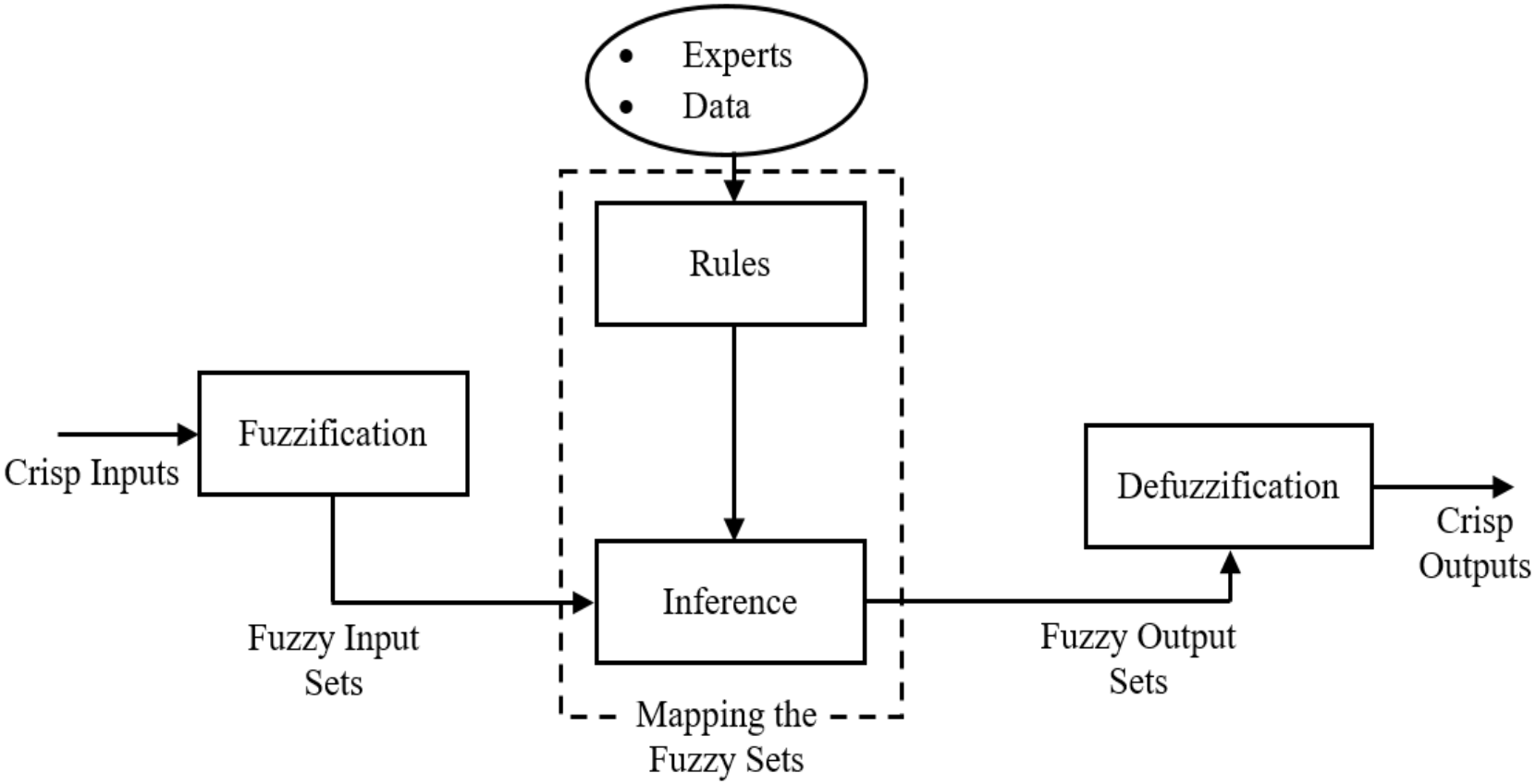
Type-1 Fuzzy Logic System (T1FLS)

Dr. Wafa’ H. AlAlaween
wafa.alalaween@gmail.com

Type-1 Fuzzy Logic System (T1FLS)



T1FLS: Fuzzification

- Fuzzification step represents the process of mapping the crisp inputs (x_1, x_2 …x_n) to the fuzzy input sets (A_j^i), where A_j^i is the ith fuzzy set for the jth variable.
- The fuzzy sets are usually defined by membership functions. The most commonly used membership function is the Gaussian one:

$$\mu_j^i(x_j) = \exp\left[-\frac{1}{2}\left(\frac{x_j - m^i}{\sigma^i}\right)\right]$$

T1FLS: Rules

- The rules can be provided by experts or can be extracted from a collected data set.
- Both types can be presented as a collection of IF-THEN statements, as follows:

$$\textbf{Rule}^i\textbf{: IF } x_1 \text{ is } A_1^i \ \ldots \text{ and } x_n \text{ is } A_n^i, \textbf{ THEN } y \text{ is } B^i .$$

- Clustering/classification can be utilized to initialize the system parameters.

Continue…

- Clustering/classification is a data mining technique used to predict group membership for data instances.
- K-means clustering: clustering N data points into K disjoint subsets.
- How:
  - Specify k, the number of clusters to be generated
  - Choose k points at random as cluster centers
  - Assign each instance to its closest cluster center using Euclidean distance
  - Calculate the centroid (mean) for each cluster, use it as a new cluster center
  - Reassign all instances to the closest cluster center
  - Iterate until the cluster centers don't change anymore

Continue…

- Example:

Subject	A	B
1	1.0	1.0
2	1.5	2.0
3	3.0	4.0
4	5.0	7.0
5	3.5	5.0
6	4.5	5.0
7	3.5	4.5

Inference and Defuzzification

- The inference process combines the defined rules to map the input fuzzy sets to the output fuzzy sets.
- The output fuzzy set is then defuzzified to get a crisp one.
- By using centre average defuzzification method, such a mapping can be represented as follows:

$$f(x|\theta) = \frac{\sum_{i=1}^{R} b_i \prod_{j=1}^{n} \exp\left[-\frac{1}{2}\left(\frac{x_j - c_j^i}{\sigma_j^i}\right)^2\right]}{\sum_{i=1}^{R} \prod_{j=1}^{n} \exp\left[-\frac{1}{2}\left(\frac{x_j - c_j^i}{\sigma_j^i}\right)^2\right]},$$

Continue…

- The model parameters need to be optimized by employing an adaptive back-propagation network.
- Assignment: Steepest descent method.