Fuzzy Logic Foundations

Fuzzy Expert Systems

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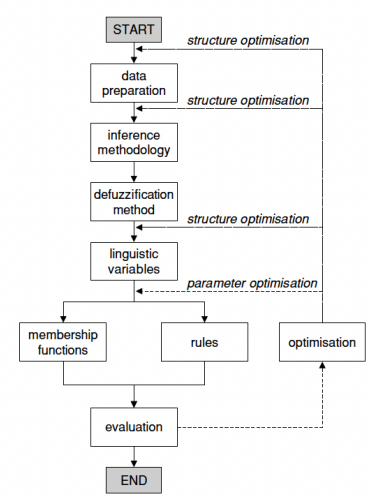
Agenda

1. Intelligent Fuzzy Systems Process

2. Fuzzy Models: Mamdani vs. Sugeno

Intelligent Fuzzy Systems Process



Note:

The FIS process is the same for both Mamdani and Sugeno models. The key difference lies in the **rule output** (consequent) and how the final output is computed.

Agenda

1. Intelligent Fuzzy Systems Process

2. Fuzzy Models: Mamdani vs. Sugeno

The Mamdani Model: Intuitive & Linguistic

Key Concept: The output of each rule is a FUZZY SET.

This model is excellent at capturing expert knowledge in a human-like, linguistic way.

Rule Structure:

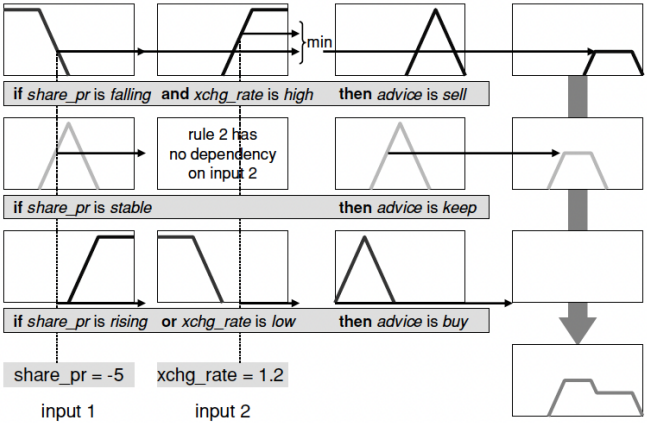
IF-THEN

IF *service* is **good**
AND *food* is **tasty**
THEN *tip* is **generous**.

Process:

1. Evaluate the "IF" part (antecedent).
2. "Clip" or "scale" the output fuzzy set (*generous*).
3. Aggregate all output fuzzy sets from all rules.
4. **Defuzzify** the final aggregate shape to get a single crisp number (e.g., using Centroid).

The Mamdani Model: Intuitive & Linguistic



Note:

The defuzzification step (e.g., Centroid) is computationally expensive, especially with many rules or complex shapes.

The Sugeno (TSK) Model: Computational & Precise

Key Concept: The output of each rule is a MATH FUNCTION (a constant or linear polynomial).

This model is computationally efficient and works very well for control systems and data-driven modeling (like ANFIS).

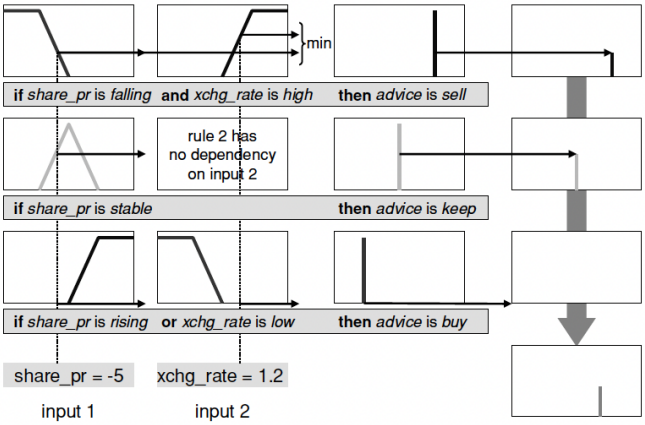
IF-THEN **Rule Structure (Zero-Order):**

IF *service* is **good**
AND *food* is **tasty**
THEN *tip* = **20%**.

IF-THEN **Rule Structure (First-Order):**

IF *service* is **good**
AND *food* is **tasty**
THEN *tip* = **c1*service + c2*food + k**.

The Sugeno (TSK) Model: Computational & Precise



Note:

The Sugeno model is very efficient and fast, making it ideal for real-time applications.

Mamdani vs. Sugeno

Mamdani	Sugeno (TSK)
Rule Output (Consequent)	
A Fuzzy Set. *"tip is **generous**"*	A mathematical function (constant or linear). *"tip = **20**" or "tip = f(x,y)"*
Final Output Aggregation	
The aggregate of all output fuzzy sets.	A weighted average of each rule's crisp output.
Final Output Type	
Fuzzy. Requires **defuzzification** (e.g., Centroid) to get a crisp number.	Crisp. No defuzzification needed.
Best For	
Capturing human expert knowledge. Systems where the output needs to be linguistically interpretable.	Control systems, data-driven modeling, optimization problems (`ANFIS`, `tunefis`).
Computational Cost	
Higher. The defuzzification step is computationally expensive.	Lower. Very efficient and fast.