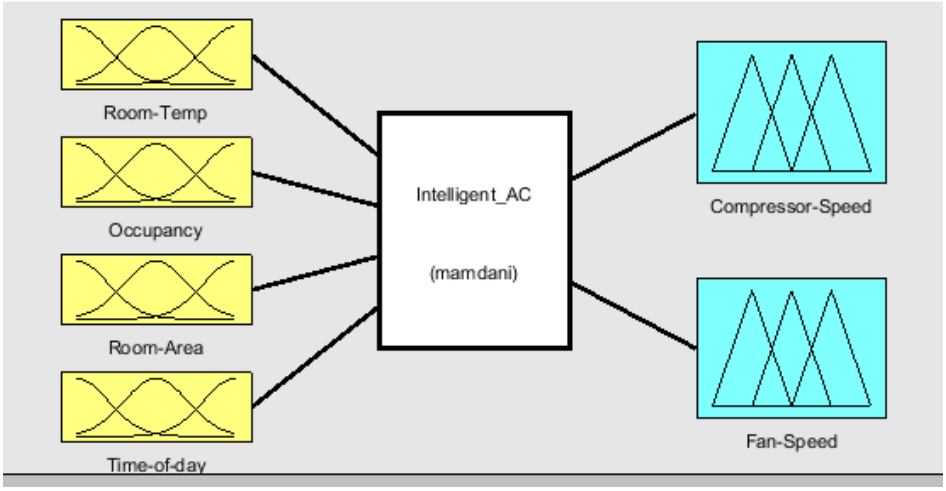
Air conditioners and air conditioning systems are integral part of almost every institution. They contribute significant part of total energy consumption. Studies suggest that in locations like auditoriums, indoor stadiums and conference halls, air conditioning can contribute as much as 75% of total energy intake. For example, a Survey in the Pantaloons mall, Bhuba-neswar, Odisha in summer season shows a daily average con-sumption of 2300 units of electricity by their 320 ton central air conditioning system. Even in homes and offices, power con-sumed by air conditioners is significant.

In this experiment, we have devised a scheme implementing Fuzzy Logic in the Air-Conditioning system. With the help of this logic the Air-Conditioner would assess the environmental factors like temperature, humidity, etc and thereby provides comfortable levels of cooling and optimized electricity consumption.

## Lab Activity

## Procedure:

- Typed fuzzy in command prompt.
  >>fuzzy
- Fuzzy logic designer: Untitled opened and exported file by "**Intelligent_AC**".
- Changed the name of input1 by **Room-Temperature,** input2 by **Occupancy**, input3 by **Room-Area**, input4 by **Time-of-day**, output1 by **Compressor-Speed** & output2 by **Fan-Speed**.
- Chose defuzzification **Centriod.**



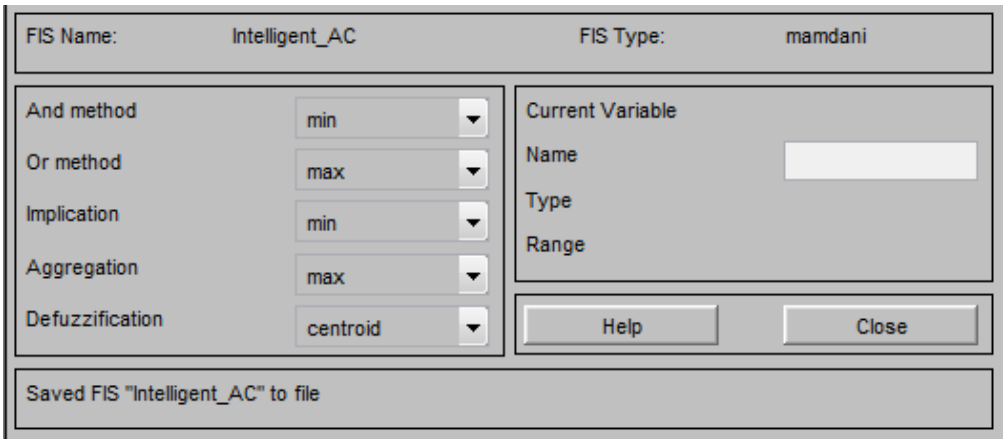



**Figure 1:** Fuzzy logic designer

- Double clicked on the Room-Temperature and added 3 member functions (MFs) as shown in figure 2; also, changed the range of Input from [0 1] to [0 51].

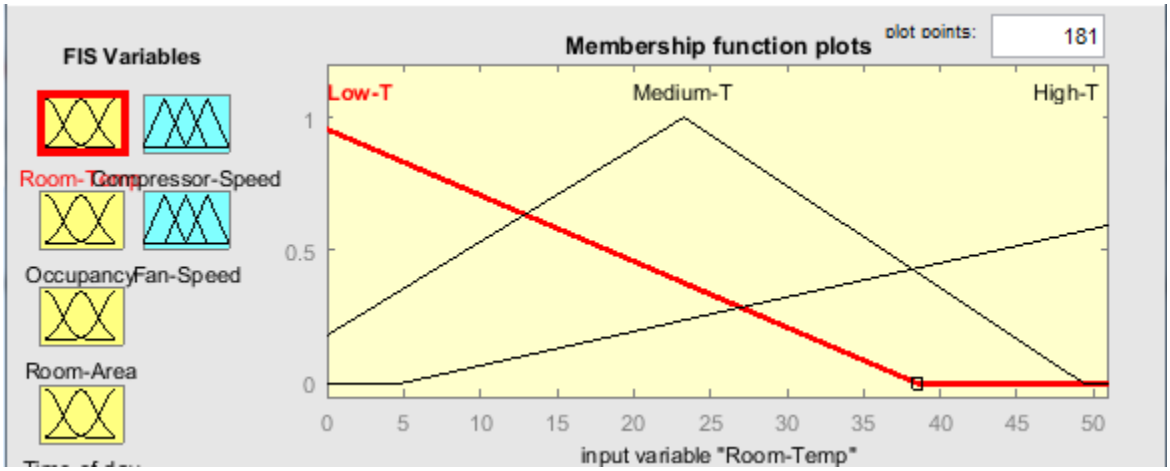



**Figure 2:** Room-Temperature's MFs

- Then added the MFs of Occupancy and changed its range [0 1] to [0 9].

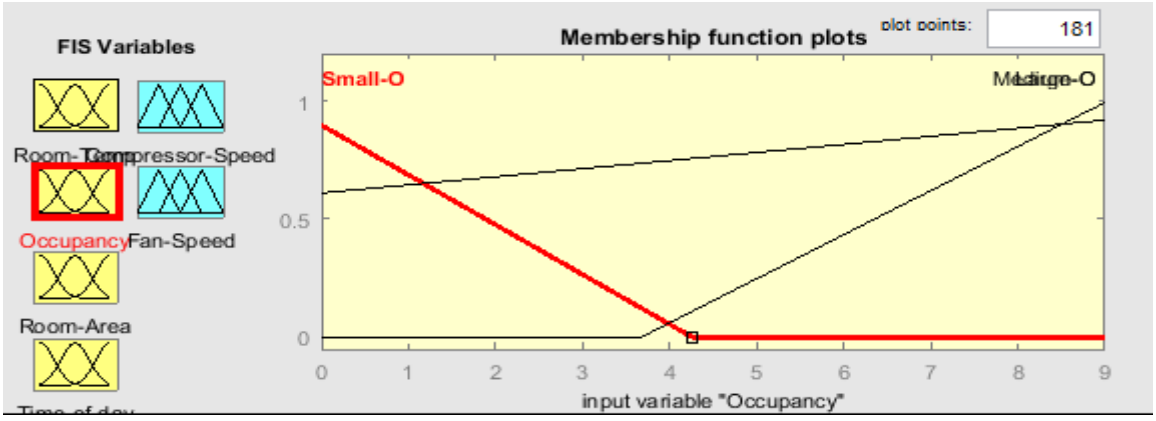



**Figure 3:** Occupancy's MFs

- Then added the MFs of Room-Aera and changed its range [0 1] to [0 10].

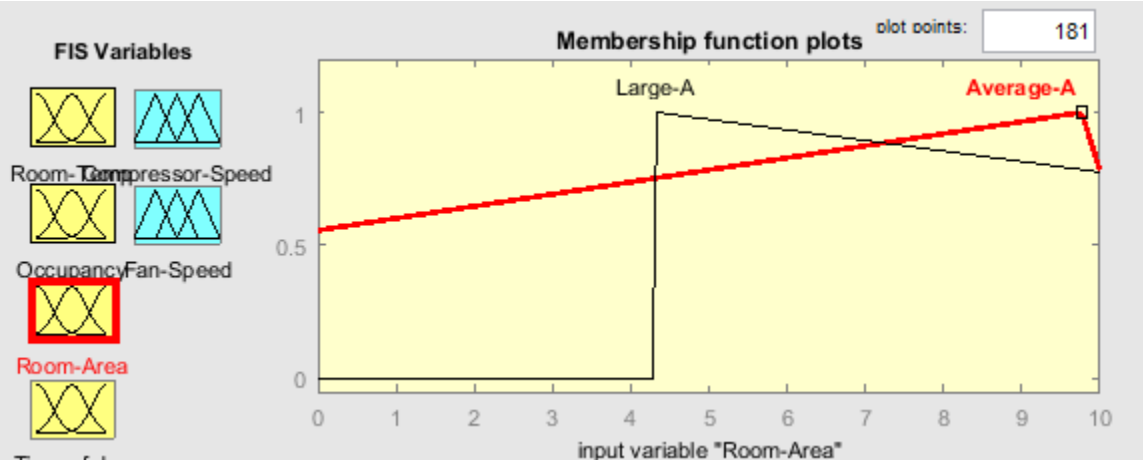



**Figure 4:** Room-Area's MFs

- Then added the MFs of Time-of-day and changed its range [0 1] to [0 24].

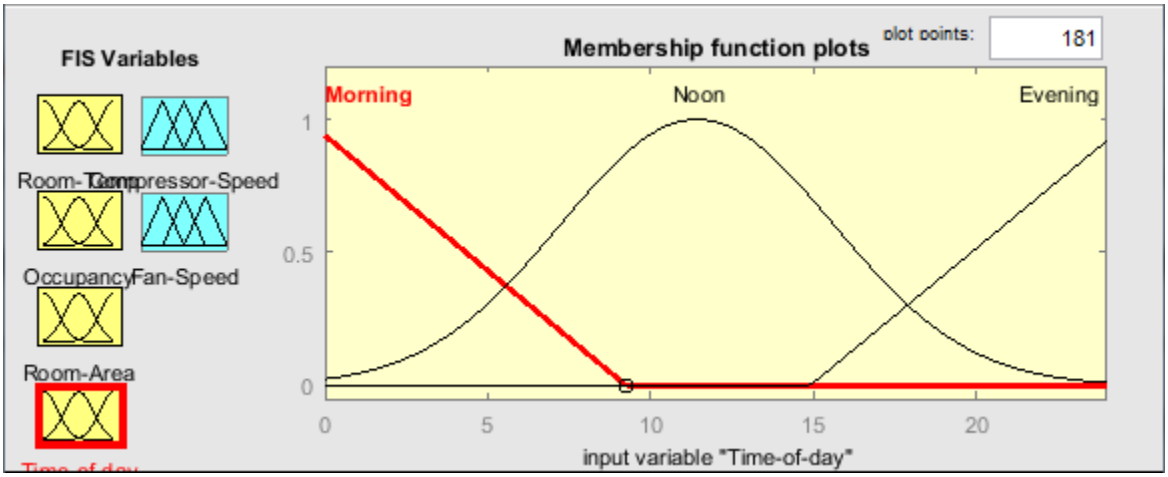



**Figure 5:** Time-of-day's MFs

- Then added the 5 MFs of Compressor-Speed and changed its range [0 1] to [0 150].

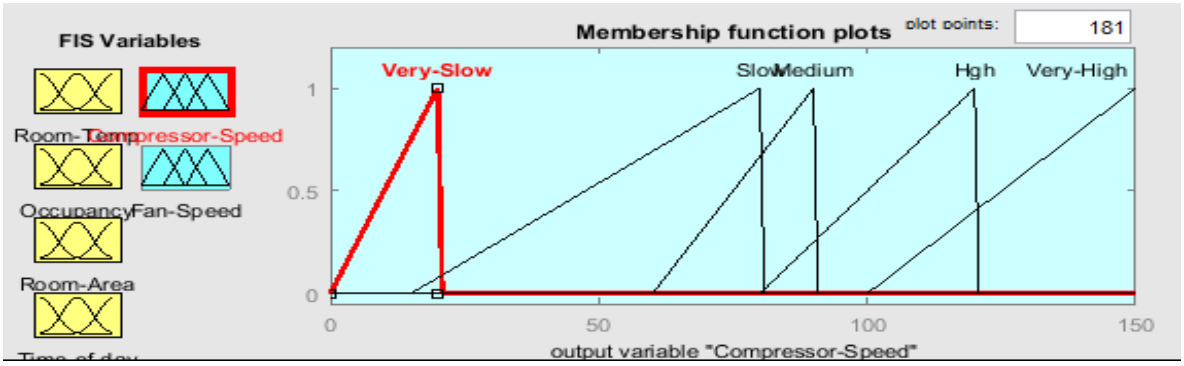



**Figure 6:** Compressor-Speed MFs

- Then added the 5 MFs of Fan-Speed and changed its range [0 1] to [0 150].

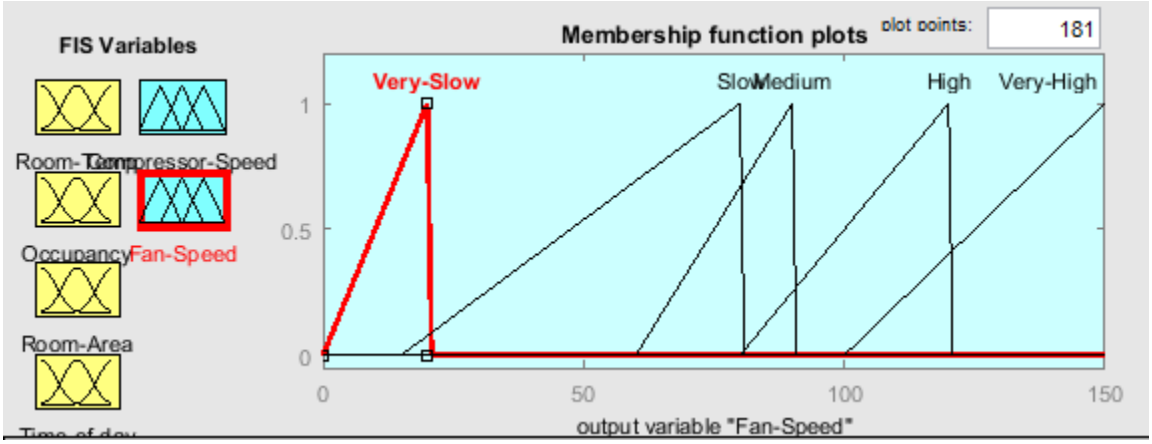



**Figure 7:** Fan-Speed's MFs

## Rules:

1. If (Room-Temp is Low-T) and (Occupancy is Small-O) and (Room-Area is Average-A) and (Time-of-day is Morning) then (Compressor-Speed is Very-Slow)(Fan-Speed is Very-Slow) (1)
2. If (Room-Temp is Low-T) and (Occupancy is Small-O) and (Room-Area is Average-A) and (Time-of-day is Noon) then (Compressor-Speed is Slow)(Fan-Speed is Slow) (1)
3. If (Room-Temp is Low-T) and (Occupancy is Small-O) and (Room-Area is Average-A) and (Time-of-day is Evening) then (Compressor-Speed is Very-Slow)(Fan-Speed is Very-Slow) (1)
4. If (Room-Temp is Low-T) and (Occupancy is Small-O) and (Room-Area is Large-A) and (Time-of-day is Morning) then (Compressor-Speed is Very-Slow)(Fan-Speed is Very-Slow) (1)
5. If (Room-Temp is Low-T) and (Occupancy is Small-O) and (Room-Area is Large-A) and (Time-of-day is Noon) then (Compressor-Speed is Slow)(Fan-Speed is Slow) (1)
6. If (Room-Temp is Low-T) and (Occupancy is Small-O) and (Room-Area is Large-A) and (Time-of-day is Evening) then (Compressor-Speed is Very-Slow)(Fan-Speed is Very-Slow) (1)
7. If (Room-Temp is Low-T) and (Occupancy is Medium-O) and (Room-Area is Average-A) and (Time-of-day is Morning) then (Compressor-Speed is Very-Slow)(Fan-Speed is Very-Slow) (1)
8. If (Room-Temp is Low-T) and (Occupancy is Medium-O) and (Room-Area is Average-A) and (Time-of-day is Noon) then (Compressor-Speed is Slow)(Fan-Speed is Slow) (1)
9. If (Room-Temp is Low-T) and (Occupancy is Medium-O) and (Room-Area is Average-A) and (Time-of-day is Evening) then (Compressor-Speed is Very-Slow)(Fan-Speed is Very-Slow) (1)
10. If (Room-Temp is Low-T) and (Occupancy is Large-O) and (Room-Area is Average-A) and (Time-of-day is Morning) then (Compressor-Speed is Slow)(Fan-Speed is Slow) (1)
11. If (Room-Temp is Low-T) and (Occupancy is Large-O) and (Room-Area is Average-A) and (Time-of-day is Noon) then (Compressor-Speed is Slow)(Fan-Speed is Slow) (1)
12. If (Room-Temp is Low-T) and (Occupancy is Large-O) and (Room-Area is Average-A) and (Time-of-day is Evening) then (Compressor-Speed is Slow)(Fan-Speed is Slow) (1)
13. If (Room-Temp is Low-T) and (Occupancy is Large-O) and (Room-Area is Large-A) and (Time-of-day is Morning) then (Compressor-Speed is Slow)(Fan-Speed is Slow) (1)
14. If (Room-Temp is Low-T) and (Occupancy is Large-O) and (Room-Area is Large-A) and (Time-of-day is Noon) then (Compressor-Speed is Medium)(Fan-Speed is Medium) (1)
15. If (Room-Temp is Low-T) and (Occupancy is Large-O) and (Room-Area is Large-A) and (Time-of-day is Evening) then (Compressor-Speed is Slow)(Fan-Speed is Slow) (1)
16. If (Room-Temp is Low-T) and (Occupancy is Medium-O) and (Room-Area is Large-A) and (Time-of-day is Morning) then (Compressor-Speed is Slow)(Fan-Speed is Slow) (1)
17. If (Room-Temp is Low-T) and (Occupancy is Medium-O) and (Room-Area is Large-A) and (Time-of-day is Noon) then (Compressor-Speed is Medium)(Fan-Speed is Medium) (1)
18. If (Room-Temp is Low-T) and (Occupancy is Medium-O) and (Room-Area is Large-A) and (Time-of-day is Evening) then (Compressor-Speed is Slow)(Fan-Speed is Slow) (1)
19. If (Room-Temp is Medium-T) and (Occupancy is Small-O) and (Room-Area is Average-A) and (Time-of-day is Morning) then (Compressor-Speed is Slow)(Fan-Speed is Slow) (1)
20. If (Room-Temp is Medium-T) and (Occupancy is Small-O) and (Room-Area is Average-A) and (Time-of-day is Noon) then (Compressor-Speed is Medium)(Fan-Speed is Medium) (1)
21. If (Room-Temp is Medium-T) and (Occupancy is Small-O) and (Room-Area is Average-A) and (Time-of-day is Evening) then (Compressor-Speed is Slow)(Fan-Speed is Slow) (1)
22. If (Room-Temp is Medium-T) and (Occupancy is Small-O) and (Room-Area is Large-A) and (Time-of-day is Morning) then (Compressor-Speed is Slow)(Fan-Speed is Slow) (1)
23. If (Room-Temp is Medium-T) and (Occupancy is Small-O) and (Room-Area is Large-A) and (Time-of-day is Noon) then (Compressor-Speed is Medium)(Fan-Speed is Medium) (1)
24. If (Room-Temp is Medium-T) and (Occupancy is Small-O) and (Room-Area is Large-A) and (Time-of-day is Evening) then (Compressor-Speed is Slow)(Fan-Speed is Slow) (1)
25. If (Room-Temp is Medium-T) and (Occupancy is Medium-O) and (Room-Area is Average-A) and (Time-of-day is Morning) then (Compressor-Speed is Slow)(Fan-Speed is Slow) (1)
26. If (Room-Temp is Medium-T) and (Occupancy is Medium-O) and (Room-Area is Average-A) and (Time-of-day is Noon) then (Compressor-Speed is Medium)(Fan-Speed is Medium) (1)
27. If (Room-Temp is Medium-T) and (Occupancy is Medium-O) and (Room-Area is Average-A) and (Time-of-day is Evening) then (Compressor-Speed is Slow)(Fan-Speed is Slow) (1)
28. If (Room-Temp is Medium-T) and (Occupancy is Medium-O) and (Room-Area is Large-A) and (Time-of-day is Morning) then (Compressor-Speed is Medium)(Fan-Speed is Medium) (1)
29. If (Room-Temp is Medium-T) and (Occupancy is Medium-O) and (Room-Area is Large-A) and (Time-of-day is Noon) then (Compressor-Speed is Hgh)(Fan-Speed is High) (1)
30. If (Room-Temp is Medium-T) and (Occupancy is Medium-O) and (Room-Area is Large-A) and (Time-of-day is Evening) then (Compressor-Speed is Medium)(Fan-Speed is Medium) (1)
31. If (Room-Temp is Medium-T) and (Occupancy is Large-O) and (Room-Area is Average-A) and (Time-of-day is Morning) then (Compressor-Speed is Medium)(Fan-Speed is Medium) (1)
32. If (Room-Temp is Medium-T) and (Occupancy is Large-O) and (Room-Area is Average-A) and (Time-of-day is Noon) then (Compressor-Speed is Hgh)(Fan-Speed is High) (1)
33. If (Room-Temp is Medium-T) and (Occupancy is Large-O) and (Room-Area is Average-A) and (Time-of-day is Evening) then (Compressor-Speed is Medium)(Fan-Speed is Medium) (1)
34. If (Room-Temp is Medium-T) and (Occupancy is Large-O) and (Room-Area is Large-A) and (Time-of-day is Morning) then (Compressor-Speed is Medium)(Fan-Speed is Medium) (1)
35. If (Room-Temp is Medium-T) and (Occupancy is Large-O) and (Room-Area is Large-A) and (Time-of-day is Noon) then (Compressor-Speed is Hgh)(Fan-Speed is High) (1)
36. If (Room-Temp is Medium-T) and (Occupancy is Large-O) and (Room-Area is Large-A) and (Time-of-day is Evening) then (Compressor-Speed is Medium)(Fan-Speed is Medium) (1)
37. If (Room-Temp is High-T) and (Occupancy is Small-O) and (Room-Area is Average-A) and (Time-of-day is Morning) then (Compressor-Speed is Medium)(Fan-Speed is Medium) (1)
38. If (Room-Temp is High-T) and (Occupancy is Small-O) and (Room-Area is Average-A) and (Time-of-day is Noon) then (Compressor-Speed is Hgh)(Fan-Speed is High) (1)
39. If (Room-Temp is High-T) and (Occupancy is Small-O) and (Room-Area is Average-A) and (Time-of-day is Evening) then (Compressor-Speed is Medium)(Fan-Speed is Medium) (1)
40. If (Room-Temp is High-T) and (Occupancy is Small-O) and (Room-Area is Large-A) and (Time-of-day is Morning) then (Compressor-Speed is Hgh)(Fan-Speed is High) (1)
41. If (Room-Temp is High-T) and (Occupancy is Small-O) and (Room-Area is Large-A) and (Time-of-day is Noon) then (Compressor-Speed is Very-High)(Fan-Speed is Very-High) (1)
42. If (Room-Temp is High-T) and (Occupancy is Small-O) and (Room-Area is Large-A) and (Time-of-day is Evening) then (Compressor-Speed is Hgh)(Fan-Speed is High) (1)
43. If (Room-Temp is High-T) and (Occupancy is Medium-O) and (Room-Area is Average-A) and (Time-of-day is Morning) then (Compressor-Speed is Hgh)(Fan-Speed is High) (1)
44. If (Room-Temp is High-T) and (Occupancy is Medium-O) and (Room-Area is Average-A) and (Time-of-day is Noon) then (Compressor-Speed is Very-High)(Fan-Speed is Very-High) (1)
45. If (Room-Temp is High-T) and (Occupancy is Medium-O) and (Room-Area is Average-A) and (Time-of-day is Evening) then (Compressor-Speed is Hgh)(Fan-Speed is High) (1)
46. If (Room-Temp is High-T) and (Occupancy is Medium-O) and (Room-Area is Large-A) and (Time-of-day is Morning) then (Compressor-Speed is Hgh)(Fan-Speed is High) (1)
47. If (Room-Temp is High-T) and (Occupancy is Medium-O) and (Room-Area is Large-A) and (Time-of-day is Noon) then (Compressor-Speed is Very-High)(Fan-Speed is Very-High) (1)
48. If (Room-Temp is High-T) and (Occupancy is Medium-O) and (Room-Area is Large-A) and (Time-of-day is Evening) then (Compressor-Speed is Hgh)(Fan-Speed is High) (1)
49. If (Room-Temp is High-T) and (Occupancy is Large-O) and (Room-Area is Average-A) and (Time-of-day is Morning) then (Compressor-Speed is Hgh)(Fan-Speed is High) (1)
50. If (Room-Temp is High-T) and (Occupancy is Large-O) and (Room-Area is Average-A) and (Time-of-day is Noon) then (Compressor-Speed is Very-High)(Fan-Speed is Very-High) (1)
51. If (Room-Temp is High-T) and (Occupancy is Large-O) and (Room-Area is Average-A) and (Time-of-day is Evening) then (Compressor-Speed is Hgh)(Fan-Speed is High) (1)
52. If (Room-Temp is High-T) and (Occupancy is Large-O) and (Room-Area is Large-A) and (Time-of-day is Morning) then (Compressor-Speed is Hgh)(Fan-Speed is High) (1)

53. If (Room-Temp is High-T) and (Occupancy is Large-O) and (Room-Area is Large-A) and (Time-of-day is Noon) then (Compressor-Speed is Very-High)(Fan-Speed is Very-High) (1)
54. If (Room-Temp is High-T) and (Occupancy is Large-O) and (Room-Area is Large-A) and (Time-of-day is Evening) then (Compressor-Speed is Hgh)(Fan-Speed is High) (1)

**Figure 8:** Rule Editor: Intelligent_AC

## Results:

Change the values for testing purpose as shown below;

- First set value of Room-Temp = 25.5, Occupancy = 4.5, Room-Area = 5, Time-of-day = 12 then our output Compressor-Speed & Fan-Speed = 89.4.

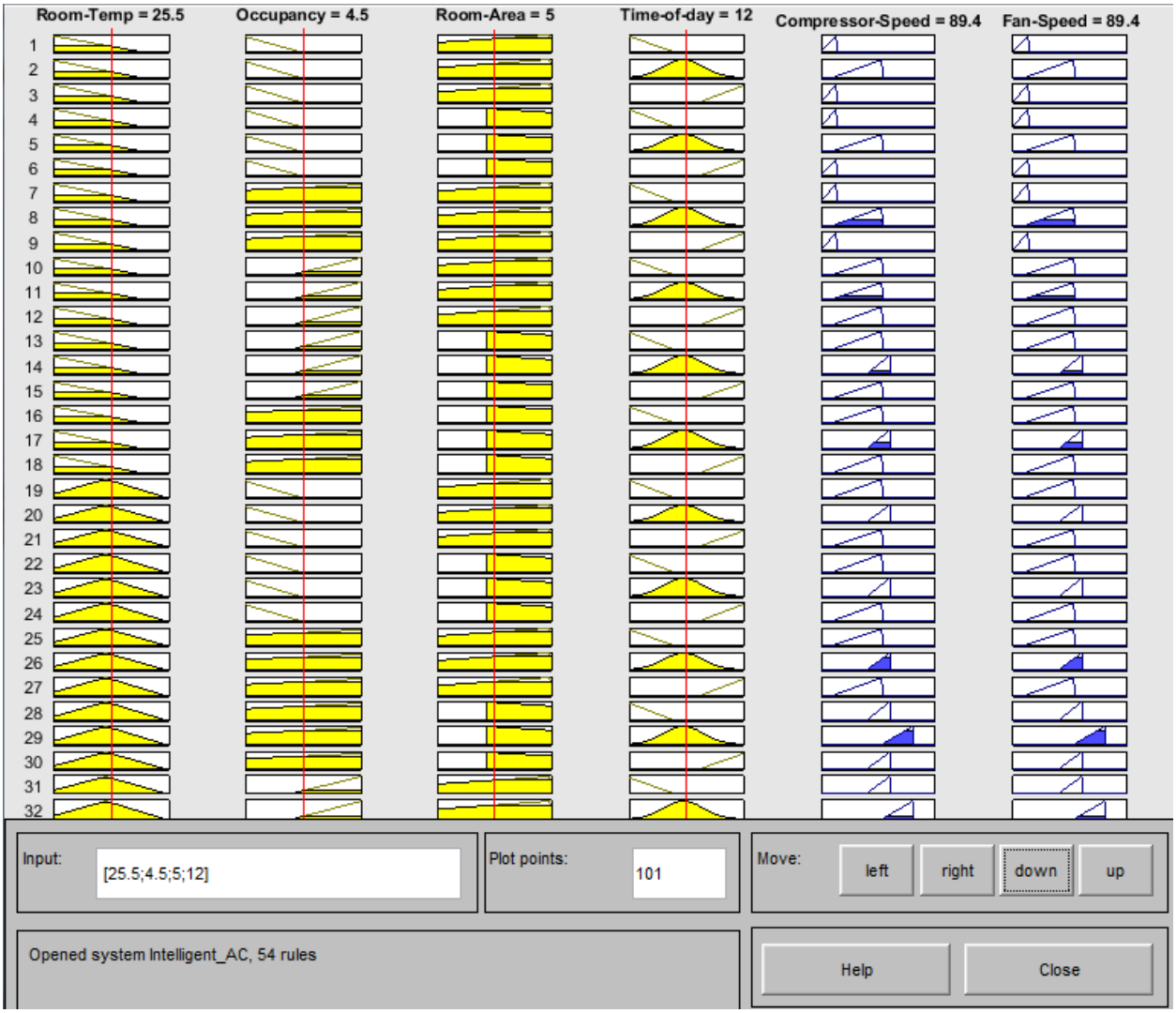



**Figure 9:** Rule Viewer: Intelligent_AC

- First set value of Room-Temp = 39.1, Occupancy = 7.01, Room-Area = 6.69, Time-of-day = 11.1 then our output Compressor-Speed & Fan-Speed = 110.

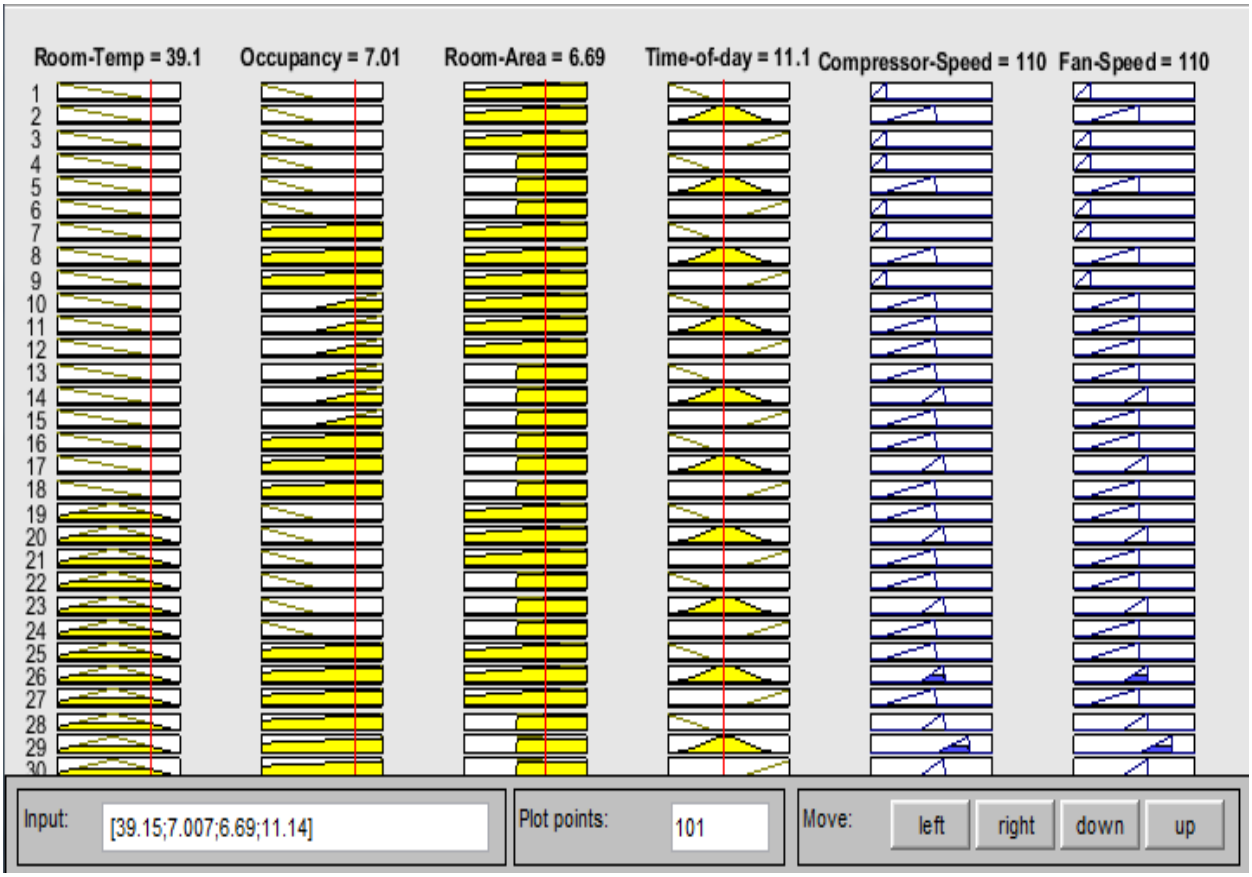



**Figure 10:** Rule Viewer: Intelligent_AC

- Overall, Input (Time-of-day, Occupancy) and output (Compressor-Speed & Fan-Speed) relation.

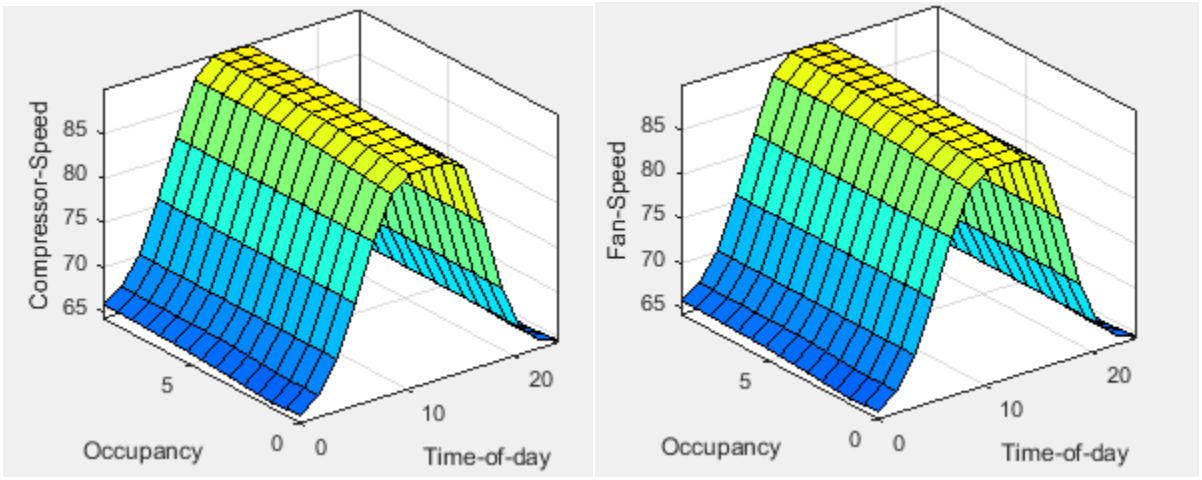



**Figure 11:** Surface Viewer: Intelligent_AC

- Overall, Input (Time-of-day, Room_area) and output (Compressor-Speed & Fan-Speed) relation.

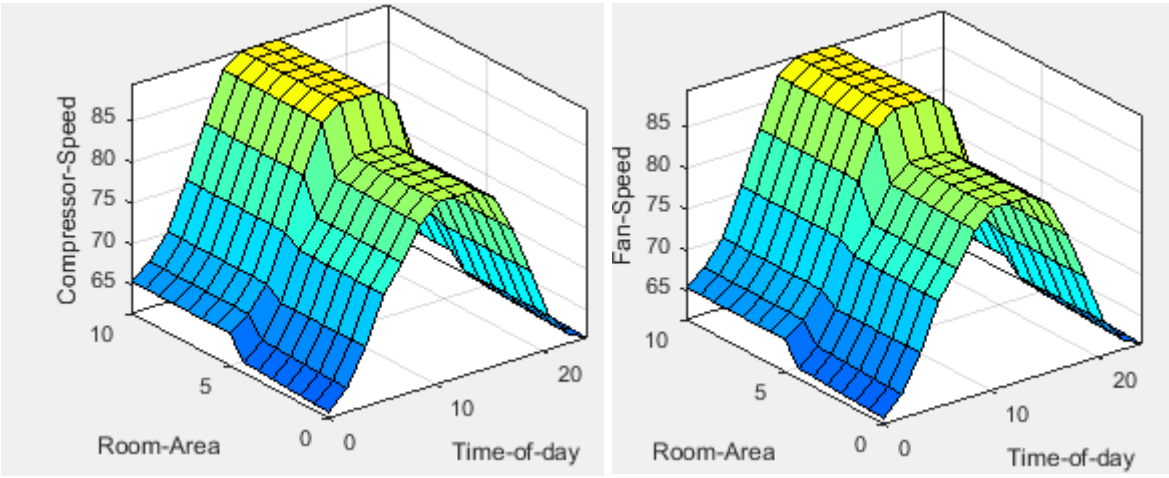



**Figure 12:** Surface Viewer: Intelligent_AC

- Overall, Input (Time-of-day, Time-of-day) and output (Compressor-Speed & Fan-Speed) relation.

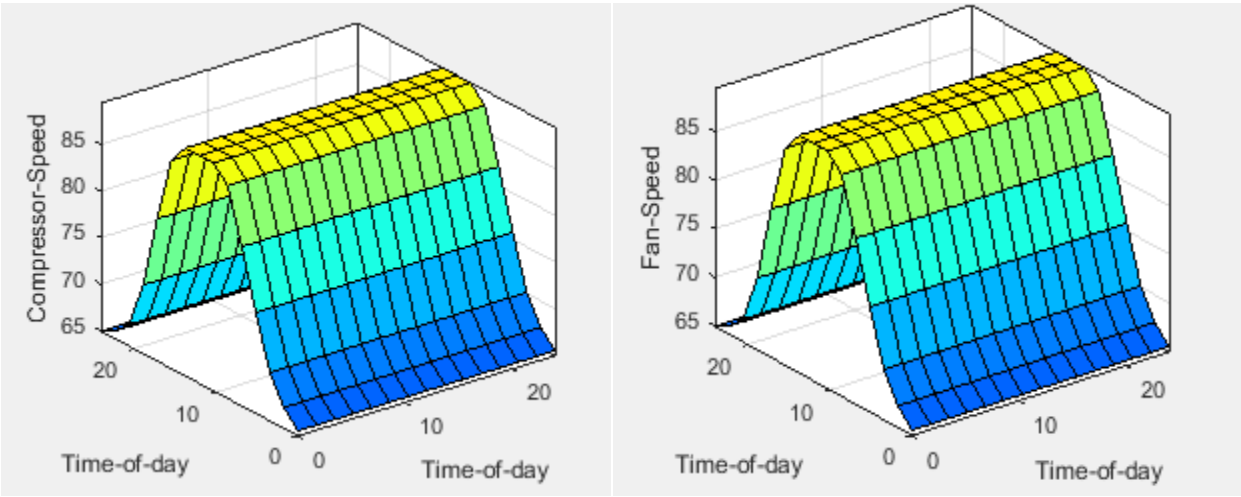



**Figure 13:** Surface Viewer: Intelligent_AC

- Relationship of Room-Temp with Compressor-Speed & Fan-Speed.

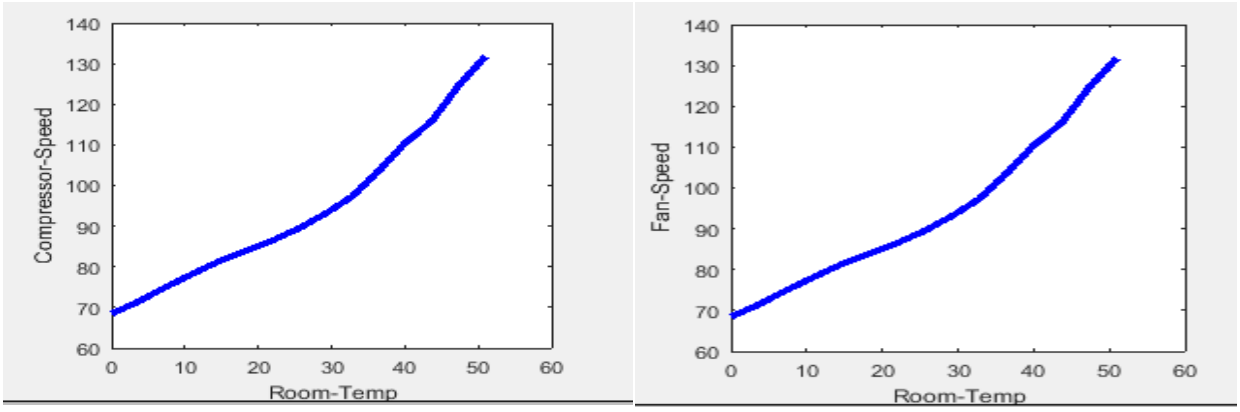



**Figure 14:** Surface Viewer: Intelligent_AC

- Relationship of Occupancy with Compressor-Speed & Fan-Speed.

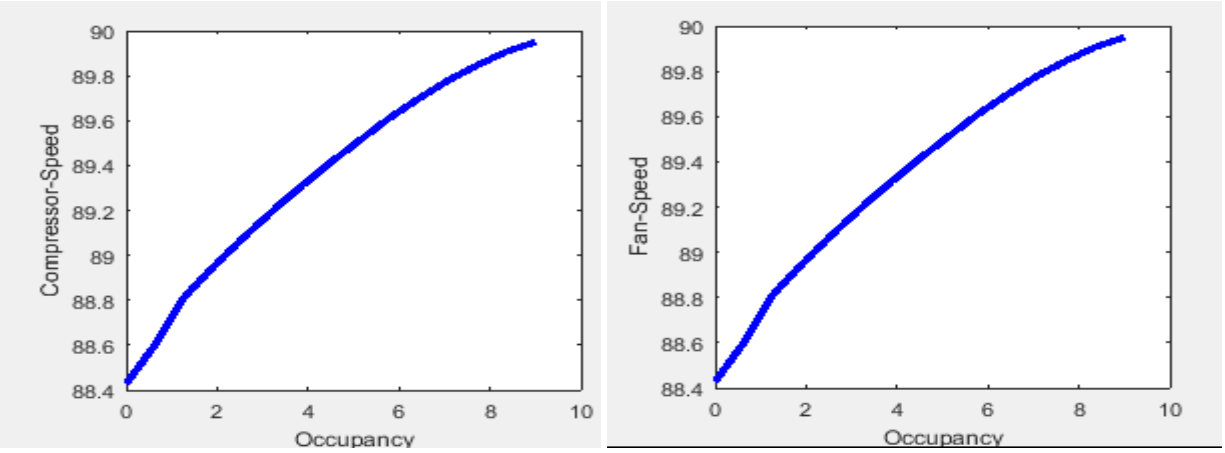



**Figure 15:** Surface Viewer: Intelligent_AC

- Relationship of Room-Area with Compressor-Speed & Fan-Speed.

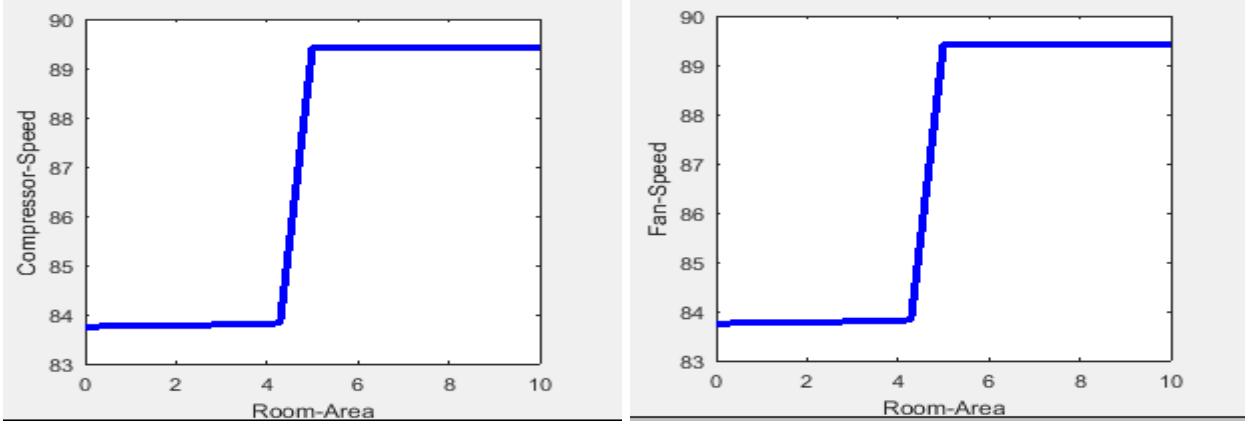



**Figure 16:** Surface Viewer: Intelligent_AC

- Relationship of Room-Area with Compressor-Speed & Fan-Speed.

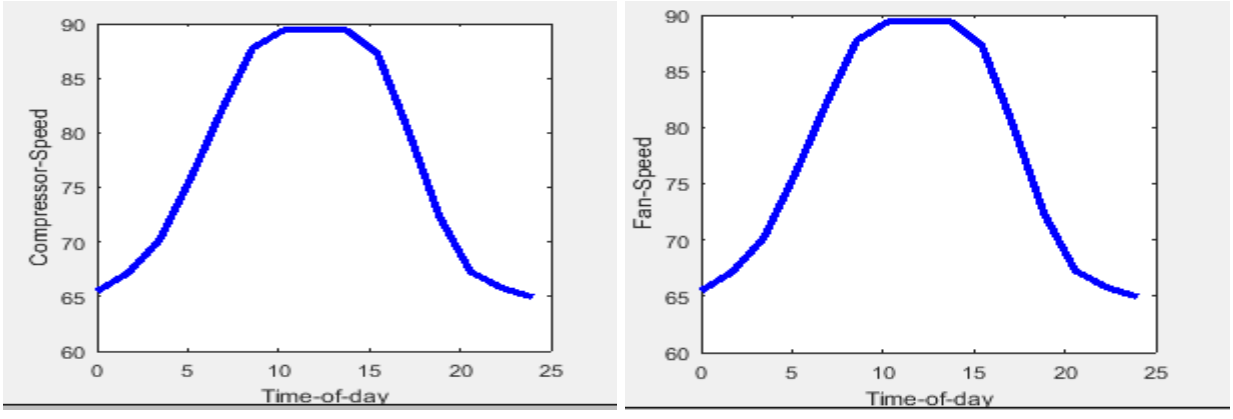



**Figure 17:** Surface Viewer: Intelligent_AC

# Lab # 6

## Objectives:

Fuzzy Rule Based Diagnostic System For Detecting The Lung Cancer Disease.

## Introduction:

Lung cancer, also known as carcinoma of the lung or pulmonary carcinoma, is a malignant lung tumor characterized by uncontrolled cell growth in tissues of the lung. In this report, we present a novel fuzzy system to detect the stage of lung cancer considering important and common symptoms of the disease and duration time the symptoms started. Systems designed to address the issue of detecting lung cancer had a poor quality design due to considering many irrelevant symptoms, Or by concentrating on the use of better algorithms than using more trustworthy and more accurate data set. Our proposed fuzzy system is able to detect the lung cancer in patients with more precision than all previous systems which attended to address the issue. In our fuzzy system, staging the lung cancer disease, has been conducted according to the specific symptoms associated with the specific stage of cancer, for detecting the stage with more precision.
Nowadays, fuzzy systems are being extensively used in different types of medical systems. In a Fuzzy rule based mamadani-type inference system designed which simulates the opinion of specialists with the high accuracy of 96 percent in assessment of breast cancer risk in person. In a fuzzy system using visual studio and using weighted average has been designed, but also is considered too much symptoms which most of them are related very much to pneumonia and bronchitis (e.g. fever) which is going to make the performance suffer. In designed fuzzy system can list the lung related diseases based on the probability of being exposed, acsendingly. In fuzzy system uses the same designed algorithm in, and output, which is based on the advances if the disease comprised 6 stages, from not being a cancer to life critical stage. Although a variety of lung cancer detection systems have been proposed in the literature, no single approach can be considered superior or a guarantee for satisfactory results in terms of classification accuracy or efficiency.

## Lab Activity

## Procedure:

- Typed fuzzy in command prompt.
  >>fuzzy
- Fuzzy logic designer: Untitled opened and exported file by "**Lungs_Cancer**".
- Changed the name of input1 by **Age,** input2 by **Smoker**, input3 by **Coughing**, input4 by **Bone-pain**, input5 by **Weight-loss**, & output1 **Your-Lung-Cancer.**
- Chose defuzzification **Centriod.**

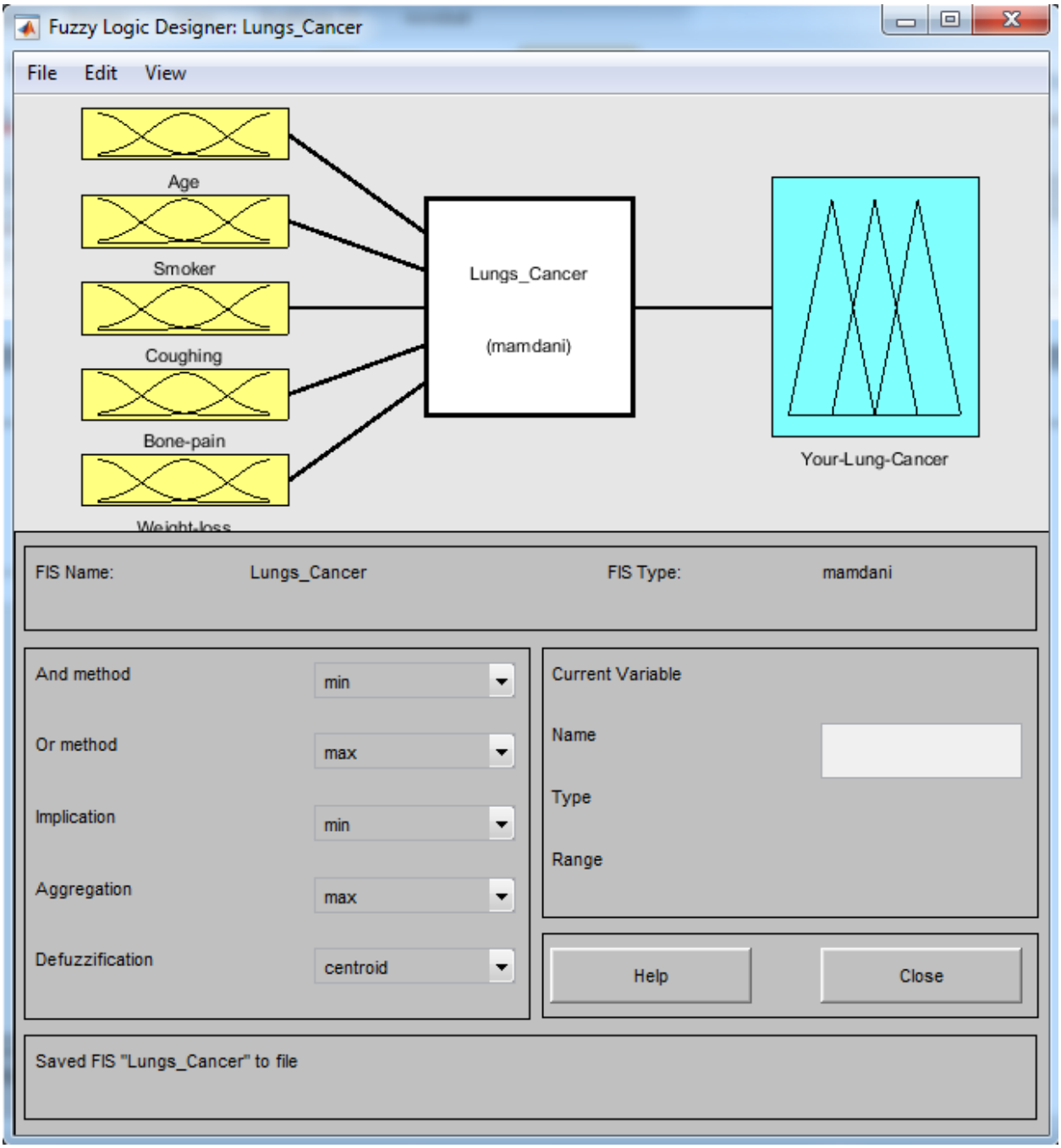



**Figure 1:** Fuzzy logic designer

- Double clicked on the Age and added 2 member functions (MFs) as shown in figure 2; also, changed the range of Input from [0 1] to [0 80].

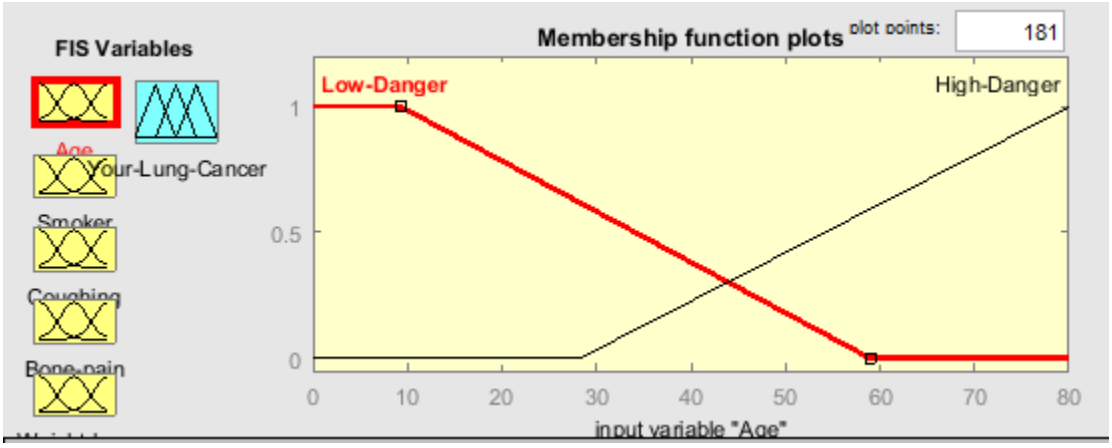



**Figure 2:** Age's MFs

- Then added the MFs of Smoker and changed its range [0 1] to [0 10].

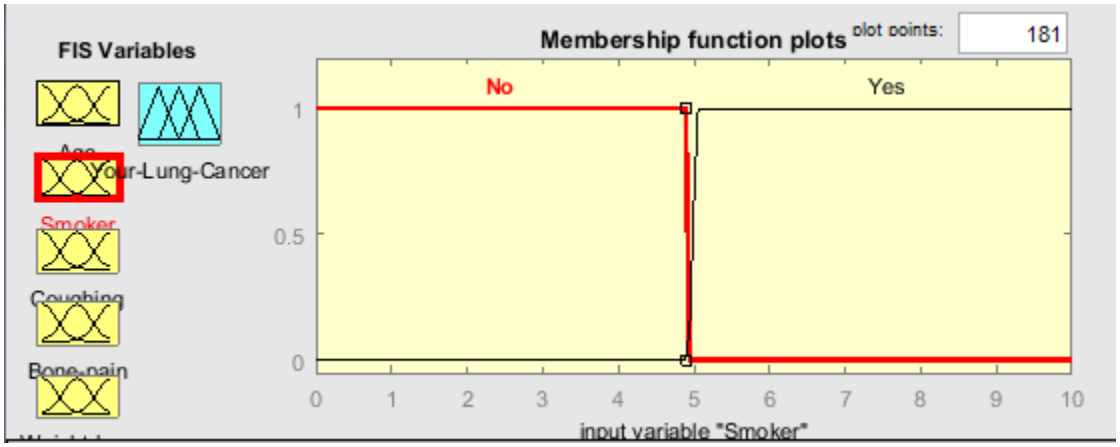



**Figure 3:** Smoker's MFs

- Then added the MFs of Coughing and changed its range [0 1] to [0 40].

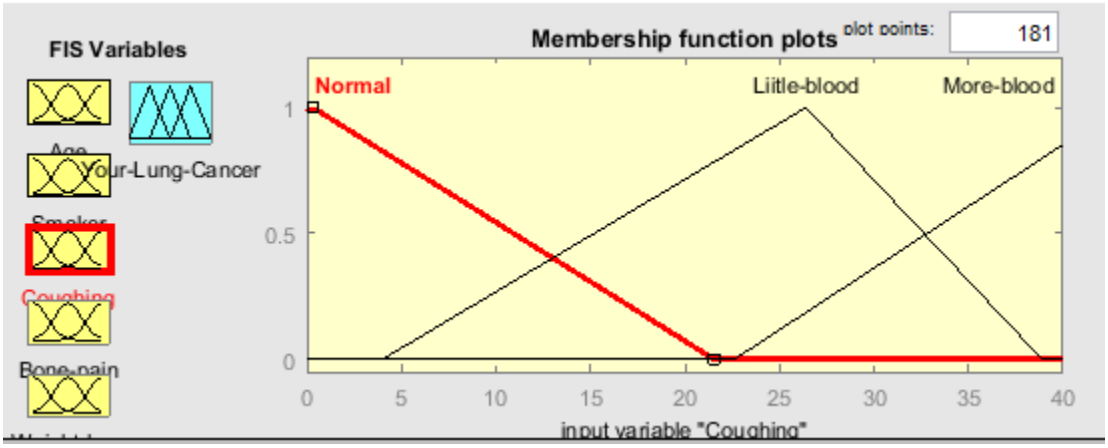



**Figure 4:** Coughing's MFs

- Then added the MFs of Bone-pain and changed its range [0 1] to [0 30].

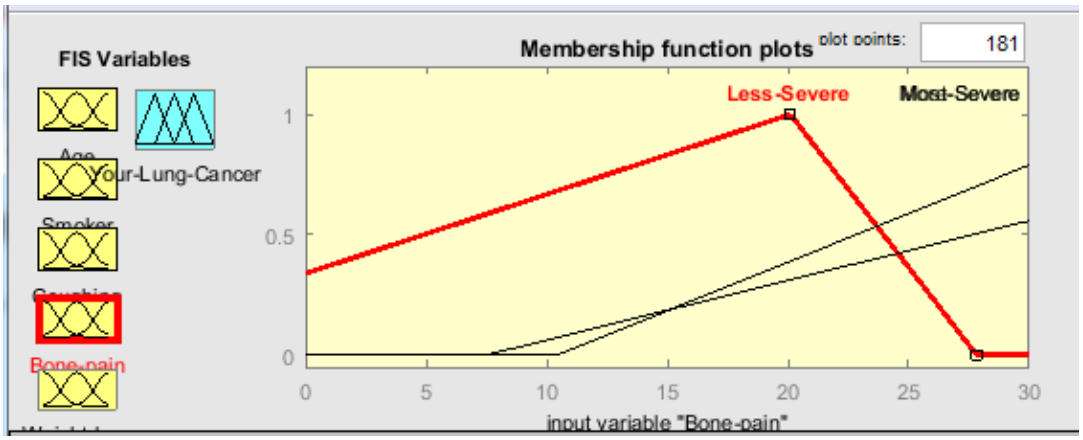



**Figure 5:** Bone-pain's MFs

- Then added the MFs of Weight-loss and changed its range [0 1] to [0 100].

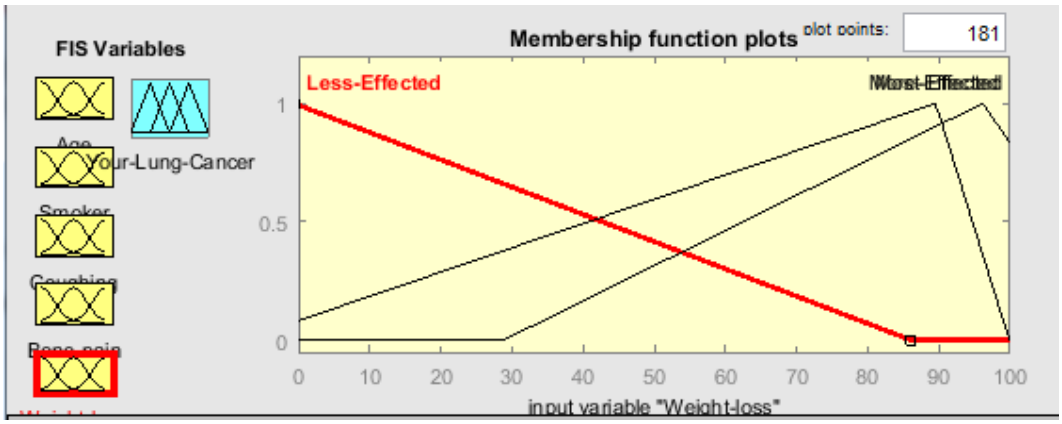



**Figure 6:** Weight-loss's MFs

- Then added the 4 MFs of Your-Lung-Cancer and changed its range [0 1] to [0 50].

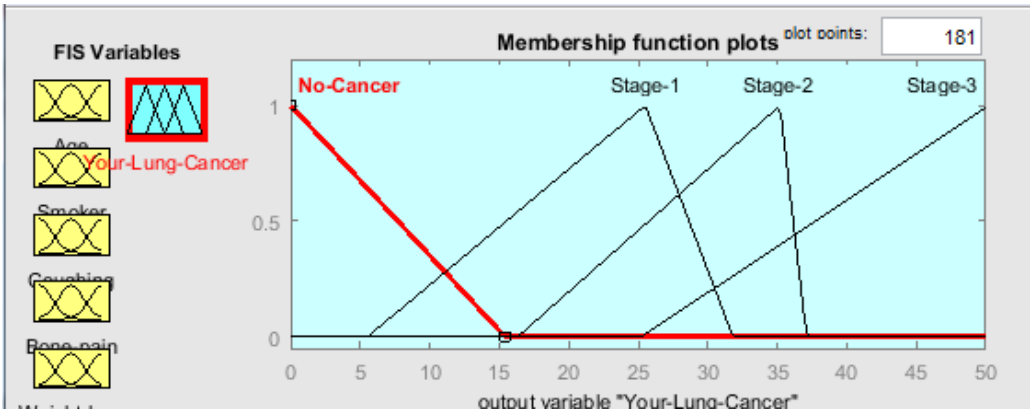



**Figure 7:** Your-Lung-Cancer's MFs

## Rules:

1. If (Age is Low-Danger) and (Smoker is No) and (Coughing is Normal) and (Bone-pain is Less-Severe) and (Weight-loss is Less-Effected) then (Your-Lung-Cancer is No-Cancer) (1)
2. If (Age is Low-Danger) and (Smoker is No) and (Coughing is Normal) and (Bone-pain is Less-Severe) and (Weight-loss is More-Effected) then (Your-Lung-Cancer is No-Cancer) (1)
3. If (Age is Low-Danger) and (Smoker is No) and (Coughing is Normal) and (Bone-pain is Less-Severe) and (Weight-loss is Most-Effected) then (Your-Lung-Cancer is No-Cancer) (1)
4. If (Age is Low-Danger) and (Smoker is No) and (Coughing is Normal) and (Bone-pain is More-Severe) and (Weight-loss is Less-Effected) then (Your-Lung-Cancer is No-Cancer) (1)
5. If (Age is Low-Danger) and (Smoker is No) and (Coughing is Normal) and (Bone-pain is More-Severe) and (Weight-loss is More-Effected) then (Your-Lung-Cancer is No-Cancer) (1)
6. If (Age is Low-Danger) and (Smoker is No) and (Coughing is Normal) and (Bone-pain is More-Severe) and (Weight-loss is Most-Effected) then (Your-Lung-Cancer is Stage-1) (1)
7. If (Age is Low-Danger) and (Smoker is No) and (Coughing is Normal) and (Bone-pain is Most-Severe) and (Weight-loss is Less-Effected) then (Your-Lung-Cancer is No-Cancer) (1)
8. If (Age is Low-Danger) and (Smoker is No) and (Coughing is Normal) and (Bone-pain is Most-Severe) and (Weight-loss is More-Effected) then (Your-Lung-Cancer is No-Cancer) (1)
9. If (Age is Low-Danger) and (Smoker is No) and (Coughing is Normal) and (Bone-pain is Most-Severe) and (Weight-loss is Most-Effected) then (Your-Lung-Cancer is Stage-1) (1)
10. If (Age is Low-Danger) and (Smoker is No) and (Coughing is Liitle-blood) and (Bone-pain is Less-Severe) and (Weight-loss is Less-Effected) then (Your-Lung-Cancer is No-Cancer) (1)
11. If (Age is Low-Danger) and (Smoker is No) and (Coughing is Liitle-blood) and (Bone-pain is Less-Severe) and (Weight-loss is More-Effected) then (Your-Lung-Cancer is No-Cancer) (1)
12. If (Age is Low-Danger) and (Smoker is No) and (Coughing is Liitle-blood) and (Bone-pain is Less-Severe) and (Weight-loss is Most-Effected) then (Your-Lung-Cancer is Stage-1) (1)
13. If (Age is Low-Danger) and (Smoker is No) and (Coughing is Liitle-blood) and (Bone-pain is More-Severe) and (Weight-loss is Less-Effected) then (Your-Lung-Cancer is No-Cancer) (1)
14. If (Age is Low-Danger) and (Smoker is No) and (Coughing is Liitle-blood) and (Bone-pain is More-Severe) and (Weight-loss is More-Effected) then (Your-Lung-Cancer is Stage-1) (1)
15. If (Age is Low-Danger) and (Smoker is No) and (Coughing is Liitle-blood) and (Bone-pain is More-Severe) and (Weight-loss is Most-Effected) then (Your-Lung-Cancer is Stage-1) (1)
16. If (Age is Low-Danger) and (Smoker is No) and (Coughing is Liitle-blood) and (Bone-pain is Most-Severe) and (Weight-loss is Less-Effected) then (Your-Lung-Cancer is No-Cancer) (1)
17. If (Age is Low-Danger) and (Smoker is No) and (Coughing is Liitle-blood) and (Bone-pain is Most-Severe) and (Weight-loss is More-Effected) then (Your-Lung-Cancer is Stage-1) (1)
18. If (Age is Low-Danger) and (Smoker is No) and (Coughing is Liitle-blood) and (Bone-pain is Most-Severe) and (Weight-loss is Most-Effected) then (Your-Lung-Cancer is Stage-1) (1)
19. If (Age is Low-Danger) and (Smoker is No) and (Coughing is More-blood) and (Bone-pain is Less-Severe) and (Weight-loss is Less-Effected) then (Your-Lung-Cancer is No-Cancer) (1)
20. If (Age is Low-Danger) and (Smoker is No) and (Coughing is More-blood) and (Bone-pain is Less-Severe) and (Weight-loss is More-Effected) then (Your-Lung-Cancer is Stage-1) (1)
21. If (Age is Low-Danger) and (Smoker is No) and (Coughing is More-blood) and (Bone-pain is Less-Severe) and (Weight-loss is Most-Effected) then (Your-Lung-Cancer is Stage-1) (1)
22. If (Age is Low-Danger) and (Smoker is No) and (Coughing is More-blood) and (Bone-pain is More-Severe) and (Weight-loss is Less-Effected) then (Your-Lung-Cancer is No-Cancer) (1)
23. If (Age is Low-Danger) and (Smoker is No) and (Coughing is More-blood) and (Bone-pain is More-Severe) and (Weight-loss is More-Effected) then (Your-Lung-Cancer is Stage-1) (1)
24. If (Age is Low-Danger) and (Smoker is No) and (Coughing is More-blood) and (Bone-pain is More-Severe) and (Weight-loss is Most-Effected) then (Your-Lung-Cancer is Stage-1) (1)
25. If (Age is Low-Danger) and (Smoker is No) and (Coughing is More-blood) and (Bone-pain is Most-Severe) and (Weight-loss is Less-Effected) then (Your-Lung-Cancer is No-Cancer) (1)
26. If (Age is Low-Danger) and (Smoker is No) and (Coughing is More-blood) and (Bone-pain is Most-Severe) and (Weight-loss is More-Effected) then (Your-Lung-Cancer is Stage-1) (1)
27. If (Age is Low-Danger) and (Smoker is No) and (Coughing is More-blood) and (Bone-pain is Most-Severe) and (Weight-loss is Most-Effected) then (Your-Lung-Cancer is Stage-1) (1)
28. If (Age is Low-Danger) and (Smoker is Yes) and (Coughing is Normal) and (Bone-pain is Less-Severe) and (Weight-loss is Less-Effected) then (Your-Lung-Cancer is No-Cancer) (1)
29. If (Age is Low-Danger) and (Smoker is Yes) and (Coughing is Normal) and (Bone-pain is Less-Severe) and (Weight-loss is More-Effected) then (Your-Lung-Cancer is No-Cancer) (1)
30. If (Age is Low-Danger) and (Smoker is Yes) and (Coughing is Normal) and (Bone-pain is More-Severe) and (Weight-loss is Less-Effected) then (Your-Lung-Cancer is No-Cancer) (1)
31. If (Age is Low-Danger) and (Smoker is Yes) and (Coughing is Normal) and (Bone-pain is More-Severe) and (Weight-loss is More-Effected) then (Your-Lung-Cancer is No-Cancer) (1)
32. If (Age is Low-Danger) and (Smoker is Yes) and (Coughing is Normal) and (Bone-pain is More-Severe) and (Weight-loss is Most-Effected) then (Your-Lung-Cancer is Stage-1) (1)
33. If (Age is Low-Danger) and (Smoker is Yes) and (Coughing is Normal) and (Bone-pain is Most-Severe) and (Weight-loss is Less-Effected) then (Your-Lung-Cancer is No-Cancer) (1)
34. If (Age is Low-Danger) and (Smoker is Yes) and (Coughing is Normal) and (Bone-pain is Most-Severe) and (Weight-loss is More-Effected) then (Your-Lung-Cancer is No-Cancer) (1)
35. If (Age is Low-Danger) and (Smoker is Yes) and (Coughing is Normal) and (Bone-pain is Most-Severe) and (Weight-loss is Most-Effected) then (Your-Lung-Cancer is Stage-1) (1)
36. If (Age is Low-Danger) and (Smoker is Yes) and (Coughing is Liitle-blood) and (Bone-pain is Less-Severe) and (Weight-loss is Less-Effected) then (Your-Lung-Cancer is No-Cancer) (1)
37. If (Age is Low-Danger) and (Smoker is Yes) and (Coughing is Liitle-blood) and (Bone-pain is Less-Severe) and (Weight-loss is More-Effected) then (Your-Lung-Cancer is Stage-1) (1)
38. If (Age is Low-Danger) and (Smoker is Yes) and (Coughing is Liitle-blood) and (Bone-pain is Less-Severe) and (Weight-loss is Most-Effected) then (Your-Lung-Cancer is Stage-1) (1)
39. If (Age is Low-Danger) and (Smoker is Yes) and (Coughing is Liitle-blood) and (Bone-pain is More-Severe) and (Weight-loss is Less-Effected) then (Your-Lung-Cancer is No-Cancer) (1)
40. If (Age is Low-Danger) and (Smoker is Yes) and (Coughing is Liitle-blood) and (Bone-pain is More-Severe) and (Weight-loss is More-Effected) then (Your-Lung-Cancer is Stage-1) (1)
41. If (Age is Low-Danger) and (Smoker is Yes) and (Coughing is Liitle-blood) and (Bone-pain is More-Severe) and (Weight-loss is Most-Effected) then (Your-Lung-Cancer is Stage-1) (1)
42. If (Age is Low-Danger) and (Smoker is Yes) and (Coughing is Liitle-blood) and (Bone-pain is Most-Severe) and (Weight-loss is Less-Effected) then (Your-Lung-Cancer is Stage-1) (1)
43. If (Age is Low-Danger) and (Smoker is Yes) and (Coughing is Liitle-blood) and (Bone-pain is Most-Severe) and (Weight-loss is More-Effected) then (Your-Lung-Cancer is Stage-1) (1)
44. If (Age is Low-Danger) and (Smoker is Yes) and (Coughing is Liitle-blood) and (Bone-pain is Most-Severe) and (Weight-loss is Most-Effected) then (Your-Lung-Cancer is Stage-1) (1)
45. If (Age is Low-Danger) and (Smoker is Yes) and (Coughing is More-blood) and (Bone-pain is Less-Severe) and (Weight-loss is Less-Effected) then (Your-Lung-Cancer is No-Cancer) (1)
46. If (Age is Low-Danger) and (Smoker is Yes) and (Coughing is More-blood) and (Bone-pain is Less-Severe) and (Weight-loss is More-Effected) then (Your-Lung-Cancer is Stage-1) (1)
47. If (Age is Low-Danger) and (Smoker is Yes) and (Coughing is More-blood) and (Bone-pain is Less-Severe) and (Weight-loss is Most-Effected) then (Your-Lung-Cancer is Stage-1) (1)
48. If (Age is Low-Danger) and (Smoker is Yes) and (Coughing is More-blood) and (Bone-pain is More-Severe) and (Weight-loss is Less-Effected) then (Your-Lung-Cancer is No-Cancer) (1)
49. If (Age is Low-Danger) and (Smoker is Yes) and (Coughing is More-blood) and (Bone-pain is More-Severe) and (Weight-loss is More-Effected) then (Your-Lung-Cancer is Stage-1) (1)
50. If (Age is Low-Danger) and (Smoker is Yes) and (Coughing is More-blood) and (Bone-pain is More-Severe) and (Weight-loss is Most-Effected) then (Your-Lung-Cancer is Stage-1) (1)
51. If (Age is Low-Danger) and (Smoker is Yes) and (Coughing is More-blood) and (Bone-pain is Most-Severe) and (Weight-loss is Less-Effected) then (Your-Lung-Cancer is No-Cancer) (1)
52. If (Age is Low-Danger) and (Smoker is Yes) and (Coughing is More-blood) and (Bone-pain is Most-Severe) and (Weight-loss is More-Effected) then (Your-Lung-Cancer is Stage-1) (1)
53. If (Age is Low-Danger) and (Smoker is Yes) and (Coughing is More-blood) and (Bone-pain is Most-Severe) and (Weight-loss is Most-Effected) then (Your-Lung-Cancer is Stage-1) (1)
54. If (Age is Low-Danger) and (Smoker is Yes) and (Coughing is Normal) and (Bone-pain is Less-Severe) and (Weight-loss is Most-Effected) then (Your-Lung-Cancer is No-Cancer) (1)
55. If (Age is High-Danger) and (Smoker is No) and (Coughing is Normal) and (Bone-pain is Less-Severe) and (Weight-loss is Less-Effected) then (Your-Lung-Cancer is No-Cancer) (1)
56. If (Age is High-Danger) and (Smoker is No) and (Coughing is Normal) and (Bone-pain is Less-Severe) and (Weight-loss is More-Effected) then (Your-Lung-Cancer is No-Cancer) (1)
57. If (Age is High-Danger) and (Smoker is No) and (Coughing is Normal) and (Bone-pain is Less-Severe) and (Weight-loss is Most-Effected) then (Your-Lung-Cancer is Stage-1) (1)
58. If (Age is High-Danger) and (Smoker is No) and (Coughing is Normal) and (Bone-pain is More-Severe) and (Weight-loss is Less-Effected) then (Your-Lung-Cancer is No-Cancer) (1)
59. If (Age is High-Danger) and (Smoker is No) and (Coughing is Normal) and (Bone-pain is More-Severe) and (Weight-loss is More-Effected) then (Your-Lung-Cancer is Stage-1) (1)
60. If (Age is High-Danger) and (Smoker is No) and (Coughing is Normal) and (Bone-pain is More-Severe) and (Weight-loss is Most-Effected) then (Your-Lung-Cancer is Stage-1) (1)
61. If (Age is High-Danger) and (Smoker is No) and (Coughing is Normal) and (Bone-pain is Most-Severe) and (Weight-loss is Less-Effected) then (Your-Lung-Cancer is No-Cancer) (1)
62. If (Age is High-Danger) and (Smoker is No) and (Coughing is Normal) and (Bone-pain is Most-Severe) and (Weight-loss is More-Effected) then (Your-Lung-Cancer is Stage-1) (1)
63. If (Age is High-Danger) and (Smoker is No) and (Coughing is Normal) and (Bone-pain is Most-Severe) and (Weight-loss is Most-Effected) then (Your-Lung-Cancer is Stage-1) (1)
64. If (Age is High-Danger) and (Smoker is No) and (Coughing is Liitle-blood) and (Bone-pain is Less-Severe) and (Weight-loss is Less-Effected) then (Your-Lung-Cancer is No-Cancer) (1)
65. If (Age is High-Danger) and (Smoker is No) and (Coughing is Liitle-blood) and (Bone-pain is Less-Severe) and (Weight-loss is More-Effected) then (Your-Lung-Cancer is Stage-1) (1)
66. If (Age is High-Danger) and (Smoker is No) and (Coughing is Liitle-blood) and (Bone-pain is Less-Severe) and (Weight-loss is Most-Effected) then (Your-Lung-Cancer is Stage-1) (1)
67. If (Age is High-Danger) and (Smoker is No) and (Coughing is Liitle-blood) and (Bone-pain is More-Severe) and (Weight-loss is Less-Effected) then (Your-Lung-Cancer is Stage-1) (1)
68. If (Age is High-Danger) and (Smoker is No) and (Coughing is Liitle-blood) and (Bone-pain is More-Severe) and (Weight-loss is More-Effected) then (Your-Lung-Cancer is Stage-1) (1)
69. If (Age is High-Danger) and (Smoker is No) and (Coughing is Liitle-blood) and (Bone-pain is More-Severe) and (Weight-loss is Most-Effected) then (Your-Lung-Cancer is Stage-1) (1)
70. If (Age is High-Danger) and (Smoker is No) and (Coughing is Liitle-blood) and (Bone-pain is Most-Severe) and (Weight-loss is Less-Effected) then (Your-Lung-Cancer is Stage-1) (1)
71. If (Age is High-Danger) and (Smoker is No) and (Coughing is Liitle-blood) and (Bone-pain is Most-Severe) and (Weight-loss is More-Effected) then (Your-Lung-Cancer is Stage-1) (1)
72. If (Age is High-Danger) and (Smoker is No) and (Coughing is Liitle-blood) and (Bone-pain is Most-Severe) and (Weight-loss is Most-Effected) then (Your-Lung-Cancer is Stage-1) (1)
73. If (Age is High-Danger) and (Smoker is No) and (Coughing is More-blood) and (Bone-pain is Less-Severe) and (Weight-loss is Less-Effected) then (Your-Lung-Cancer is Stage-1) (1)
74. If (Age is High-Danger) and (Smoker is No) and (Coughing is More-blood) and (Bone-pain is Less-Severe) and (Weight-loss is More-Effected) then (Your-Lung-Cancer is Stage-1) (1)
75. If (Age is High-Danger) and (Smoker is No) and (Coughing is More-blood) and (Bone-pain is Less-Severe) and (Weight-loss is Most-Effected) then (Your-Lung-Cancer is Stage-1) (1)
76. If (Age is High-Danger) and (Smoker is No) and (Coughing is More-blood) and (Bone-pain is More-Severe) and (Weight-loss is Less-Effected) then (Your-Lung-Cancer is Stage-1) (1)
77. If (Age is High-Danger) and (Smoker is No) and (Coughing is More-blood) and (Bone-pain is More-Severe) and (Weight-loss is More-Effected) then (Your-Lung-Cancer is Stage-1) (1)
78. If (Age is High-Danger) and (Smoker is No) and (Coughing is More-blood) and (Bone-pain is More-Severe) and (Weight-loss is Most-Effected) then (Your-Lung-Cancer is Stage-1) (1)
79. If (Age is High-Danger) and (Smoker is No) and (Coughing is More-blood) and (Bone-pain is Most-Severe) and (Weight-loss is Less-Effected) then (Your-Lung-Cancer is Stage-1) (1)
80. If (Age is High-Danger) and (Smoker is No) and (Coughing is More-blood) and (Bone-pain is Most-Severe) and (Weight-loss is More-Effected) then (Your-Lung-Cancer is Stage-2) (1)

81. If (Age is High-Danger) and (Smoker is No) and (Coughing is More-blood) and (Bone-pain is Most-Severe) and (Weight-loss is Most-Effected) then (Your-Lung-Cancer is Stage-2) (1)
82. If (Age is High-Danger) and (Smoker is Yes) and (Coughing is Normal) and (Bone-pain is Less-Severe) and (Weight-loss is Less-Effected) then (Your-Lung-Cancer is No-Cancer) (1)
83. If (Age is High-Danger) and (Smoker is Yes) and (Coughing is Normal) and (Bone-pain is Less-Severe) and (Weight-loss is More-Effected) then (Your-Lung-Cancer is Stage-1) (1)
84. If (Age is High-Danger) and (Smoker is Yes) and (Coughing is Normal) and (Bone-pain is Less-Severe) and (Weight-loss is Most-Effected) then (Your-Lung-Cancer is Stage-1) (1)
85. If (Age is High-Danger) and (Smoker is Yes) and (Coughing is Normal) and (Bone-pain is More-Severe) and (Weight-loss is Less-Effected) then (Your-Lung-Cancer is No-Cancer) (1)
86. If (Age is High-Danger) and (Smoker is Yes) and (Coughing is Normal) and (Bone-pain is More-Severe) and (Weight-loss is More-Effected) then (Your-Lung-Cancer is Stage-1) (1)
87. If (Age is High-Danger) and (Smoker is Yes) and (Coughing is Normal) and (Bone-pain is More-Severe) and (Weight-loss is Most-Effected) then (Your-Lung-Cancer is Stage-1) (1)
88. If (Age is High-Danger) and (Smoker is Yes) and (Coughing is Normal) and (Bone-pain is Most-Severe) and (Weight-loss is Less-Effected) then (Your-Lung-Cancer is Stage-1) (1)
89. If (Age is High-Danger) and (Smoker is Yes) and (Coughing is Normal) and (Bone-pain is Most-Severe) and (Weight-loss is More-Effected) then (Your-Lung-Cancer is Stage-1) (1)
90. If (Age is High-Danger) and (Smoker is Yes) and (Coughing is Normal) and (Bone-pain is Most-Severe) and (Weight-loss is Most-Effected) then (Your-Lung-Cancer is Stage-1) (1)
91. If (Age is High-Danger) and (Smoker is Yes) and (Coughing is Liitle-blood) and (Bone-pain is Less-Severe) and (Weight-loss is Less-Effected) then (Your-Lung-Cancer is Stage-1) (1)
92. If (Age is High-Danger) and (Smoker is Yes) and (Coughing is Liitle-blood) and (Bone-pain is Less-Severe) and (Weight-loss is More-Effected) then (Your-Lung-Cancer is Stage-1) (1)
93. If (Age is High-Danger) and (Smoker is Yes) and (Coughing is Liitle-blood) and (Bone-pain is Less-Severe) and (Weight-loss is Most-Effected) then (Your-Lung-Cancer is Stage-1) (1)
94. If (Age is High-Danger) and (Smoker is Yes) and (Coughing is Liitle-blood) and (Bone-pain is More-Severe) and (Weight-loss is Less-Effected) then (Your-Lung-Cancer is Stage-1) (1)
95. If (Age is High-Danger) and (Smoker is Yes) and (Coughing is Liitle-blood) and (Bone-pain is More-Severe) and (Weight-loss is More-Effected) then (Your-Lung-Cancer is Stage-2) (1)
96. If (Age is High-Danger) and (Smoker is Yes) and (Coughing is Liitle-blood) and (Bone-pain is More-Severe) and (Weight-loss is Most-Effected) then (Your-Lung-Cancer is Stage-2) (1)
97. If (Age is High-Danger) and (Smoker is Yes) and (Coughing is Liitle-blood) and (Bone-pain is Most-Severe) and (Weight-loss is Less-Effected) then (Your-Lung-Cancer is Stage-2) (1)
98. If (Age is High-Danger) and (Smoker is Yes) and (Coughing is Liitle-blood) and (Bone-pain is Most-Severe) and (Weight-loss is More-Effected) then (Your-Lung-Cancer is Stage-2) (1)
99. If (Age is High-Danger) and (Smoker is Yes) and (Coughing is Liitle-blood) and (Bone-pain is Most-Severe) and (Weight-loss is Most-Effected) then (Your-Lung-Cancer is Stage-2) (1)
100. If (Age is High-Danger) and (Smoker is Yes) and (Coughing is More-blood) and (Bone-pain is Less-Severe) and (Weight-loss is Less-Effected) then (Your-Lung-Cancer is Stage-2) (1)
101. If (Age is High-Danger) and (Smoker is Yes) and (Coughing is More-blood) and (Bone-pain is Less-Severe) and (Weight-loss is More-Effected) then (Your-Lung-Cancer is Stage-2) (1)
102. If (Age is High-Danger) and (Smoker is Yes) and (Coughing is More-blood) and (Bone-pain is Less-Severe) and (Weight-loss is Most-Effected) then (Your-Lung-Cancer is Stage-2) (1)
103. If (Age is High-Danger) and (Smoker is Yes) and (Coughing is More-blood) and (Bone-pain is More-Severe) and (Weight-loss is Less-Effected) then (Your-Lung-Cancer is Stage-2) (1)
104. If (Age is High-Danger) and (Smoker is Yes) and (Coughing is More-blood) and (Bone-pain is More-Severe) and (Weight-loss is More-Effected) then (Your-Lung-Cancer is Stage-3) (1)
105. If (Age is High-Danger) and (Smoker is Yes) and (Coughing is More-blood) and (Bone-pain is More-Severe) and (Weight-loss is Most-Effected) then (Your-Lung-Cancer is Stage-3) (1)
106. If (Age is High-Danger) and (Smoker is Yes) and (Coughing is More-blood) and (Bone-pain is Most-Severe) and (Weight-loss is Less-Effected) then (Your-Lung-Cancer is Stage-2) (1)
107. If (Age is High-Danger) and (Smoker is Yes) and (Coughing is More-blood) and (Bone-pain is Most-Severe) and (Weight-loss is More-Effected) then (Your-Lung-Cancer is Stage-3) (1)
108. If (Age is High-Danger) and (Smoker is Yes) and (Coughing is More-blood) and (Bone-pain is Most-Severe) and (Weight-loss is Most-Effected) then (Your-Lung-Cancer is Stage-3) (1)

**Figure 8:** Rule Editor: Lungs_Cancer

## Results:

Change the values for testing purpose as shown below;

- First set value of Age = 40, Smoker = 5 (Yes), Coughing = 20, Bone-pain = 15, Weight-loss = 50 then our output Compressor-Speed = 16.8 (Stage 1).

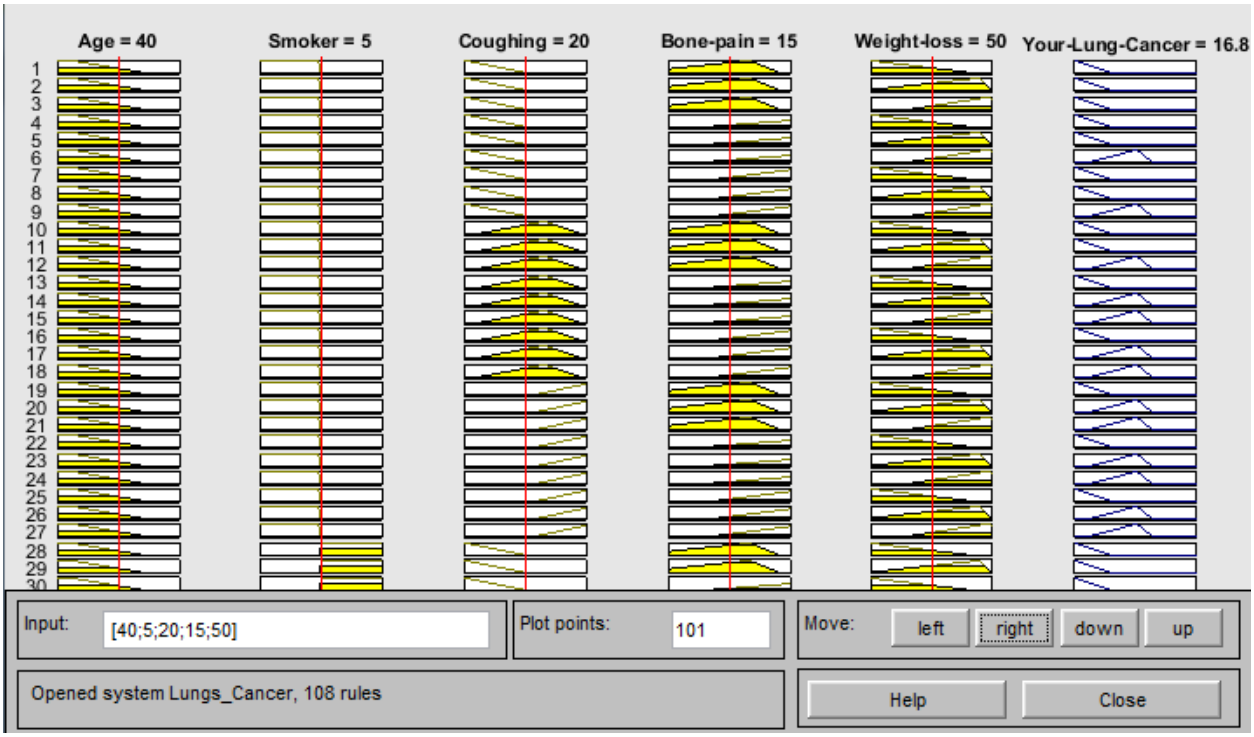



**Figure 9:** Rule Viewer: Lungs_Cancer

- Then set value of Age = 60, Smoker = 7 (Yes), Coughing = 35, Bone-pain = 25, Weight-loss = 90 then our output Compressor-Speed = 32.4 (Stage 3).

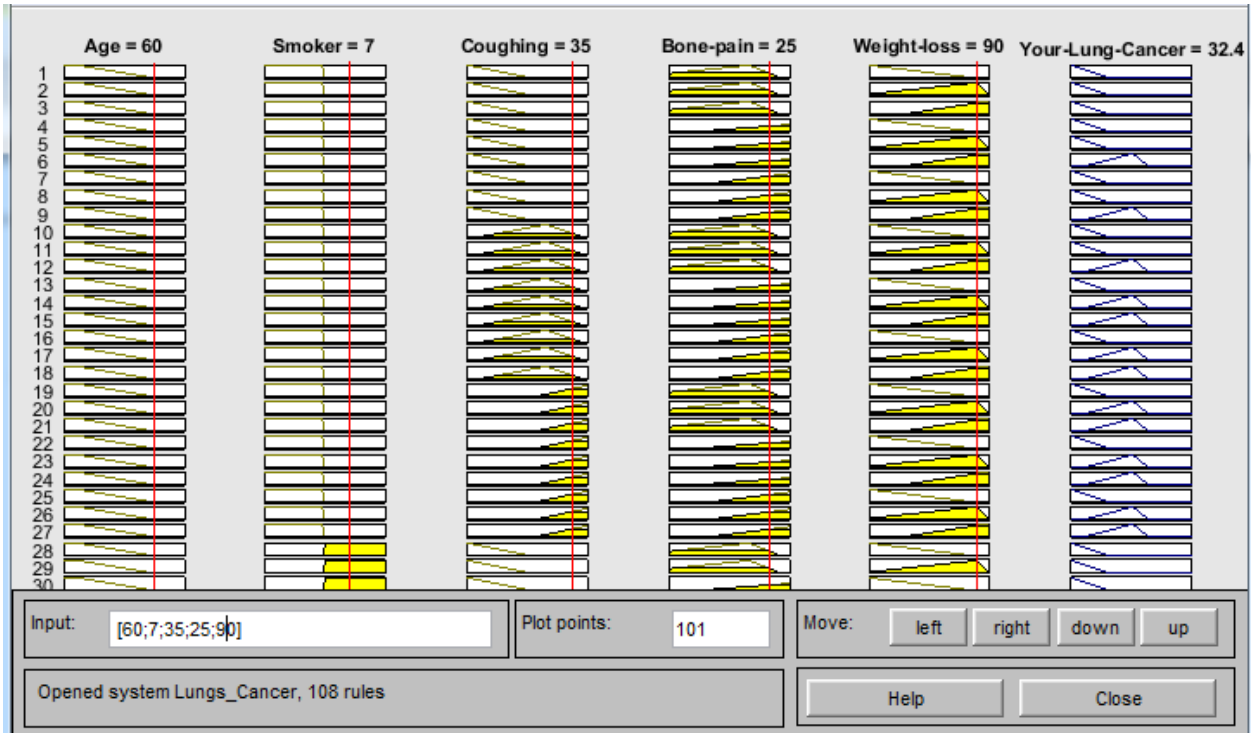



**Figure 10:** Rule Viewer: Lungs_Cancer

- Overall, Input (Age, Smoker) and output (Your-Lung-Cancer) relation.

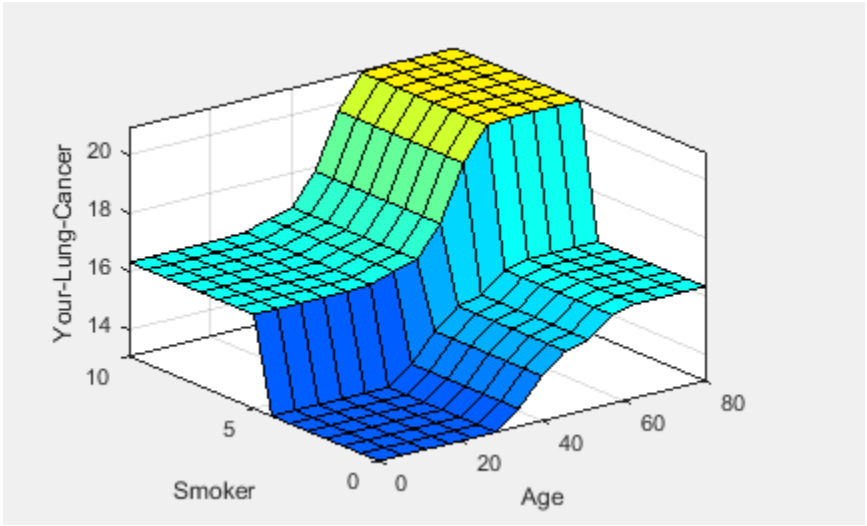



**Figure 11:** Surface Viewer: Lungs_Cancer

- Overall, Input (Age, Coughing) and output (Your-Lung-Cancer) relation.

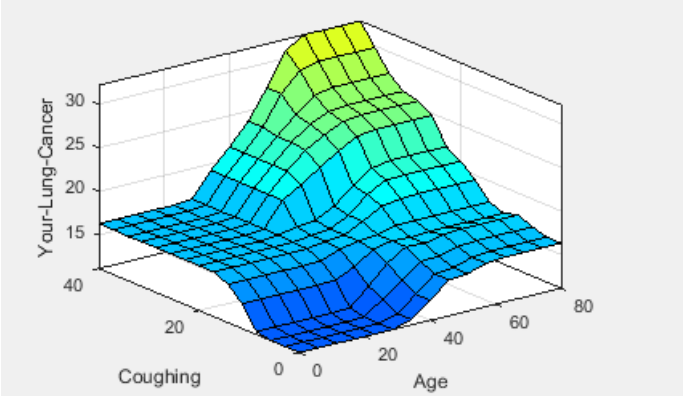



**Figure 12:** Surface Viewer: Lungs_Cancer

- Overall, Input (Age, Bone-pain) and output (Your-Lung-Cancer) relation.

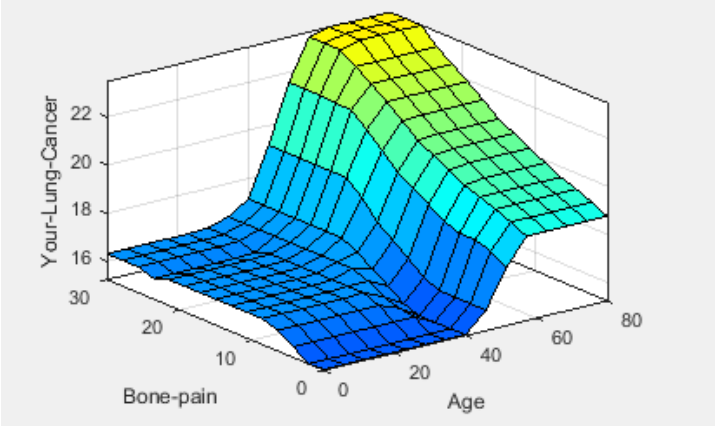



**Figure 13:** Surface Viewer: Lungs_Cancer

- Overall, Input (Age, Weight-loss) and output (Your-Lung-Cancer) relation.

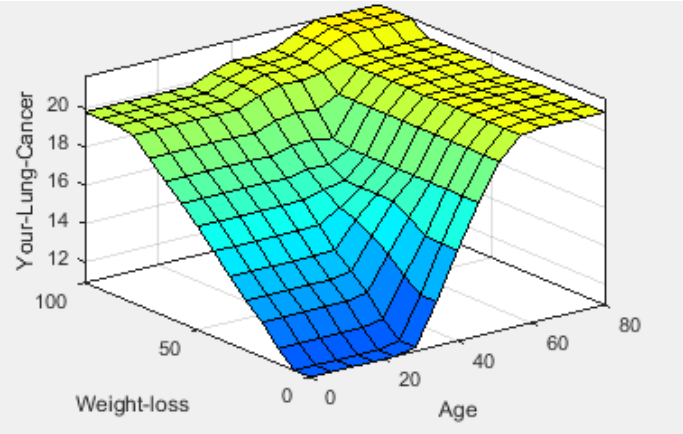



**Figure 14:** Surface Viewer: Lungs_Cancer

- Relationship of Age with Your-Lung-Cancer.

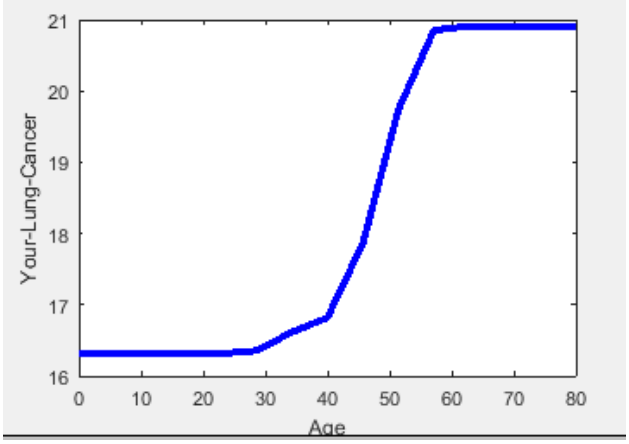



**Figure 15:** Surface Viewer: Lungs_Cancer

- Relationship of Smoker with Your-Lung-Cancer.

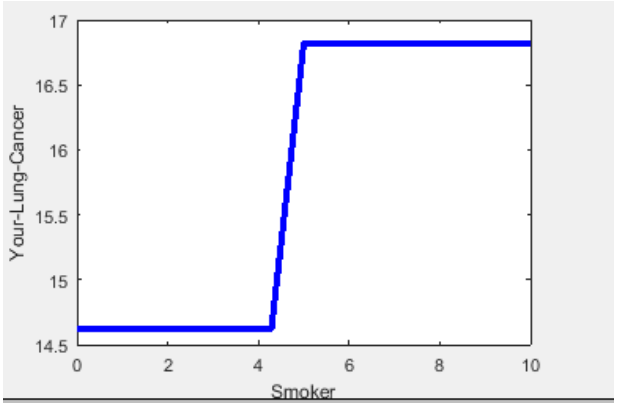



**Figure 16:** Surface Viewer: Lungs_Cancer

- Relationship of Coughing with Your-Lung-Cancer.

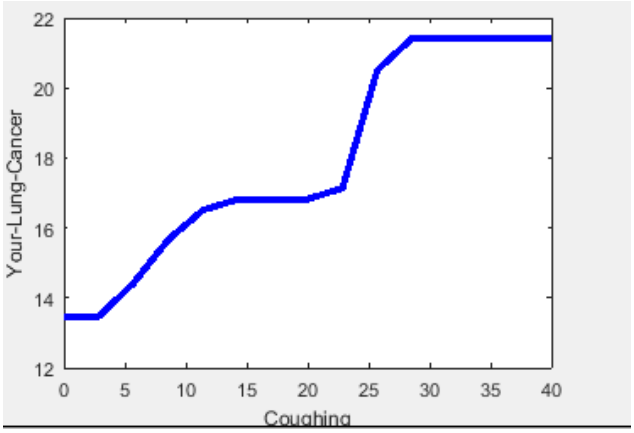



**Figure 17:** Surface Viewer: Lungs_Cancer

- Relationship of Bone-pain with Your-Lung-Cancer.

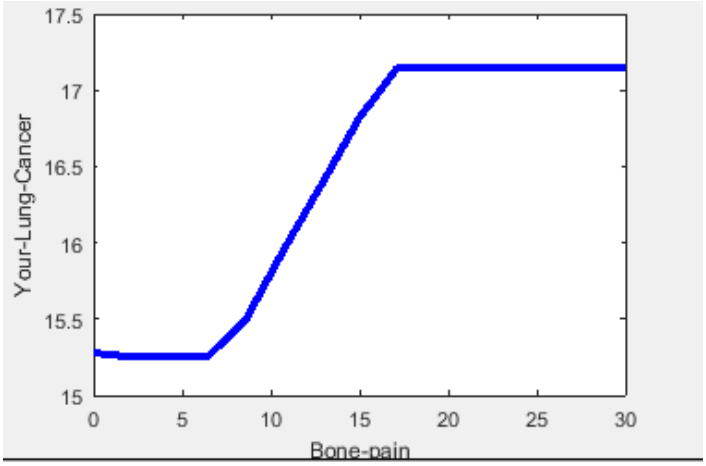



**Figure 18:** Surface Viewer: Lungs_Cancer

- Relationship of Weight-loss with Your-Lung-Cancer.

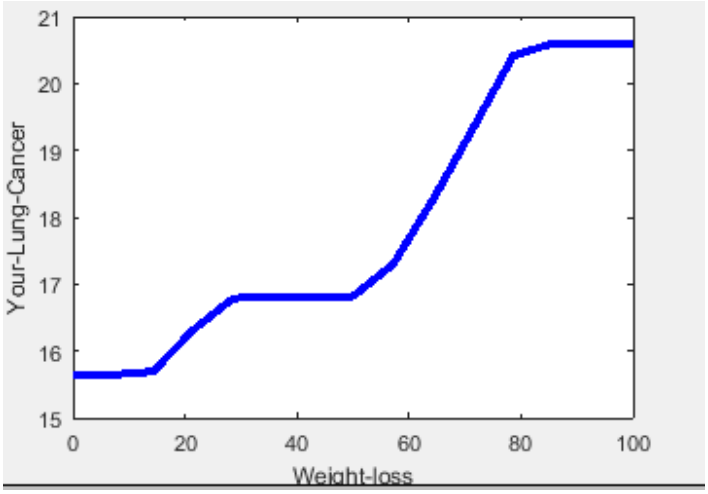



**Figure 19:** Surface Viewer: Lungs_Cancer

## Lab # 7

Toyota Corolla fuel consumption

### Objectives:

- On which factors, Toyota Corolla fuel consumption depend.

### Background:

The new gorgeous and mighty Toyota 2010 model is full of good features. It delivers a high level fuel efficiency and performance. Toyota Corolla is not only the bestselling car in the world but also top-selling car in Asian auto market. Toyota Corolla 2010 model is refined mid-size four door sedan car of 10th generation. You can enjoy the ultimate driving experience on Toyota Corolla due to its super Electronic control transmission (ECT) system and stunning acceleration. Newly designed body structure, good-looking curved doors and beautiful front and rear lamps enhance the exterior attraction of the latest model of Toyota Xli/Gli 2010.

**Figure 1:** Toyota Corolla Xli/Gli

Wheelbase of the new 2010 Toyota Corolla is 102.4 inch, thus giving the improved scope for the passenger space. It the 2010, Toyota additionally gives the shoppers with the second risk in the terms of engine, which has a 2.4 liter engine that will end up 158 horsepower in 6000 rpm. This proves robustness of the car, which has the overgrown, all alternative models that was launched previously by this company.

Toyota Corolla not only provides you ample customization but also gives you impressive mileage i.e. overall fuel efficiency of Toyota Corolla is **14.5 km in one liter** of petrol.

Masterly crafted interior and eye catching exterior makes it executive sedan car. Overall this elegant car is a combination of performance, style and reliability.

### Background:

Fuel consumption of cars is most commonly measured in liters of fuel which are used on average per 100 kilometers (l/100 km). The standard fuel consumption is determined not on public roads, but on test stands using identical test cycles for all vehicles. The average consumption of cars is determined on public roads and depends strongly on traffic conditions and driving style.

In our daily life, we experienced how much our car average in city and out of city (on long route). Fuel consumption basically depends on distance, car speed and road condition. Our main focus on distance and car speed. I'm talking about car's fuel consumption, not about car's average.

As you know, fuel consumption is directly proportional to distance. It has linear relation with distance. As distance increases, fuel consumption also increased. Car fuel consumption also has linear relation with road condition. Worst the road, more fuel consumed.

If your car is going 0 mph your engine is still running. Just to keep the cylinders moving and the various fans, pumps and generators running consumes a certain amount of fuel. And depending on how many accessories (such as headlights and air conditioning) you have running, your car will use even more fuel.

So even when the car is sitting still it uses quite a lot of fuel. Cars get the very worst mileage at 0 mph; they use gasoline but don't cover any miles. When you put the car in drive and start moving at say 1 mph, the car uses only a tiny bit more fuel, because the road load is very small at 1 mph. At this speed the car uses about the same amount of fuel, but it went 1 mile in an hour. This represents a dramatic increase in mileage. Now if the car goes 2 mph, again it uses only a tiny bit more fuel, but goes twice as far. The mileage almost doubled! At speed 37.28 mph (60 km/h) to 62.13 mph (100 km/h) our car's fuel average is very good, above the 100 km/h speed car use more fuel.

## Fuzzy Logic:

### Procedure:

- Typed fuzzy in command prompt.
  >>fuzzy
- Fuzzy logic designer: Untitled opened and exported file by "**Car_fuel_Consumption**".
- Changed the name of input1 by **Distance,** input2 by **Speed**, input3 by **Road** and output1 by **Fuel-Consumption**.
- Chose defuzzification **Centriod.**

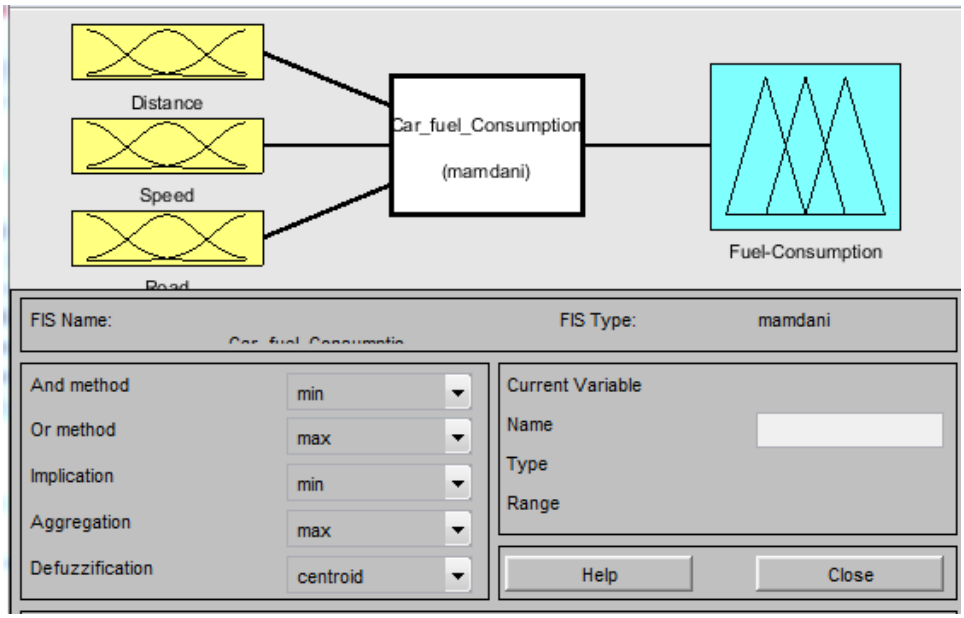



**Figure 2:** Fuzzy logic designer

- Double clicked on the Distance and added 3 member functions (MFs) as shown in figure 2; also, changed the range of Input from [0  1] to [0 400].

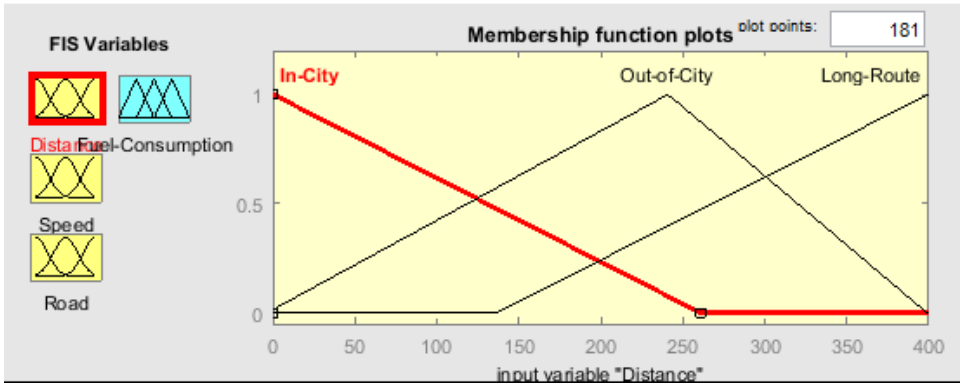



**Figure 3:** Distance's MFs

- Then added the MFs of Speed and changed its range [0 1] to [0 140].

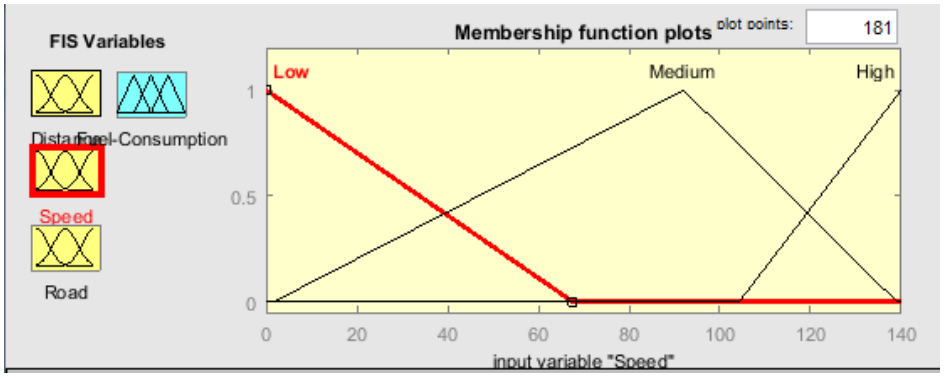



**Figure 4:** Speed's MFs

- Then added the MFs of Road and changed its range [0 1] to [0 10].

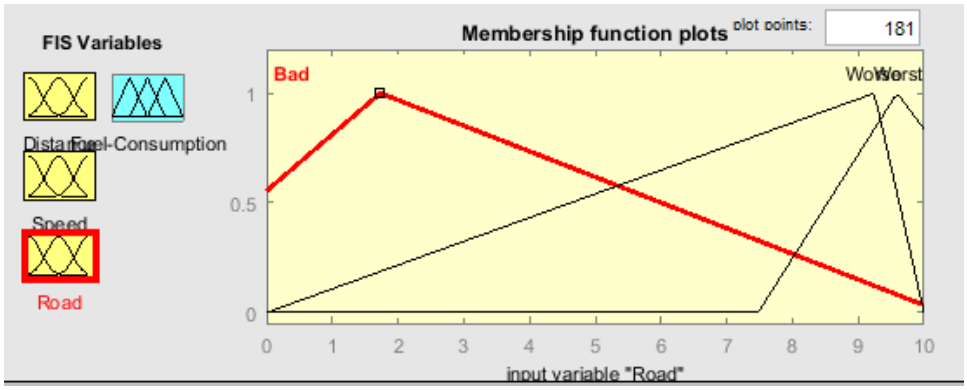



**Figure 5:** Road's MFs

- Then added the 4 MFs of Fuel-consumption and changed its range [0 1] to [4 16].

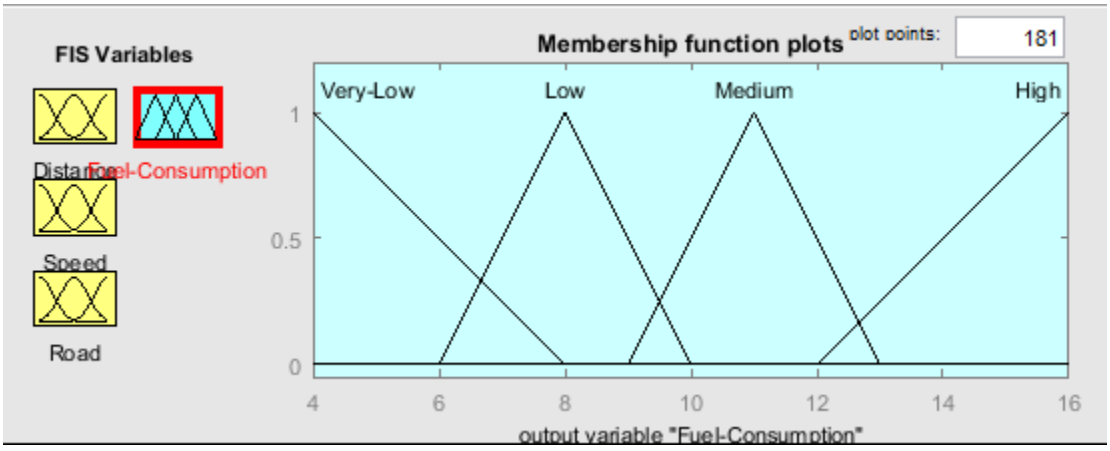



**Figure 6:** Fuel-consumption's MFs

## Rules:

1. If (Distance is In-City) and (Speed is Low) and (Road is Bad) then (Fuel-Consumption is Low) (1)
2. If (Distance is In-City) and (Speed is Low) and (Road is Worse) then (Fuel-Consumption is Low) (1)
3. If (Distance is In-City) and (Speed is Low) and (Road is Worst) then (Fuel-Consumption is Low) (1)
4. If (Distance is In-City) and (Speed is Medium) and (Road is Bad) then (Fuel-Consumption is Very-Low) (1)
5. If (Distance is In-City) and (Speed is Medium) and (Road is Worse) then (Fuel-Consumption is Very-Low) (1)
6. If (Distance is In-City) and (Speed is Medium) and (Road is Worst) then (Fuel-Consumption is Very-Low) (1)
7. If (Distance is In-City) and (Speed is High) and (Road is Bad) then (Fuel-Consumption is Low) (1)
8. If (Distance is In-City) and (Speed is High) and (Road is Worse) then (Fuel-Consumption is Low) (1)
9. If (Distance is In-City) and (Speed is High) and (Road is Worst) then (Fuel-Consumption is Low) (1)
10. If (Distance is Out-of-City) and (Speed is Low) and (Road is Bad) then (Fuel-Consumption is Low) (1)
11. If (Distance is Out-of-City) and (Speed is Low) and (Road is Worse) then (Fuel-Consumption is Medium) (1)
12. If (Distance is Out-of-City) and (Speed is Low) and (Road is Worst) then (Fuel-Consumption is Medium) (1)
13. If (Distance is Out-of-City) and (Speed is Medium) and (Road is Bad) then (Fuel-Consumption is Very-Low) (1)
14. If (Distance is Out-of-City) and (Speed is Medium) and (Road is Worse) then (Fuel-Consumption is Low) (1)
15. If (Distance is Out-of-City) and (Speed is Medium) and (Road is Worst) then (Fuel-Consumption is Low) (1)
16. If (Distance is Out-of-City) and (Speed is High) and (Road is Bad) then (Fuel-Consumption is Low) (1)
17. If (Distance is Out-of-City) and (Speed is High) and (Road is Worse) then (Fuel-Consumption is Medium) (1)
18. If (Distance is Out-of-City) and (Speed is High) and (Road is Worst) then (Fuel-Consumption is Medium) (1)
19. If (Distance is Long-Route) and (Speed is Low) and (Road is Bad) then (Fuel-Consumption is Medium) (1)
20. If (Distance is Long-Route) and (Speed is Low) and (Road is Worse) then (Fuel-Consumption is High) (1)
21. If (Distance is Long-Route) and (Speed is Low) and (Road is Worst) then (Fuel-Consumption is High) (1)
22. If (Distance is Long-Route) and (Speed is Medium) and (Road is Bad) then (Fuel-Consumption is Low) (1)
23. If (Distance is Long-Route) and (Speed is Medium) and (Road is Worse) then (Fuel-Consumption is Medium) (1)
24. If (Distance is Long-Route) and (Speed is Medium) and (Road is Worst) then (Fuel-Consumption is Medium) (1)
25. If (Distance is Long-Route) and (Speed is High) and (Road is Bad) then (Fuel-Consumption is Medium) (1)
26. If (Distance is Long-Route) and (Speed is High) and (Road is Worse) then (Fuel-Consumption is High) (1)
27. If (Distance is Long-Route) and (Speed is High) and (Road is Worst) then (Fuel-Consumption is High) (1)

**Figure 7:** Rule Editor: Car_fuel_Consumption

## Results:

Change the values for testing purpose as shown below;

- First set value of Distance = 200, Speed = 70 and Road = 5, then our output Fuel-Consumption = 7.54.

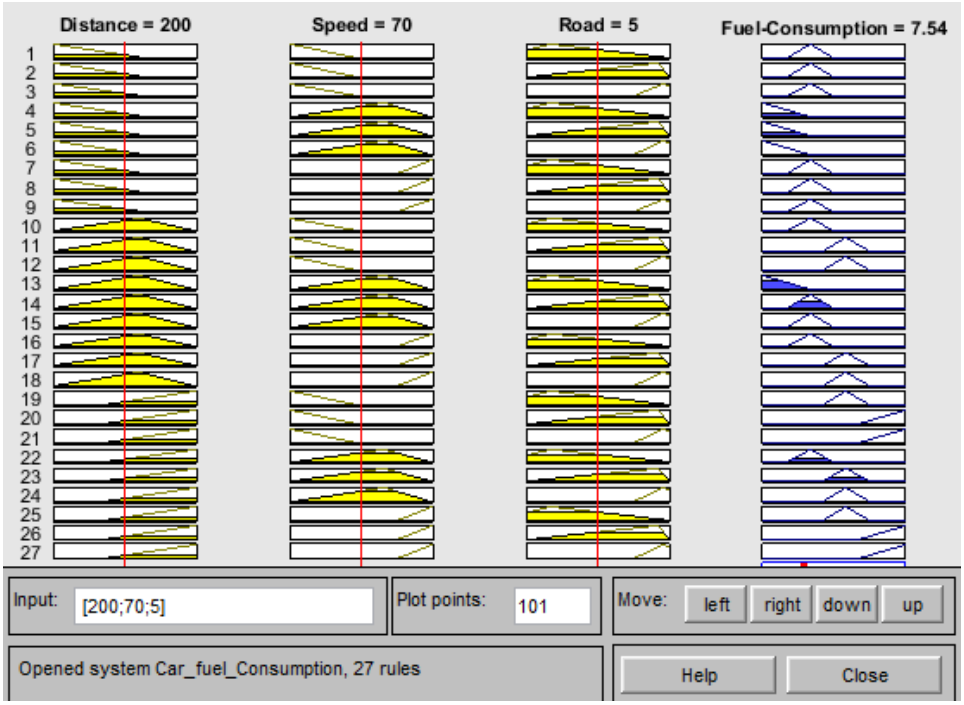



**Figure 8:** Rule Viewer: Car_fuel_Consumption

- First set value of Distance = 300, Speed = 50 and Road = 8, then our output Fuel-Consumption = 9.82.

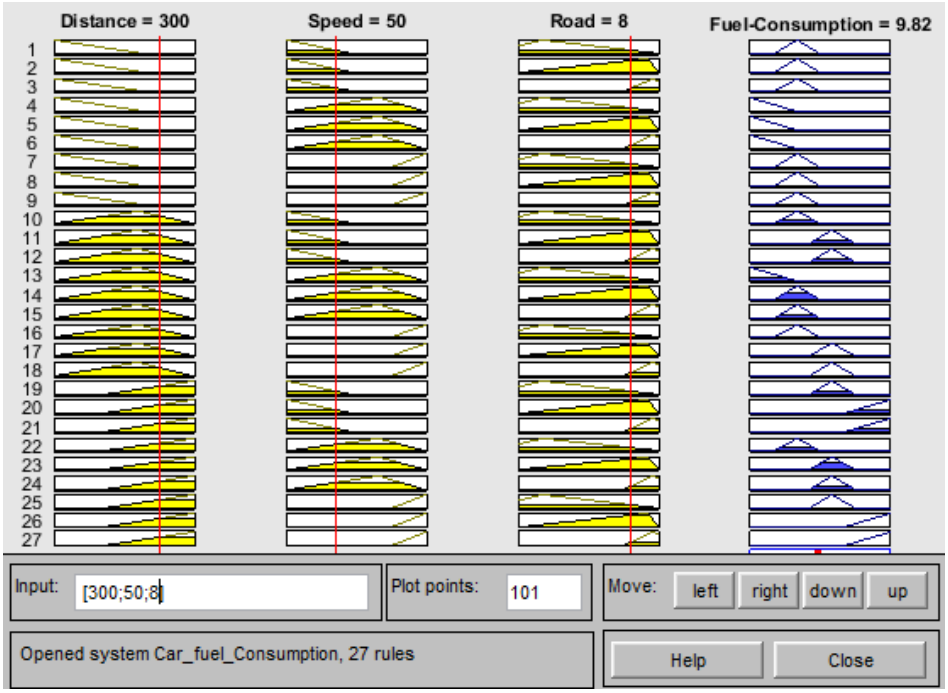



**Figure 9:** Rule Viewer: Car_fuel_Consumption

- Overall, Input (Distance, Speed) and output (Fuel-Consumption) relation.

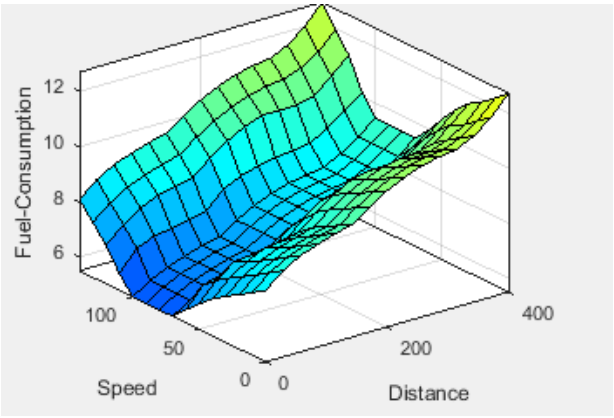



**Figure 10:** Surface Viewer: Car_fuel_Consumption

- Overall, Input (Distance, Road) and output (Fuel-Consumption) relation.

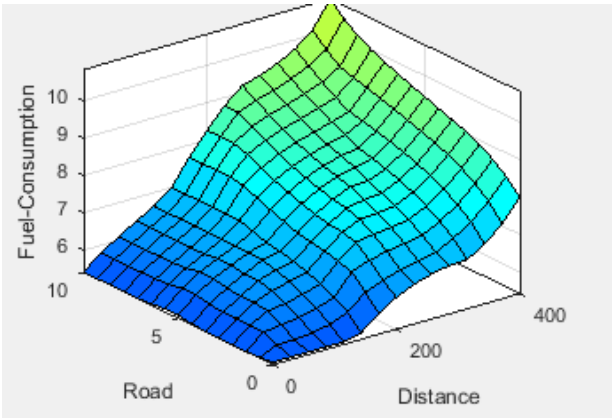



**Figure 11:** Surface Viewer: Car_fuel_Consumption

- Relationship of Distance with Fuel-Consumption.

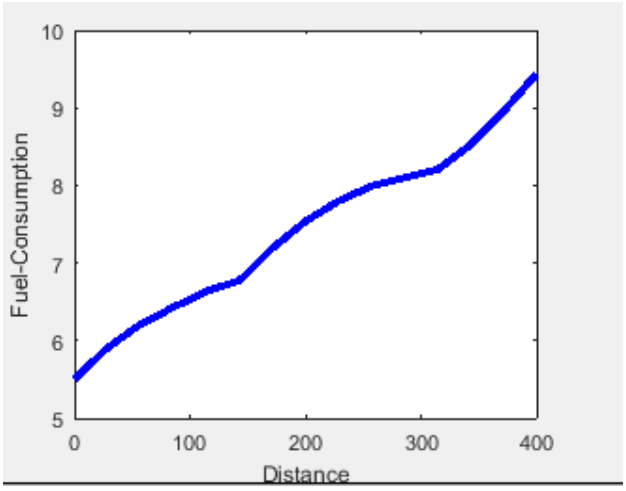



**Figure 12:** Surface Viewer: Car_fuel_Consumption

- Relationship of Speed with Fuel-Consumption.

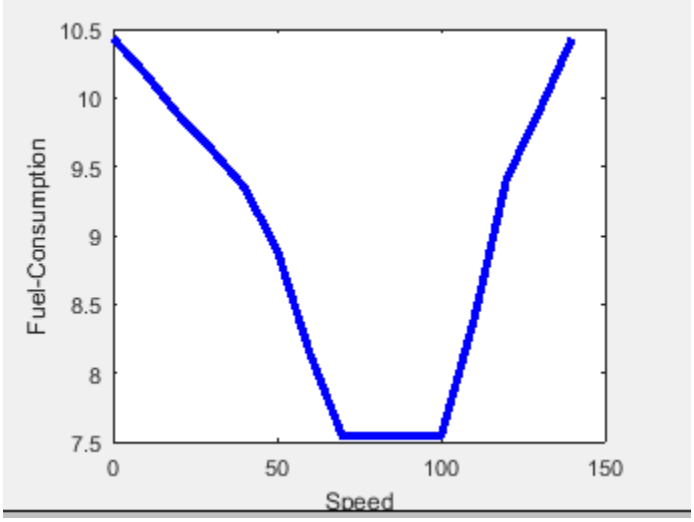



**Figure 13:** Surface Viewer: Car_fuel_Consumption

- Relationship of Road with Fuel-Consumption.

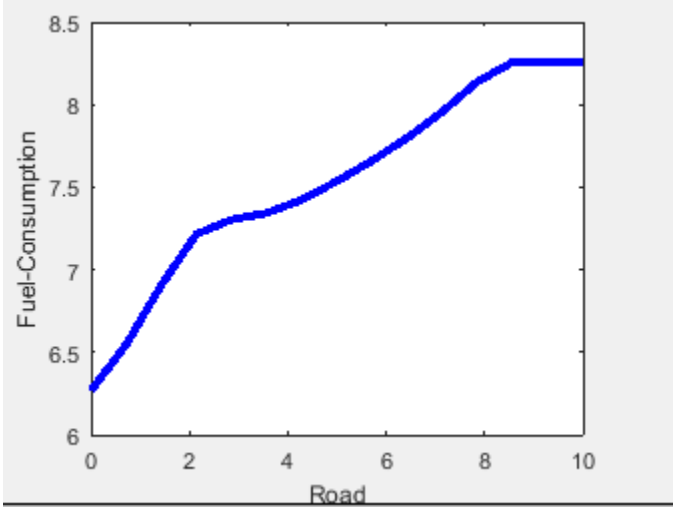



**Figure 14:** Surface Viewer: Car_fuel_Consumption

## Conclusion:

- As you see, as distance increases, fuel consumption increased.
- On average speed, car's fuel consumption decreased.
- And fuel consumption also increased, when road condition going worst.

## Motivated by;

I've Toyota corolla 2010 model. I'm motivated by my father's driving experience. He has good knowledge about car fuel consumption and its average. I implemented his knowledge on fuzzy logic and made this report.

# Lab # 8

## Objectives:

Introduction to Artificial Neural Networks and Activation functions

## Introduction:

An Artificial Neuron Network (ANN), popularly known as Neural Network is a computational model based on the structure and functions of biological neural networks. It is like an artificial human nervous system for receiving, processing, and transmitting information in terms of Computer Science.

Basically, there are 3 different layers in a neural network:-

1. **Input Layer** (All the inputs are fed in the model through this layer).
2. **Hidden Layers** (There can be more than one hidden layers which are used for processing the inputs received from the input layers).
3. **Output Layer** (The data after processing is made available at the output layer).

Following is the manner in which these layers are laid

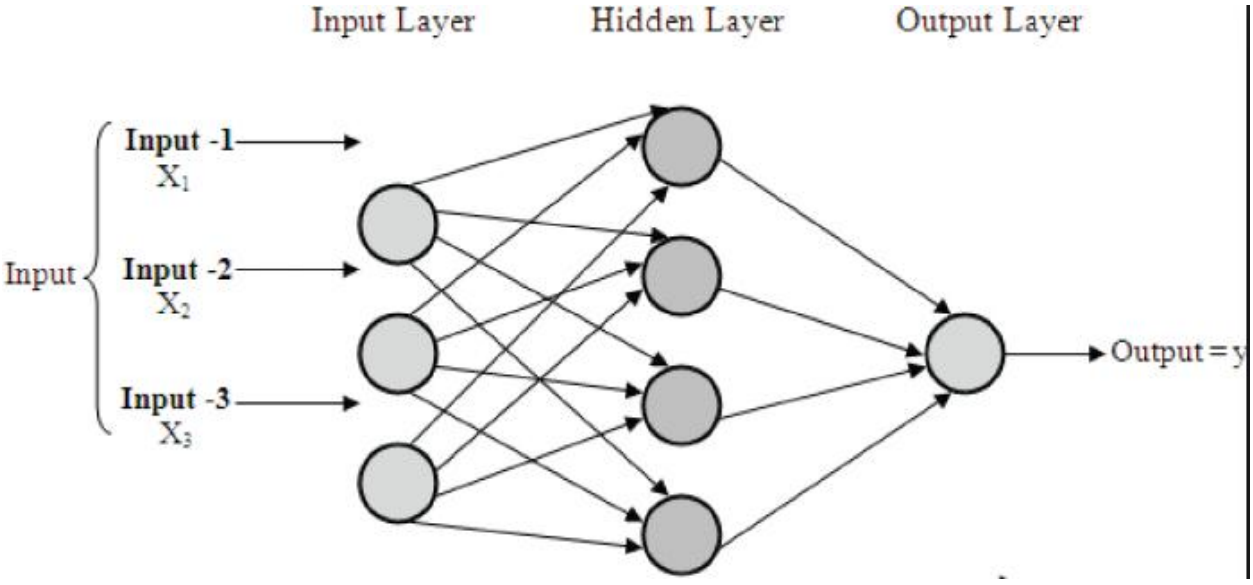



**Figure 1:** ANN basic diagram

**Input Layer:**

The Input layer communicates with the external environment that presents a pattern to the neural network. Its job is to deal with all the inputs only. This input gets transferred to the hidden layers which are explained below. The input layer should represent the condition for which we are training the neural

network. Every input neuron should represent some independent variable that has an influence over the output of the neural network

**Hidden Layer:**

The hidden layer is the collection of neurons which has activation function applied on it and it is an intermediate layer found between the input layer and the output layer. Its job is to process the inputs obtained by its previous layer. So it is the layer which is responsible extracting the required features from the input data. Many researches has been made in evaluating the number of neurons in the hidden layer but still none of them was successful in finding the accurate result. Also there can be multiple hidden layers in a Neural Network. So you must be thinking that how many hidden layers have to be used for which kind of problem. Suppose that if we have a data which can be separated linearly, then there is no need to use hidden layer as the activation function can be implemented to input layer which can solve the problem. But in case of problems which deals with complex decisions, we can use 3 to 5 hidden layers based on the degree of complexity of the problem or the degree of accuracy required. That certainly not means that if we keep on increasing the number of layers, the neural network will give high accuracy! A stage comes when the accuracy becomes constant or falls if we add an extra layer! Also, we should also calculate the number of neurons in each network. If the number of neurons are less as compared to the complexity of the problem data then there will be very few neurons in the hidden layers to adequately detect the signals in a complicated data set. If unnecessary more neurons are present in the network then Over fitting may occur. Several methods are used till now which do not provide the exact formula for calculating the number of hidden layer as well as number of neurons in each hidden layer.

**Output Layer:**

The output layer of the neural network collects and transmits the information accordingly in way it has been designed to give. The pattern presented by the output layer can be directly traced back to the input layer. The number of neurons in output layer should be directly related to the type of work that the neural network was performing. To determine the number of neurons in the output layer, first consider the intended use of the neural network.

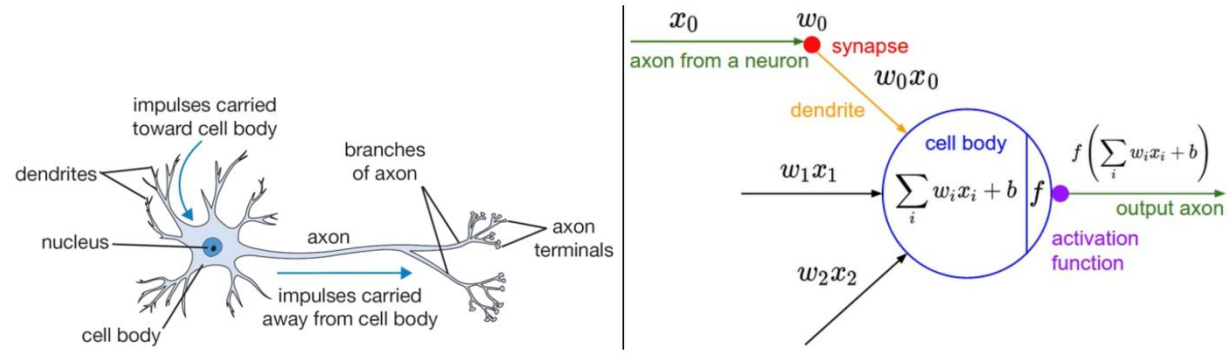
**Activation Function:**

So what does an artificial neuron do? Simply put, it calculates a "weighted sum" of its input, adds a bias and then decides whether it should be "fired" or not (yeah right, an activation function does this, but let's go with the flow for a moment).
So consider a neuron.

$$Y = \sum (weight * input) + bias$$

Now, the value of Y can be anything ranging from -inf to +inf. The neuron really doesn't know the bounds of the value. So how do we decide whether the neuron should fire or not (why this firing pattern? Because we learnt it from biology that's the way brain works and brain is a working testimony of an awesome and intelligent system).

We decided to add "activation functions" for this purpose. To check the Y value produced by a neuron and decide whether outside connections should consider this neuron as "fired" or not. Or rather let's say—"activated" or not.




A cartoon drawing of a biological neuron (left) and its mathematical model (right).

**Figure 2:** Comparison of Neural network with Artificial Neural network

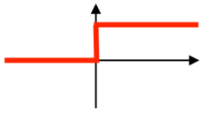
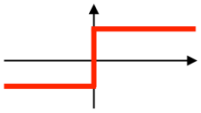
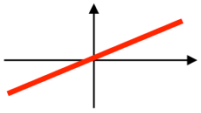
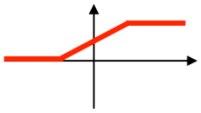
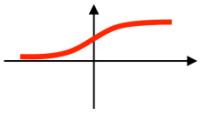
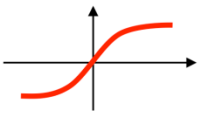
| Activation function | Equation | Example | 1D Graph |
|---|---|---|---|
| Unit step (Heaviside) | $\phi(z) = \begin{cases} 0, & z \leq 0, \\ 1, & z > 0, \end{cases}$ | Perceptron variant |  |
| Sign (Signum) | $\phi(z) = \begin{cases} -1, & z \leq 0, \\ 1, & z > 0, \end{cases}$ | Perceptron variant |  |
| Linear | $\phi(z) = z$ | Adaline, linear regression |  |
| Piece-wise linear | $\phi(z) = \begin{cases} 1, & z \geq \frac{1}{2}, \\ z + \frac{1}{2}, & -\frac{1}{2} < z < \frac{1}{2}, \\ 0, & z \leq -\frac{1}{2}, \end{cases}$ | Support vector machine |  |
| Logistic (sigmoid) | $\phi(z) = \frac{1}{1 + e^{-z}}$ | Logistic regression, Multi-layer NN |  |
| Hyperbolic tangent | $\phi(z) = \frac{e^{z} - e^{-z}}{e^{z} + e^{-z}}$ | Multi-layer NN |  |

**Figure 3:** Different type of Activation function

## Lab Activity

### Procedure:

- Typed nndtoc in command prompt.
  >>nndtoc

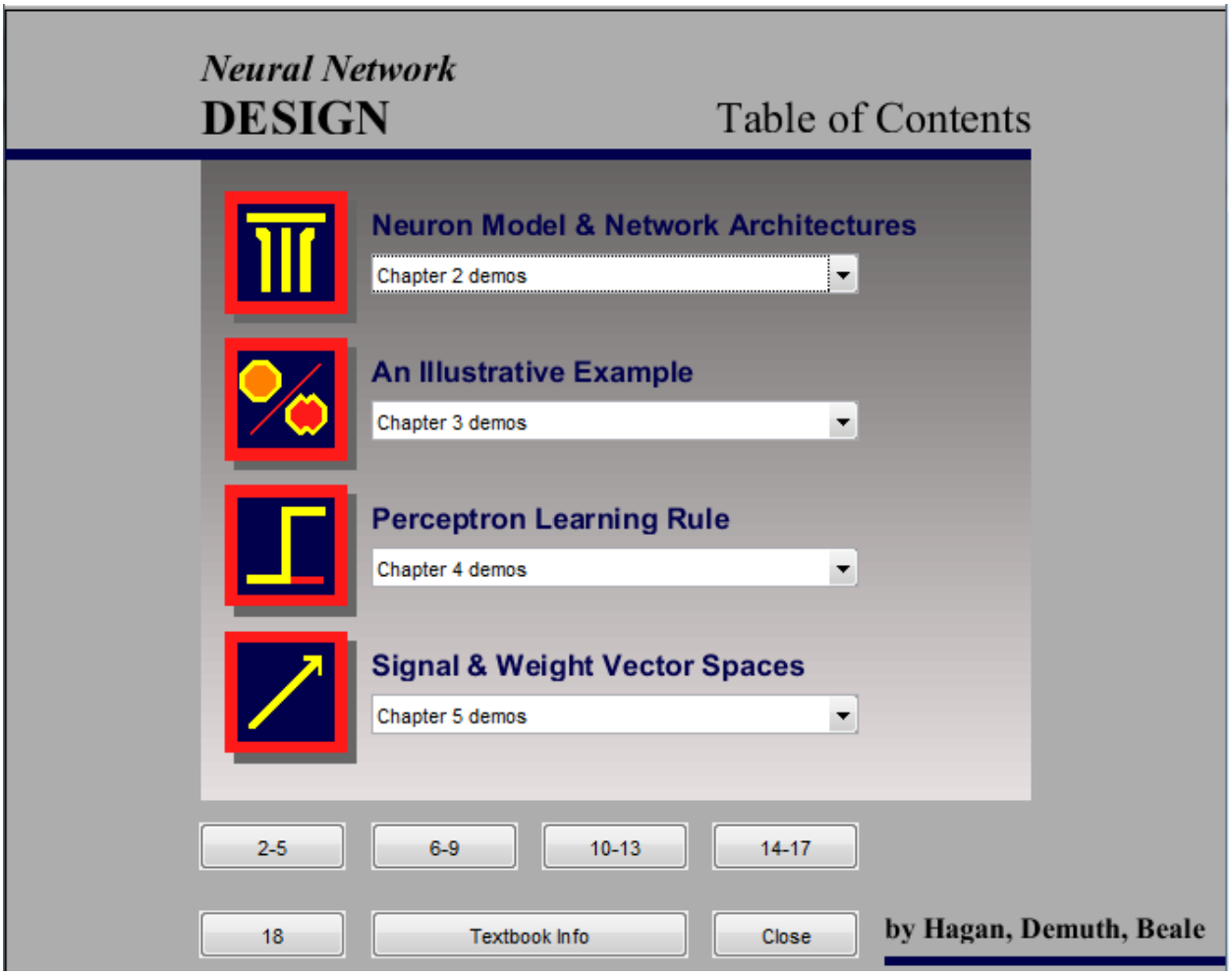
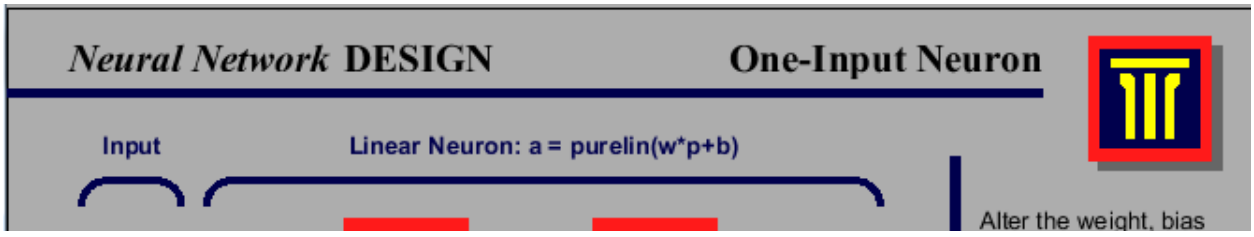



**Figure 4:** Neural network design window

- Then clicked on one-input neuron from Chapter 2 demos.



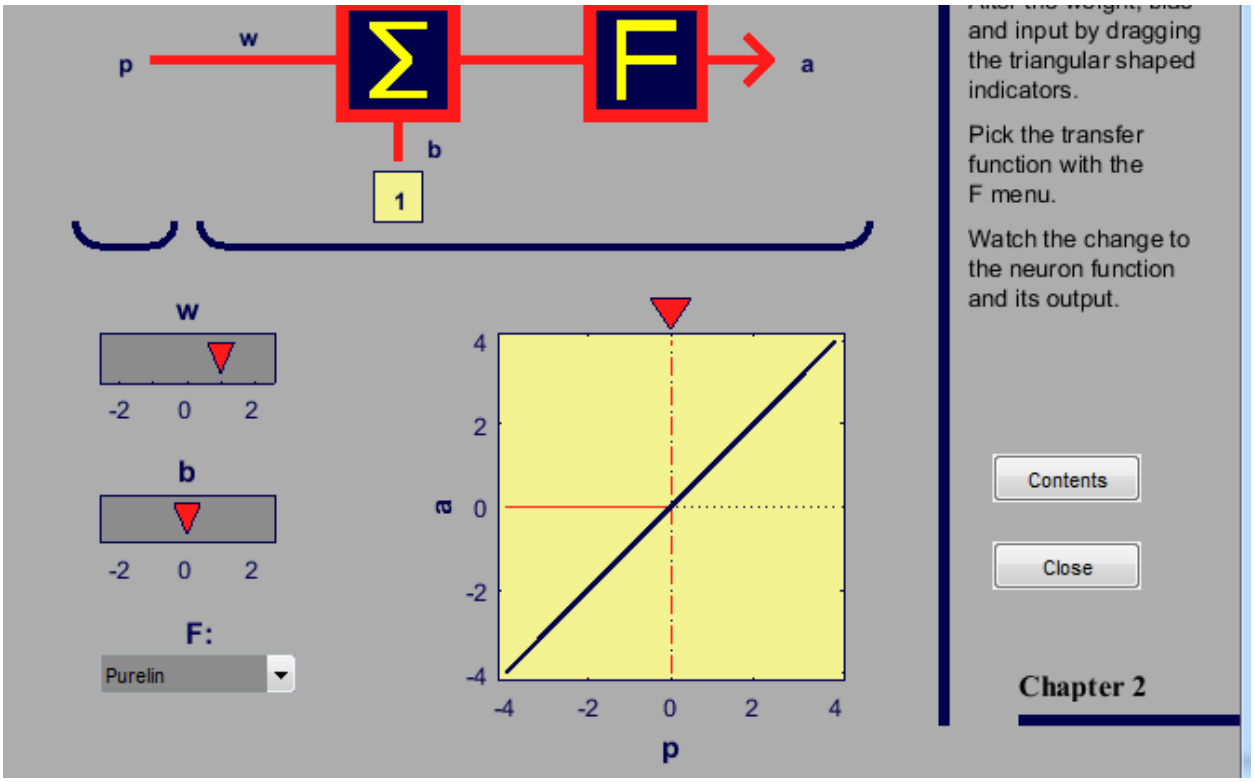



**Figure 5:** One-input neuron

## Results:

- Changed the input's weight ≅ 0 and bias weight ≅ 2 with activation function (A.F) Purelin (linear).

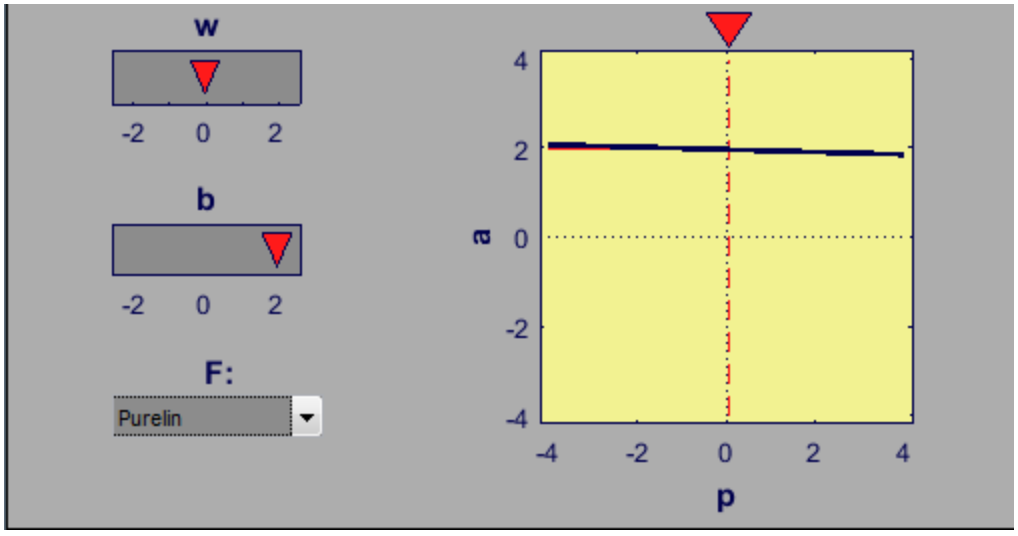



**Figure 6:** One-input neuron, Purelim A.F

- Changed the activation function, Hardlim (Binary).

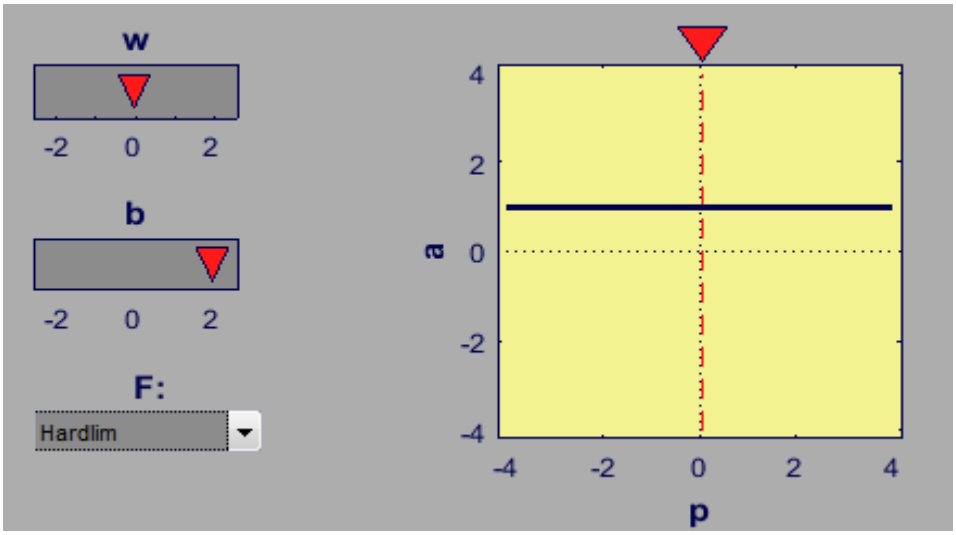



**Figure 7:** One-input neuron, Hardlim A.F

- Replaced the Hardlim with logsig (sigmoid) A.F.

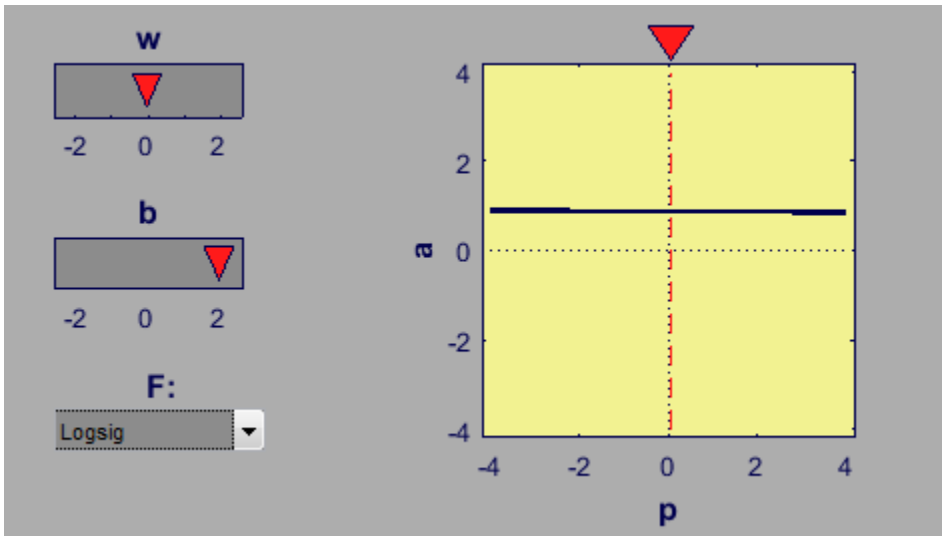



**Figure 7:** One-input neuron, logsi A.F

- Replaced the logsig with Hardlims (Bipolar) A.F. Changed the input's weight.

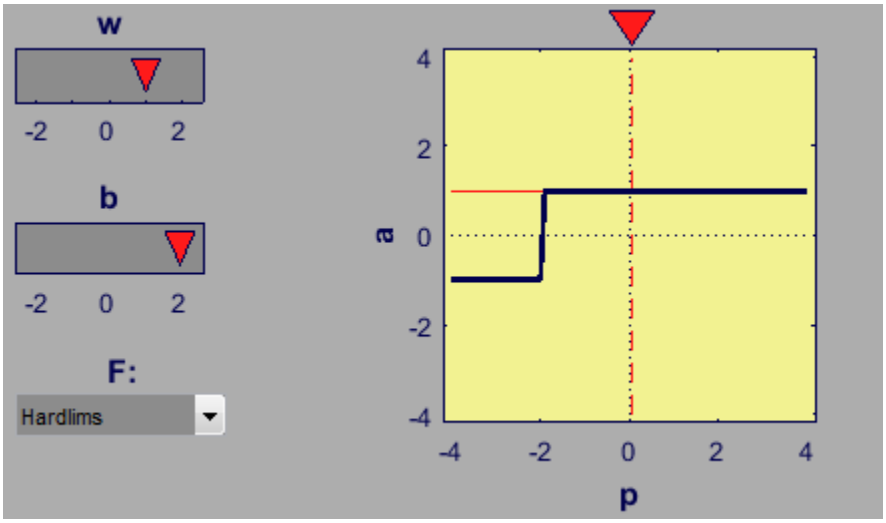



**Figure 8:** One-input neuron, Hardlims A.F

- Same procedure for two-input neurons.

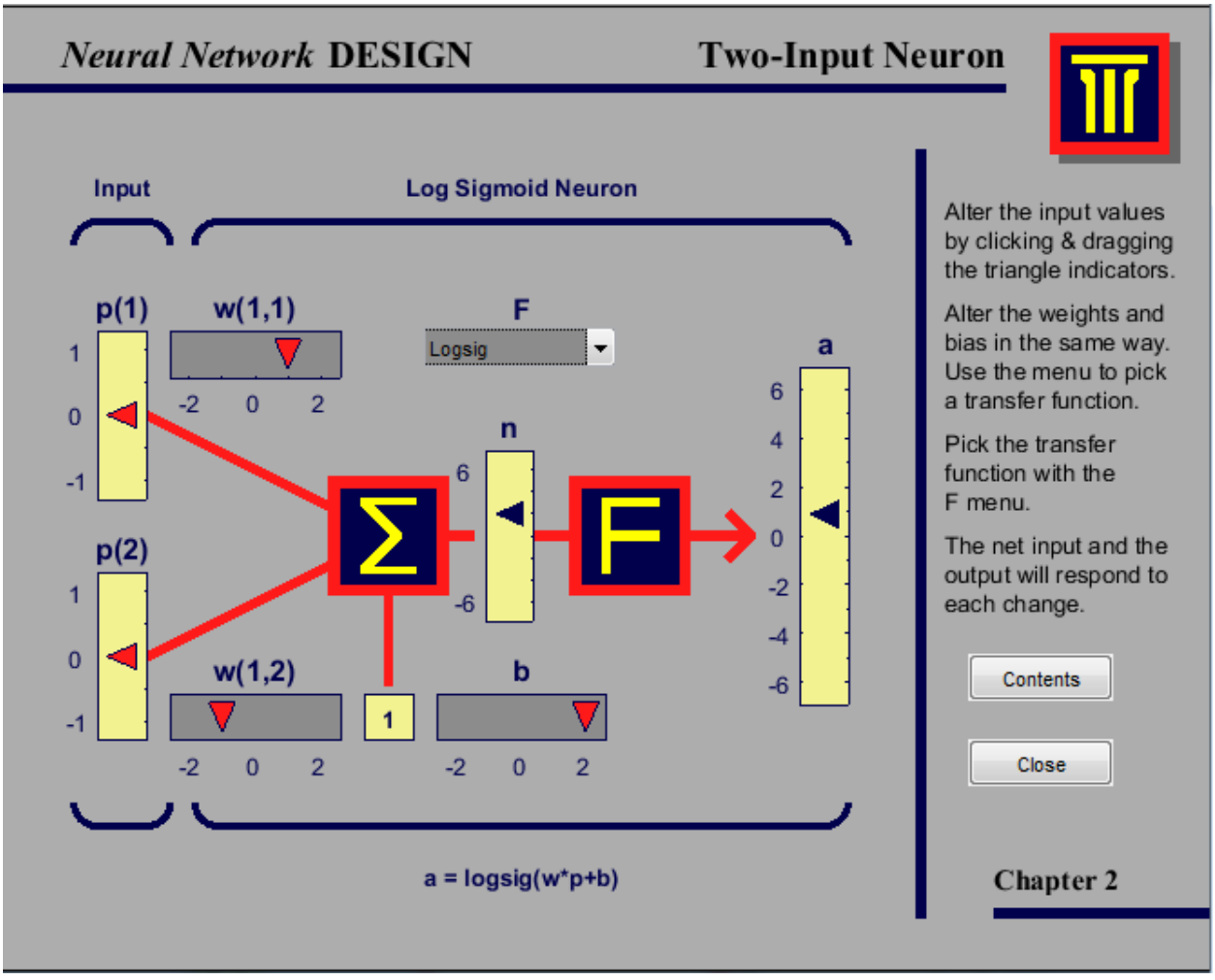



**Figure 9:** Two-input neuron, logsig A.F

# Lab # 9

## Objectives:

Create Artificial Neural Networks in MATLAB

## Introduction:

An Artificial Neuron Network (ANN), popularly known as Neural Network is a computational model based on the structure and functions of biological neural networks. It is like an artificial human nervous system for receiving, processing, and transmitting information in terms of Computer Science.

Basically, there are 3 different layers in a neural network:-

1. **Input Layer** (All the inputs are fed in the model through this layer).
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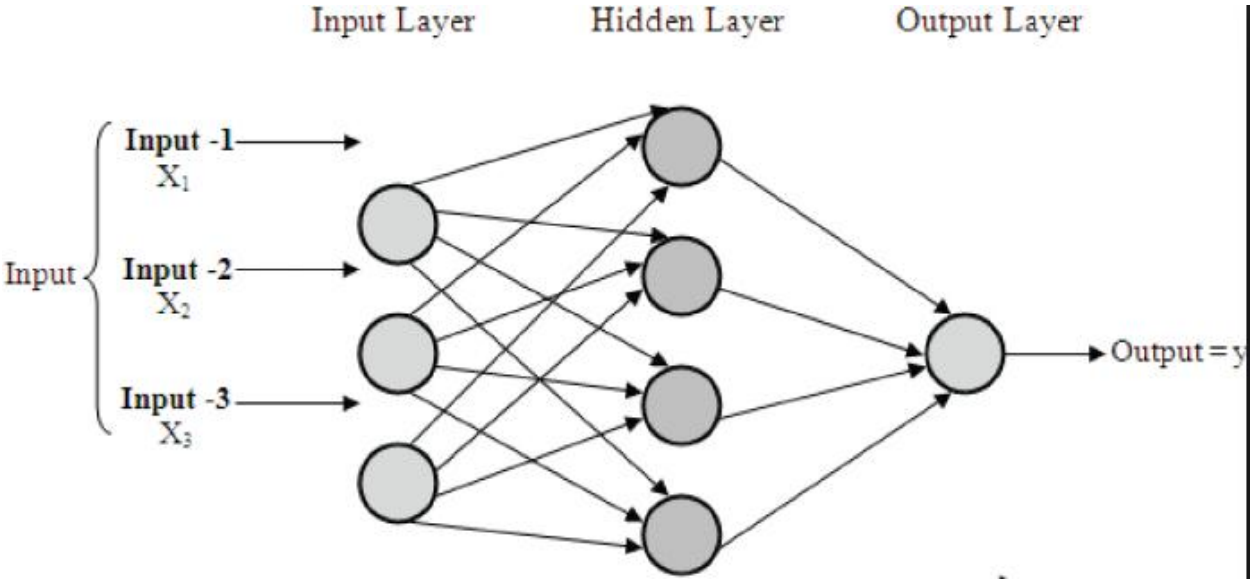


**Figure 1:** ANN basic diagram

**Input Layer:**

The Input layer communicates with the external environment that presents a pattern to the neural network. Its job is to deal with all the inputs only. This input gets transferred to the hidden layers which are explained below. The input layer should represent the condition for which we are training the neural

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**Activation Function:**

So what does an artificial neuron do? Simply put, it calculates a "weighted sum" of its input, adds a bias and then decides whether it should be "fired" or not (yeah right, an activation function does this, but let's go with the flow for a moment).
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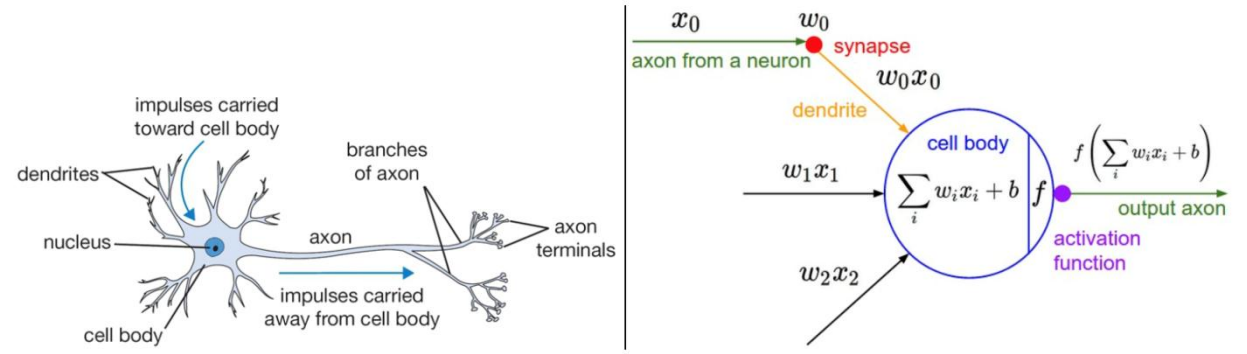


A cartoon drawing of a biological neuron (left) and its mathematical model (right).

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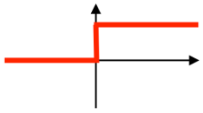
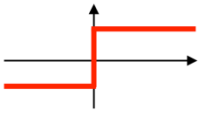
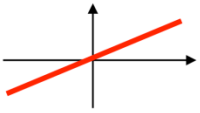
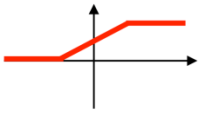
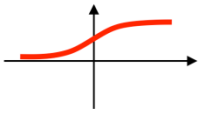
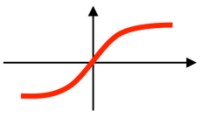
| Unit step (Heaviside) | $\phi(z) = \begin{cases} 0, & z \leq 0, \\ 1, & z > 0, \end{cases}$ | Perceptron variant |  |
| Sign (Signum) | $\phi(z) = \begin{cases} -1, & z \leq 0, \\ 1, & z > 0, \end{cases}$ | Perceptron variant |  |
| Linear | $\phi(z) = z$ | Adaline, linear regression |  |
| Piece-wise linear | $\phi(z) = \begin{cases} 1, & z \geq \frac{1}{2}, \\ z + \frac{1}{2}, & -\frac{1}{2} < z < \frac{1}{2}, \\ 0, & z \leq -\frac{1}{2}, \end{cases}$ | Support vector machine |  |
| Logistic (sigmoid) | $\phi(z) = \frac{1}{1 + e^{-z}}$ | Logistic regression, Multi-layer NN |  |
| Hyperbolic tangent | $\phi(z) = \frac{e^{z} - e^{-z}}{e^{z} + e^{-z}}$ | Multi-layer NN |  |

**Figure 3:** Different type of Activation function

## Lab Activity

### Procedure:

- Typed network in command prompt.
  >>network

```
>> network

ans =

    Neural Network

              name: 'Custom Neural Network'
          userdata: (your custom info)

    dimensions:

         numInputs: 0
         numLayers: 0
        numOutputs: 0
    numInputDelays: 0
    numLayerDelays: 0
  numFeedbackDelays: 0
  numWeightElements: 0
        sampleTime: 1

    connections:

       biasConnect: []
      inputConnect: []
      layerConnect: []
     outputConnect: []

    subobjects:

            inputs: {0x1 cell array of 0 inputs}
            layers: {0x1 cell array of 0 layers}
           outputs: {1x0 cell array of 0 outputs}
            biases: {0x1 cell array of 0 biases}
      inputWeights: {0x0 cell array of 0 weights}
      layerWeights: {0x0 cell array of 0 weights}

    functions:
```

```
      adaptFcn: (none)
    adaptParam: (none)
      derivFcn: 'defaultderiv'
     divideFcn: (none)
   divideParam: (none)
    divideMode: 'sample'
       initFcn: 'initlay'
    performFcn: 'mse'
  performParam: .regularization, .normalization
      plotFcns: {}
    plotParams: {1x0 cell array of 0 params}
      trainFcn: (none)
    trainParam: (none)

weight and bias values:

            IW: {0x0 cell} containing 0 input weight matrices
            LW: {0x0 cell} containing 0 layer weight matrices
             b: {0x1 cell} containing 0 bias vectors

methods:

         adapt: Learn while in continuous use
     configure: Configure inputs & outputs
        gensim: Generate Simulink model
          init: Initialize weights & biases
       perform: Calculate performance
           sim: Evaluate network outputs given inputs
         train: Train network with examples
          view: View diagram
   unconfigure: Unconfigure inputs & outputs

evaluate:       outputs = ans(inputs)
```

```
>> N = network (1,2,[1;1],[1;0],[0 0;1 0],[0 1]);
>> view (N)
```

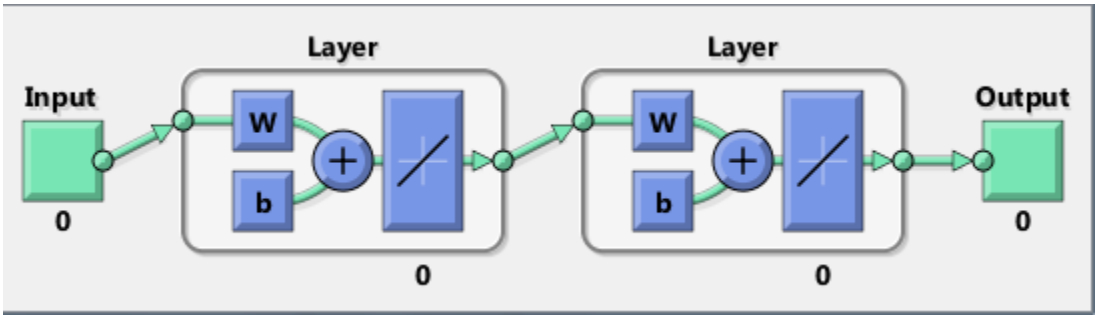



**Figure 4:** Neural network

**network (# of inputs, # of layers, bias connect, input connect, layer connect, output connect)**

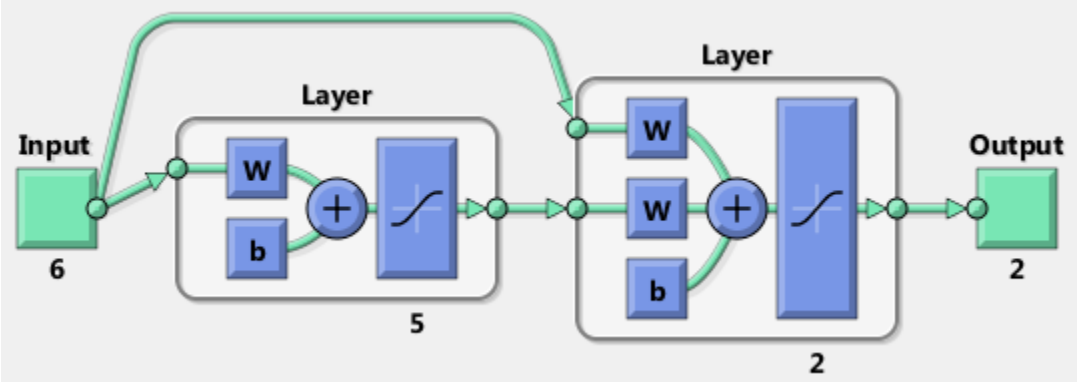
- **Bias Connect:** It is a Boolean vector.
- **Input Connect:** It is a Boolean matrix.
- **Layer Connect:** It is a Boolean matrix for 2 layers.
- **Output Connect:** It is a Boolean vector.

## Example solved by Sir

### M-file Code:

```
%%  lab task (Example given by Sir)
input=[1:6];
outputs=[1 2];
n=network(1,2,[1;1],[1;1],[0 0;1 0],[0 1]);
n.layers{1}.size=5;
n.layers{2}.size=7;
n.layers{1}.transferFcn='tansig';
n.layers{2}.transferFcn='tansig';
n=configure(n,input',outputs')
initialinput=n(input')
n.trainFcn='trainlm';
n.performFcn='mse';
n=train(n,input',outputs')
Final_output=n(input')
view(n)
```

### Results:



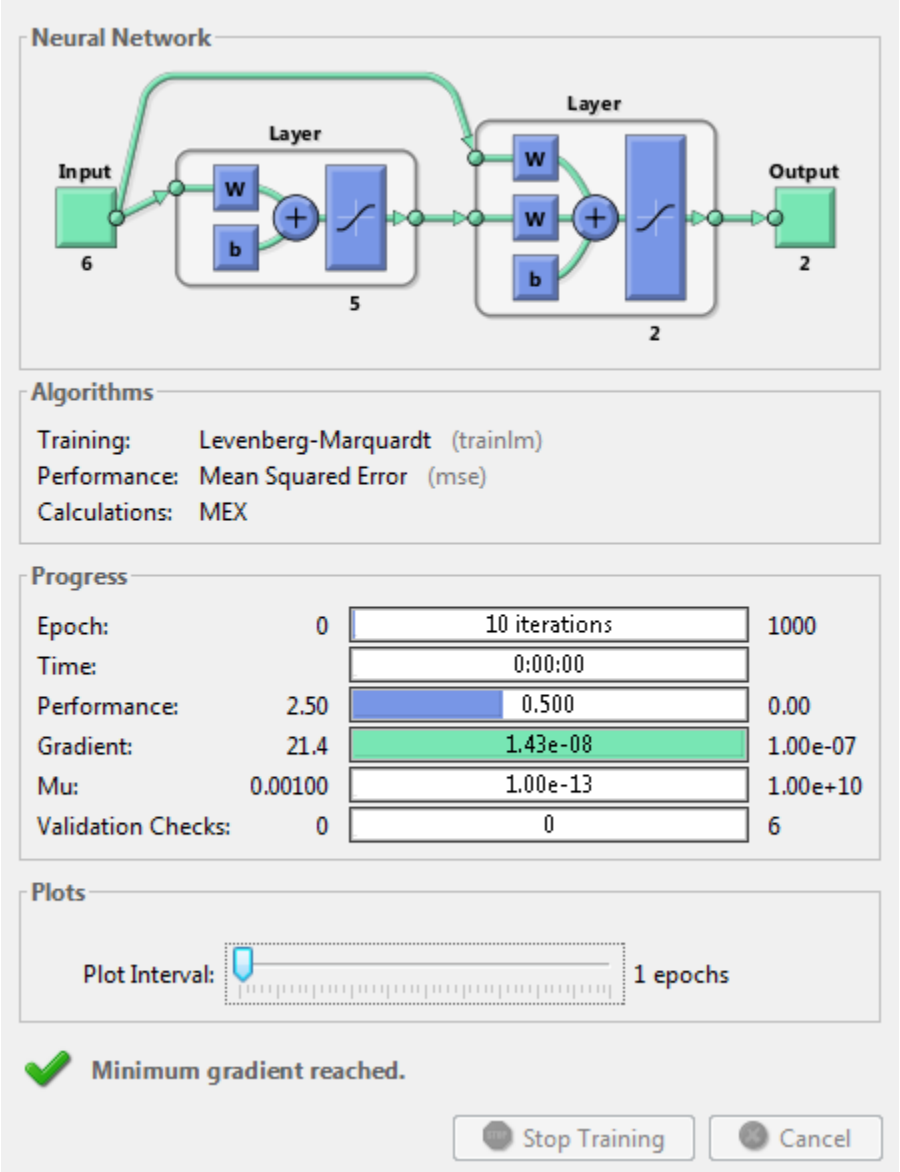



**Figure 5:** Output

# Lab # 10

## Objectives:

Neural Networks for patter classification

## Introduction:

One of the simplest tasks that neural nets can be trained to perform is pattern classification. In pattern classification problems, each input vector (pattern) belongs, or does not belong, to a particular class or category. For a neural net approach, we assume we have a set of training patterns for which the correct classification is known. The output unit represents membership in the class with a response of 1; a response of - 1 (or 0 if binary representation is used) indicates that the pattern is not a member of the class.2: Simple NN for Pattern Classification.

In pattern recognition problems, you want a neural network to classify inputs into a set of target categories.

For example, recognize the vineyard that a particular bottle of wine came from, based on chemical analysis (winw_dataset); or classify a tumor as benign or malignant, based on uniformity of cell size, clump thickness, mitosis (cancer_dataset).

The Neural Pattern Recognition app will help you select data, create and train a network, and evaluate its performance using cross-entropy and confusion matrices.

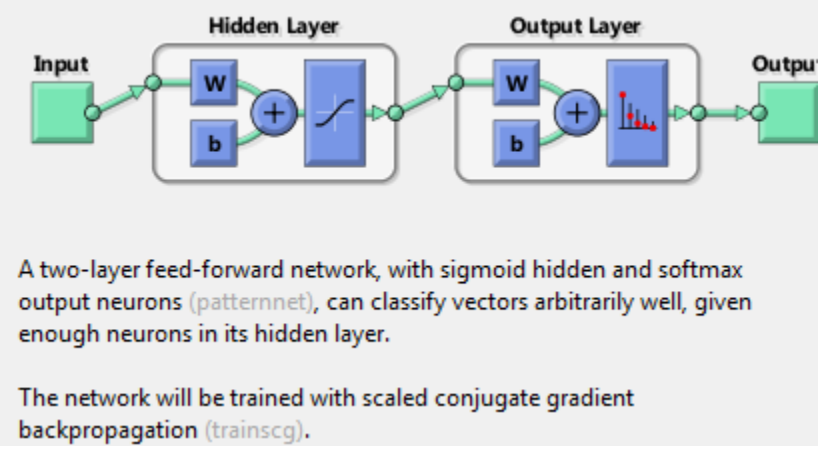



**Figure 1:** Neural network

## Lab Activity

### Procedure:

- Typed nnstart in command prompt.
  >> nnstart

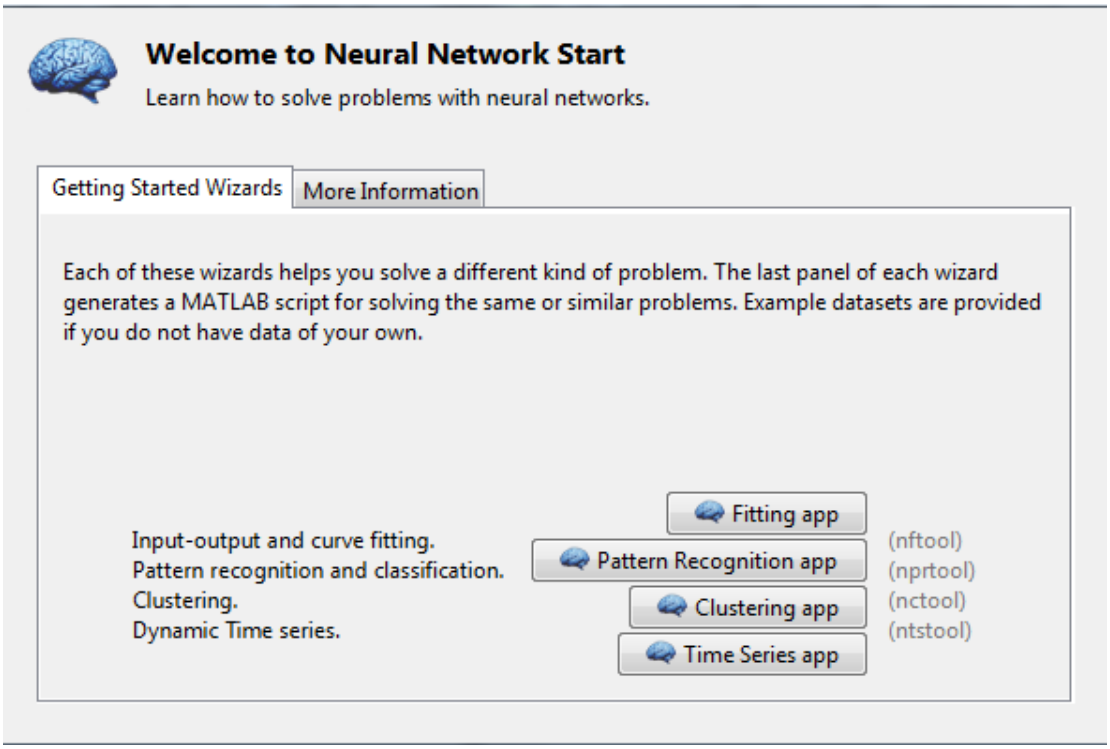



**Figure 2:** Neural network Start

- Then clicked on **Pattern Recognition app**, and clicked on **Next** button.

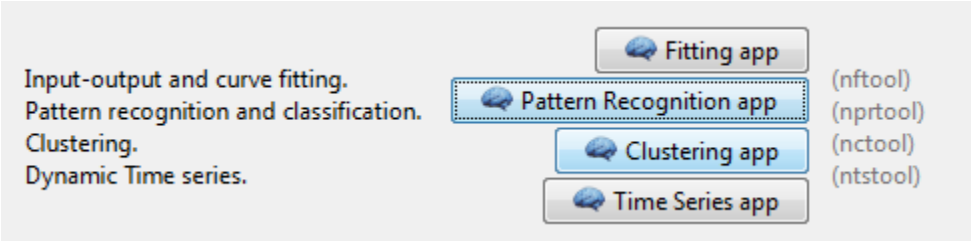



**Figure 3:** Step1


**Figure 4:** Step2

- Then clicked on **Load Example data set**.

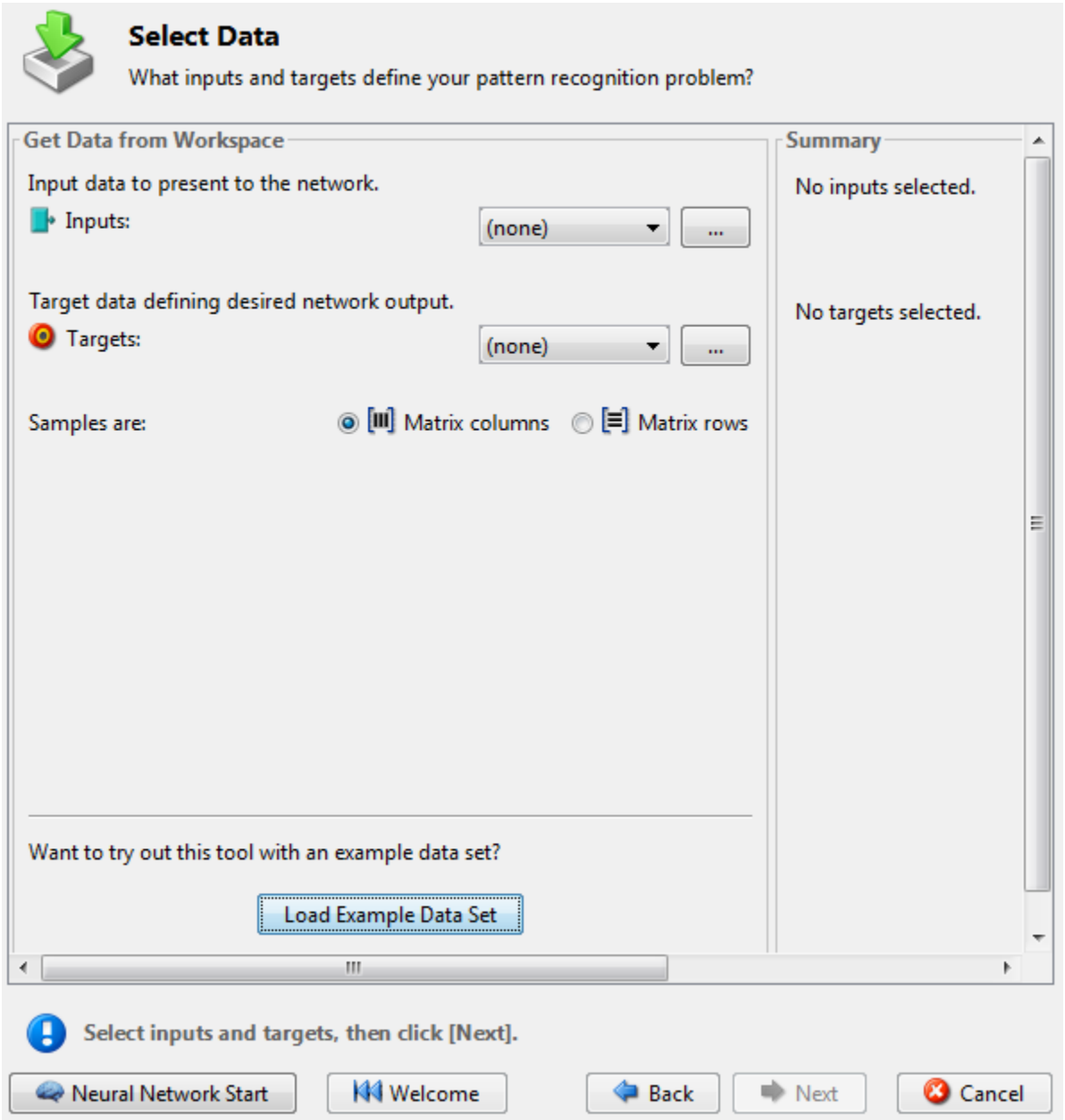



**Figure 5:** Step3

## Iris Flowers

LOAD iris_dataset. MAT loads these two variables:

irisInputs - a 4x150 matrix of four attributes of 1000 flowers.

1. Sepal length in cm
2. Sepal width in cm
3. Petal length in cm
4. Petal width in cm

irisTargets - a 3x150 matrix of 1000 associated class vectors defining which of four classes each input is assigned to. Classes are represented by a 1 in one of four rows, with zeros in the others.

[X,T] = iris_dataset loads the inputs and targets into variables of your own choosing.

- Once data is imported then clicked on **Next**.

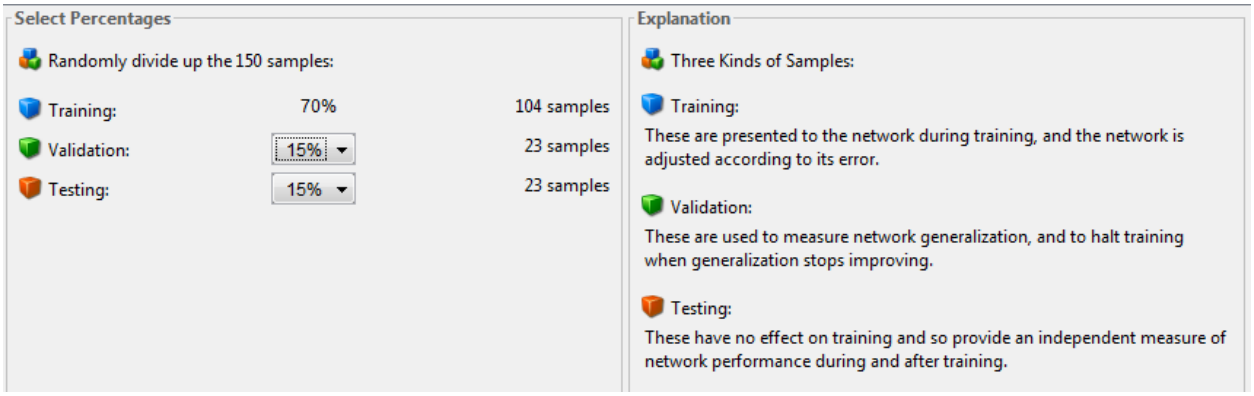



**Figure 6:** Select Parameters

- Training, validation and testing percentages selected then clicked on **Next**. Number of hidden layer was 10 then clicked on **Next.**
- Then trained the data.

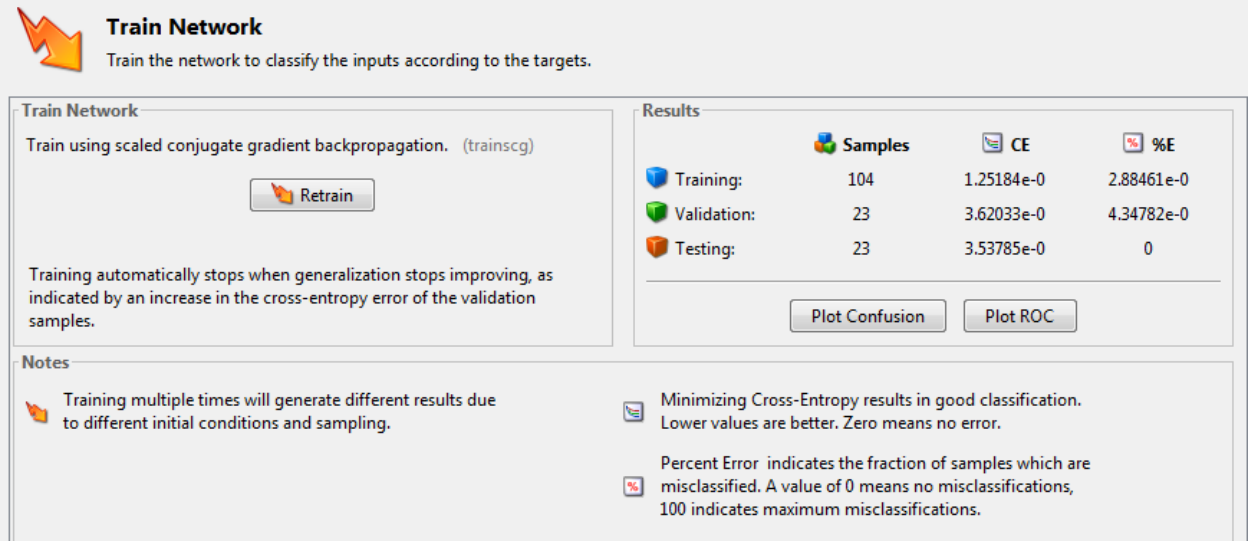



**Figure 7:** Train Network

## Results:

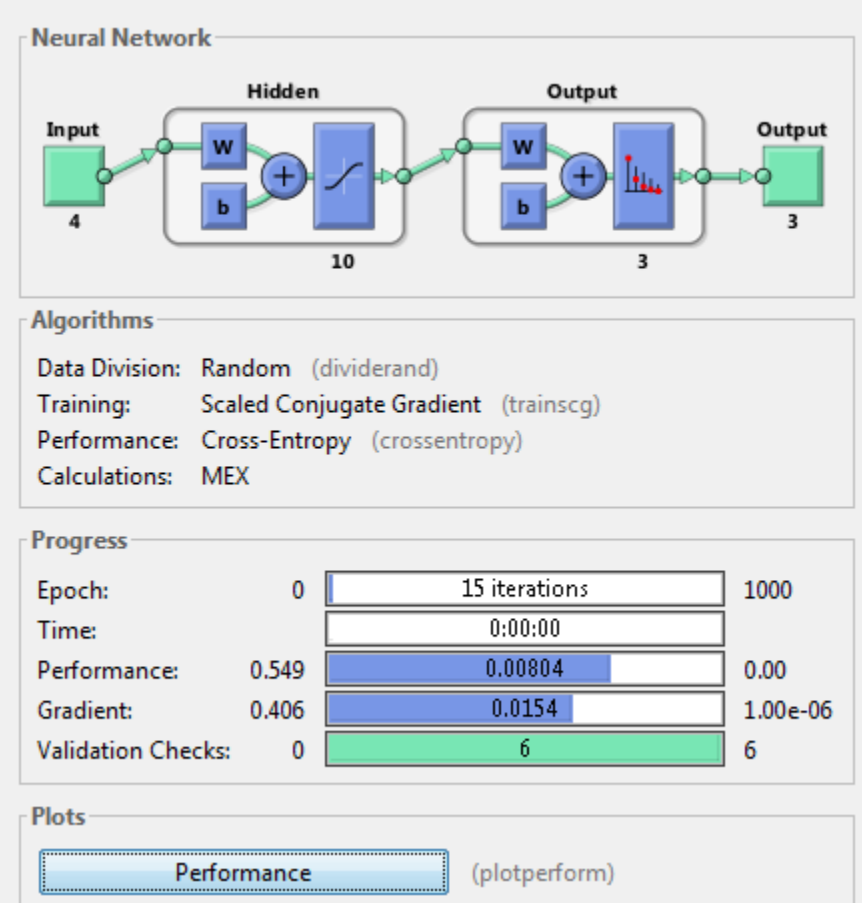



**Figure 8:** Iterations Result

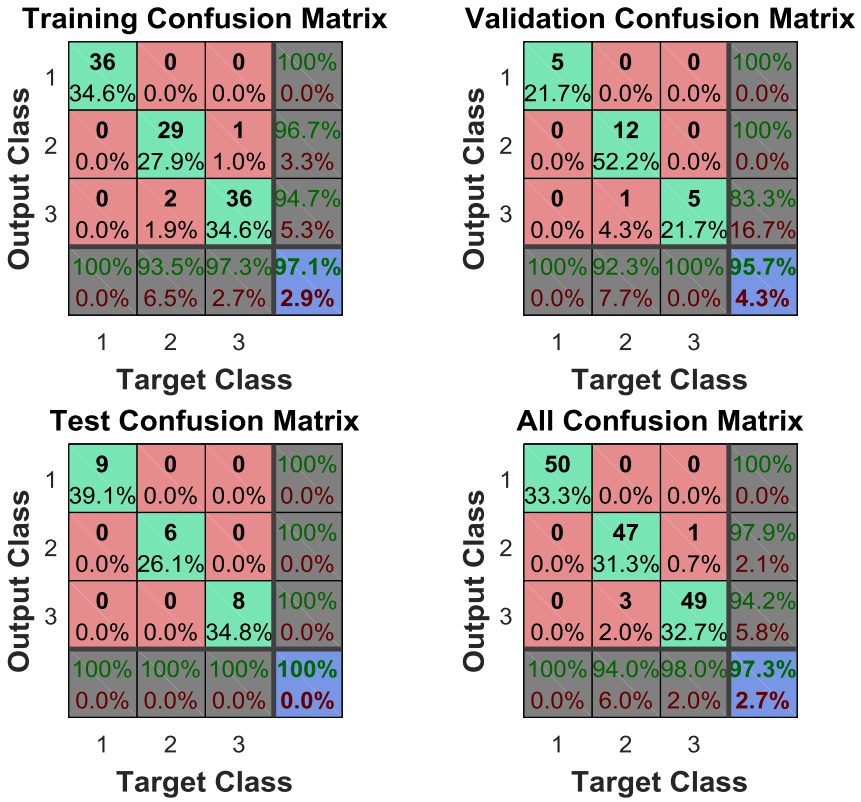



**Figure 9:** Plot Confusion

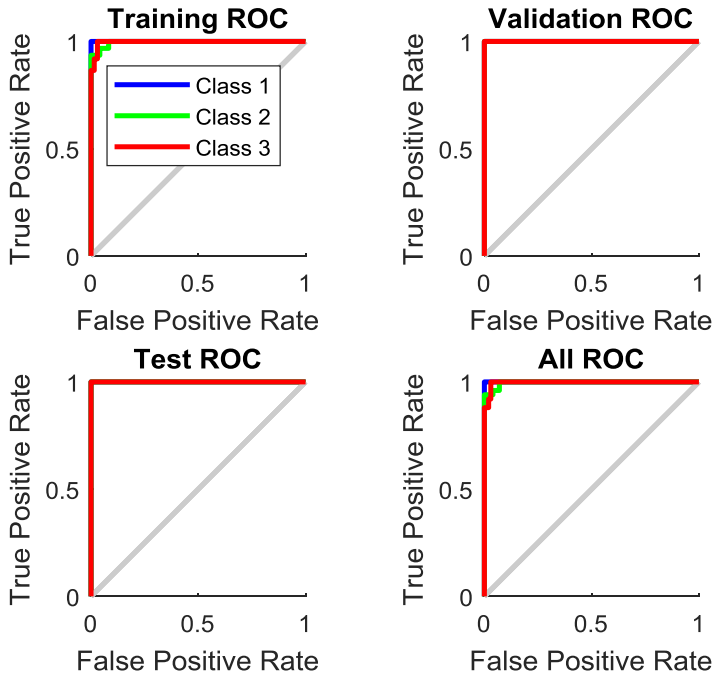



**Figure 10:** Plot ROC

## Breast Cancer

LOAD cancer_dataset.MAT loads these two variables:

cancerInputs - a 9x699 matrix defining nine attributes of 699 biopsies.

1. Clump thickness
2. Uniformity of cell size
3. Uniformity of cell shape
4. Marginal Adhesion
5. Single epithelial cell size
6. Bare nuclei
7. Bland chomatin
8. Normal nucleoli
9. Mitoses

cancerTargets - a 2x966 matrix where each column indicates a correct category with a one in either element 1 or element 2.

1. Benign
2. Malignant

[X,T] = cancer_dataset loads the inputs and targets into variables of your own choosing.

- Same procedure, as did before.

### Results:

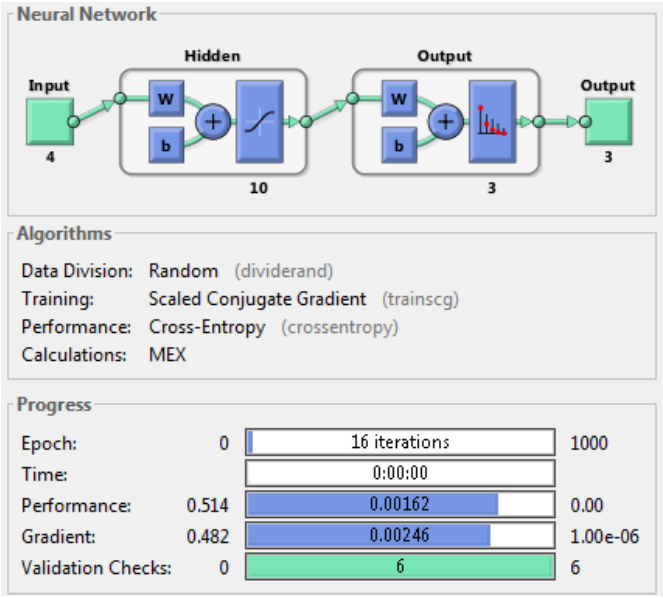



**Figure 11:** Iterations Result

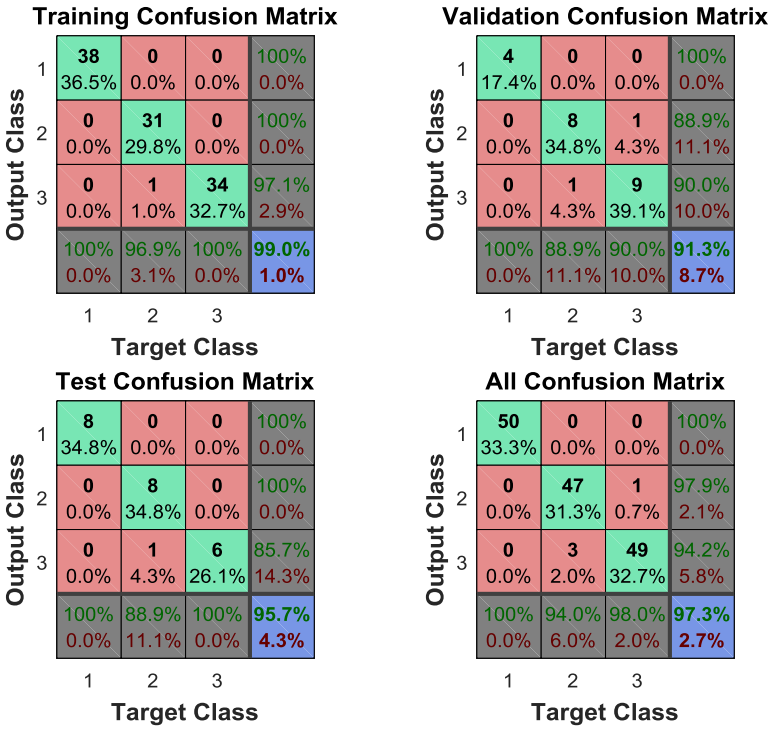



**Figure 12:** Plot Confusion

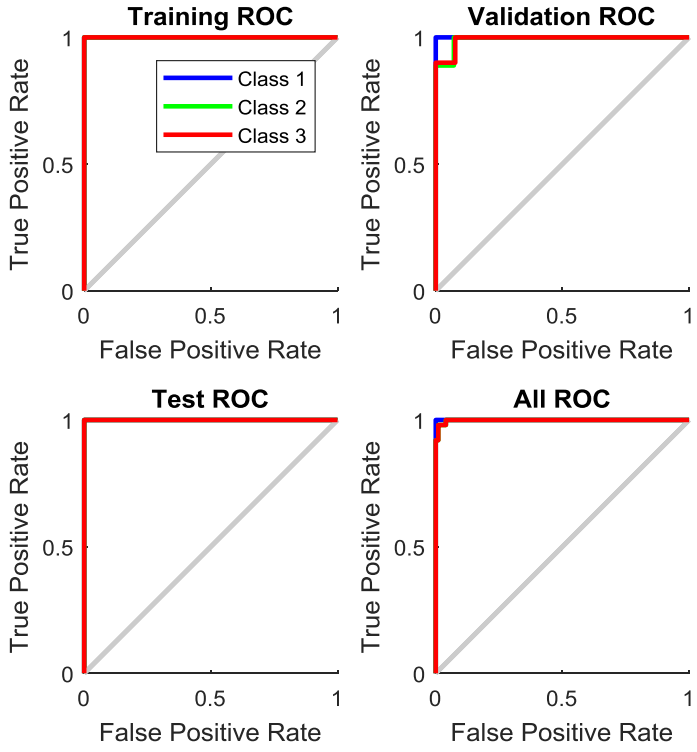



**Figure 13:** Plot ROC

# Lab # 11

## Objectives:

Implementing backpropagation algorithm in Neural Network

## Introduction:

An Artificial Neuron Network (ANN), popularly known as Neural Network is a computational model based on the structure and functions of biological neural networks. It is like an artificial human nervous system for receiving, processing, and transmitting information in terms of Computer Science.

Basically, there are 3 different layers in a neural network:-

1. **Input Layer** (All the inputs are fed in the model through this layer).
2. **Hidden Layers** (There can be more than one hidden layers which are used for processing the inputs received from the input layers).
3. **Output Layer** (The data after processing is made available at the output layer).

Following is the manner in which these layers are laid

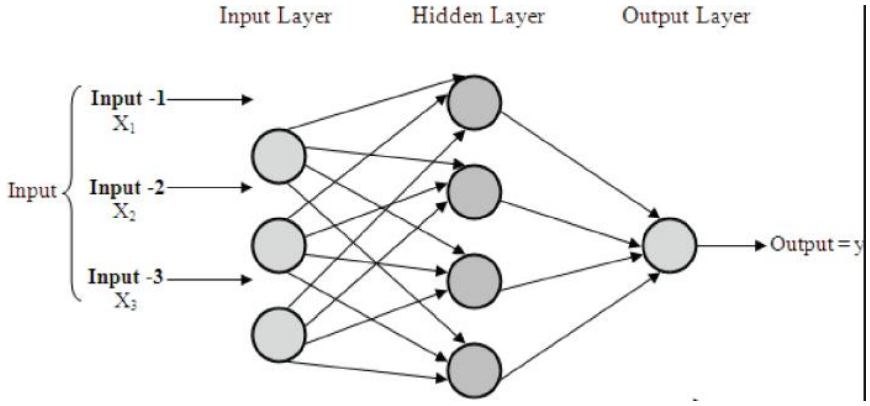



**Figure 1:** ANN basic diagram

**Activation Function:**

So what does an artificial neuron do? Simply put, it calculates a "weighted sum" of its input, adds a bias and then decides whether it should be "fired" or not (yeah right, an activation function does this, but let's go with the flow for a moment).
So consider a neuron.

$$Y = \sum (weight * input) + bias$$

Now, the value of Y can be anything ranging from -inf to +inf. The neuron really doesn't know the bounds of the value. So how do we decide whether the neuron should fire or not (why this firing pattern? Because

we learnt it from biology that's the way brain works and brain is a working testimony of an awesome and intelligent system).

We decided to add "activation functions" for this purpose. To check the Y value produced by a neuron and decide whether outside connections should consider this neuron as "fired" or not. Or rather let's say—"activated" or not.

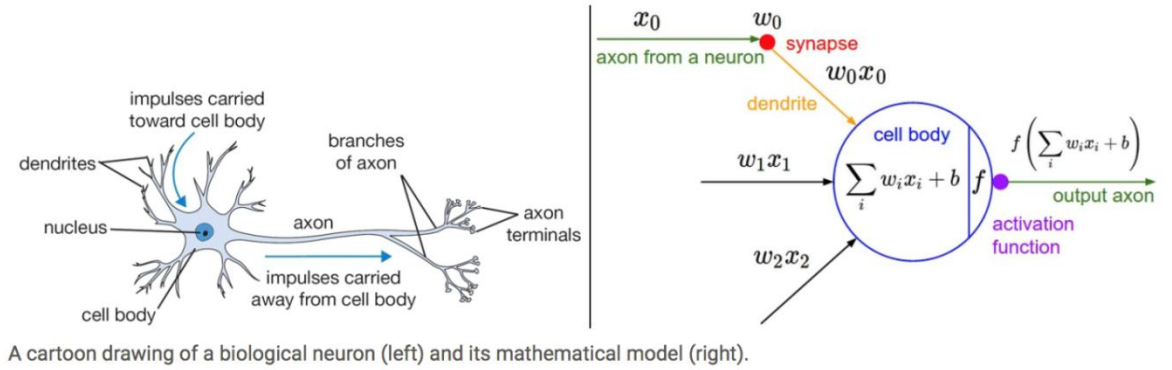



**Figure 2:** Comparison of Neural network with Artificial Neural network

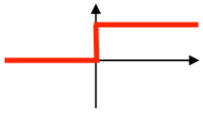
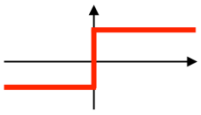
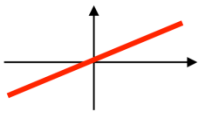
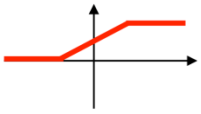
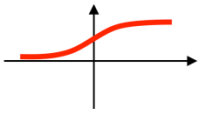
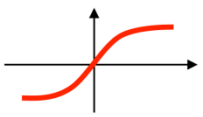
| Activation function | Equation | Example | 1D Graph |
|---|---|---|---|
| Unit step (Heaviside) | $\phi(z) = \begin{cases} 0, & z \leq 0, \\ 1, & z > 0, \end{cases}$ | Perceptron variant |  |
| Sign (Signum) | $\phi(z) = \begin{cases} -1, & z \leq 0, \\ 1, & z > 0, \end{cases}$ | Perceptron variant |  |
| Linear | $\phi(z) = z$ | Adaline, linear regression |  |
| Piece-wise linear | $\phi(z) = \begin{cases} 1, & z \geq \frac{1}{2}, \\ z + \frac{1}{2}, & -\frac{1}{2} < z < \frac{1}{2}, \\ 0, & z \leq -\frac{1}{2}, \end{cases}$ | Support vector machine |  |
| Logistic (sigmoid) | $\phi(z) = \frac{1}{1 + e^{-z}}$ | Logistic regression, Multi-layer NN |  |
| Hyperbolic tangent | $\phi(z) = \frac{e^{z} - e^{-z}}{e^{z} + e^{-z}}$ | Multi-layer NN |  |

**Figure 3:** Different type of Activation function

**Backpropagation:**

The Backpropagation algorithm looks for the minimum value of the error function in weight space using a technique called the delta rule or gradient descent. The weights that minimize the error function is then considered to be a solution to the learning problem.

**Why We Need Backpropagation?**

While designing a Neural Network, in the beginning, we initialize weights with some random values or any variable for that fact. Now obviously, we are not superhuman. So, it's not necessary that whatever weight values we have selected will be correct, or it fits our model the best.

Okay, fine, we have selected some weight values in the beginning, but our model output is way different than our actual output i.e. the error value is huge. Now, how will you reduce the error?

Basically, what we need to do, we need to somehow explain the model to change the parameters (weights), such that error becomes minimum. Let's put it in an another way, we need to train our model. One way to train our model is called as Backpropagation. Consider the diagram below:

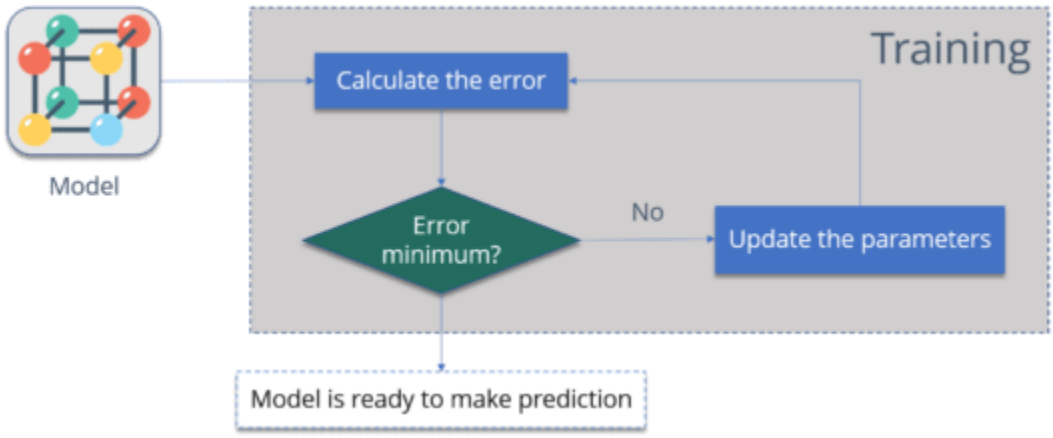



**Figure 4:** Backpropagation

Let me summarize the steps for you:

- **Calculate the error** – How far is your model output from the actual output.
- **Minimum Error** – Check whether the error is minimized or not.
- **Update the parameters** – If the error is huge then, update the parameters (weights and biases). After that again check the error. Repeat the process until the error becomes minimum.
- **Model is ready to make a prediction** – Once the error becomes minimum, you can feed some inputs to your model and it will produce the output.

## Lab Activity

### M-file Code:

```
%% Data from User:
%% Inputs, Weights, target, learning rate.
%% let our target =0.9
x1=0.5;x2=0.7; T=0.9; eta=0.4;
w1=0.1;w2=-0.3;w3=0.4;w4=0.1;w5=0.6;w6=0.7;w7=-0.4;
w8=0.1;w9=0.2;w10=0.3;w11=0.4;w12=-0.1;w13=0.6;
%% Hidden Lyers
a=1*(w1)+x1*(w4)+x2*(w7); a= 1/(1+exp(-a))
b=1*(w2)+x1*(w5)+x2*(w8); b= 1/(1+exp(-b))
c=1*(w3)+x1*(w6)+x2*(w9); c= 1/(1+exp(-c))
%% Output
d=a*(w10)+b*(w11)+c*(w12)+1*(w13);d=1/(1+exp(-d))
                          %% Back Propegation
%% 1st step
w10_new=w10+eta*(T-d)*(d)*(1-d)*a
w11_new=w11+eta*(T-d)*(d)*(1-d)*b
w12_new=w12+eta*(T-d)*(d)*(1-d)*c
w13_new=w13+eta*(T-d)*(d)*(1-d)*1
%% 2nd step
w1_new=w1+eta*(w10*(T-d)*(d)*(1-d)*a*(1-a)*1)
w4_new=w4+eta*(w10*(T-d)*(d)*(1-d)*a*(1-a)*x1)
w7_new=w7+eta*(w10*(T-d)*(d)*(1-d)*a*(1-a)*x2)

w2_new=w2+eta*(w11*(T-d)*(d)*(1-d)*b*(1-b)*1)
w5_new=w5+eta*(w11*(T-d)*(d)*(1-d)*b*(1-b)*x1)
w8_new=w8+eta*(w11*(T-d)*(d)*(1-d)*b*(1-b)*x2)

w3_new=w3+eta*(w12*(T-d)*(d)*(1-d)*c*(1-c)*1)
w6_new=w6+eta*(w12*(T-d)*(d)*(1-d)*c*(1-c)*x1)
w9_new=w9+eta*(w12*(T-d)*(d)*(1-d)*c*(1-c)*x2)
%% Hidden Lyers
a_new=1*(w1_new)+x1*(w4_new)+x2*(w7_new); a_new= 1/(1+exp(-a_new))
b_new=1*(w2_new)+x1*(w5_new)+x2*(w8_new); b_new= 1/(1+exp(-b_new))
c_new=1*(w3_new)+x1*(w6_new)+x2*(w9_new); c_new= 1/(1+exp(-c_new))
%% Output
d_new=a_new*(w10_new)+b_new*(w11_new)+c_new*(w12_new)+1*(w13_new);d_new=1/(1+exp(-d_new))
```

### Output:

```
>> Back_propegation

a =

    0.4675


b =

    0.5175
```

```
c =

    0.7089


d =

    0.7061


w10_new =

    0.3075


w11_new =

    0.4083


w12_new =

   -0.0886

w13_new =

    0.6161


w1_new =

    0.1012


w4_new =

    0.1006


w7_new =

   -0.3992

w2_new =

   -0.2984
```

```
w5_new =

    0.6008


w8_new =

    0.1011


w3_new =

    0.3997


w6_new =

    0.6998


w9_new =

    0.1998

a_new =

    0.4681


b_new =

    0.5182


c_new =

    0.7088


d_new =

    0.7128
```

Comment:

As you see, our output improved by updating weights.

# Lab # 12

## Objectives:

Introduction to Genetic algorithm in MATLAB

## Introduction:

The genetic algorithm is a method for solving both constrained and unconstrained optimization problems that is based on natural selection, the process that drives biological evolution. The genetic algorithm repeatedly modifies a population of individual solutions. At each step, the genetic algorithm selects individuals at random from the current population to be parents and uses them to produce the children for the next generation. Over successive generations, the population "evolves" toward an optimal solution. You can apply the genetic algorithm to solve a variety of optimization problems that are not well suited for standard optimization algorithms, including problems in which the objective function is discontinuous, non-differentiable, stochastic, or highly nonlinear. The genetic algorithm can address problems of mixed integer programming, where some components are restricted to be integer-valued.

The genetic algorithm uses three main types of rules at each step to create the next generation from the current population:

- **Selection rules** select the individuals, called parents, that contribute to the population at the next generation.
- **Crossover rules** combine two parents to form children for the next generation.
- **Mutation rules** apply random changes to individual parents to form children.

The genetic algorithm differs from a classical, derivative-based, optimization algorithm in two main ways, as summarized in the following table.

| **Classical Algorithm** | **Genetic Algorithm** |
|---|---|
| Generates a single point at each iteration. The sequence of points approaches an optimal solution. | Generates a population of points at each iteration. The best point in the population approaches an optimal solution. |
| Selects the next point in the sequence by a deterministic computation. | Selects the next population by computation which uses random number generators. |

## M-file code:

Code attached at the end of this lab session.

## Results:

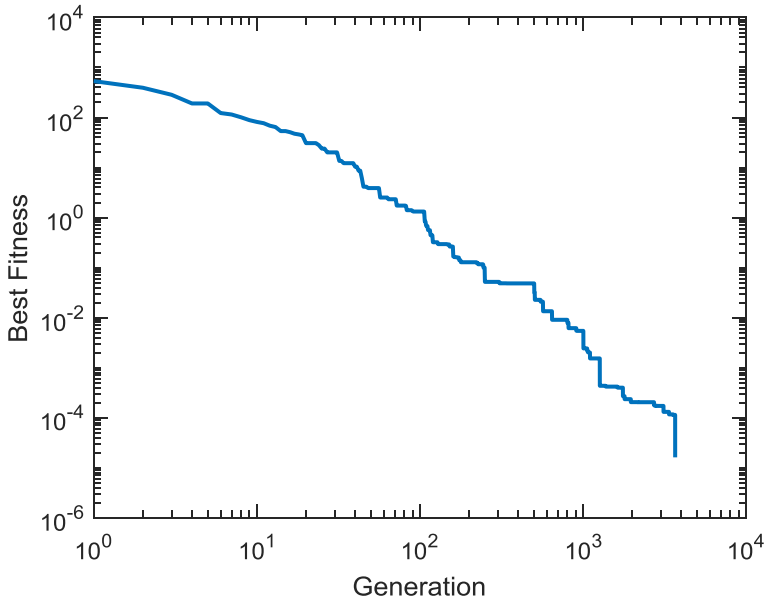



**Figure 1:** Cost function

- This showed the evolution of the cost function with respect to the generation.

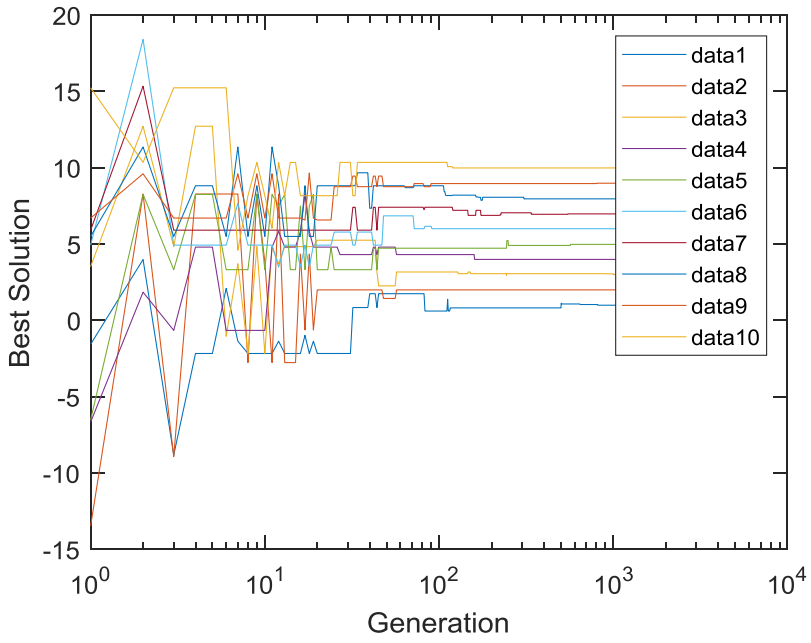



**Figure 2:** Output

- This showed the evolution of the elite (best solution) with respect to the generation.

```
clear; close all;

% Call my_ga to evolve
[best_fitness, elite, generation] = my_ga(10, 'my_fitness', 100, 50, 0.1, 10000, 1.0e-4);

% Decode according to the fitness function
best_solution = (2 * elite(1 : generation, :) - 1) * 20;

% Evolution of the best fitness:
figure
loglog(1 : generation, best_fitness(1 : generation), 'linewidth',2)
xlabel('Generation','fontsize',12);
ylabel('Best Fitness','fontsize',12);
set(gca,'fontsize',12,'ticklength',get(gca,'ticklength')*2);

% Evolution of the best solution:
figure
semilogx(1 : generation, best_solution)
xlabel('Generation','fontsize',12);
ylabel('Best Solution','fontsize',12);
set(gca,'fontsize',12,'ticklength',get(gca,'ticklength')*2);
```

```
function y = my_fitness(population)
% Get the population size and the number of variables:
[population_size, number_of_variables] = size(population);
% Assume each variable is within the range of [-20, 20].
population = (2 * population - 1) * 20;
% Assume the function to be minimized is y = (x1 - 1)^2 + (x2 - 2)^2 + ...
y = sum( (population - kron(ones(population_size, 1), 1 : number_of_variables)).^2, 2);
```

```
function [best_fitness, elite, generation] = my_ga(number_of_variables, fitness_function,↙
...
    population_size, parent_number, mutation_rate, maximal_generation, minimal_cost)
cumulative_probabilities = cumsum((parent_number:-1:1) / sum(parent_number:-1:1));
best_fitness = ones(maximal_generation, 1);
elite = zeros(maximal_generation, number_of_variables);
child_number = population_size - parent_number;
population = rand(population_size, number_of_variables); % values in [0, 1]
for generation = 1 : maximal_generation
    cost = feval(fitness_function, population);
    [cost, index] = sort(cost);
    population = population(index(1:parent_number), :);
    best_fitness(generation) = cost(1);
    elite(generation, :) = population(1, :);
    if best_fitness(generation) < minimal_cost; break; end
    for child = 1:2:child_number % crossover
        mother = min(find(cumulative_probabilities > rand));
        father = min(find(cumulative_probabilities > rand));
        crossover_point = ceil(rand*number_of_variables);
        mask1 = [ones(1, crossover_point), zeros(1, number_of_variables -↙
crossover_point)];
        mask2 = not(mask1);
        mother_1 = mask1 .* population(mother, :);
        mother_2 = mask2 .* population(mother, :);
        father_1 = mask1 .* population(father, :);
        father_2 = mask2 .* population(father, :);
        population(parent_number + child, :) = mother_1 + father_2;
        population(parent_number+child+1, :) = mother_2 + father_1;
    end
    % mutation
    mutation_population = population(2:population_size, :);
    number_of_elements = (population_size - 1) * number_of_variables;
    number_of_mutations = ceil(number_of_elements * mutation_rate);
    mutation_points = ceil(number_of_elements * rand(1, number_of_mutations));
    mutation_population(mutation_points) = rand(1, number_of_mutations);
    population(2:population_size, :) = mutation_population;
end
```