Assignment Sheet 10

Assignment 37 Quantifiers

Assuming the conditions of Assignment 27, what fuzzy truth values do you get for the proposition “There exists a small single-digit prime number in the decimal number system”? Which problem arises thereby?

Hint: Directly use the dual t-conorms $\bot_{\max}(a, b) = \max\{a, b\}$ and $\bot_{\text{sum}}(a, b) = a + b - a \cdot b$.

Assignment 38 Programming

Implement necessary data structures and algorithms for a Mamdani-Assilian controller that shall operate on two input variables ξ_1 and ξ_2. In detail, implement the following steps:

a) Enable the user to enter the ranges for ξ_1, ξ_2 and for η.

b) Implement an interface *s.t.* the user can specify linguistic terms for a given variable.

c) Implement a routine that partitions a variable by letting the user define membership functions for all linguistic terms of the chosen variable.

d) In order to input a fuzzy rule base, implement a method that enables the user to specify a linguistic term as output for all combinations of linguistic terms of ξ_1 and ξ_2. This can be done effectively by representing the rule base as a two-dimensional matrix.

e) Implement a method that creates a fuzzy set as control output for a given (ξ_1, ξ_2).

f) Implement the three defuzzification methods discussed in the lecture.

g) Create a method that randomly generates l input tuples (ξ_1, ξ_2) and automatically predicts their outputs η given your fuzzy controller. This three-dimensional data set shall be stored as comma separated values (CSV) file.

h) Put all parts together into a main method *s.t.* the user can create a fuzzy controller.

i) Verify if your code produces the same results for parts a) and b) of Assignment 34.

Assignment 39 Takagi-Sugeno Controller

Construct a Takagi-Sugeno controller with two inputs and one output that computes the following (partially defined) function (cf. Assignment 35):

$$\begin{aligned} (1,0) &\mapsto 2, \quad (1,3) \mapsto 4, \\ (0,2) &\mapsto 2, \quad (2,2) \mapsto 4, \\ (2,0) &\mapsto 2. \end{aligned}$$

Determine the output of your controller for the inputs $(1, 1)$ and $(1.5, 1.5)$.

Fuzzy Systems
Prof. Dr. Rudolf Kruse, Christian Moewes

Assignment 40 Takagi-Sugeno Controller

Consider the following definition of triangular fuzzy numbers

$$\mu_{l,m,r} = \begin{cases} \frac{x-l}{m-l} & \text{if } l \le x \le m, \\ \frac{r-x}{r-m} & \text{if } m \le x \le r, \\ 0 & \text{otherwise} \end{cases}$$

whereas $l, m, r \in \mathbb{R}$ and $l < m < r$. Now, let a Takagi-Sugeno controller with the rule base be given as follows

R_1 **: if** x **is** μ_1 **then** $y = 2$**,**
R_2 **: if** x **is** μ_2 **then** $y = x$**,**
R_3 **: if** x **is** μ_3 **then** $y = 3 - x^2$**,**

whereas $x \in X = [0, 8]$ and X is partitioned by $\mu_1 = \mu_{0,2,4},\ \mu_2 = \mu_{2,4,6},\ \mu_3 = \mu_{4,6,8}$.

a) Compute the output of the controller by using the weighted sum

$$f(x) = \frac{\sum_{r=1}^{3} \mu_{R_r}(x) \cdot f_{R_r}(x)}{\sum_{r=1}^{3} \mu_{R_r}(x)},$$

whereas $\mu_{R_r}(x)$ is the degree of fulfillment that the rule R_r "fires", and f_{R_r} is the output of the rule R_r.

b) Draw the output into a diagram.