A fuzzy logic-based pharmaceutical procurement system

Abstract:

In the realm of pharmaceutical procurement, maintaining adequate inventory levels is crucial for ensuring the uninterrupted availability of essential medications. However, traditional procurement methods often face challenges in adapting to dynamic demand patterns and unforeseen circumstances. This paper proposes a fuzzy logic-based procurement system to address these limitations and optimize the procurement process.

The proposed system utilizes fuzzy logic to manage the inherent uncertainty and imprecision associated with pharmaceutical demand. By employing linguistic variables, the system effectively captures the qualitative aspects of inventory levels, usage rates, lead times, supplier reliability and budget. Membership functions are employed to represent the gradual transition between different linguistic categories, enabling the system to make nuanced decisions based on the prevailing conditions.

These rules incorporate the relationships between inventory levels, usage rates, lead times, supplier reliability and budget to determine the appropriate procurement actions. The system prioritizes orders based on the urgency of replenishing inventory, ensuring that critical medications are procured promptly.

The fuzzy logic-based procurement system offers several advantages over traditional methods. Its ability to handle uncertainty and adapt to dynamic demand patterns enhances the efficiency and effectiveness of the procurement process. By prioritizing orders based on urgency, the system ensures that critical medications are procured promptly, preventing stockouts and disruptions in patient care.

The implementation of the fuzzy logic-based procurement system can significantly improve the pharmaceutical supply chain, ensuring that patients have uninterrupted access to the medications they need.

Introduction:

The pharmaceutical industry faces a constant challenge in maintaining adequate inventory levels to meet patient needs while optimizing resource utilization and adhering to budgetary constraints. Traditional procurement methods often struggle to adapt to dynamic demand patterns, manage uncertainty, and incorporate multiple factors into decision-making. This paper proposes a fuzzy logic-based procurement system that addresses these limitations by employing fuzzy sets and linguistic variables to represent the inherent uncertainty and imprecision associated with pharmaceutical procurement. The system utilizes a comprehensive rule base to determine appropriate procurement actions based on inventory levels, usage rates, lead times, budget availability, and supplier reliability. This approach enables the system to make informed decisions that optimize procurement processes, minimize stockouts, and ensure the uninterrupted availability of essential medications.

Linguistic Variables

Inventory Level:-

Represents the current amount of a specific medicine in stock.

- **Low**

  Indicates that the inventory is dangerously low and an order should be placed soon.

- **Medium**

  Indicates that the inventory is sufficient for the immediate needs.

- **High**

  Indicates that the inventory is abundant and an order is not immediately necessary.

- **Usage Rate:-**

  Represents the average daily consumption of a specific medicine.

  - **Slow**

    Indicates that the medicine is used infrequently and an order is not needed frequently.

  - **Moderate**

    Indicates that the medicine is used at a moderate rate and orders should be placed regularly.

  - **Fast**

    Indicates that the medicine is used frequently and orders should be placed regularly to avoid stockouts.

- **Delivery Time:**

  Represents the time it takes to receive an order from the supplier.

  - **Short**

    Indicates that orders are received quickly and stockouts are unlikely.

  - **Moderate**

    Indicates that orders take some time to arrive and stockouts may occur if not managed properly.

  - **Long**

    Indicates that orders take a long time to arrive and stockouts are more likely.

- **Supplier Reliability:**

  Assessing the supplier's dependability and trustworthiness in fulfilling orders.

  - **Low**

    Reflects a history of delays, incomplete orders, or quality issues.

  - **Moderate**

    Signifies a generally dependable supplier with occasional minor issues.

  - **High**

    Indicates a consistently reliable supplier with a proven track record.

- **Budget:**

  Illustrates the financial resources available for medicine procurement.

  - **Low**

    Indicates tight budgetary constraints and limited purchasing power.

  - **Moderate**

    Signifies adequate funding for essential purchases.

  - **High**

    Indicates ample funds for procurement and flexibility in order quantities.

Mathematical Representation

Inventory Level:

Low(x)= $\begin{Bmatrix} 0 & x > 50 \\ \frac{50-x}{50} & 0 < x < 50 \\ 1 & x = 0 \end{Bmatrix}$

Medium(x)= $\begin{Bmatrix} 0 & x \leq 0 \; or \; x > 100 \\ \frac{x}{50} & 0 < x \leq 50 \\ \frac{100-x}{50} & 50 < x < 100 \end{Bmatrix}$

High(x)= $\begin{Bmatrix} 0 & x < 50 \\ \frac{x-50}{50} & 50 < x < 100 \\ 1 & x \leq 100 \end{Bmatrix}$

Usage Rate

Slow(x)= $\begin{Bmatrix} 0 & x > 50 \\ \frac{50-x}{50} & 0 < x < 50 \\ 1 & x = 0 \end{Bmatrix}$

Moderate(x)= $\begin{Bmatrix} 0 & x \leq 0 \; or \; x > 100 \\ \frac{x}{50} & 0 < x \leq 50 \\ \frac{100-x}{50} & 50 < x < 100 \end{Bmatrix}$

Fast(x)= $\begin{Bmatrix} 0 & x < 50 \\ \frac{x-50}{50} & 50 < x < 100 \\ 1 & x = 100 \end{Bmatrix}$

Delivery Time:

Slow(x)= $\begin{cases} 0 & x > 50 \\ \frac{50-x}{50} & 0 < x < 50 \\ 1 & x = 0 \end{cases}$

Medium(x)= $\begin{cases} 0 & x \leq 0 \; or \; x > 100 \\ \frac{x}{50} & 0 < x \leq 50 \\ \frac{100-x}{50} & 50 < x < 100 \end{cases}$

Fast(x)= $\begin{cases} 0 & x < 50 \\ \frac{x-50}{50} & 50 < x < 100 \\ 1 & x = 100 \end{cases}$

Supplier Reliability:

Low(x)= $\begin{cases} 0 & x > 50 \\ \frac{50-x}{50} & 0 < x < 50 \\ 1 & x = 0 \end{cases}$

Medium(x)= $\begin{cases} 0 & x \leq 0 \; or \; x > 100 \\ \frac{x}{50} & 0 < x \leq 50 \\ \frac{100-x}{50} & 50 < x < 100 \end{cases}$

High(x)= $\begin{cases} 0 & x < 50 \\ \frac{x-50}{50} & 50 < x < 100 \\ 1 & x = 100 \end{cases}$

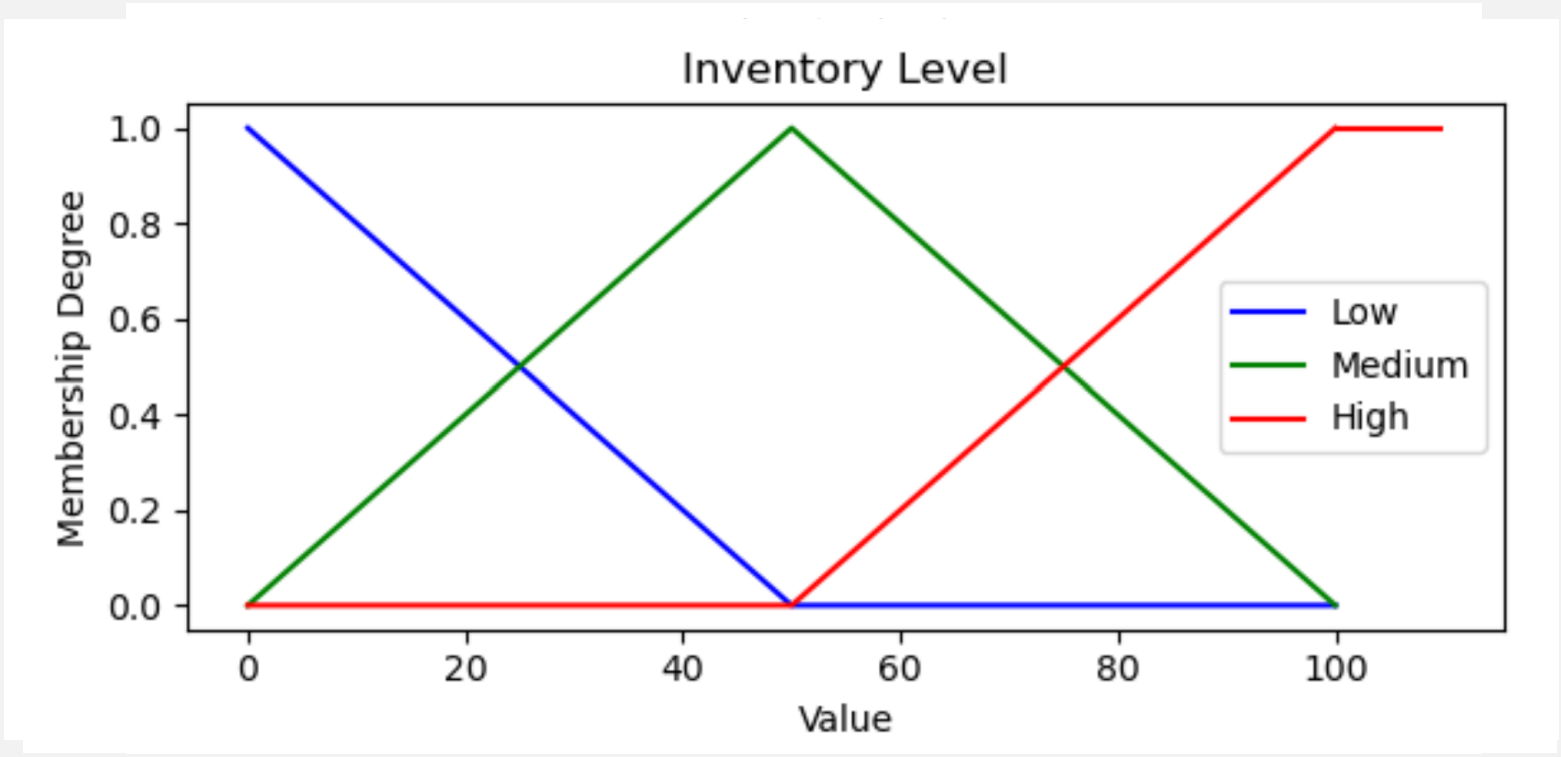
Budget:

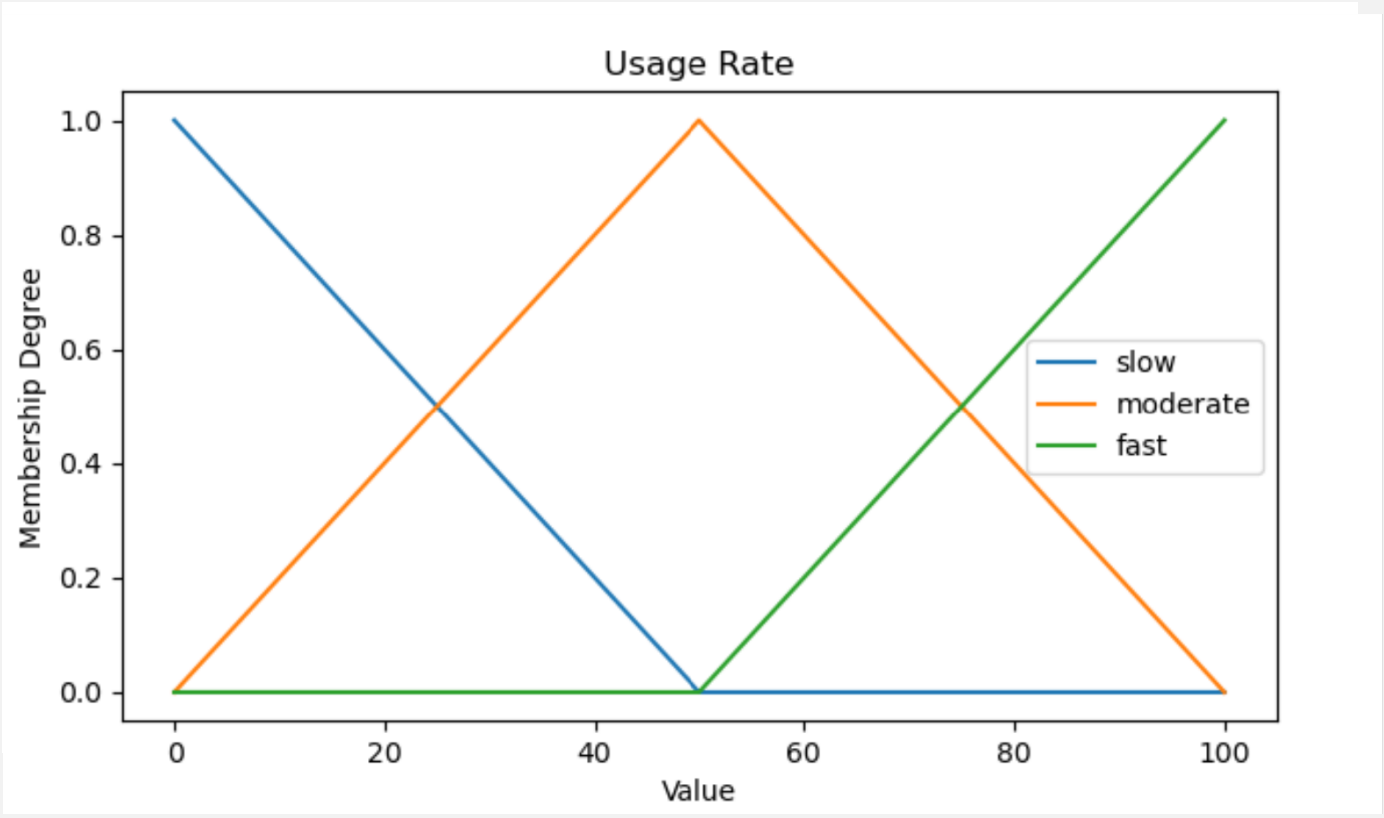
Low(x)= $\begin{cases} 0 & x > 50 \\ \frac{50-x}{50} & 0 < x < 50 \\ 1 & x = 0 \end{cases}$

Medium(x)= $\begin{cases} 0 & x \leq 0 \; or \; x > 100 \\ \frac{x}{50} & 0 < x \leq 50 \\ \frac{100-x}{50} & 50 < x < 100 \end{cases}$

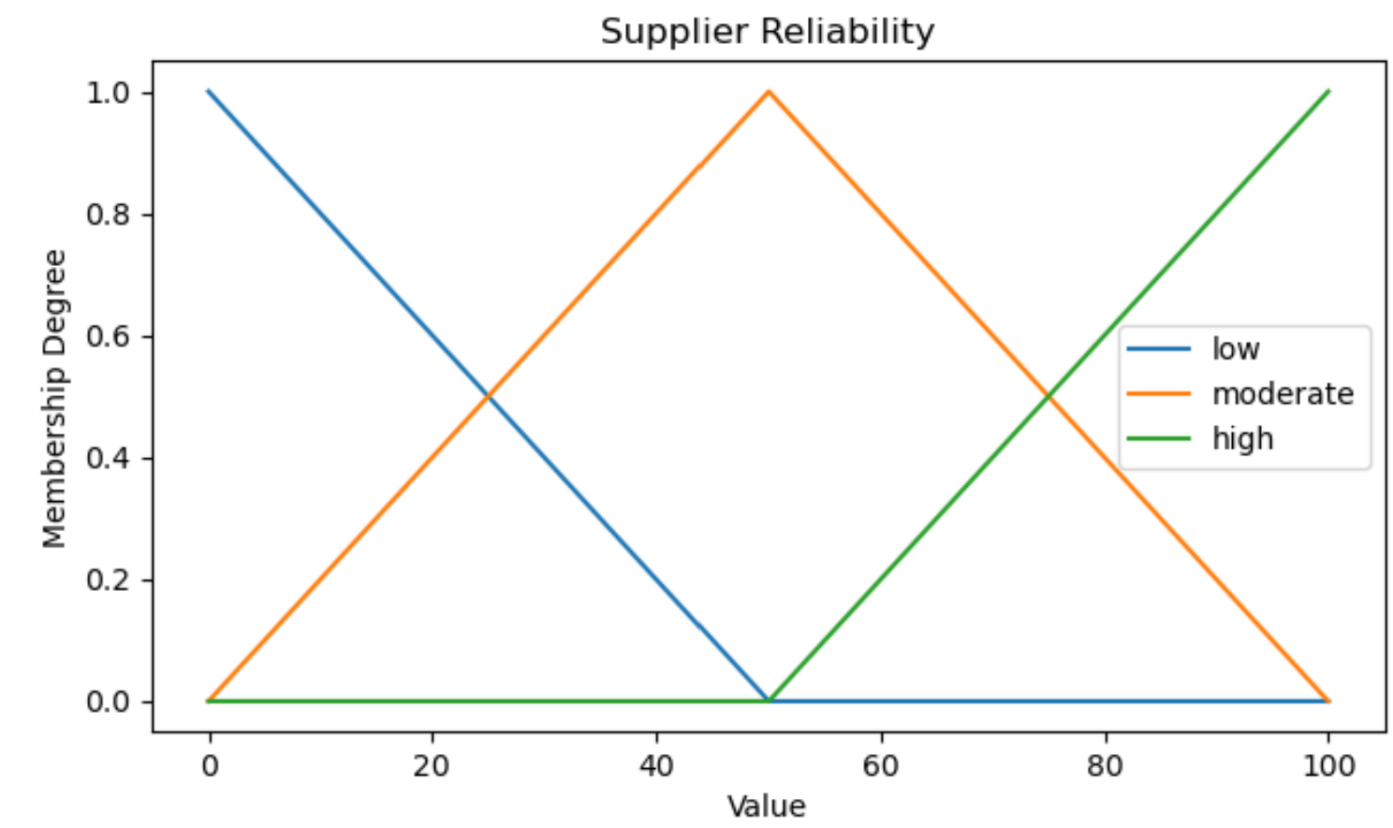
High(x)= $\begin{cases} 0 & x < 50 \\ \frac{x-50}{50} & 50 < x < 100 \\ 1 & x = 100 \end{cases}$

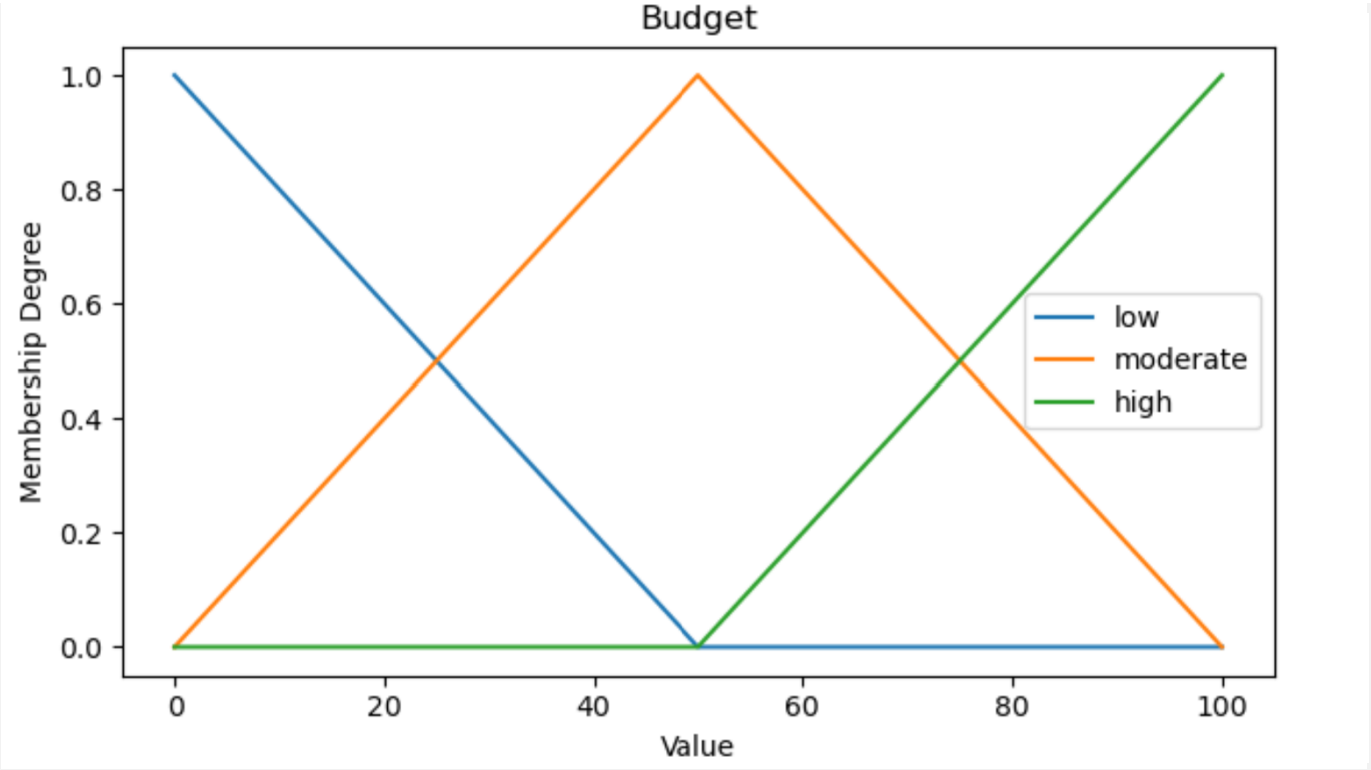
Graphical Representation




Usage Rate
Membership Degree
1.0
0.8
0.6
0.4
0.2
0.0
0
20
40
60
80
100
Value
slow
moderate
fast


Delivery Time
Membership Degree
1.0
0.8
0.6
0.4
0.2
0.0
0
20
40
60
80
100
Value
short
moderate
long





Reason:

We have decided to use this plot graph as there's a gradual increase and decrease in the membership values.

Rule Based System

The rule base is based on the following considerations:

- IF Inventory Level is Low AND Usage Rate is Fast AND Budget is Moderate THEN Place Order with Moderate Priority
- IF Inventory Level is Medium AND Usage Rate is Moderate AND Delivery Time is Long AND Supplier Reliability is Low THEN Place Order with Low Priority
- IF Inventory Level is High AND Usage Rate is Slow AND Budget is Low THEN Monitor Inventory Level Closely
- IF Inventory Level is Low AND Usage Rate is Fast AND Delivery Time is Short AND Supplier Reliability is High THEN Place Order with High Priority
- IF Inventory Level is Medium AND Usage Rate is Fast AND Delivery Time is Moderate AND Supplier Reliability is Low THEN Place Order with Moderate Priority
- IF Inventory Level is High AND Usage Rate is Moderate AND Delivery Time is Long AND Supplier Reliability is Moderate THEN Monitor Inventory Level Closely
- IF Inventory Level is Low AND Usage Rate is Slow AND Budget is Low THEN Monitor Inventory Level Closely
- IF Inventory Level is Medium AND Usage Rate is Slow AND Delivery Time is Short AND Supplier Reliability is High THEN Monitor Inventory Level Closely
- IF Inventory Level is High AND Usage Rate is Slow AND Delivery Time is Moderate AND Supplier Reliability is Moderate THEN No Action is Necessary
- IF Inventory Level is Low AND Usage Rate is Moderate AND Budget is High THEN Place Order with High Priority
- IF Inventory Level is Medium AND Usage Rate is Moderate AND Delivery Time is Short AND Supplier Reliability is High THEN Place Order with Moderate Priority
- IF Inventory Level is High AND Usage Rate is Moderate AND Delivery Time is Short AND Supplier Reliability is Low THEN No Action is Necessary