K. J. Somaiya College of Engineering, Mumbai-77

Department of Computer Engineering

Batch: C2 Roll No.: 16010122323

Experiment No. : 07

Grade: AA / AB / BB / BC / CC / CD /DD

Signature of the Staff In-charge with date

Title: Implementation of fuzzy operations (COMPLEMENT, UNION ,INTERSECTION) on fuzzy sets.

Objective: To understand fuzzy operations

Expected Outcome of Experiment:

CO4 : Apply basics of Fuzzy logic and neural networks

Books/ Journals/ Websites referred:

Pre Lab/ Prior Concepts:
Fuzzy logic:

Definition of Fuzzy Set:

A **fuzzy set** is an extension of a classical set where an element can have degrees of membership. In classical sets, an element either belongs to the set or it doesn't (0 or 1). However, in fuzzy sets, each element has a membership value between 0 and 1, indicating the degree to which the element belongs to the set.

Fuzzy Set Operations:

1. **Union (OR Operation)**:
   The membership value of an element in the union of two fuzzy sets is the maximum of its membership values in the individual sets.
   Formula:

   μA∪B(x)=max⁡(μA(x),μB(x))\mu_{A \cup B}(x) = \max(\mu_A(x), \mu_B(x))μA∪B(x)=max(μA(x),μB(x))

2. **Intersection (AND Operation)**:
   The membership value of an element in the intersection of two fuzzy sets is the minimum of its membership values in the individual sets.
   Formula:

   μA∩B(x)=min⁡(μA(x),μB(x))\mu_{A \cap B}(x) = \min(\mu_A(x), \mu_B(x))μA∩B(x)=min(μA(x),μB(x))

3. **Complement (NOT Operation)**:
   The membership value of an element in the complement of a fuzzy set is 1 minus the membership value in the set.
   Formula:

   μ¬A(x)=1−μA(x)\mu_{\neg A}(x) = 1 - \mu_A(x)μ¬A(x)=1−μA(x)

Fuzzy Inference System (FIS):

A **Fuzzy Inference System** is a framework for reasoning with fuzzy logic. It involves the following key steps:

1. **Fuzzification**: Convert crisp inputs into fuzzy sets by applying membership functions.
2. **Rule Evaluation**: Apply a set of fuzzy rules (if-then statements) to the fuzzified inputs.
3. **Aggregation of Rules**: Combine the outputs of all the fuzzy rules into a single fuzzy set.
4. **Defuzzification**: Convert the aggregated fuzzy output back into a crisp value using methods like centroid or weighted average.

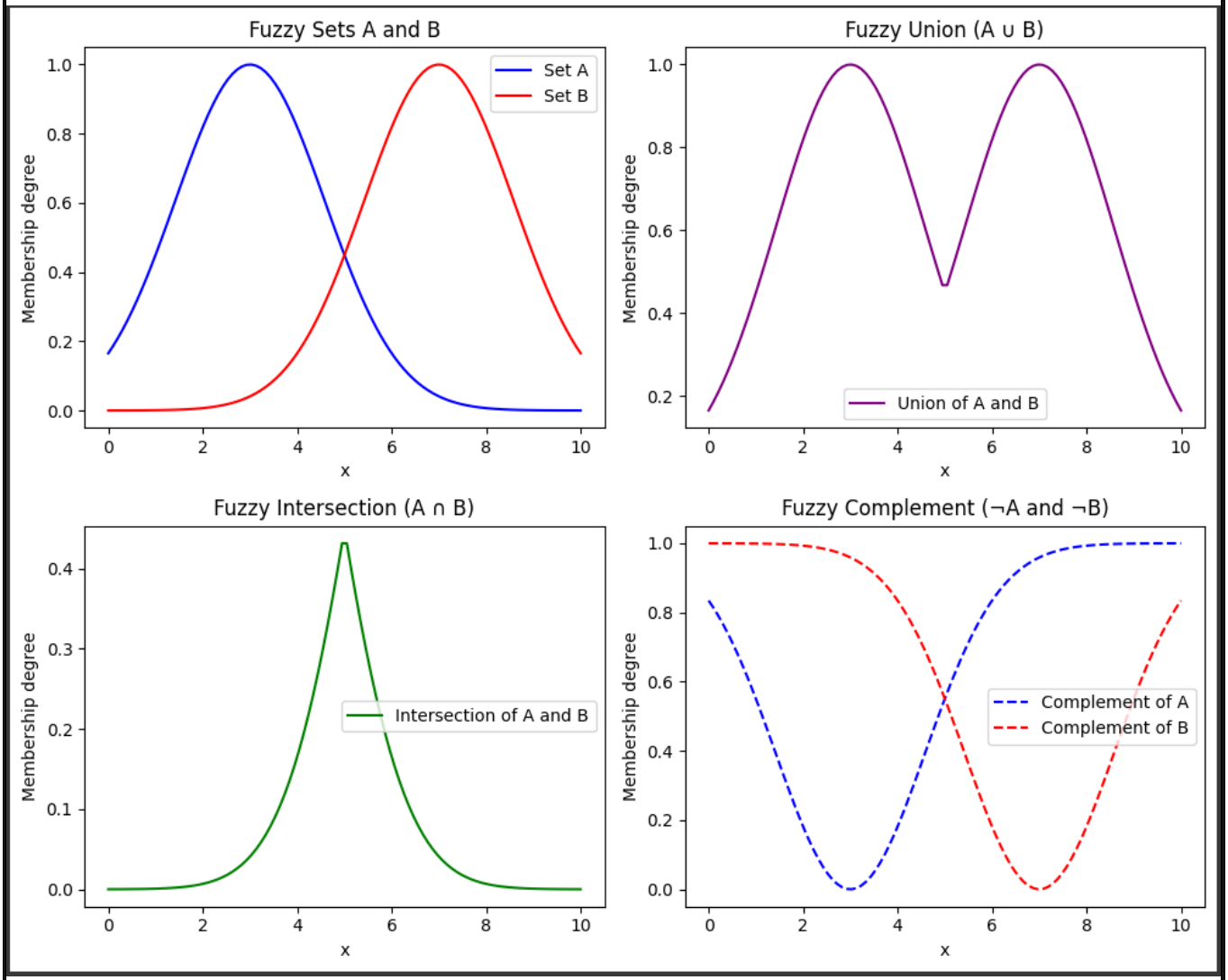
Common FIS types include **Mamdani** and **Sugeno** models.

Implementation Details:

1. Implement the fuzzy operations- Union, intersection, compliment and visualize the same.

```
import numpy as np
import matplotlib.pyplot as plt

x = np.linspace(0, 10, 100)
A = np.exp(-0.2 * (x - 3)**2
B = np.exp(-0.2 * (x - 7)**2)

union = np.maximum(A, B)
intersection = np.minimum(A, B)
complement_A = 1 - A
complement_B = 1 - B

plt.figure(figsize=(10, 8))

plt.subplot(2, 2, 1)
plt.plot(x, A, label='Set A', color='blue')
plt.plot(x, B, label='Set B', color='red')
plt.title('Fuzzy Sets A and B')
plt.xlabel('x')
plt.ylabel('Membership degree')
plt.legend()

plt.subplot(2, 2, 2)
plt.plot(x, union, label='Union of A and B', color='purple')
plt.title('Fuzzy Union (A ∪ B)')
plt.xlabel('x')
plt.ylabel('Membership degree')
plt.legend()
```

```
plt.subplot(2, 2, 3)
plt.plot(x, intersection, label='Intersection of A and B',
color='green')
plt.title('Fuzzy Intersection (A ∩ B)')
plt.xlabel('x')
plt.ylabel('Membership degree')
plt.legend()

plt.subplot(2, 2, 4)
plt.plot(x, complement_A, label='Complement of A',
color='blue', linestyle='dashed')
plt.plot(x, complement_B, label='Complement of B',
color='red', linestyle='dashed')
plt.title('Fuzzy Complement (¬A and ¬B)')
plt.xlabel('x')
plt.ylabel('Membership degree')
plt.legend()

plt.tight_layout()
plt.show()
```



Post Lab Descriptive Questions :

Q1 Two fuzzy sets A and B are given with membership functions μA(x) = {0.2, 0.4, 0.8, 0.5, 0.1} μB(x) = {0.1, 0.3, 0.6, 0.3, 0.2} Then the value of μ —— will be A∩B

(A) {0.9, 0.7, 0.4, 0.8, 0.9}

(B) {0.2, 0.4, 0.8, 0.5, 0.2}

(C) {0.1, 0.3, 0.6, 0.3, 0.1}

(D) {0.7, 0.3, 0.4, 0.2, 0.7}

ANS: (C) {0.1, 0.3, 0.6, 0.3, 0.1}

Q2 The height h(A) of a fuzzy set A is defined as h(A) =sup A(x) where x belongs to A. Then the fuzzy set A is called normal when

(A)h(A)=0
(B)h(A)<0
(C)h(A)=1
(D)h(A)<1

ANS: (C) h(A) = 1

Q3 If A and B are two fuzzy sets with membership functions μA(x) = {0.6, 0.5, 0.1, 0.7, 0.8} μB(x) = {0.9, 0.2, 0.6, 0.8, 0.5}

Then the value of μ Complement A∪B(x) will be

(A) {0.9, 0.5, 0.6, 0.8, 0.8}
(B) {0.6, 0.2, 0.1, 0.7, 0.5}
(C) {0.1, 0.5, 0.4, 0.2, 0.2}
(D) {0.1,0.5,0.4,0.2,0.3}

ANS: (C) {0.1, 0.5, 0.4, 0.2, 0.2}

Date: _____ **Signature of faculty in-charge**