EXPERIMENT-1.1

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Branch: AI **Section: MAI-1**
Semester-2 **Date of Performance:**
Subject Name: Soft Computing Lab **Subject Code:24CSH-668**

AIM: To design and implement a fuzzy controller for a washing machine in MATLAB, simulating the decision-making process for determining the wash time and detergent level based on dirt level and load weight.

SOFTWARE USED: Online Matlab

Theory: A fuzzy logic controller (FLC) is a decision-making system that uses fuzzy logic to handle imprecise and uncertain data. Unlike classical logic, which operates on binary true/false conditions, fuzzy logic uses degrees of truth represented as membership functions.

Components of a Fuzzy Controller:

1. Fuzzification: Converts crisp inputs (numerical values) into fuzzy sets using membership functions.
2. Rule Base: Contains a set of "if-then" rules that define how input variables relate to output variables.
3. Inference Engine: Applies fuzzy rules to compute the fuzzy output.
4. Defuzzification: Converts fuzzy outputs back to crisp values for actionable outputs.

PROCEDURE FOR WASHING MACHINE:

Fuzzy logic controllers (FLCs) are designed to handle imprecise or vague data by mimicking human decision-making. They are particularly useful in systems where the relationships between inputs and outputs are not linear or are difficult to model mathematically.
In the context of a washing machine, the cleaning process depends on multiple factors, such as the dirt level and grease present in clothes. These factors can be modeled as inputs to a fuzzy controller, which determines the appropriate wash time based on predefined rules.

Key Components of Fuzzy Logic Control:

1. Fuzzification: Converts crisp inputs (numerical values like dirt percentage or grease level) into fuzzy sets using membership functions.
    - Example: Dirt level = 40% might partially belong to both Low and Medium categories.
2. Rule Base: A set of "if-then" rules, such as:
    - If Dirt is Low and Grease is Low, then Wash Time is Very Short.
    - If Dirt is High and Grease is High, then Wash Time is Very Large.
3. Inference Engine: Evaluates the fuzzy rules for given inputs and combines the results to generate fuzzy output values.
4. Defuzzification: Converts fuzzy output values into a single crisp value using methods such as centroid calculation

Application to Washing Machines:

Inputs:

- Dirt: Indicates how soiled the clothes are, ranging from Low to High.
- Grease: Indicates the grease level in clothes, ranging from Low to High.

Output:

- Wash Time: Represents the time required to wash the clothes, ranging from Very Short to Very Large (0 to 60 minutes).

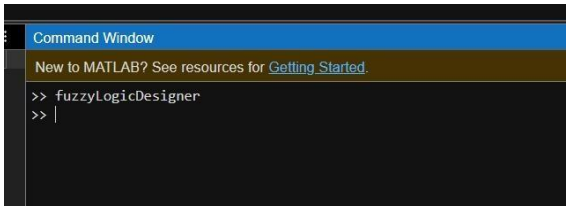
Membership Functions:

- Inputs:
  - Dirt: Low, Medium, High
  - Grease: Low, Medium, High
- Output:
  - Wash Time: Very Short, Short, Medium, Large, Very Large

Procedure:

1. **Define Input and Output Variables**:
   - Inputs: Dirt (0-100) and Grease (0-100).
   - Output: Wash Time (0-60).
2. **Define Membership Functions**:
   - Use triangular (trimf) or trapezoidal (trapmf) membership functions to represent linguistic variables for both inputs and the output.
3. **Define Fuzzy Rules**:
   - Create a set of logical rules to map inputs to the output.
   - Example Rules:
     - If Dirt is Low and Grease is Low, then Wash Time is Very Short.
     - If Dirt is High or Grease is High, then Wash Time is Very Large.
4. **Construct FIS in MATLAB**:
   - Use MATLAB's mamfis function to define the fuzzy inference system (FIS).
   - Add inputs, outputs, membership functions, and rules to the FIS.
5. **Simulate the Fuzzy Controller**:
   - Provide test input values for Dirt and Grease (e.g., Dirt = 70, Grease = 80).
   - Use the evalfis function to compute the output (Wash Time).
6. **Visualize Results**:
   - Plot membership functions for inputs and output.
   - Visualize the rule surface to understand how Dirt and Grease affect Wash Time

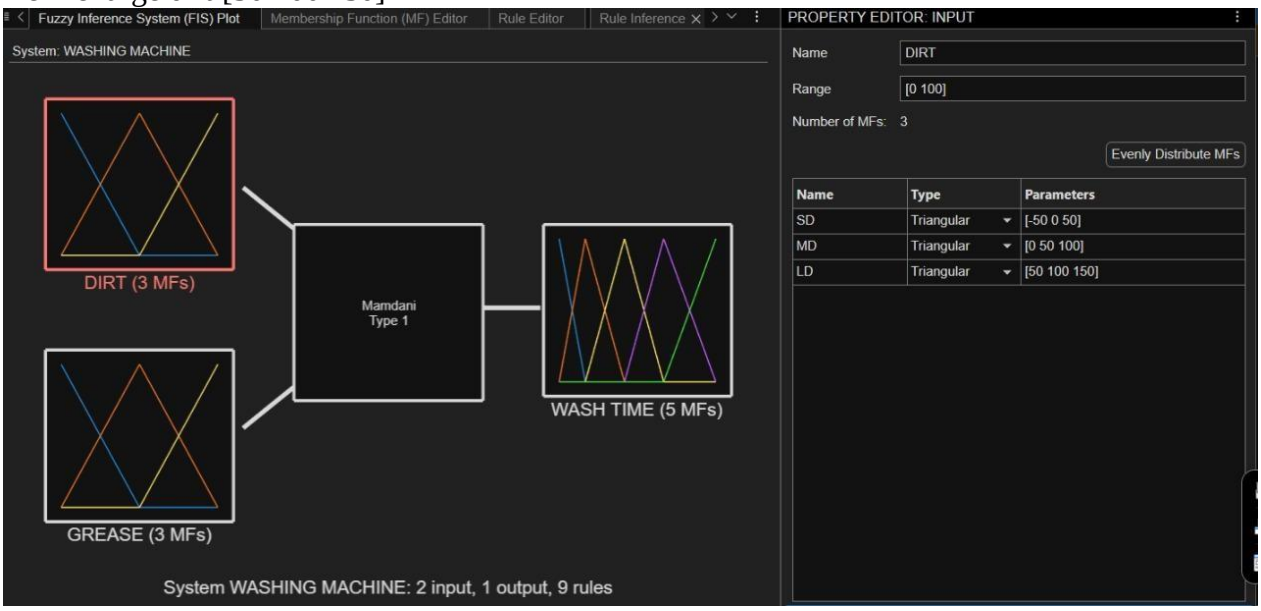
IMPLEMENTATION:



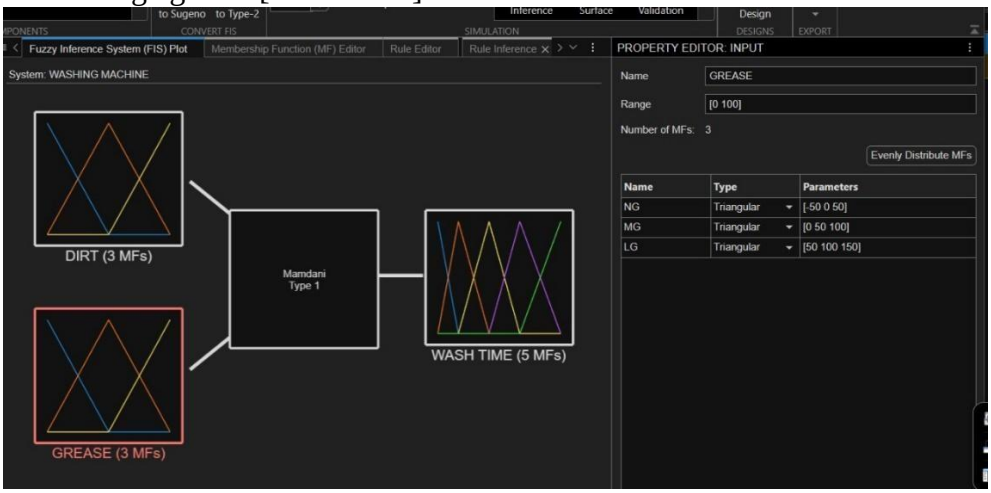
As shown above start with the command “fuzzyLogicDesigner”

NOW CHANGE INPUT NAMES TO DIRT AND GREASE
AND OUTPUT AS WASH TIME

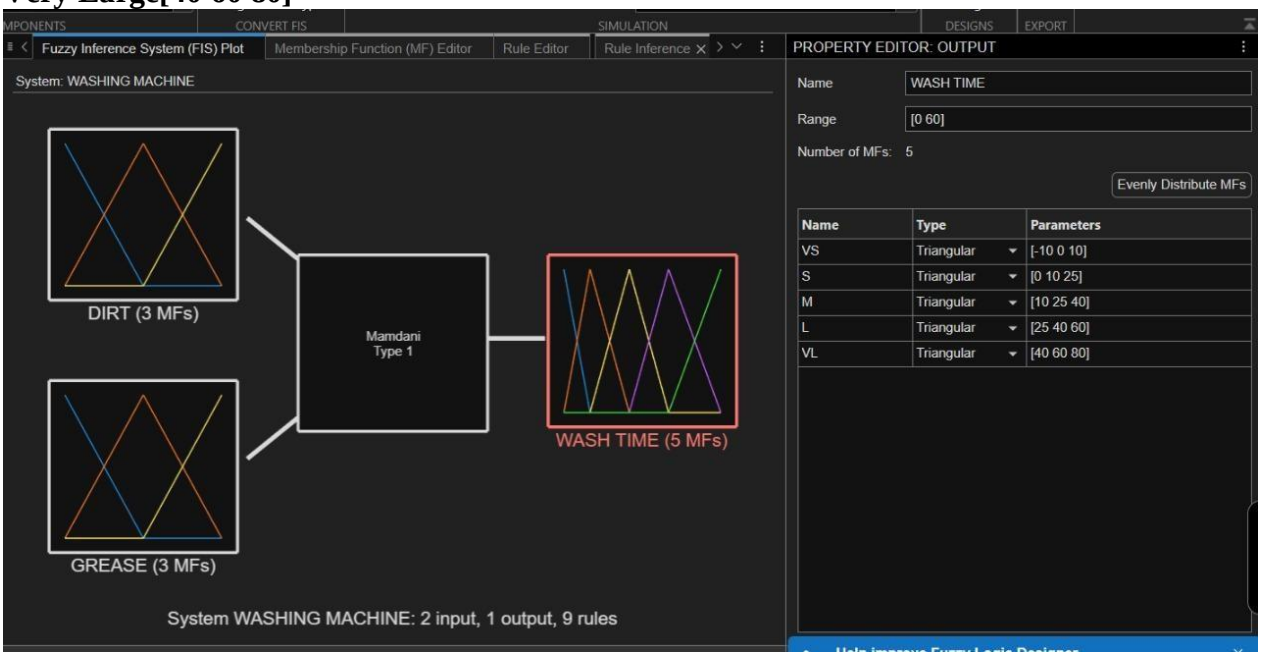
Put range of dirt between [0 100]
Define small dirt [-50 0 50]
Define medium dirt[0 50 100]
Define large dirt [50 100 150]



Put range of grease between [0 100]
Define no grease [-50 0 50]
Define medium grease[0 50 100]
Define large grease [50 100 150]



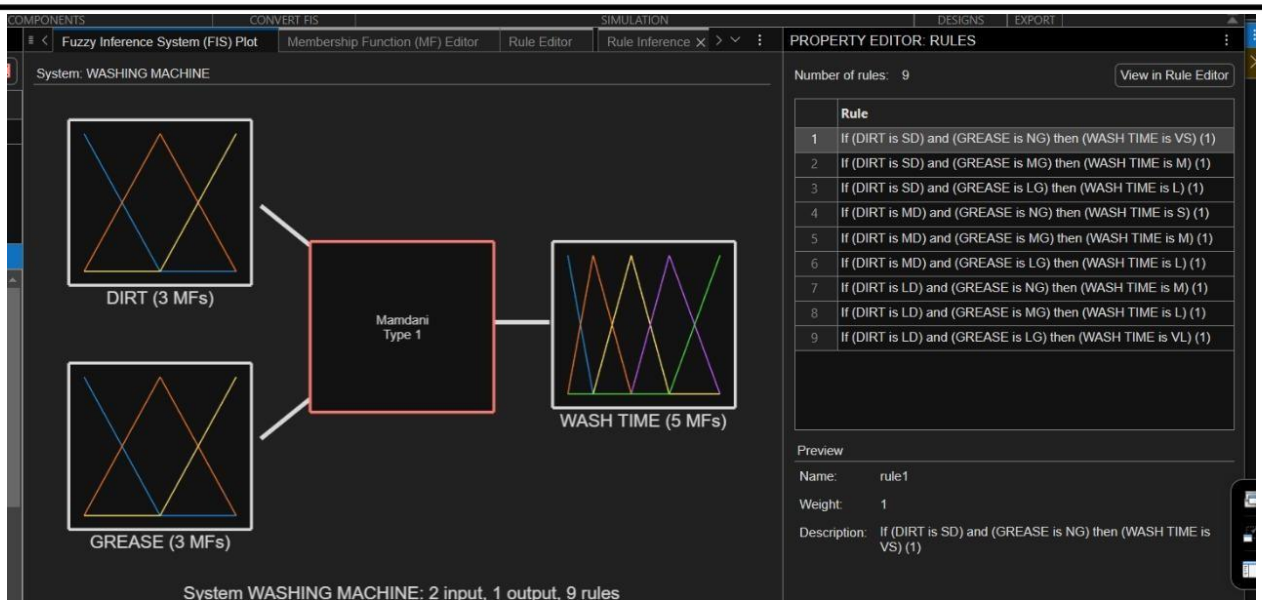
CHANGE MEMBERSHIP FUNCTIONS FOR WASH TIME AS SHOWN
Very small[10 0 100]
Small[0 10 25]
Medium[10 25 40]
Large[25 40 60]
Very Large[40 60 80]



Add Rules as shown for wash time:

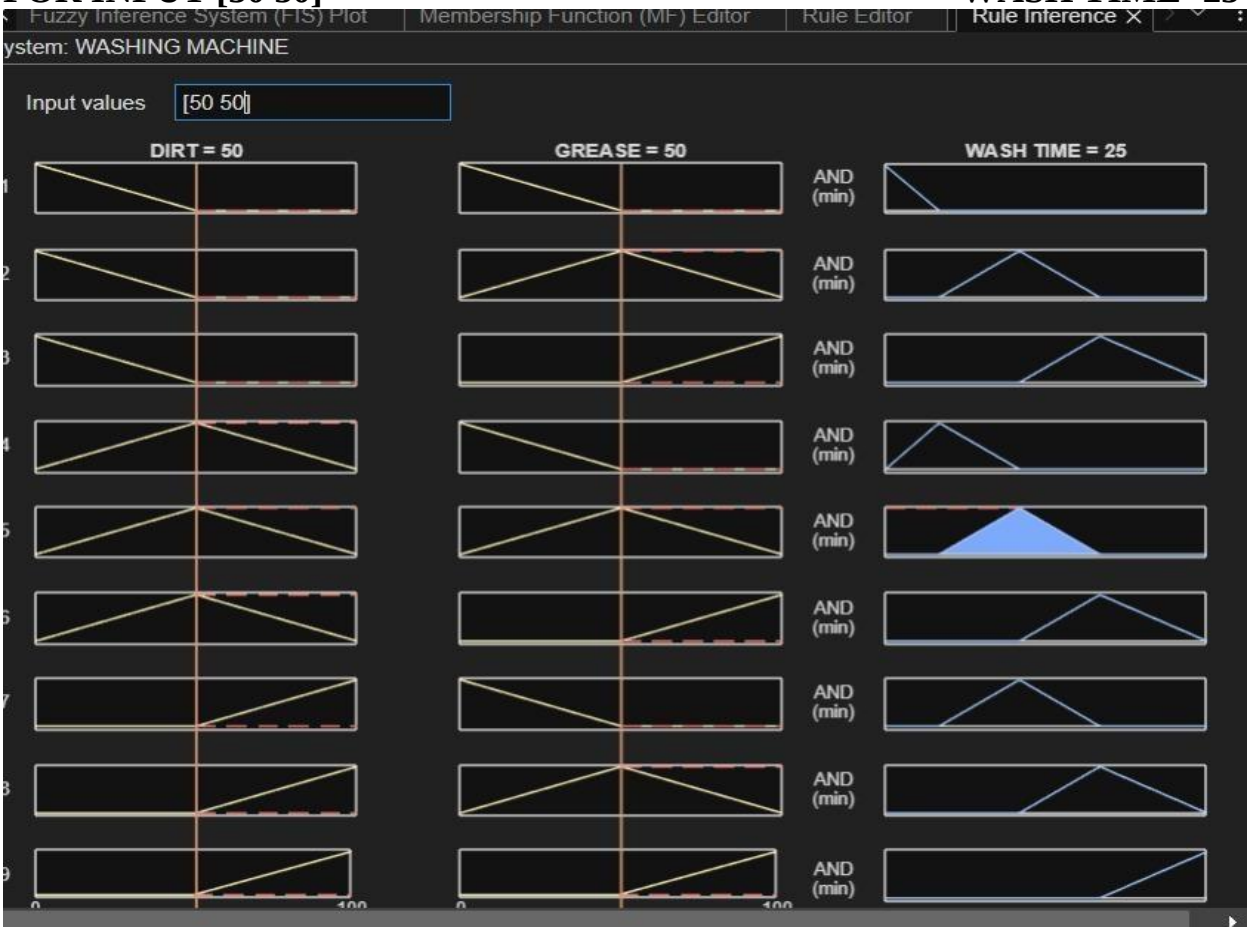
Fuzzy Rules:

1. **If** Dirt is SD (Small Dirt) **and** Grease is NG (No Grease), **then** Wash Time is VS (Very Short).
2. **If** Dirt is SD (Small Dirt) **and** Grease is MG (Medium Grease), **then** Wash Time is S (Short).
3. **If** Dirt is SD (Small Dirt) **and** Grease is LG (Large Grease), **then** Wash Time is L (Large).
4. **If** Dirt is MD (Medium Dirt) **and** Grease is NG (No Grease), **then** Wash Time is M (Medium).
5. **If** Dirt is MD (Medium Dirt) **and** Grease is MG (Medium Grease), **then** Wash Time is M (Medium).
6. **If** Dirt is MD (Medium Dirt) **and** Grease is LG (Large Grease), **then** Wash Time is L (Large).
7. **If** Dirt is LD (Large Dirt) **and** Grease is NG (No Grease), **then** Wash Time is L (Large).
8. **If** Dirt is LD (Large Dirt) **and** Grease is MG (Medium Grease), **then** Wash Time is L (Large).
9. **If** Dirt is LD (Large Dirt) **and** Grease is LG (Large Grease), **then** Wash Time is VL (Very Large).

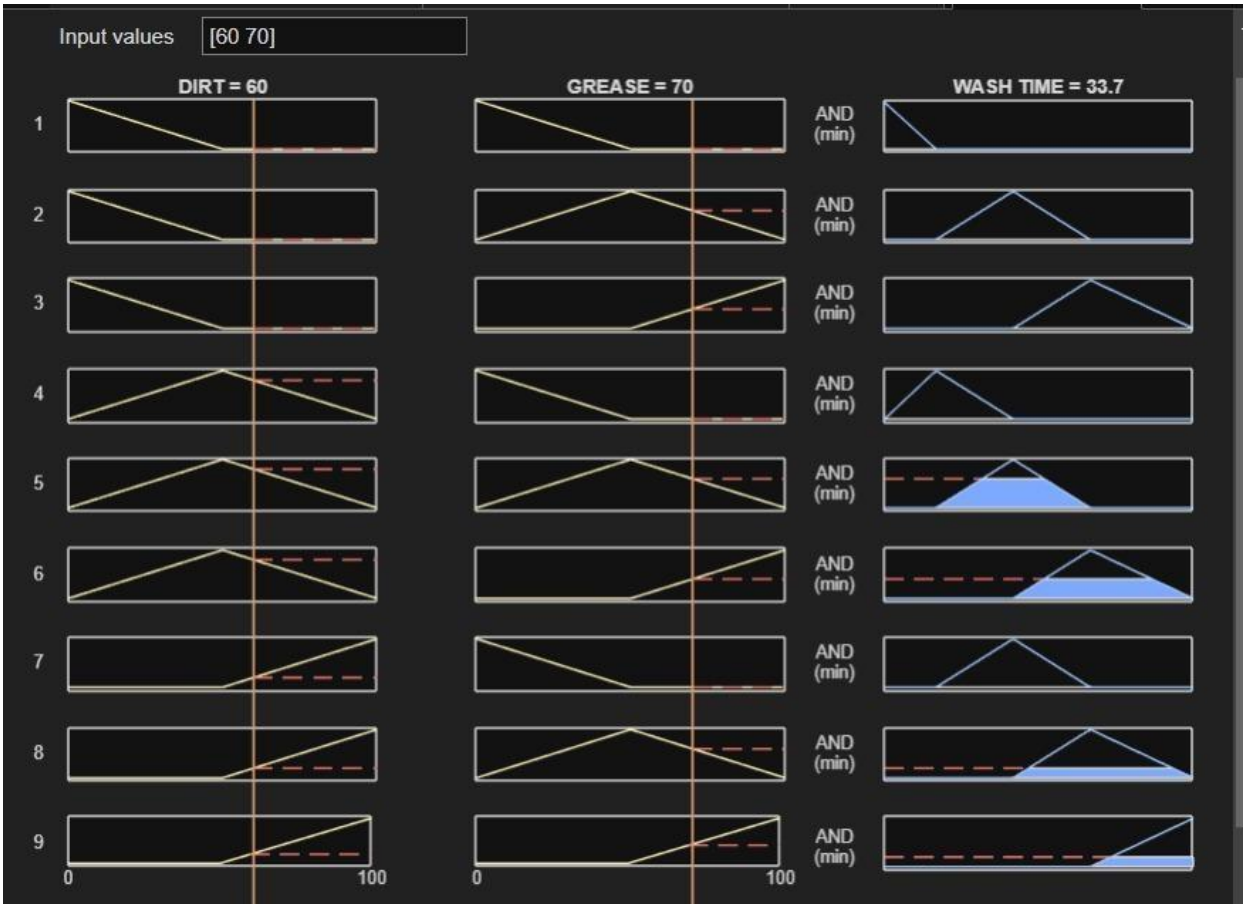


SCREENSHOT OF OUTPUT:

FOR INPUT [50 50] WASH TIME=25



FOR INPUT [60 70]
WASH TIME=33.7



LEARNING OUTCOME:

1 Understanding Fuzzy Logic Systems: Learn the basics of fuzzy logic, including fuzzification, rule evaluation, and defuzzification, and how they are applied in decision-making processes.
2 Design and Implementation: Gain the ability to design and implement a fuzzy inference system (FIS) using tools like MATLAB for practical real-world applications.
3 System Optimization: Understand how multiple inputs (like Dirt and Grease) and their linguistic variables can influence outputs (e.g., Wash Time) to optimize system performance.
4 Visualization and Analysis: Develop skills in visualizing membership functions and rule surfaces to interpret the relationships between inputs and outputs effectively.