
Algorithm 1 Cluster-Based Membership Function (MF) Generation

Require: Dataset $D = \{X_1, X_2, \dots, X_d, Y\}$, number of clusters k , clustering method (e.g., FCM, K-Means, MiniBatch K-Means)

Ensure: Centroids and Membership Functions (MFs) for each feature and target variable

- 1: Initialize the clustering method and number of clusters k
 - 2: **for** each feature X_i in dataset D **do**
 - 3: Extract the column vector of X_i
 - 4: Perform clustering on X_i using the selected method
 - 5: Obtain centroids of the resulting clusters: $C_i = \{c_{i1}, c_{i2}, \dots, c_{ik}\}$
 - 6: **for** each centroid c_{ij} in C_i **do**
 - 7: Define Membership Function MF_{ij} based on clustering results
 - 8: (*e.g., Gaussian, Triangular, or Trapezoidal shape*)
 - 9: **end for**
 - 10: Store C_i and corresponding MF_{ij}
 - 11: **end for**
 \triangleright Repeat the same process for the target variable Y
 - 12: Perform clustering on Y
 - 13: Obtain centroids: $C_Y = \{c_{Y1}, c_{Y2}, \dots, c_{Yk}\}$
 - 14: **for** each centroid c_{Yj} in C_Y **do**
 - 15: Define Membership Function MF_{Yj} based on clustering results
 - 16: **end for**
 - 17: **Output:** Centroids and MFs for all features X_1, X_2, \dots, X_d and target Y
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Algorithm 2 Rule Base Generation from Global Clustering

Require: Dataset $D = \{X_1, X_2, \dots, X_d, Y\}$, number of clusters R , clustering method (e.g., FCM, K-Means, MiniBatch K-Means)

Ensure: Fuzzy rule base $\{R_1, R_2, \dots, R_R\}$ consisting of antecedents and consequents

- 1: Combine all features and target into a single dataset $D' = [X_1, X_2, \dots, X_d, Y]$
- 2: Perform clustering on D' using the selected clustering method
- 3: Obtain R clusters:

$$\mathcal{C} = \{C_1, C_2, \dots, C_R\}, \quad R \in [2, 14]$$

- 4: **for** each cluster C_r in \mathcal{C} **do**
- 5: Extract centroid values:

$$C_r = \{x'_1, x'_2, \dots, x'_d, y'_r\}$$

- 6: Define fuzzy linguistic terms (LT) associated with each feature and target dimension
- 7: Construct fuzzy rule R_r according to Zadeh's or TSK rule format:

$$R_r : \text{IF } x'_1 \text{ is } LT_{1r} \text{ AND } x'_2 \text{ is } LT_{2r} \text{ AND } \dots \text{ AND } x'_d \text{ is } LT_{dr} \text{ THEN } y' \text{ is } LT_{yr}$$

$$R_r : \text{IF } x'_1 \text{ is } LT_{1r} \text{ AND } x'_2 \text{ is } LT_{2r} \dots \text{ AND } x'_d \text{ is } LT_{dr} \text{ THEN } y' = \beta_{0r} + \sum_{i=1}^d \beta_{ir} x'_i$$

- 8: **end for**

- 9: **Output:** Fuzzy rule base $\mathcal{R} = \{R_1, R_2, \dots, R_R\}$
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