Cairo University

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[Fuzzy Documentation]

Operations Research and Decision Support Department

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Why fuzzify crisp values

1. **Uncertainty in Input Parameters**: The cost of a product often depends on various factors such as raw material prices, labor costs, and market conditions. These factors may not always be precisely known or predictable, leading to uncertainty in the cost estimation.
2. **Variability in Production Processes**: Manufacturing processes can exhibit variability due to factors like equipment performance, human error, and material quality. This variability can affect the actual cost of producing a product, leading to uncertainty.
3. **Market Dynamics**: Prices of raw materials and labor can fluctuate based on market demand, supply chain disruptions, or economic conditions. These fluctuations introduce uncertainty into the cost estimation process.
4. **Subjectivity in Cost Assessment**: Cost estimation often involves subjective judgment, especially when considering factors such as risk, quality, and long-term investment. Different stakeholders may have different perceptions of these factors, leading to ambiguity in cost assessment.
5. **Incomplete Information**: In many cases, relevant information for cost estimation may be incomplete or imprecise. For example, historical data may not fully capture future market trends or technological advancements, making it challenging to determine the exact cost of a product.
6. **Fuzzy Boundaries**: The boundaries between cost categories (e.g., fixed costs, variable costs) may not always be clearly defined. Costs can exhibit fuzzy boundaries, making it difficult to categorize them accurately.
7. **Decision Making under Uncertainty**: Fuzzy parameters allow decision-makers to model and analyze uncertainty more effectively. By considering cost as a fuzzy parameter, decision-makers can account for uncertainty in cost estimation and make more robust decisions.
8. **Risk Management**: Considering cost as a fuzzy parameter enables better risk management by capturing the potential range of costs associated with different scenarios. This approach helps decision-makers identify and mitigate risks associated with cost uncertainty

Fuzzy concept

1. **Modeling Uncertain Variables**: In business and economic contexts, many variables are subject to uncertainty, such as production costs, demand, and sales prices. Fuzzy logic allows for the modeling of these uncertainties by defining fuzzy membership functions for these variables. For example, instead of representing the production cost as a precise value, it can be represented as a fuzzy set with a membership function that captures the range of possible costs and the degree to which each cost value is plausible.
2. **Defuzzification**: Once fuzzy membership functions are defined for uncertain variables, defuzzification is performed to convert fuzzy sets into crisp values. Defuzzification involves aggregating the fuzzy information to obtain a single, precise value that represents the uncertain variable. Various defuzzification methods can be employed, such as centroid, mean of maximum (MOM), or weighted average, depending on the application.
3. **Profit Calculation**: After defuzzification, crisp values are obtained for uncertain variables like production costs, sales prices, and demand. These crisp values are then used in traditional mathematical models to calculate profit. For example, in a manufacturing context, profit can be calculated as the difference between revenue (sales price * quantity sold) and costs (production cost * quantity produced), taking into account fixed costs and any other relevant factors.
4. **Optimization and Decision Making**: Fuzzy logic enables the optimization of decisions under uncertainty by incorporating fuzzy membership functions into decision models. By considering the uncertainties associated with various factors, such as costs and demand, fuzzy logic can help identify the optimal production quantities or pricing strategies that maximize profit or achieve other business objectives .

   fuzzy logic provides a powerful framework for handling uncertainty in decision-making processes, including profit calculation in business contexts. By representing uncertain variables as fuzzy sets with membership functions and employing defuzzification techniques to obtain crisp values, fuzzy logic facilitates more robust and adaptive decision-making in the face of uncertainty.

Steps of of fuzzifying the parameters (cost1 of 19 inch set) (cost2 of 21 inch set)

1-Triangular Membership Function:

- The code defines a function called `triangular_membership` that calculates the membership degree of a given value `x` in a
- **if isinstance(x, (float, int)):** is a conditional statement that checks if the input **x** is either a float or an integer. The **isinstance()** function returns **True** if **x** is an instance of any of the types specified in the tuple **(float, int)**.
- So, **if isinstance(x, (float, int)):** checks whether **x** is either a floating-point number or an integer. If it is, the function calculates the triangular membership value based on the conditions provided. If **x** is neither a float nor an integer, the function proceeds to the **else** block to handle arrays of values using NumPy operations.
- triangular fuzzy set. The triangular membership function is used to model fuzzy variables. It takes three parameters: `min_val`, `peak_val`, and `max_val`, which define the shape of the triangular membership function.
- The function returns an array `y` containing the membership degrees corresponding to the input values `x`.

2- Define the Range of Values for the Cost:

Two arrays, `x_c1` and `x_c2`, are created using the `numpy` function `linspace`. These arrays represent the range of values for the price.

3- Parameters for the Triangular Membership Functions:

The code defines the parameters for two triangular membership functions: `c1` and `c2`. These parameters include `C1_min`, `C1_peak`, `C1_max` for `C1`, and `P2_min`, `P2_peak`, `P2_max` for `P2`. These parameters determine the shape of the triangular membership functions.

4- Calculate Membership Degrees:

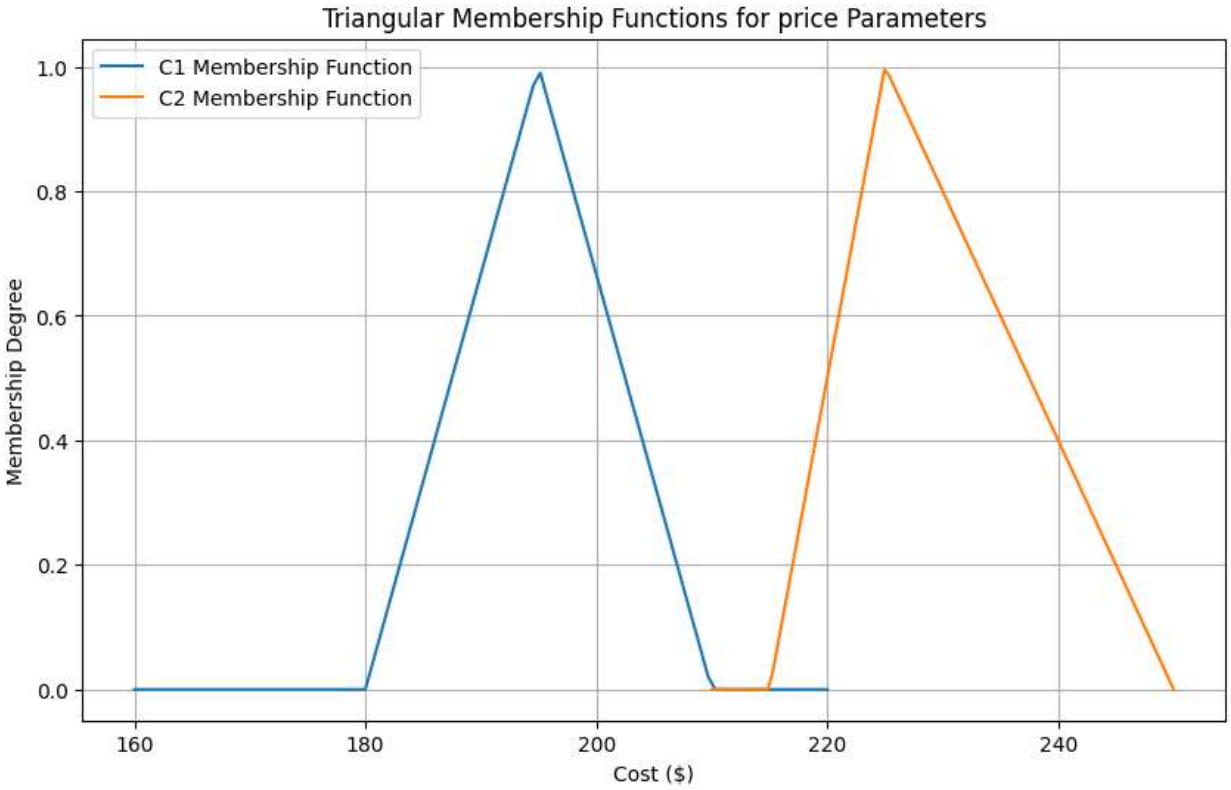
The code calculates the membership degrees for C1 and C2 by calling the `triangular_membership` function with appropriate parameters.

5. **Plotting the Triangular Membership Functions:**
    a. The code creates a figure using `matplotlib.pyplot.figure` and plots the membership functions for C1 and C2 using `matplotlib.pyplot.plot`.
    b. Labels, title, legend, and grid are added to the plot using various `matplotlib.pyplot` functions.
    c. Finally, the plot is displayed using `matplotlib.pyplot.show`.

```
# Define the initial range of values for the cost
# Define the initial range of values for the cost
x_C1 = np.linspace(180, 210, 100) // start wtih 180 /end 210 (“included) 100
number of values generated between the range
x_C2 = np.linspace(200, 250, 100)
 // start wtih 200 /end 250 (“included) 100 number of values generated between
the range

#Define the boundaries of triangular membership function to Cost to produce one
TV 19 inches anD Cost to produce one TV 21 inches

C1_min = 180 a-c1
C1_peak = 195  b or crisp cost1
C1_max = c of cost 1
C2_min = 200 a_c2
C2_peak = 225 crisp cost 2
C2_max = 250 c of cost2
```



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- The Monte Carlo simulation is performed for a specified number of simulations (`num_simulations`). In each simulation, random values within the range of `C1` and `C2` are generated (`x_c1` and `x_c2`).
- The membership degrees (`u_c1` and `u_c2`) for the generated values are calculated using the `triangular_membership` function.
- An alpha cut value is randomly chosen (`alpha_cut`), and if it is less than or equal to the membership degree of `C1`, the value of `C1` is added to the list of defuzzified `C1` values (`defuzzified_COST1`). Similarly, if the alpha cut is less than or equal to the membership degree of `C2`, the value of `C2` is added to the list of defuzzified `C2` values (`defuzzified_COST2`). The alpha cut values are also stored in the `alphacuts` list.

- The average defuzzified price values are calculated by taking the mean of the lists `defuzzified_COST1` and `defuzzified_COST2`.
- The results of the Monte Carlo simulation are printed, including the average defuzzified `C1` and `C2` values, the defuzzified values for each simulation, and the alpha cut values

```
num_simulations = 10

    x_c1 = random.uniform(C1_min, C1_max)
    x_c2 = random.uniform(C2_min, C2_max)
    u_c1 = triangular_membership(x_c1, C1_min, C1_peak, C1_max)
```

```
Average Defuzzified COST 1 (C1): $193.80

Average Defuzzified COST 2 (C2): $224.4
```