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The Implementation of Fuzzy Inference System for Predicting the Price of Oil Palm Fruit at PT. Tri Bahtera Srikandi

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ABSTRACT

Technology is widely implemented in various fields, especially in the field of oil palm fruit plantations. Oil palm plantations are one of the industrial sectors that directly benefit from the development of digital technology. Currently, many new innovations and technologies are emerging that can increase the productivity and welfare of oil palm farmers while maintaining the quality of the plants from time to time to maintain the price of oil palm fruit. PT. Tri Bahtera Srikandi is a palm oil mill that produces palm fruit into oil or CPO (Crude Palm Oil). Determining the price of oil palm fruit aims to provide fair prices to plantations and companies so that there are no losses from any party. However, the problem that arises is that when the price of palm oil fruit falls or increases periodically, the company will experience the risk of loss and uncertainty caused by fluctuations in the price of palm oil fruit. It is impossible for a company to be able to accommodate too much oil palm fruit for a long time so that if palm fruit is piled up, rot will occur in the palm oil fruit and this can affect production results and the amount of available oil or CPO (Crude Palm Oil). Therefore, it is important to predict the price of oil palm fruit in the future. Application of using the Tsukamoto fuzzy logic method in predicting the price of oil palm fruit at PT. Tri Bahtra Srikandi. It can be implemented in predicting the price of oil palm fruit accurately.

1. INTRODUCTION

With the advancement of time, technological progress is rapidly evolving[1]. Technology can simplify and expedite the exchange of information, enhancing the efficiency and effectiveness of work processes. Technology is widely implemented in various fields, particularly in the oil palm plantation sector[2]. Oil palm plantations are among the industries directly benefiting from the development of digital technology[3]. Many innovations and the latest technologies have emerged to improve productivity and the well-being of oil palm farmers[4], while also maintaining the quality of the plants over time to sustain the price of oil palm fruit.

In the Mandailing Natal Regency, there are numerous oil palm plantations managed by companies and estates, such as PT. Tri Bahtera Srikandi Patiluban Mudik. PT. Tri Bahtera Srikandi is one of the oil palm factories that processes oil palm fruit into crude palm oil (CPO). Oil palm fruit is a plant used in commercial agriculture to produce palm oil [5]. It is also an industrial plant used as raw material for cooking oil, industrial oil, and fuel.

The price of oil palm fruit is determined by the Department of Plantation (Disbun). The purpose of setting the price of oil palm fruit is to provide a fair price to plantations and companies, ensuring that no party incurs losses. However, the issue arises when the price of oil palm fruit fluctuates periodically, leading to risks and uncertainties for companies. Companies may face losses and uncertainties due to the fluctuation in the price of oil palm fruit. Companies cannot store excessive amounts of oil palm fruit for an extended period. Accumulation of oil palm fruit may lead to decay and negatively impact production results and the availability of crude palm oil (CPO).

2. LITERATURE REVIEW

The research the title "Implementation of Fuzzy Inference System to Determine Family Planning Contraceptive Methods" concludes that the parameters used for fuzzy membership functions in this study are age, mating frequency, health status, effectiveness, price, and duration. The Spearman correlation calculation yielded a correlation value of 0.606, which, according to the Spearman correlation table, falls into the strong category. Hence, it can be utilized to assist in recommending the appropriate selection of contraceptive methods for each acceptor [6]. The research with the title "APPLICATION OF FUZZY INFERENCE SYSTEM IN INTERIOR DESIGN SELECTION" employs the Mamdani method for selecting interior designs. The system generated consists of criteria for selecting designs according to user needs. Thus, the research results obtained an output value of 427.368, falling within the range of considered values [7].

2.1 Definition of Forecasting

Forecasting is the activity of estimating or predicting what will happen in the future within a specific time frame. Prediction is a systematic process of estimating what is most likely to happen in the future based on past and current information [8]. Predicting something can reduce errors in the difference between what happens and the estimated result. Prediction is synonymous with forecasting or estimation, indicating what will happen in a given situation and serving as input for planning and decision-making processes [9].

2.2 Definition of Fuzzy Logic

The foundation of fuzzy logic is the theory of fuzzy sets. In fuzzy set theory, the role of membership degree as a determinant of the presence of an element in a set is crucial[10]. Membership value or membership degree or membership function is a key characteristic of reasoning with fuzzy logic[11]. In crisp sets, the membership value ($\mu_A(x)$) for an item x in a set A is either One (1), indicating that the item is a member of the set, or Zero (0), indicating that the item is not a member. The Membership Function is a curve that shows the mapping of input data points into their membership values (often called membership degrees), which typically range from 0 to 1 [12].

2.3 Definition of Fuzzy Tsukamoto Method

The fuzzy Tsukamoto method is a decision-making method used to determine the quantity of product production[13]. This method is chosen because each consequence in the IF-THEN rule is represented using fuzzy sets in a monotonous membership function[14]. As a result, the output of each rule is then obtained by using a centered average. The advantage of this method is its speed in computation, widespread acceptance, and the ability to generate output with each rule given explicitly based on the alpha predicate (α) [15].

2.4 Oil Palm Fruit

PT. Tri Bahtera Srikandi is one of the oil palm factories located in the Patiluban Mudik District that produces palm oil. Oil palm fruit is a plant that produces oil with various benefits, serving as an industrial plant for the production of cooking oil, industrial oil, and other fuels. This fruit plays a crucial role in the oil industry by replacing coconuts as a raw material source. Additionally, oil palm is an easy-to-maintain plant with relatively high market value [16].

3. RESEARCH METHOD

3.1 Problem Identification

The fluctuation in the price of oil palm fruit, influenced by the fluctuations in the sale prices of crude palm oil (CPO) and kernel at PT. Tri Bahtera Srikandi.

3.2 Problem Analysis

In-depth analysis of the issue, focusing on the price of oil palm fruit, utilizing the Fuzzy Inference System Tsukamoto as the research subject.

3.3 Data Collection

Data collection through interviews with the manager of the oil palm factory at PT. Tri Bahtera Srikandi.

3.4 Data Processing

Processing of interview data to derive meaningful insights from the manager of the oil palm factory at PT. Tri Bahtera Srikandi.

3.5 Implementation of Fuzzy Inference System Tsukamoto

Application of the fuzzy method using previously processed data to design and build a system for predicting the price of oil palm fruit.

3.6 System Design and Development

Design of the system based on UML, including Use Case Diagrams, Activity Diagrams, and Class Diagrams. System development using PHP and MySQL as the database.

3.7 System Testing

Testing of the web-based system using PHP and MySQL to ensure compliance with specifications and measure the system's success rate.

3.8 System Implementation

The final stage involves the implementation of the oil palm fruit price prediction system by PT. Tri Bahtera Srikandi. The system is implemented as a web-based solution for easy accessibility and user flexibility.

4. RESULTS AND DISCUSSION

The required data for this research includes oil palm fruit price data such as sales data (K1), production data (K2), and oil palm fruit price data (K3) over the past year. The research extracts oil palm fruit price data, as shown in Table 1.

Table 1. Data Production from June 2022 to June 2023

Year	Moon	Sales (kg)	Production (kg)	Price (/kg)
2022	June	3.001.460	4.108.541	IDR 2,194
2022	July	3.719.470	3.542.810	IDR 2,253
2022	August	5.091.220	3.957.312	IDR 2,248
2022	September	2.831.920	2.798.744	IDR 2,216
2022	October	2.901.410	2.855.230	IDR 2,193
2022	November	2.700.230	2.704.804	IDR 2,115
2022	December	2.437.970	2.389.989	IDR 2,627
2023	January	3.300.000	3.395.004	IDR 2,698
2023	February	2.811.590	2.543.630	IDR 2,621
2023	March	3.704.570	3.910.493	IDR 2,840
2023	April	3.652.580	3.689.932	IDR 2,575
2023	May	3.804.000	3.802.376	IDR 2,389
2023	June	3.200.000	2.800.000	?

From the above calculations, the following results are obtained:

- Highest sales = 5,091,220
- Lowest sales = 2,437,970
- Highest production = 4,108,541
- Lowest production = 2,389,989
- Highest price = 2,840
- Lowest price = 2,115

4.1 Determining Variables and Domains (Fuzzification)

The formation of fuzzy sets is the first step when using the Tsukamoto Method.

4.2 Inference Engine

From the description above, four fuzzy sets are formed: Low Sales, High Sales, Decreasing Production, Increasing Production, Decreasing Price, Increasing Price. Four fuzzy rules are obtained as follows:

[R1] IF High Sales and Increasing Production, THEN the Price of Oil Palm Fruit INCREASES.
[R2] IF High Sales and Decreasing Production, THEN the Price of Oil Palm Fruit INCREASES.
[R3] IF Low Sales and Increasing Production, THEN the Price of Oil Palm Fruit DECREASES.
[R4] IF Low Sales and Decreasing Production, THEN the Price of Oil Palm Fruit DECREASES.

4.3 Rule Composition

Based on the four fuzzy rules above, the values of R and z are determined for each rule. Steps are taken to convert these four rules to obtain the values of R and z for each rule.

4.4 Defuzzification Process

In the Tsukamoto method, to determine the crisp output, center-average defuzzification is used.
Therefore, the predicted price of oil palm fruit in June 2023 according to the Tsukamoto Method is Rp 2,373.

Table 2. Data Production from June 2022 to June 2023

Year	Moon	Sales (kg)	Production (kg)	Price (/kg)
2022	June	3.001.460	4.108.541	IDR 2,194
2022	July	3.719.470	3.542.810	IDR 2,253
2022	August	5.091.220	3.957.312	IDR 2,248
2022	September	2.831.920	2.798.744	IDR 2,216
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2023	May	3.804.000	3.802.376	IDR 2,389
2023	June	3.200.000	2.800.000	IDR 2,373

Based on the built system, the system implementation is obtained as follows:

a. Form Login

The login menu is used to restrict system access rights, where only users with an account or those registered in the system database are authorized to access the system. The following image is a representation of the login menu interface.

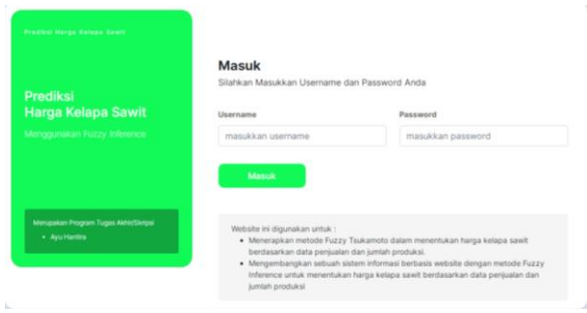

Figure 1. Form Login

Users first fill in the username and password registered in the system database. The system then verifies the user account data. If successful, the system displays the next menu; otherwise, it shows an error message for incorrect username or password and remains on the login menu.

b. Admin Interface

The Admin Interface is the main menu that appears after a user successfully logs in. Here is the admin interface:

Figure 2. Admin Interface

This Admin Interface displays the main menu of the system, also showing the total number of products and predicted prices that have been input into the system. In the master data menu section, there are other menus such as oil palm data and price data.

c. Product Data Display

In the product data display, it shows a list of product data that has been entered into the system. This product data page is used to view the list of entered products. Here is the product data page:

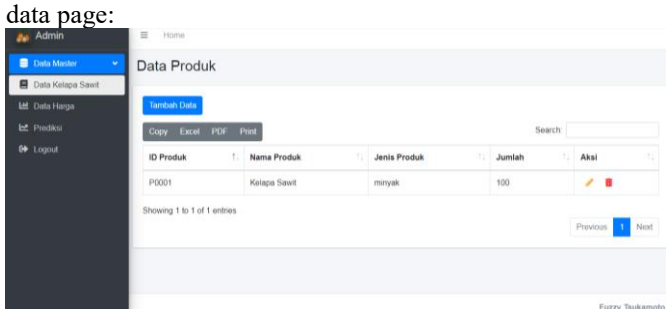

Figure 4. Product Data Display

d. Price Data Display

The Price Data Display is a page that contains information about product orders, including the quantity of sales, production, and the price of oil palm fruit. It includes commands for adding new data, as well as options for editing and deleting data through action commands. Here is the price data display:

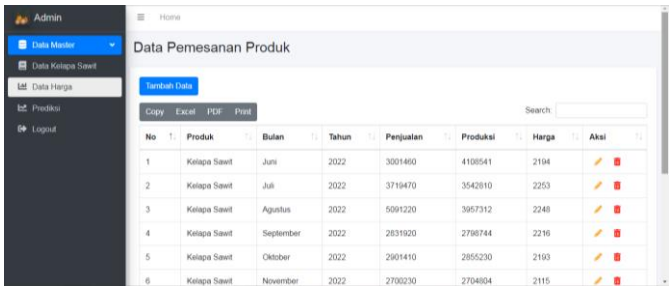

Figure 5. Price Data Display

When you want to add data in the order form, it will appear as the following display:

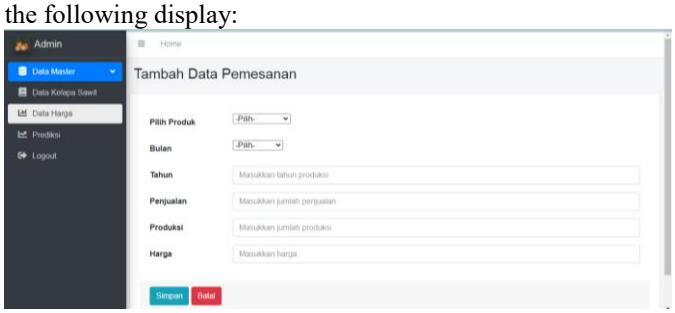

Figure 6. The display for adding data in the order form

e. Tampilan Form Prediksi

The Prediction Form display shows the processed data that has resulted in automatic predictions. Here is the prediction form view:

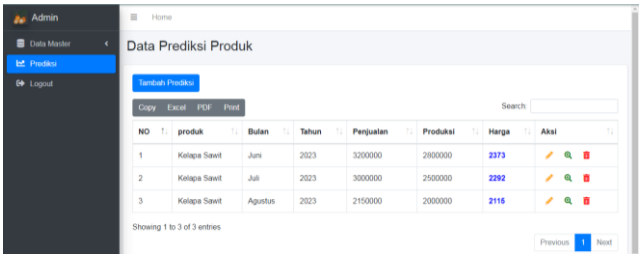

Figure 7. The display of the prediction data form

When you want to add a prediction, it will appear as the following display:

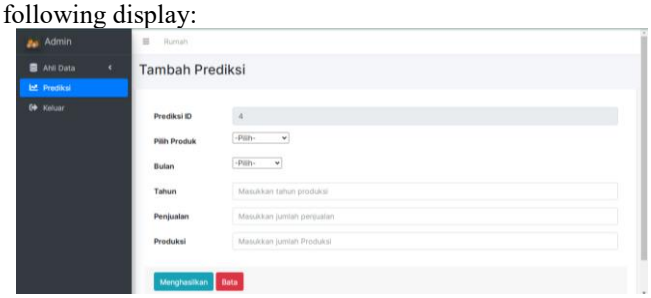

Figure 8. The display for adding a prediction

The book size should be in A4 (8.27 inches × 11.69 inches). Do not change the current page settings when you use the template.

The number of pages for the manuscript must be no more than ten, including all the sections. Please make sure that the whole text ends on an even page. Please do not insert page numbers. Please do not use the Headers or the Footers because they are reserved for the technical editing by editors.

5. CONCLUSIONS

The implementation utilizes the Tsukamoto fuzzy logic method to predict the price of oil palm fruit at PT. Tri Bahtra Srikandi. This enables accurate predictions of oil palm fruit prices. The design and development of the Tsukamoto fuzzy logic system are carried out using XAMPP software, UML, and the PHP programming language. The constructed system significantly aids in predicting oil palm fruit prices more quickly, efficiently, and accurately. Equations

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