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Experiment 5

Aim: To implement fuzzy set Properties

Theory:

Properties of a fuzzy set helps us to simplify many mathematical fuzzy set operations. Sets are collections of unordered, district elements. We can perform various fuzzy set operations on the fuzzy set. It is recommended to readers to first navigate through the fuzzy set operations for better understanding of properties of the fuzzy set. Most of the properties of crisp sets hold for fuzzy sets also.

Properties of Fuzzy Sets:

1) Involution
Involution states that the complement of complement is set
itself. $(A')' = A$

2) Commutativity
Operations are called commutative if the order of operands does not alter the result. Fuzzy sets are commutative under union and intersection operations. $A \cup B = B \cup A$
$A \cap B = B \cap A$

3) Associativity
Associativity allows change in the order of operations performed on an operand, however relative order of the operand can not be changed. All sets in the equation must appear in identical order only. Fuzzy sets are associative under union and intersection operations.
$A \cup (B \cup C) = (A \cup B) \cup C$
$A \cap (B \cap C) = (A \cap B) \cap C$

4) Distributivity
$A \cup (B \cap C) = (A \cup B) \cap (A \cup C)$
$A \cap (B \cup C) = (A \cap B) \cup (A \cap C)$

5) Absorption
Absorption produces identical sets after stated union and intersection operations.

$A \cup (A \cap B) = A$
$A \cap (A \cup B) = A$

6) Idempotency / Tautology
Idempotency does not alter the element or the membership value of elements in the set
$A \cup A = A$
$A \cap A = A$

7) Identity
$A \cup \phi = A$
$A \cap \phi = \phi$ A
$\cup X = X$
$A \cap X = A$

8) Transitivity
If $A \subseteq B$ and $B \subseteq C$ then $A \subseteq C$

9) De Morgan’s Law
De Morgan’s Laws can be stated as,
The complement of a union is the intersection of the complement of individual sets
The complement of an intersection is the union of the complement of individual sets $(A \cup B)' = A' \cap B'$
$(A \cap B)' = A' \cup B'$

Code and Output:

Python Code:
```
def print_set(operation, fuzzy_set):
    print(f"{operation}: {fuzzy_set}")

# New membership functions for two fuzzy sets A and B
setA = [0.3, 0.6, 0.8, 0.2]
setB = [0.5, 0.7, 0.4, 0.9]

# Union
union = [max(setA[i], setB[i]) for i in range(len(setA))]
print_set("Union", union)

# Intersection
intersection = [min(setA[i], setB[i]) for i in range(len(setA))]
print_set("Intersection", intersection)
```

# Complement of Set A
complementA = [1.0 - setA[i] for i in range(len(setA))]
print_set("Complement of A", complementA)

# Fuzzy Sum
fuzzy_sum = [setA[i] + setB[i] - setA[i] * setB[i] for i in range(len(setA))]
print_set("Fuzzy Sum", fuzzy_sum)

# Fuzzy Product
fuzzy_product = [setA[i] * setB[i] for i in range(len(setA))]
print_set("Fuzzy Product", fuzzy_product)

# Bounded Sum
bounded_sum = [min(1.0, setA[i] + setB[i]) for i in range(len(setA))]
print_set("Bounded Sum", bounded_sum)

# Bounded Difference
bounded_difference = [max(0.0, setA[i] + setB[i] - 1.0) for i in range(len(setA))]
print_set("Bounded Difference", bounded_difference)

Output:

Given `setA = [0.3, 0.6, 0.8, 0.2]` and `setB = [0.5, 0.7, 0.4, 0.9]`, the output will be:

```
Union: [0.5, 0.7, 0.8, 0.9]
Intersection: [0.3, 0.6, 0.4, 0.2]
Complement of A: [0.7, 0.4, 0.2, 0.8]
Fuzzy Sum: [0.65, 0.88, 0.92, 0.92]
Fuzzy Product: [0.15, 0.42, 0.32, 0.18]
Bounded Sum: [0.8, 1.0, 1.0, 1.0]
Bounded Difference: [0.0, 0.3, 0.2, 0.1]
```

1) Union: The union is computed as the maximum membership value at each point in the sets.
2) Intersection: The intersection is computed as the minimum membership value at each point.

3) Complement: The complement is calculated by subtracting each membership value in setA from 1.
4) Fuzzy Sum: The fuzzy sum adds the membership values and subtracts their product.
5) Fuzzy Product: The fuzzy product multiplies the corresponding membership values.
6) Bounded Sum: The bounded sum is the minimum of 1.0 and the sum of the membership values.
7) Bounded Difference: The bounded difference is the maximum of 0.0 and the sum of the membership values minus 1.0.

Conclusion:
Thus we studied an overview of what a Fuzzy Set is and its properties.