A Fuzzy Logic Based Price Estimation System for Second Hand Clothing

Akın Engin Kılınç, Ceydanur Akdoğan, Emre Şahin Atak, İlayda Sokur, Kadir Burak Semerci

ABSTRACT

The rapid expension of the second-hand market and the increase in product diversity, combined with the prevalence of subjective evaluations in pricing processes, have complicated the establishment of fair pricing on e-commerce platforms. The aim of this study is to minimize human-induced uncertainty by employing fuzzy logic and to develop an automated, consistent pricing decision support system. To this end, a Mamdani-type fuzzy inference system was designed using the MATLAB Fuzzy Logic Toolbox. Brand Segment (Economy, Highstreet, Luxury), Material Type (Synthetic, Natural, Noble), and Condition (New, Used, Damaged) were defined as the model's input variables; all variables were normalized to the range of [0, 1] to ensure ease of processing and standardization. For the system's output, Price Multiplier, a precise 5-level linguistic grading ranging from 'Very Low' to 'Very High' was established. A total of 27 if-then rules were constructed for the decision-making mechanism, and the defuzzification process was executed using the Centroid method. The resulting price multiplier was applied to the product's 'Base Price' to calculate the final estimated price. The system's performance was validated using real-world data from 20 products obtained from the Dolap application, and it was observed that the model produced consistent results aligned with market conditions.

Keywords: Fuzzy logic, second hand clothing, price estimation, membership functions, mamdani inference system.

1 Introduction

Real-world decision making problems frequently contain uncertainty, incomplete information and subjective assessments that cannot be expressed through crisp boundaries. In second-hand sales markets, garment prices are shaped by perceptual criteria such as brand segment, level of use and material quality, which are described mostly by linguistic terms. Classical mathematical and statistical methods require deterministic thresholds; however, these approaches remain insufficient to represent the inherent vagueness of human evaluations [1,5]. This situation makes it necessary to employ more flexible modeling frameworks that are closer to the way complex judgments are formed [6].

Fuzzy logic provides such a framework by enabling gradual membership instead of binary classification. Based on Zadeh's fuzzy set theory, elements may belong to more than one set with different degrees, and concepts like "low," "medium," and "high" can be translated into computable variables [1,3–6]. The literature shows that fuzzy logic has become an effective tool for multi-criteria decision support and qualitative evaluation problems [2–6].

Among fuzzy inference systems, the Mamdani method has been one of the most widely adopted due to its intuitive IF–THEN rule structure and high interpretability [2]. Mamdani-based models have been successfully implemented in real-estate valuation, finance, education, service quality measurement and supply-chain management [7–13,15–18]. Furthermore, the selection of membership functions and defuzzification techniques and their influence on outputs have been examined in various studies [16–21]. Recent MATLAB implementations using the Fuzzy Logic Toolbox also report practical and consistent results in different assessment domains [19–25].

In this study, a decision support model for pricing garments in second-hand sales is developed in MATLAB using Mamdani-type fuzzy inference to evaluate Brand, Condition and Material variables simultaneously [8,11,14].

Section 2 presents the preliminaries and the structure of the fuzzy inference system, Section 3 explains the methods and Mamdani-based MATLAB implementation, and Section 4 discusses the application results. The final part provides conclusions and general evaluation.

2 Preliminaries

In this section, the mathematical foundation of the suggested price prediction system is explained using fundamental concepts from Fuzzy Logic theory. Fuzzy sets, membership functions, variables, and Fuzzy Inference System's structure are all defined.

2.1 Fuzzy Sets and Logic

In classical logic, an element either fully belongs to a set or not belong at all whereas Fuzzy Logic allows degrees of membership. Fuzzy set theory, proposed by Lotfi Zadeh in 1965, is more suitable for the human thought system because of taking into account uncertain situations.

Let X be a universal set and let A be defined as a membership function $\mu_{A(x)}$ that associates every element of x in the set X with a real number in the interval [0,1].

$$A = \{ (x, \mu_{A(x)} \mid x \in X \}$$

$\mu_{A(x)}$ is the degree of membership. If the value is 1, it is called full membership, if it is 0 then there is no membership. Values between 0 and 1 mean partial membership.

2.2 Linguistic Variables

Linguistic variables are variables understood in spoken language, rather than mathematical expressions and values. In accordance with the subject of study, the brand, condition, and material inputs that are used in this study are linguistic variables. These variables are further divided into sub-linguistic variables within themselves, and each sub-linguistic variable has its own specific membership function.

2.3 Fuzzy Inference System

Fuzzy Inference System is a structure that maps inputs to outputs by using fuzzy logic. In this study, the Mamdani method, which is the most widely used inference method, was employed.

A basic Mamdani FIS structure has four main components:

1) Fuzzification: Converts numerical input values into fuzzy membership degrees through membership functions.

2) Rule Base: Defines the logical behavior of the system.

3) Inference Engine: The rules are evaluated. The min operator is commonly used for inference, while the max operator is used for rule aggregation.

4) Defuzzification: Finally, the fuzzy output is converted back into a crisp value.

2.4 Defuzzification

The output we obtain at the end of the inference process is a fuzzy set, but it is difficult to use this practically. Therefore, this fuzzy output needs to be converted into a crisp value. In this study, the Centroid method is used for defuzzification. The formula is expressed as:

$$z^* = \frac{\int \mu C(z) z dz}{\int \mu C(z) dz}$$

In this formula, z* represents the crisp output value and $\mu_{C(z)}$represents the aggregated membership function of the output variable. This method is preferred because it covers all rules and provides a smooth transition.

3 Methodology

In this study, a Mamdani-type Fuzzy Inference System is proposed for pricing second-hand clothing. The proposed model aims to transform vague concepts in the second-hand clothing market (e.g., "gently used" or "affordable luxury brand") into mathematically calculable values. The main purpose of the system is to calculate a consistent "Price Multiplier" according to product characteristics.

3.1 Linguistic Variables and Fuzzification

There are three linguistic input variables that have been defined for the establishment of this model: Brand, Condition and Material. All three variables are defined on a numerical scale in the range [0, 1]. To determine the meanings of these numerical values, a comprehensive dictionary was established. The linguistic definitions, membership boundaries, and specific ranges used in this study are presented in **Table 1.** As seen in the table, boundary values such as 0.25 and 0.75 represent transition regions where a product may belong to both categories simultaneously.

Table 1

Input/Range Value	**Brand**	**Condition**	**Material**
0.00	Pure Economy (Full Membership)	Fully Damaged (Full Membership)	Pure Synthetic (Full Membership)
0.00 – 0.17	Low-End Economy	Strongly Damaged	Strongly Synthetic
0.17 – 0.25	High-End Economy	Wearable Damaged	High-Quality Synthetic
0.25	Economy-HighStreet (Equal Membership)	Damaged-Used (Equal Membership)	Synthetic-Natural (Equal Membership)
0.25 – 0.35	Entry HighStreet	Fair Condition	Poly-Blend
0.35 – 0.50	Lower HighStreet	Visibly Worn	Natural Blend
0.50	Standard HighStreet (Full Membership)	Standard Used (Full Membership)	Standard Natural (Full Membership)
0.50 – 0.65	Upper HighStreet	Lightly Used	High-Grade Natural
0.65 – 0.75	Premium HighStreet	Excellent Condition	Premium Natural
0.75	HighStreet-Luxury (Equal Membership)	Used-New (Equal Membership)	Natural-Noble (Equal Membership)
0.75 – 0.85	Accessible Luxury	Like New	Noble Blend
0.85 – 1.00	High-End Luxury	Unworn	Pure Noble
1.00	Pure Luxury (Full Membership)	Fully New (Full Membership)	Pure Noble (Full Membership)

3.2 Membership Functions

Input and Output Parameters

Brand

For the brand parameter, which is an important factor in the sale of second-hand clothing, the input range has been defined within the range of 0 to 1.

Linguistic expressions for brand parameters:

- Economy

- HighStreet

- Luxury

Mathematical membership functions for linguistic expressions of the brand parameter are as follows.

$$\mu_{Economy}(x; 0,0.416667) = \begin{cases} 1 - 2.4x, & 0 \leq x < 0.416667 \\ 0, & 0.416667 \leq x \end{cases}$$

$$\mu_{HighStreet}(x; 0.083,0.5,0.916) = \begin{cases} 0, & x < 0.083 \\ 2.4x - 0.2, & 0.083 \leq x < 0.5 \\ -2.4x + 2.2, & 0.5 \leq x < 0.916 \\ 0, & 0.916 \leq x \end{cases}$$

$$\mu_{Luxury}(x; 0.58,1) = \begin{cases} 0, & x < 0.583 \\ 2.4x - 1.4, & 0.583 \leq x \leq 1 \end{cases}$$

Condition

For the condition parameter, which is another important factor in the sale of second-hand clothing, the input range has been defined within the range of 0 to 1.

Linguistic expressions for condition parameter:

- Damaged

- Used

- New

Mathematical membership functions for linguistic expressions of the condition parameter are as follows.

$$\mu_{Damaged}(x; 0,0.416667) = \begin{cases} 1 - 2.4x, & 0 \le x < 0.416667 \\ 0, & 0.416667 \le x \end{cases}$$

$$\mu_{Used}(x; 0.083,0.5,0.916) = \begin{cases} 0, & x < 0.083 \\ 2.4x - 0.2, & 0.083 \le x < 0.5 \\ -2.4x + 2.2, & 0.5 \le x < 0.916 \\ 0, & 0.916 \le x \end{cases}$$

$$\mu_{New}(x; 0.58,1) = \begin{cases} 0, & x < 0.583 \\ 2.4x - 1.4, & 0.583 \le x \le 1 \end{cases}$$

Material

For the material parameter, which is another important factor in the sale of second-hand clothing, the input range has been defined within the range of 0 to 1.

Linguistic expressions for material parameter:

- Synthetic
- Natural
- Noble

Mathematical membership functions for linguistic expressions of the material parameter are as follows.

$$\mu_{Synthetic}(x; 0,0.416667) = \begin{cases} 1 - 2.4x, & 0 \leq x < 0.416667 \\ 0, & 0.416667 \leq x \end{cases}$$

$$\mu_{Natural}(x; 0.083,0.5,0.916) = \begin{cases} 0, & x < 0.083 \\ 2.4x - 0.2, & 0.083 \leq x < 0.5 \\ -2.4x + 2.2, & 0.5 \leq x < 0.916 \\ 0, & 0.916 \leq x \end{cases}$$

$$\mu_{Noble}(x; 0.58,1) = \begin{cases} 0, & x < 0.583 \\ 2.4x - 1.4, & 0.583 \leq x \leq 1 \end{cases}$$

Price Multiplier

The only output of the fuzzy system to be modeled is the price multiplier and the output range has been defined between 0 and 1 (inclusive).

Linguistic expressions for price multiplier output parameter:

- Very Low
- Low
- Medium
- High
- Very High

Mathematical membership functions for linguistic expressions of the material parameter are as follows.

$$\mu_{VeryLow}(x;0{,}0.2) = \begin{cases} -5x+1, & 0 \le x < 0.2 \\ 0, & 0.2 \le x \end{cases}$$

$$\mu_{Low}(x;0.15{,}0.3{,}0.45) = \begin{cases} 0, & x < 0.15 \\ 6.67x-1, & 0.15 \le x < 0.3 \\ -6.67x+3, & 0.3 \le x < 0.45 \\ 0, & 0.45 \le x \end{cases}$$

$$\mu_{Medium}(x;0.4{,}0.5{,}0.6) = \begin{cases} 0, & x < 0.4 \\ 10x-4, & 0.4 \le x < 0.5 \\ -10x+6, & 0.5 \le x < 0.6 \\ 0, & 0.6 \le x \end{cases}$$

$$\mu_{High}(x;0.55,0.7,0.85) = \begin{cases} 0, & x < 0.55 \\ 6.67x - 3.67, & 0.55 \leq x < 0.7 \\ -6.67x + 5.67, & 0.7 \leq x < 0.85 \\ 0, & 0.85 \leq x \end{cases}$$

$$\mu_{VeryHigh}(x;0.8,1) = \begin{cases} 0, & x < 0.8 \\ 5x - 4, & 0.8 \leq x \leq 1 \end{cases}$$

3.3 Rule Base and Inference Mechanism

The system makes decisions based on a series of IF-THEN rules. A total of 27 rules were created to cover various input combinations (e.g., IF Brand is low BUT Material is high, THEN Price is Low"). System uses 3 main inputs, but the output sensitivity allows for finer linguistic classification as shown in Table 2. The simulation of the system was carried out using the MATLAB Fuzzy Logic Toolbox. For defuzzification, the Centroid method has been adopted in order to obtain accurate prediction results.

4 Application

4.0.1 Implementation Overview

The fuzzy logic procedure we propose has been programmed in MATLAB using the Fuzzy Logic Toolbox for implementation in this study. This section is intended to provide information on how the theoretical information about this system presented in Sections 2 and 3 has been put into practice in a real computational environment. We will not repeat the theoretical information detailed previously but will discuss how to implement a fuzzy model designed based on the method outlined in both Section 2 and Section 3 within the confines of MATLAB and thus provide evidence of the actual functioning of the fuzzy model.

4.0.2 Input Variables and Membership Function Design

The developed fuzzy inference system has three inputs, Brand, Condition, and Material, and one output, PriceMultiplier. In order to create a consistent and comparable way of evaluating different product attributes, each input was normalised into the range of [0,1]. For each input, we created three triangular membership functions that have at least one overlapped region between them; thus ensuring that a smooth transition from one of the categories of the input attribute (Brand, Condition, or Material) to another will occur without the presence of a discontinuity in output values. The fuzzy inference system has input variables that are supposed to be between 0 and 1. The membership function parameters for the fuzzy inference system sometimes go a little bit outside of this range. The reason we used MATLAB's "Evenly Distribute MF's" function for all input values is to provide balanced coverage of the input range and smooth transitions between categories. After using this function the reason values start from specific numbers like -0.41667 or 0.083333 is MATLAB automatically generates the membership functions and spaces them out evenly. The triangular membership functions are placed at distances across the input space of the fuzzy inference system so that they cover the space symmetrically and overlap smoothly. Because of this the base points of some triangular membership functions for the inference system might be slightly less than 0 or more, than 1. It is important to note that these values do not expand the actual input domain of the system; negative or out of range values are never provided as inputs, and MATLAB enforces the [0,1] input range during evaluation. The extended bounds only define the geometric shape of the membership functions and help prevent abrupt transitions at the boundaries, leading to more stable fuzzy inference and defuzzification behaviour.

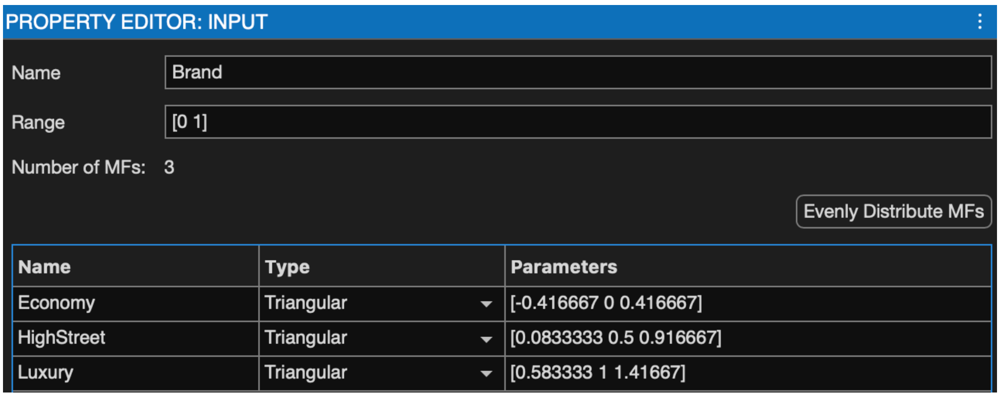

Figure 1.0: The "Evenly Distribute MF's" function is showed from a example, it's applied for all input values.

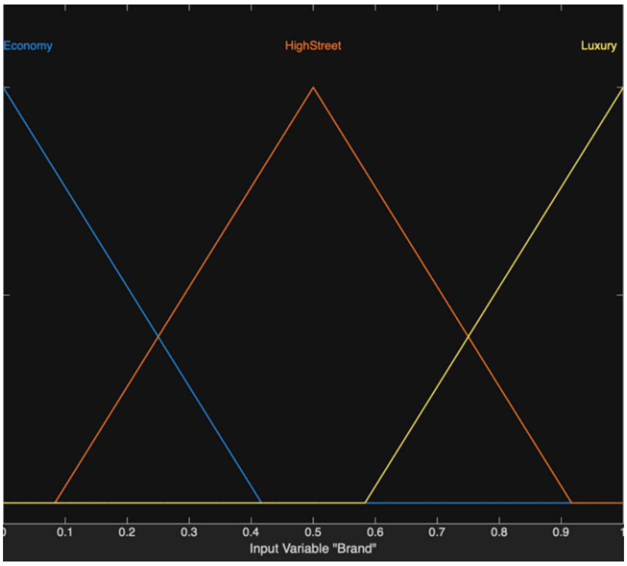

Figure 1.1: Triangular membership functions defined for the Brand input variable.

Name	Type	Parameters
Economy	Triangular	[-0.416667 0 0.416667]
HighStreet	Triangular	[0.0833333 0.5 0.916667]
Luxury	Triangular	[0.583333 1 1.41667]

Figure 1.2: Parameters of the membership functions for the Brand input variable.

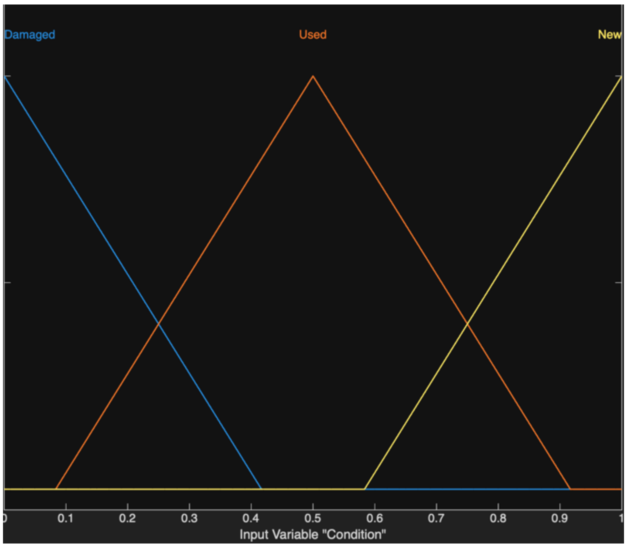

Figure 2.1: Triangular membership functions defined for the Condition input variable.

Name	Type	Parameters
Damaged	Triangular	[-0.416667 0 0.416667]
Used	Triangular	[0.0833333 0.5 0.916667]
New	Triangular	[0.583333 1 1.41667]

Figure 2.2: Parameters of the membership functions for the Condition input variable.

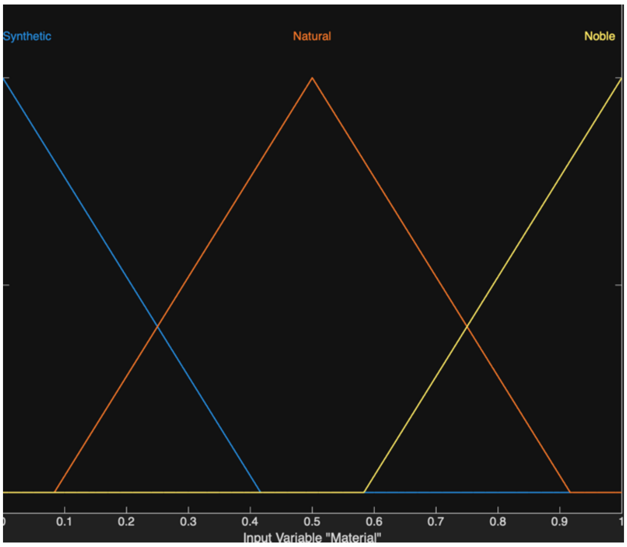

Figure 3.1: Triangular membership functions defined for the Material input variable.

Name	Type	Parameters
Synthetic	Triangular	[-0.416667 0 0.416667]
Natural	Triangular	[0.0833333 0.5 0.916667]
Noble	Triangular	[0.583333 1 1.41667]

Figure 3.2: Parameters of the membership functions for the Material input variable.

4.0.3 Output Variable Definition

The numbers we used for the PriceMultiplier membership functions were chosen because of what they mean. How they relate to each other. We wanted them to make sense. Each function is shaped like a triangle. They are lined up to show how the price impact gets stronger from VeryLow to VeryHigh. We picked the points to be at prices that seem like normal reference points, like a little influence, a medium influence and a big influence. Then we adjusted the upper limits so that each function overlaps with the ones next, to it the PriceMultiplier functions overlap so that the PriceMultiplier membership functions work well together. This overlap ensures smooth transitions between adjacent linguistic terms and prevents abrupt changes in the output. Slight extensions beyond the normalized range were introduced only to improve centroid-based defuzzification stability at extreme output values; however, these extensions do not imply the existence of negative or out-of-range price multipliers, as the effective output domain remains constrained within the normalized [0,1] interval. Overall, the parameter values were determined to balance interpretability, continuity, and robustness of the fuzzy output.

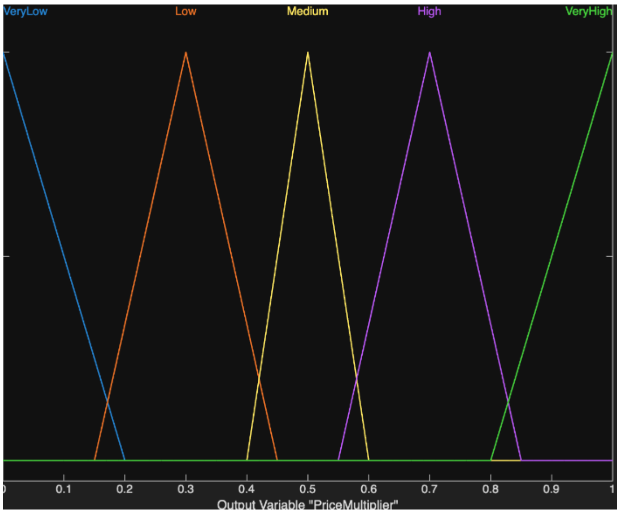

Figure 4.1: Triangular membership functions defined for the PriceMultiplier output variable.

Name	Type	Parameters
VeryLow	Triangular	[-0.2 0 0.2]
Low	Triangular	[0.15 0.3 0.45]
Medium	Triangular	[0.4 0.5 0.6]
High	Triangular	[0.55 0.7 0.85]
VeryHigh	Triangular	[0.8 1 1.2]

Figure 4.2: Parameters of the membership functions for the PriceMultiplier output variable.

4.0.4 Fuzzy Inference Mechanism

For implementation purposes, a Mamdani-style fuzzy inference system was utilized. The AND operator was used as the logical conjunction for use within the fuzzy rules, while the aggregation of all the rules was completed using the maximum operator. The centroid method for defuzzification of the aggregated fuzzy output was employed as one method to create one crisp output from the aggregated fuzzy output set.

4.0.5 Rule Base Construction

The decision-making component of the fuzzy inference system was represented by the complete rule base of 27 total fuzzy rules and included all possible combinations of the Brand, Condition, and Material variables. All 27 were constructed using the MATLAB Fuzzy Logic Toolbox's Rule Editor interface, ensuring the completeness and logical integrity of the fuzzy rule base.

	Rule	Weig...	Name
1	If Brand is Economy and Condition is Damaged and Material is Synthetic then PriceMultiplier is VeryLow	1	rule1
2	If Brand is Economy and Condition is Damaged and Material is Natural then PriceMultiplier is VeryLow	1	rule2
3	If Brand is Economy and Condition is Damaged and Material is Noble then PriceMultiplier is Low	1	rule3
4	If Brand is Economy and Condition is Used and Material is Synthetic then PriceMultiplier is Low	1	rule4
5	If Brand is Economy and Condition is Used and Material is Natural then PriceMultiplier is Medium	1	rule5
6	If Brand is Economy and Condition is Used and Material is Noble then PriceMultiplier is Medium	1	rule6
7	If Brand is Economy and Condition is New and Material is Synthetic then PriceMultiplier is Medium	1	rule7
8	If Brand is Economy and Condition is New and Material is Natural then PriceMultiplier is High	1	rule8
9	If Brand is Economy and Condition is New and Material is Noble then PriceMultiplier is High	1	rule9
10	If Brand is HighStreet and Condition is Damaged and Material is Synthetic then PriceMultiplier is VeryLow	1	rule10
11	If Brand is HighStreet and Condition is Damaged and Material is Natural then PriceMultiplier is Low	1	rule11
12	If Brand is HighStreet and Condition is Damaged and Material is Noble then PriceMultiplier is Medium	1	rule12
13	If Brand is HighStreet and Condition is Used and Material is Synthetic then PriceMultiplier is Medium	1	rule13
14	If Brand is HighStreet and Condition is Used and Material is Natural then PriceMultiplier is Medium	1	rule14
15	If Brand is HighStreet and Condition is Used and Material is Noble then PriceMultiplier is High	1	rule15
16	If Brand is HighStreet and Condition is New and Material is Synthetic then PriceMultiplier is High	1	rule16
17	If Brand is HighStreet and Condition is New and Material is Natural then PriceMultiplier is High	1	rule17
18	If Brand is HighStreet and Condition is New and Material is Noble then PriceMultiplier is VeryHigh	1	rule18
19	If Brand is Luxury and Condition is Damaged and Material is Synthetic then PriceMultiplier is Low	1	rule19
20	If Brand is Luxury and Condition is Damaged and Material is Natural then PriceMultiplier is Medium	1	rule20
21	If Brand is Luxury and Condition is Damaged and Material is Noble then PriceMultiplier is Medium	1	rule21
22	If Brand is Luxury and Condition is Used and Material is Synthetic then PriceMultiplier is Medium	1	rule22
23	If Brand is Luxury and Condition is Used and Material is Natural then PriceMultiplier is High	1	rule23
24	If Brand is Luxury and Condition is Used and Material is Noble then PriceMultiplier is VeryHigh	1	rule24
25	If Brand is Luxury and Condition is New and Material is Synthetic then PriceMultiplier is High	1	rule25
26	If Brand is Luxury and Condition is New and Material is Natural then PriceMultiplier is VeryHigh	1	rule26
27	If Brand is Luxury and Condition is New and Material is Noble then PriceMultiplier is VeryHigh	1	rule27

Figure 5: The complete rule base consisting of 27 IF-THEN rules defined in the MATLAB Rule Editor.

4.0.6 System Architecture

To provide clarity regarding the fuzzy inference system architecture, the overall layout of the Mamdani fuzzy inference system (including all three input variables, the Mamdani inference block, and the final output variable) was created through the toolbox-generated system diagram.

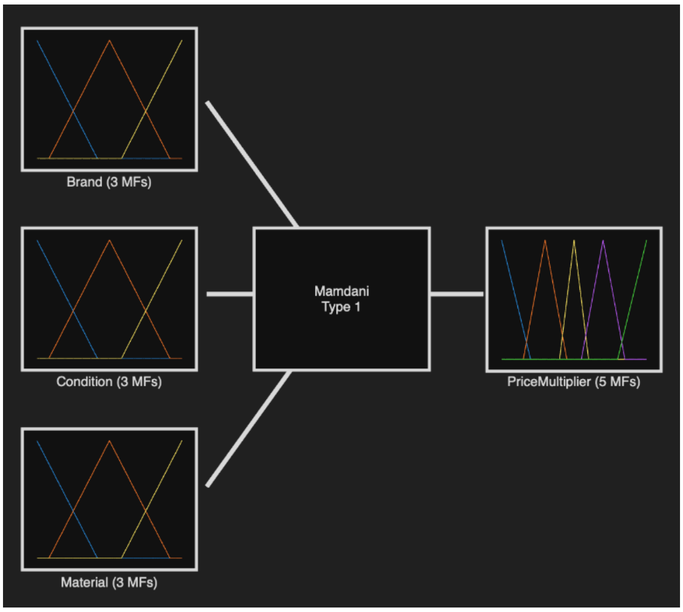

Figure 6: Architecture of the proposed Mamdani fuzzy inference system.

4.0.7 System Validation and Test Scenarios

The fuzzy logic system was validated by various test scenarios, using Evalfis function in MATLAB. One of these tests was used to examine extreme system behavior. For example, the scenarios (0, 0, 0) and (1, 1, 1) confirmed that both VeryLow and VeryHigh PriceMultiplier outputs are produced when either of these extreme input conditions are present. Intermediate value tests were also carried out and indicated smooth transitions in system output and behavior along with expected responses, due to rules defined in the rule base.

```
>> fis = readfis("bulanikodev.fis");

% Test input matrisi (Brand, Condition, Material)
X = [
 0.65 0.60 0.35
 0.25 0.50 0.00
 1.00 0.50 1.00
 0.50 1.00 0.20
 0.17 0.25 0.00
 0.85 0.17 0.35
 0.35 0.50 0.50
 0.50 1.00 0.65
 0.50 1.00 0.50
 0.25 0.50 0.25
 0.00 0.25 0.00
 0.50 0.25 0.50
 0.85 1.00 0.17
 0.65 0.65 1.00
 0.17 1.00 0.00
 0.35 0.25 0.00
 0.65 0.50 0.85
 0.85 0.85 0.65
 0.85 0.50 0.85
 0.50 1.00 0.50
];

% Fuzzy inference
Y = evalfis(fis, X);
```

```
% Sonuçları tablo olarak göster
ResultTable = table( ...
    X(:,1), X(:,2), X(:,3), Y, ...
    'VariableNames', {'Brand','Condition','Material','PriceMultiplier'} );

disp(ResultTable)
```

Brand	Condition	Material	PriceMultiplier
0.65	0.6	0.35	0.58423
0.25	0.5	0	0.3786
1	0.5	1	0.93667
0.5	1	0.2	0.7
0.17	0.25	0	0.26164
0.85	0.17	0.35	0.45547
0.35	0.5	0.5	0.5
0.5	1	0.65	0.73763
0.5	1	0.5	0.7
0.25	0.5	0.25	0.3786
0	0.25	0	0.2108
0.5	0.25	0.5	0.3786
0.85	1	0.17	0.74818
0.65	0.65	1	0.73763
0.17	1	0	0.58041
0.35	0.25	0	0.28851
0.65	0.5	0.85	0.70353
0.85	0.85	0.65	0.79662
0.85	0.5	0.85	0.79662
0.5	1	0.5	0.7

Figure 7: Numerical validation results showing calculated outputs for various input scenarios.

4.0.8 Price Estimation Method

The fuzzy inference output represents a PriceMultiplier, not an absolute price value. The PriceMultiplier will be applied to the base price (zero condition price) to obtain an estimated product value. Therefore, the Fuzzy Logic System takes into account the relative importance of the attributes of Brand, Condition, and Material to be able to determine a PriceMultiplier. The base price level is externally defined or predetermined.

The Estimated Product Value is mathematically calculated using the following equation:

Estimated Price = Retail Price * PriceMultiplier

Using this equation provides an effective and simple method of estimating Products Value using a fuzzy inference system without affecting its ability to work independently of scale, or its ability to provide easy to understand methods of interpreting Product Value estimation.

4.1 Findings

This fuzzy logic-based system was created to help determine the price of second-hand clothing. In this system, brand, condition and material parameters are selected as inputs, while the price multiplier is selected as the output. To test this system, random 20 data were randomly selected using the "Dolap" mobile app. The values obtained are shown in Table 2. The fuzzy inference system was tested using sample input combinations, and the MATLAB implementation is provided in Appendix A.

Table 2

No	Retail Price (TL)	Brand Input	Condition Input	Material Input	MATLAB Output (Multiplier)	Estimated Price (TL)	Actual Sales Price (TL)	Error Margin
1	5,000	0.65	0.60	0.35	**0.5842**	2,921	3,100	5.8%
2	400	0.25	0.50	0.00	**0.3786**	151	165	8.5%
3	14,000	1.00	0.50	1.00	**0.9367**	13,113	12,800	2.4%
4	2,500	0.50	1.00	0.20	**0.7000**	1,750	2,000	12.5%
5	1,500	0.17	0.25	0.00	**0.2616**	392	410	4.4%
6	12,000	0.85	0.17	0.35	**0.4555**	5,466	5,100	7.2%
7	550	0.35	0.50	0.50	**0.5000**	275	250	10.0%
8	1,800	0.50	1.00	0.65	**0.7376**	1,327	1,500	11.5%
9	550	0.50	1.00	0.50	**0.7000**	385	350	10.0%
10	940	0.25	0.50	0.25	**0.3786**	356	400	11.0%
11	400	0.00	0.25	0.00	**0.2108**	84	80	5.0%
12	1,500	0.50	0.25	0.50	**0.3786**	568	520	9.2%
13	7,500	0.85	1.00	0.17	**0.7482**	5,611	5,500	2.0%
14	7,500	0.65	0.65	1.00	**0.7376**	5,532	5,300	4.4%
15	310	0.17	1.00	0.00	**0.5804**	180	200	10.0%
16	2,000	0.35	0.25	0.00	**0.2885**	577	550	4.9%
17	6,000	0.65	0.50	0.85	**0.7035**	4,221	4,100	3.0%
18	30,000	0.85	0.85	0.65	**0.7966**	23,898	23,500	1.7%
19	4,000	0.85	0.50	0.85	**0.7966**	3,186	3,300	3.5%
20	1,200	0.50	1.00	0.50	**0.7000**	840	850	1.2%

Explanation and Commends for Table 2

The results from 20 randomly selected used products are summarized in Table 2. Based on the linguistic scales and membership definitions were described in Table 1, the input values for Brand, Condition, and Material were determined. The original market price of the item in its zero-condition state is displayed in this table's "Retail Price" column. The simulation process is shown in Figure 7, and the 'MATLAB Output' represents the defuzzified Price Multiplier generated by the fuzzy inference system. Retail Price was multiplied by this MATLAB-generated multiplier to obtain the "Estimated Price." Lastly, we calculated the "Error Margin," which we will discuss in more detail, by comparing these estimated values with the "Actual Sales Price" obtained from the Dolap application.

4.2 Discussion

In this uncertain, unstable, and easily manipulated environment, is a 6.41% margin of error a good one?

It is true that the market is highly uncertain. For example, a brand that might be considered economic by one person could be luxurious by another. This also applies to the other parameters.

When commonly accepted perceptions are accurately considered, an average margin of error of 6.41% with only 3 input parameters can help people to estimate the value of their clothes.

What was a more effective approach?

Brand, condition and material parameters can be used with their own fuzzy systems. For example, by processing data such as the percentage of cotton and elastane in the fabric, a more accurate input value can be generated with using its own fuzzy system for the material parameter. This can help us to obtain more accurate results.

- The success of this fuzzy system model relies on user feedback. The accuracy of the data provided by the user is one of the most important factors here.

5 Results and Evaluations:

In order to test the success and applicability of the developed system in real-life scenarios, a comprehensive validation study was carried out on twenty different product data points randomly selected from a popular second-hand sales application. In this process, estimated sales values were calculated by processing the retail prices of the products with the price multipliers generated by the model, and these values were compared with the actual sales prices. When the analysis results were examined, it was determined that the system predicted market prices with a very low average margin of error of 6.41%. Considering the high uncertainty inherent in the second-hand market, the perception of product conditions that varies from person to person, and the subjective interpretability of brand value, this rate demonstrates that the system works in high harmony with market dynamics. While it was observed that the error converged to zero for some products in the test set, it was understood that in cases where deviation occurred, this difference generally stemmed from the subjectivity in users' brand perception. These obtained findings prove that the model can produce a consistent and reliable "Price Multiplier" even though only three basic input parameters are used. This result presented by the study is of great importance in terms of demonstrating that the pricing structure open to manipulation and the valuation uncertainty frequently encountered in the second-hand clothing market can be resolved with a mathematical and transparent method. The system minimizes the indecision experienced by sellers when valuing their products, while functioning as a reference mechanism offering a fair price guarantee for buyers. This situation directly contributes to the establishment of an environment of trust, which is critical for the sustainability of the circular economy. In the next phase of the study, certain technical improvements are recommended to increase the sensitivity of the system and further reduce the margin of error. Detailing the material parameter used in the current model with sub-fuzzy sets fed by more numerical data, such as the fabric's cotton, elastane, or synthetic content ratios, will increase the accuracy of the price prediction. Furthermore, since the success of the model relies heavily on the accuracy of the data provided by the user, the creation of a dynamic rule base structure that integrates user feedback into the system is recommended. When supported by such improvements, it is possible for the proposed system to be used as a standard pricing module for second-hand e-commerce platforms.

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APPENDİX A

MATLAB Code for Fuzzy Inference System Testing

This Appendix presents the MATLAB code used to test the developed Mamdani-type fuzzy inference system. The .fis file created in the Fuzzy Logic Toolbox is loaded and evaluated using multiple test input combinations representing different brand, condition, and material levels. The resulting price multiplier outputs are displayed in tabular form.

```
fis = readfis("bulanikodev.fis");

% Test input matrisi (Brand, Condition, Material)
X = [
 0.65 0.60 0.35
 0.25 0.50 0.00
 1.00 0.50 1.00
 0.50 1.00 0.20
 0.17 0.25 0.00
 0.85 0.17 0.35
 0.35 0.50 0.50
 0.50 1.00 0.65
 0.50 1.00 0.50
 0.25 0.50 0.25
 0.00 0.25 0.00
 0.50 0.25 0.50
 0.85 1.00 0.17
 0.65 0.65 1.00
 0.17 1.00 0.00
 0.35 0.25 0.00
 0.65 0.50 0.85
 0.85 0.85 0.65
 0.85 0.50 0.85
 0.50 1.00 0.50
];

% Fuzzy inference
Y = evalfis(fis, X);

% Sonuçları tablo olarak göster
ResultTable = table( ...
    X(:,1), X(:,2), X(:,3), Y, ...
    'VariableNames', {'Brand','Condition','Material','PriceMultiplier'} );

disp(ResultTable)
```