Step-by-Step Guide: Building a Fuzzy Expert System for COVID-19 Diagnosis in MATLAB

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1. *Introduction*

1.1 Overview of Fuzzy Logic and Expert Systems

Fuzzy logic is a mathematical approach that deals with uncertainty and partial truth, making it ideal for medical diagnosis where symptoms may not be clearly defined as present or absent. Unlike traditional binary logic (true/false), fuzzy logic allows for degrees of membership between 0 and 1.

An **expert system** is a computer program that emulates the decision-making ability of a human expert. It uses a knowledge base of rules and facts to make inferences and provide recommendations.

1.2 Application to COVID-19 Diagnosis

COVID-19 symptoms can vary significantly in severity and presentation among individuals. A fuzzy expert system can help assess the likelihood of COVID-19 infection based on multiple symptoms, providing a risk assessment that accounts for the uncertainty inherent in medical diagnosis.

1.3 System Objectives and Benefits

- Provide preliminary COVID-19 risk assessment based on common symptoms
- Handle uncertainty in symptom severity reporting
- Offer consistent evaluation criteria
- Assist healthcare professionals in triage decisions
- Provide educational tool for understanding symptom relationships

2. Prerequisites

2.1 Software Requirements

- **MATLAB R2019a or later** (recommended for full compatibility)
- **Fuzzy Logic Toolbox** (essential for this project)

2.2 Knowledge Requirements

- Basic MATLAB programming skills
- Understanding of fuzzy logic concepts (membership functions, rules, defuzzification)
- Familiarity with MATLAB workspace and command window
- Basic understanding of COVID-19 symptoms

2.3 Checking Prerequisites

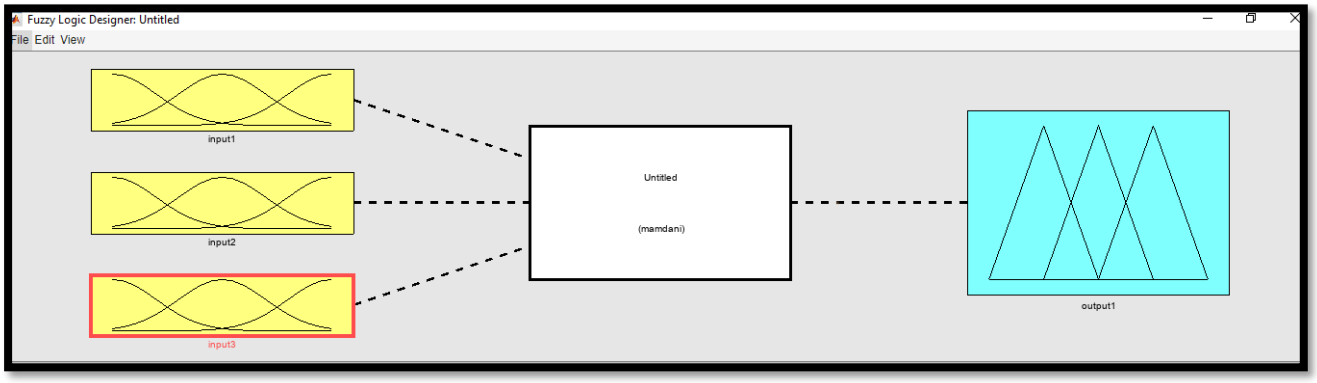
To verify that you have the Fuzzy Logic Toolbox installed, run the following command in MATLAB:

3. Step 1: System Design and Planning

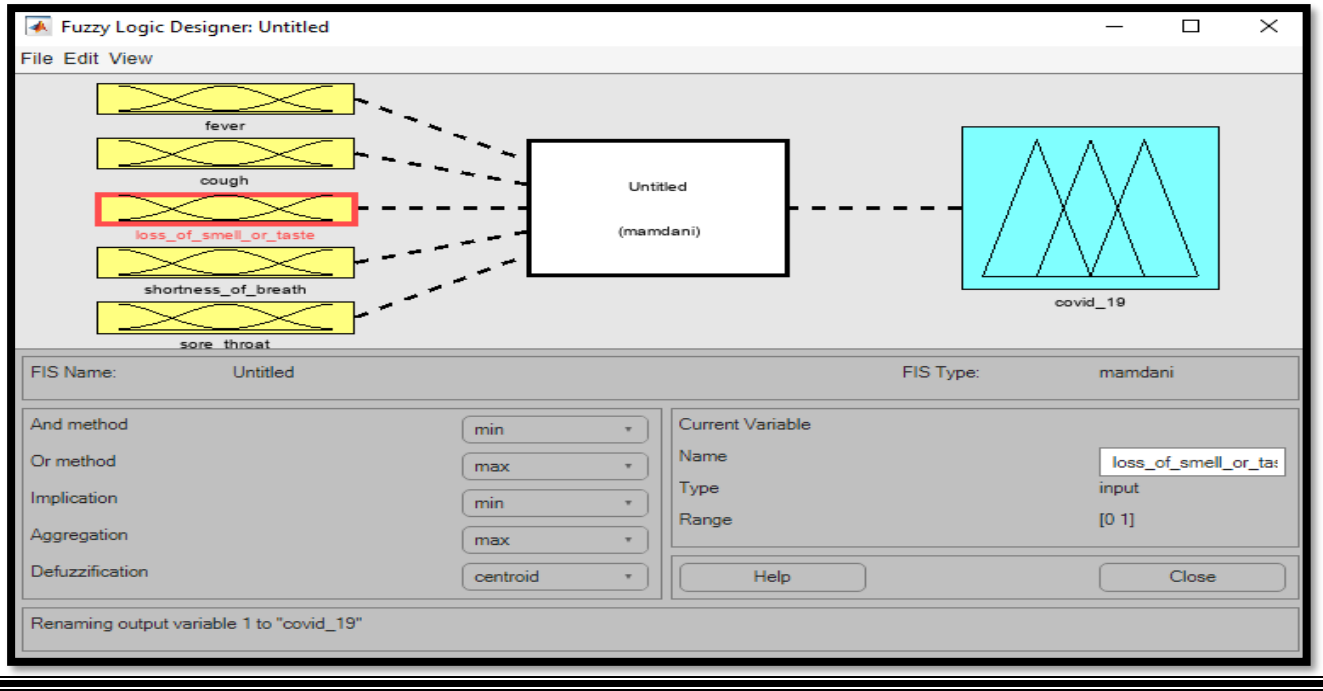
3.1 Input Variables Definition

Our fuzzy expert system will use five input variables representing common COVID-19 symptoms:

Input Variable	Range	Unit	Description
Fever	36-42	°C	Body temperature measurement
Cough	0-10	Severity scale	Cough intensity (0=none, 10=severe)
Loss of Smell/Taste	0-10	Severity scale	Anosmia/Ageusia level
Shortness of Breath	0-10	Severity scale	Difficulty breathing
Sore Throat	0-10	Severity scale	Throat pain/irritation

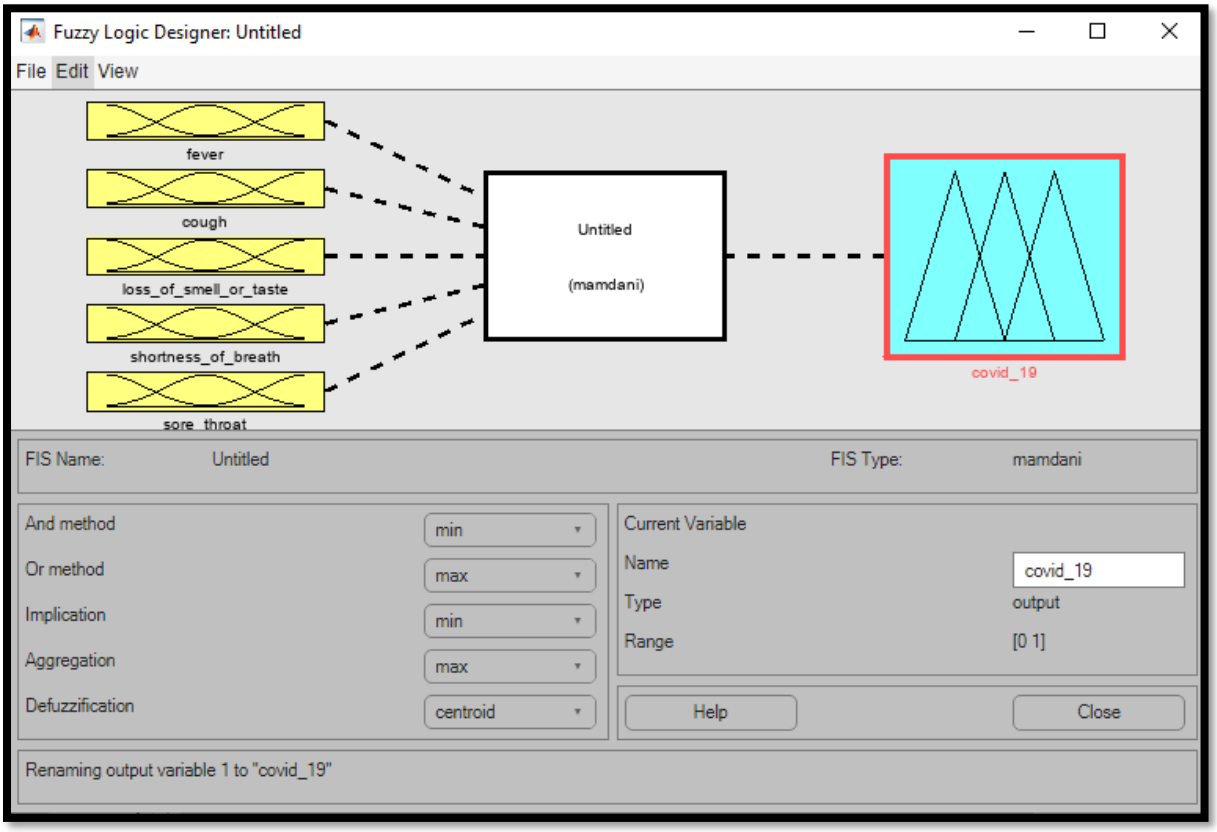


- **Now names the inputs.**



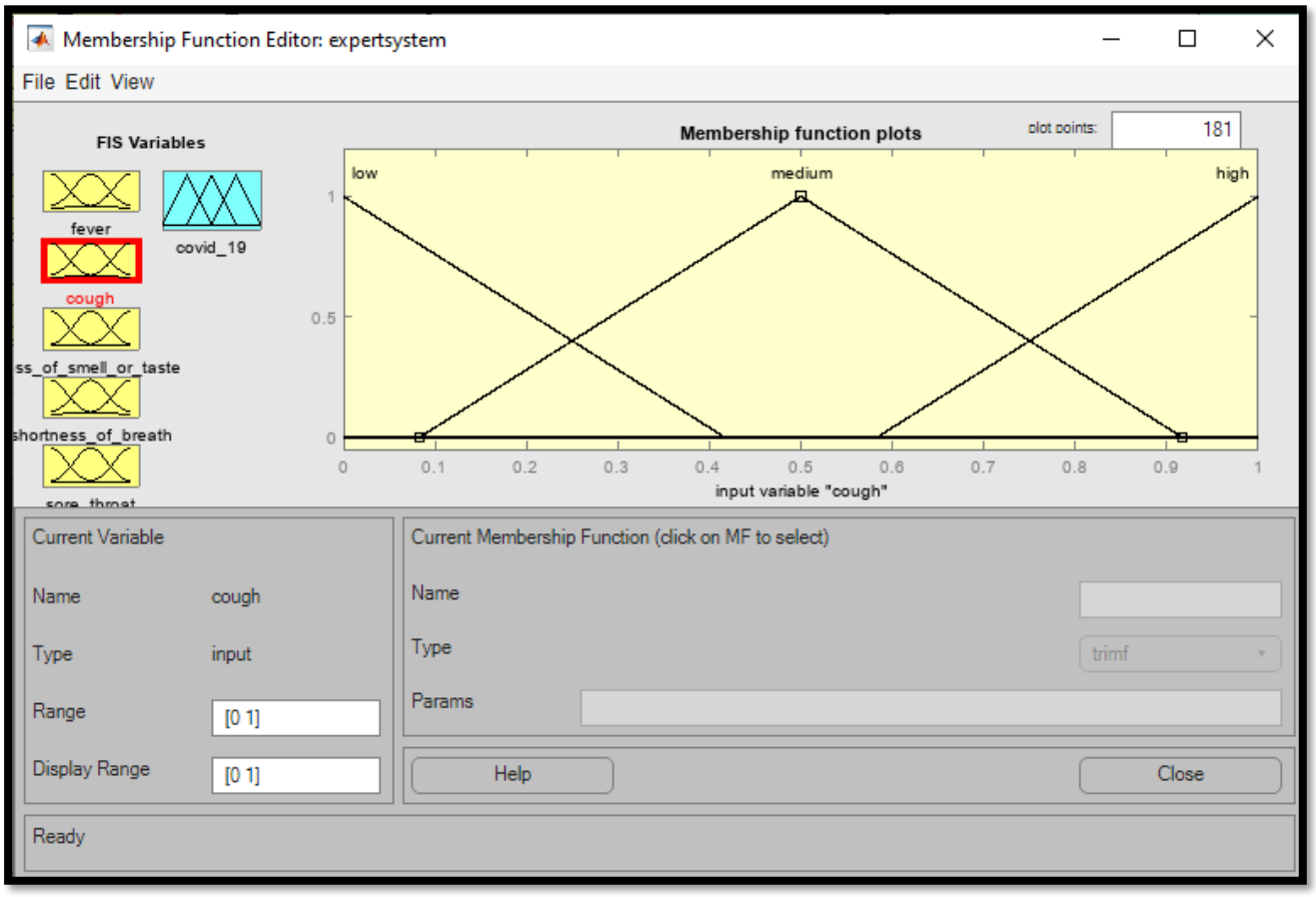
3.2 Output Variable Definition

Output Variable	Range	Unit	Description
COVID-19 Risk	0-100	Percentage	Likelihood of COVID-19 infection



3.3 Membership Functions Selection

We will use **triangular and trapezoidal membership functions** for their simplicity and interpretability. Each input variable will have three membership functions: **Low**, **Medium**, and **High**.



4. Step 2: Creating the FIS (Fuzzy Inference System)

4.1 GUI Method using fuzzyLogicDesigner

The graphical approach provides an intuitive interface for building fuzzy systems:

1. Open MATLAB and type: `fuzzyLogicDesigner`
2. Select "Mamdani" FIS type
3. Save your FIS file as "covid19_diagnosis.fis"
4. Add input and output variables using the GUI

Output Risk Level Interpretation

Risk Level	Range (%)	Recommendation
Very Low	0-20	Low probability of COVID-19
Low	15-40	Monitor symptoms
Medium	40-55	Consider testing
High	45-70	Strongly recommend testing
Very High	65-100	Immediate medical attention

5. Step 5: Creating Fuzzy Rules

5.1 Rule Construction Logic

Fuzzy rules are created based on medical knowledge about COVID-19 symptoms. The general format is:

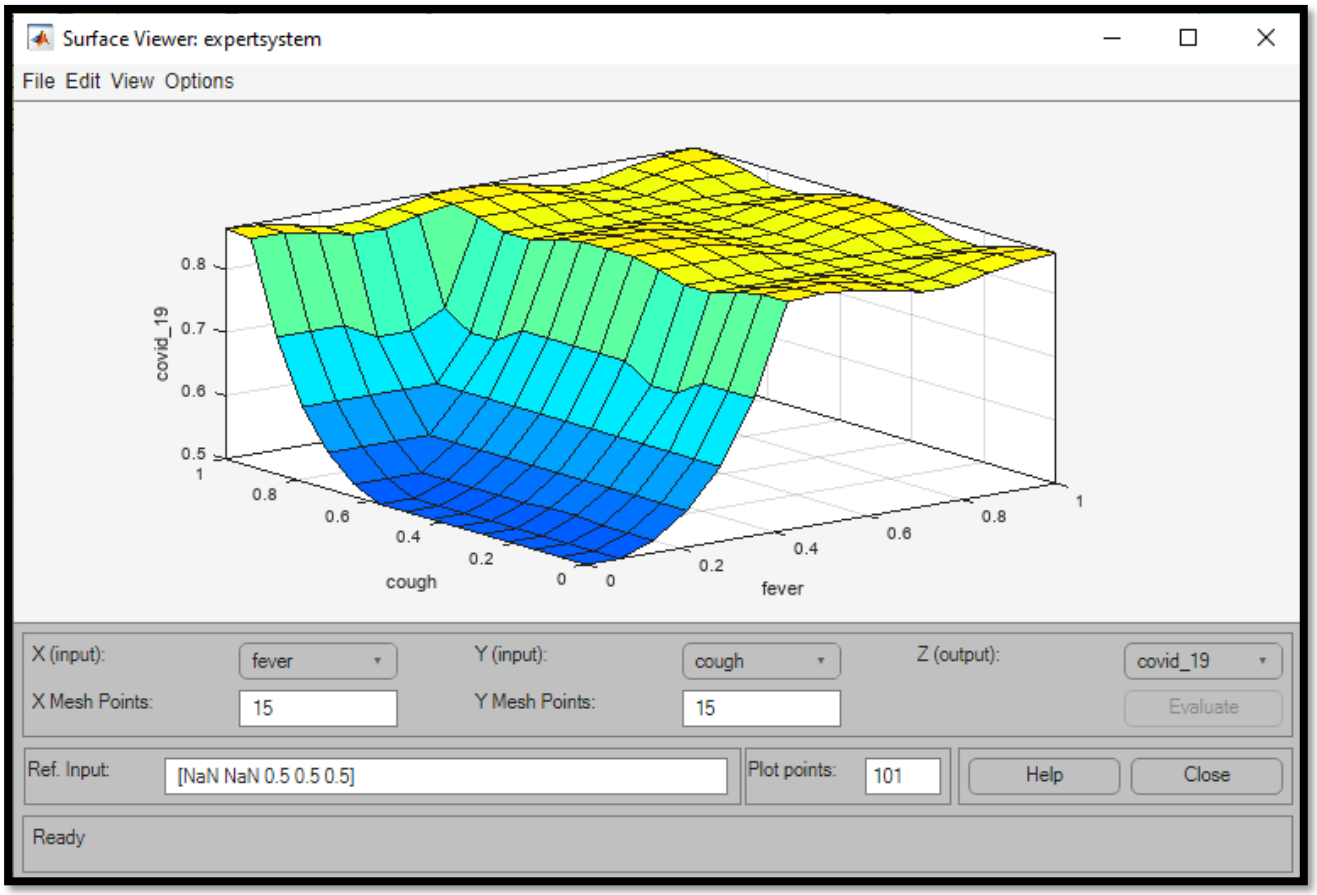
IF (condition1) **AND/OR** (condition2) **THEN** (conclusion

5.2 Using Rule Viewer

The Rule Viewer provides a visual interface for examining how rules in a fuzzy inference system are applied to input data. It displays the contribution of each rule, showing how inputs are mapped through membership functions and how outputs are generated. By presenting this process graphically, the Rule Viewer helps users understand system behavior, verify logic, and fine-tune fuzzy rules for improved performance.

5.3 Using Surface Viewer

The Surface Viewer is a tool that allows users to examine 3D surface models in an interactive way. It enables rotation, zooming, and inspection of detailed surface features, making it easier to analyze shapes, textures, and structural patterns. By providing a clear visual representation, the Surface Viewer helps users better understand complex surfaces and supports tasks such as design review, quality inspection, and data interpretation



6. Step 8: Evaluation and Validation

6.1 Result Interpretation Guidelines

- **Very Low (0-20%):** Symptoms are likely not COVID-19 related
- **Low (15-35%):** Some concern but low probability
- **Medium (30-50%):** Moderate concern, testing recommended
- **High (45-70%):** High concern, immediate testing advised
- **Very High (65-100%):** Critical concern, immediate medical attention

6.2 System Limitations

- Based on limited symptom set - COVID-19 has many other possible symptoms
- Does not consider patient history, age, or comorbidities
- Rules are based on general medical knowledge, not trained on patient data
- Cannot replace professional medical diagnosis
- Symptom severity assessment is subjective