

Fuzzy Logic - Comparative Analysis between Mandani & Sugeno Expert System

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We have 2 inputs in our expert system :

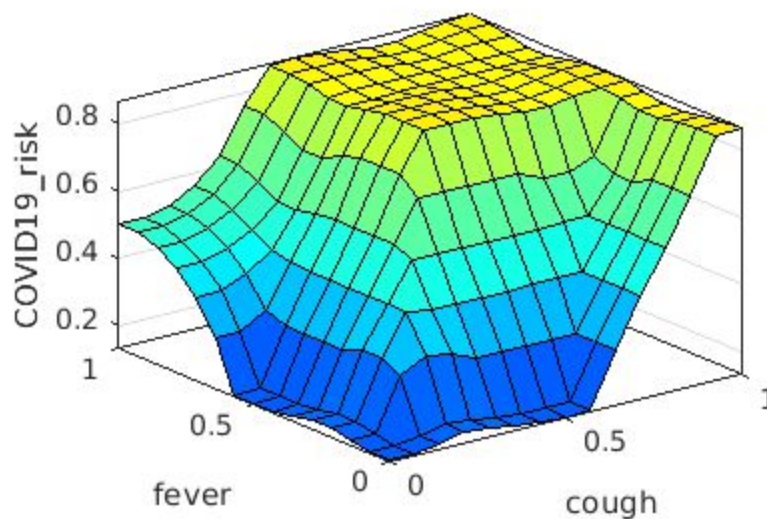
1. Cough
2. Fever

The rules for both inference systems are as follows :

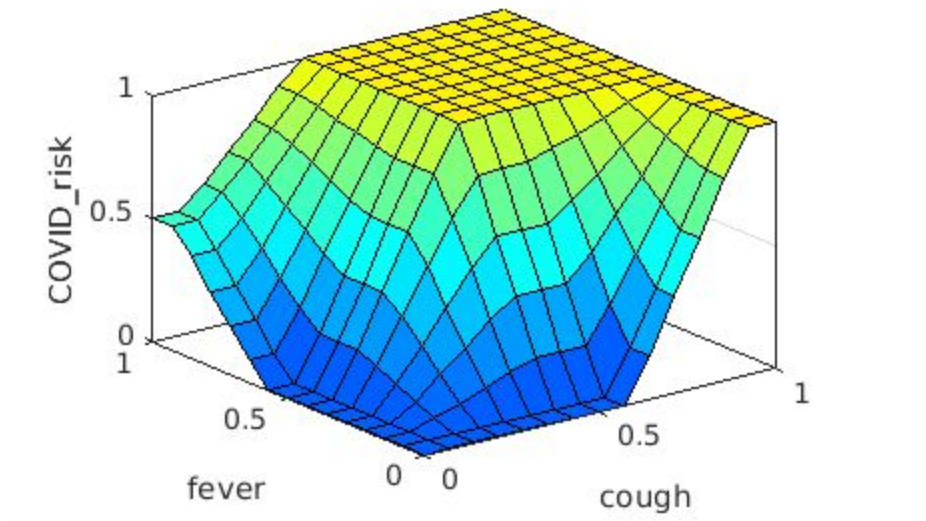
1. If (cough is mild) and (fever is low) then (COVID19_risk is low_risk) (1)
2. If (cough is mild) and (fever is moderate) then (COVID19_risk is low_risk) (1)
3. If (cough is mild) and (fever is high) then (COVID19_risk is moderate_risk) (1)
4. If (cough is moderate) and (fever is low) then (COVID19_risk is low_risk) (1)
5. If (cough is moderate) and (fever is moderate) then (COVID19_risk is high_risk) (1)
6. If (cough is moderate) and (fever is high) then (COVID19_risk is high_risk) (1)
7. If (cough is high) and (fever is low) then (COVID19_risk is high_risk) (1)
8. If (cough is high) and (fever is moderate) then (COVID19_risk is high_risk) (1)
9. If (cough is high) and (fever is high) then (COVID19_risk is high_risk) (1)

The membership function used in both the inputs as well as the output for Mandani are triangular.

Surface Graph for Mandani:



Surface Graph for Sugeno:



We will always set the input as [cough ; fever]

- In the above graphs, we can see that surface plot of Mandani is much more intuitive than that of Sugeno and more continuous. This is not the case in general, where generally Sugeno is more continuous.
- When we set the inputs as [0.3 ; 0.9], then:
 - Mandani gives 0.643 and Sugeno gives 0.816
 - We can see that the cough lies in both moderate and low but the weightage of moderate is quite high and fever is high.
 - In this case, the output must be high_risk as per our rules. Sugeno gives us a good result, but mandani gives us the centroid of the region which will be broad as the result will lie in both high_risk and moderate risk.
- When we take the input as [0.8 ; 0.2]
 - Mandani gives 0.587 and sugeno gives 0.773.
 - We can see that Sugeno outperforms Mandani in this case as the result must be much closer to the moderate region.

These are the primary differences between Mandani FIS and Sugeno FIS:

Mamdani FIS

- Output membership function is present

- Crisp result is obtained through defuzzification of rules' consequent
- Non-continuous output surface
- MISO (Multiple Input Single Output) and MIMO (Multiple Input Multiple Output) systems
- Expressive power and Interpretable rule consequents
- Less flexibility in system design

Sugeno FIS

- No output membership function is present
- No defuzzification: crisp result is obtained using weighted average of the rules' consequent
- Continuous output surface
- Only MISO systems
- Loss of interpretability
- More flexibility in system design