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Implementation Fuzzy Mamdani Algorithm To Predict Web Based Inventory

Bambang Adiwinoto [a,1], Dian Novianto[a,2]

[a] Institut Sains dan Bisnis Atma Luhur, Indonesia
[1] baw@atmaluhur.ac.id; [2] diannovianto@atmaluhur.ac.id*;

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ABSTRACT

Mamdani's fuzzy algorithm enables the use of fuzzy logic to overcome the uncertainties and ambiguities associated with inventory predictions. This study describes implementing the Mamdani fuzzy algorithm to predict web-based inventory. Fuzzy algorithms allow unambiguous logic to deal with the uncertainties and ambiguities associated with inventory predictions. We collect relevant inventory data, including input variables such as the number of items sold, customer demand, and other factors that affect inventory. We also use historical inventory data to create the Mamdani fuzzy model. We implement fuzzification by specifying a linguistic variable for each input variable and converting the numeric to a linguistic value using a predefined membership function, then build a rule-based fuzzy mamdani which includes a set of rules that relate language values as input variables with linguistic values of output variables., i.e., inventory prediction. After the inference process, we apply defuzzification using the Mamdani method to convert the linguistic values of the output variables into numeric values that can be used in practice. Through this implementation, we managed to integrate the power of Mamdani's fuzzy algorithm with web technology so that users can access the inventory prediction system online. This system can assist inventory managers in making better decisions in production planning, stock procurement, and delivery schedule. This system is expected to increase efficiency and optimize inventory availability in a rapidly changing business environment.

1. Introduction

Of the total population of Indonesia, as much as 62.10 percent of Indonesia's population accessed the Internet in 2021 [1]. It shows that the penetration of information technology is very good so that it can be utilized in the business sector. Indonesia is included in the list of countries with the largest e-commerce growth, with a growth of 78 percent, and is ranked 1st in the world [2]. With the increasing growth of e-commerce, of course, sellers have a storage mechanism for the goods that are sold. One thing that can be done by utilizing information technology is web-based inventory management. Through the web, we can access information in the form of text and sound, images, videos, and animations [3]. Inventory of goods (inventory) is the stock of an item or resource used in a company organization. To carry out the inventory function, companies generally maintain four types of inventory. the four types of inventories are (1) raw material inventories, (2) goods inventories, (3) maintenance or repair or supplier operations (MRO) inventories, and (4) finished goods inventories [4]. Inventory management is vital in maintaining the smooth running of business operations. Inefficient inventory can lead to high costs, stock shortages, or even excess unsold stock. Therefore, accurate and timely inventory predictions are needed to optimize the availability of goods and increase customer satisfaction. In recent years, web technology has experienced rapid development and has become integral to various aspects of our lives, including in business. With a web application, inventory managers can use this technology to gain easy, fast, and continuous access to inventory management systems. One of the approaches used in predicting inventory is the Mamdani fuzzy algorithm. Mamdani's fuzzy algorithm allows for modeling uncertainty and ambiguity in inventory data processing. The Mamdani fuzzy method has a mathematical concept that underlies fuzzy reasoning, which is easy to understand and very simple and very flexible, then have a tolerance for inaccurate data; the results of the previous studies have calculated that the Mamdani fuzzy method has a lower fault rate than the Sugeno method in terms of predictions [5]. This algorithm can overcome the variations and uncertainties associated with inventory predictions by utilizing fuzzy logic. In this research, we will implement the Mamdani fuzzy algorithm in predicting web-based inventory. Using these techniques is expected to provide a greater level of trust and confidence because it can be tested scientifically for storage or deviation [6]. By using web technology, the inventory prediction system will become more interactive and accessible online. Because the computer system is very good at predicting goods and can reduce the difference in errors from the data requirements to be met, it is hoped that the prediction results can be minimized and concentrated because the results obtained have been through fuzzy logic calculations with valid data [7]. It allows users to input inventory variables, such as the number of items sold and customer requests, via an easy-to-use web interface. This implementation aims to provide more accurate inventory predictions and assist inventory managers in making better decisions in planning production, stock procurement, and scheduling shipments. With the existence of a web-based inventory prediction system that uses the Mamdani fuzzy algorithm, it can improve operational efficiency and optimize inventory availability in a dynamic and changing business environment.

2. Method

2.1. Fuzzy Mamdani

Mamdani's fuzzy algorithm does not require specific data or definite numerical values. In inventory prediction, there are situations where the available data cannot be measured with precision, such as "little," "medium," or "a lot." Mamdani's fuzzy algorithm allows the use of fuzzy sets that reflect the membership level of a value in a particular set. Thus, this algorithm can process more qualitative data and handle uncertainties in inventory data processing. The Mamdani method is a method known as the min-max method. Ebrahim Mamdani demonstrated this method in 1975. To run this method and produce output there are 4 stages to go through, including [8]:

1. Form a fuzzy sets.

Membership Function: Applies membership functions to input variables to convert numeric values into membership values in a predefined fuzzy set. For example, if the input variable is "number of items sold" and has membership functions of "small," "medium," and "many," then each numeric value will be assigned a membership value in that set.

2. Apply the function of implication.

in this method, the function of implication that is used between max and min is Min, and it can be writte $\mu_{A \cap B} = \min(\mu_A[x], (\mu_B[x],)$

3. Composition of rules

Using fuzzy rules to perform inference and generate membership values that can be used as a basis for generating output variable linguistic values. The method used in making fuzzy system inference, namely max, can be written as follows: $\mu sf[Xi] = \max(\mu sf[Xi], \mu kf[Xi])$,which functioning as:

$\mu sf[Xi]$ = nilai keanggotaan solusi *fuzzy* sampai aturan ke i

$\mu kf[Xi]$ = nilai keangotaan konsekuan *fuzzy* aturan ke i

4. Affirmation

The input needed in the defuzzification process is in the form of fuzzy sets obtained from the fuzzy rules. At the same time, The resulting output is in the form of numbers in the fuzzy set domain. then when given a fuzzy set in a particular range as output, changing membership value of the output variable into a numeric value can be used in practice. One of the defuzzification methods commonly used in the Mamdani fuzzy algorithm is the centroid method, where the center point (centroid) of a fuzzy membership set output variables is used as a symbol of the resulting numerical value.

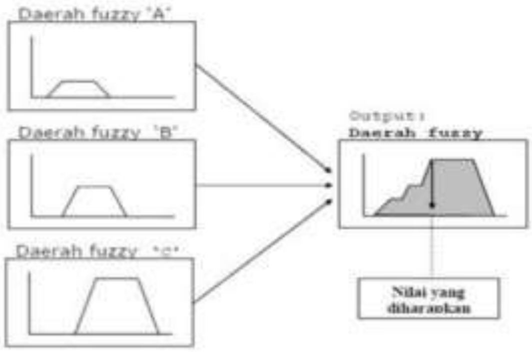


Fig 1. Defuzzification Process [9].

$$\mu(x) = \frac{\int_a^b x\mu(x)dx}{\int_a^b \mu(x)dx}$$

atau $$\mu(x) = \frac{\sum_{i=1}^{n} x_i \mu(x_i)}{\sum_{i=1}^{n} \mu(x_i)}$$

Fig 2. Bo Yuan Centroid Formula [10]

2.2. Research Procedure

This study uses a prototype model as a reference in system development. The prototype method used can produce a prototype system as an intermediary for system makers and system users to interact information system development activities. In order for the prototype-making process to work well, it is necessary to determine the rules at an early stage; that is, developers and users are required to have one understanding that this prototype is made to determine the initial requirements. Parts in the prototype can be removed or added to its parts to be under the developer's planning and analysis until so trials can be carried out concurrently with the development process [11]. The stages that this model goes through include (a) Gathering Requirements, (b) Design Process, (c) Building a Prototype, and (d) Evaluation and Improvement.

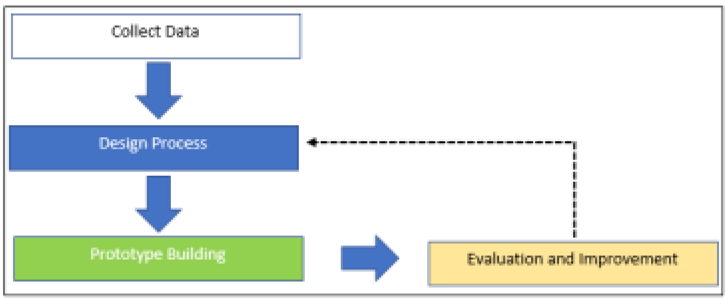


Fig 3. Prototype Model

At the needs-gathering stage in this study, the method used is qualitative, in which researchers function as the primary tool in collecting data or information [12]. The techniques used include interviews, literature study, and observation at a helmet shop in Pangkalpinang. The results based on interviews and observations, that can be noticed that the problems that occur are recording sales transactions, recording product inventory, providing sales services to consumers, and preparing reports; because the system used is still conventional, errors often occur, and delays in the process of restocking goods.

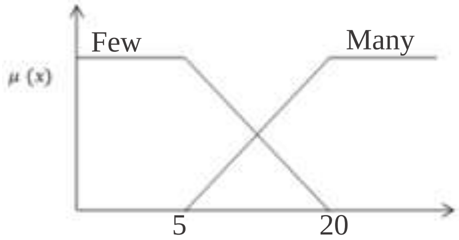
Then at the model and system design process stage, the researcher analyzed the needs and business processes running at the helmet shop, then made activity diagram running and proposals, use case, sequence, and class diagrams for databases. In addition, in the second stage, fuzzy Mamdani modeling was also carried out for inventory at the helmet shop, which was used as the research object. The domain variable inventory for the fuzzy set can look on Table 1.

Table 1. Inventory Data

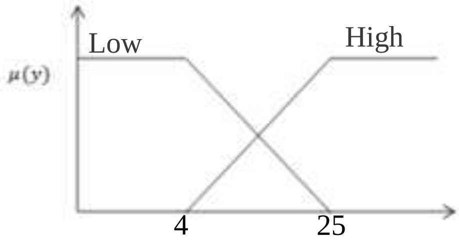
No	Inventory Data	Number of Item
1	Items come out a little	5
2	Items come out a lot	20
3	Small of Inventory	4
4	Lots of inventory	25
5	Little of purchases	5
6	Lots of purchases	25

The results of the Mamdani fuzzy method show that after data from supply and demand is available, it will automatically display procurement predictions of goods from the Mamdani fuzzy method. Several things need to be done, namely (1) determining the supply variable, (2) determining the demand variable, and (3) determining the purchasing variable. The data used from the discussion of this method is using inventory data totaling ten and demand totaling 18, then the fuzzy set domain used is as follows:

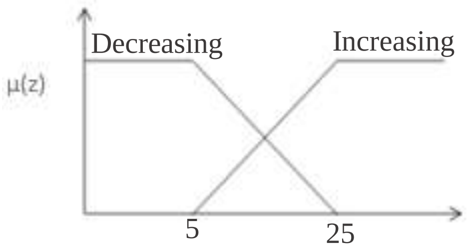
- Domain of Goods Out Fuzzy Sets consists of 2 sets, namely many and few.



- Domian of Supply Fuzzy Sets consists of 2 sets, namely high and low.



- Domain of the Goods Purchasing Fuzzy set consists of 2 sets, namely increasing and decreasing.



- The next step is to find the outgoing membership function. The formula is:
  µFewGoodsOut[x]

$$= \begin{cases} 1 , & x \le x\,min \\ \frac{x\,max - x}{x\,max - x\,min} , & x\,min \le x \le x\,max \\ 0 , & x \ge x\,max \end{cases} \longrightarrow = \begin{cases} 1 , & x \le 5 \\ \frac{20 - x}{20 - 5} , & 5 \le x \le 20 \\ 0 , & x \ge 20 \end{cases}$$

  µManyGoodsOut[x]

$$= \begin{cases} 0 , & x \le x\,min \\ \frac{x - x\,min}{x\,max - x\,min} , & x\,min \le x \le x\,max \\ 1 , & x \ge x\,max \end{cases} \longrightarrow = \begin{cases} 0 , & x \le 5 \\ \frac{x - 5}{20 - 5} , & 5 \le x \le 20 \\ 1 , & x \ge 20 \end{cases}$$

  We can find the value of the membership of µFewGoodsOut (18) with the following results:

$$= \frac{(20 - 18)}{(20 - 5)} = \frac{2}{15} = 0{,}1$$

  and for the value of membership µManyGoodsOut (18)

$$= \frac{(18 - 5)}{(20 - 5)} = \frac{13}{15} = 0{,}8$$

- Then, The process that is carried out next is to find the function of membership of the supply variable. The formula is:

  µLowSupply[y]

$$= \begin{cases} 1 , & y \le y\,min \\ \frac{y\,max - y}{y\,max - y\,min} , & y\,min \le y \le x\,max \\ 0 , & y \ge y\,max \end{cases} \longrightarrow = \begin{cases} 1 , & y \le 4 \\ \frac{25 - y}{25 - 4} , & 4 \le y \le 25 \\ 0 , & y \ge 25 \end{cases}$$

  µHighSupply[y]

$$= \begin{cases} 0 , & y \le y\,min \\ \frac{y - y\,min}{y\,max - y\,min} , & y\,min \le y \le y\,max \\ 1 , & y \ge y\,max \end{cases} \longrightarrow = \begin{cases} 0 , & y \le 4 \\ \frac{y - 4}{25 - 4} , & 4 \le y \le 25 \\ 1 , & y \ge 25 \end{cases}$$

  We can find the value of the membership µ LowSupply (10) with the following results:

$$= \frac{(25 - 10)}{(25 - 4)} = \frac{15}{21} = 0{,}7$$

  and for the value of membership µHighSupply (10)

$$= \frac{(10 - 4)}{(25 - 4)} = \frac{6}{21} = 0{,}28$$

- Then, the next step is to look for the membership function of goods purchasing, The formula is:
  µGoodsPurchasingDecreasing[z]

$$= \begin{cases} 1 , & z \le z\,min \\ \frac{z\,max - z}{z\,max - z\,min} , & z\,min \le z \le z\,max \\ 0 , & z \ge z\,max \end{cases} \longrightarrow = \begin{cases} 1 , & z \le 5 \\ \frac{25 - z}{25 - 5} , & 5 \le z \le 25 \\ 0 , & z \ge 25 \end{cases}$$

  µGoodsPurchasingIncreasing[z]

$$= \begin{cases} 0 , & z \le z\,min \\ \frac{z - z\,min}{z\,max - z\,min} , & z\,min \le z \le z\,max \\ 1 , & z \ge z\,max \end{cases} \longrightarrow = \begin{cases} 0 , & z \le 5 \\ \frac{z - 5}{25 - 5} , & 5 \le z \le 25 \\ 1 , & z \ge 25 \end{cases}$$

Based on the analysis of the limits of the membership function, four fuzzy rules can be made, including: [A1] IF Goods Out A Lot And Supply Low THEN Purchases Increase; [A2] IF Lots of Goods Out and High Supply THEN Purchases Increase; [A3] IF Fewer Goods Out And Low Supply THEN Fewer Purchases; [A4] IF Goods Come Out Few And Supply Is High THEN Purchases Decrease.

Next, the calculation of the implication function is carried out according to the Madani fuzzy stage to get the z value; the first thing to calculate is [A1] IF Lots of Goods Out and Low Supply THEN Increased Purchases, then the calculation is:

$$\begin{aligned}\alpha 1 &= \mu\text{BarangKeluarBanyak} \cap \mu\text{PersediaanRendah}\\ &= Min\,(\mu\text{BarangKeluarBanyak} \cap \mu\text{PersediaanRendah})\\ &= Min\,(0{,}8\,;0{,}7)\\ &= 0{,}7\end{aligned}$$

$$\begin{aligned}z1 &= z\max - \propto 1\,(z\,max - z\,min)\\ &= 25 - 0{,}7\,(25-5)\\ &= 25 - 0{,}7\,(20)\\ &= 25 - 14 = 11\end{aligned}$$

[A2] IF Lots of Goods Out and High Supply THEN Purchases Increase, the calculation is:

$$\begin{aligned}\alpha 2 &= \mu\text{BarangKeluarBanyak} \cap \mu\text{PersediaanTinggi}\\ &= Min\,(\mu\text{BarangKeluarBanyak} \cap \mu\text{PersediaanTinggi})\\ &= Min\,(0{,}8\,;0{,}28)\\ &= 0{,}28\end{aligned}$$

$$\begin{aligned}z2 &= z\max - \propto 1\,(z\,max - z\,min)\\ &= 25 - 0{,}28\,(25-5)\\ &= 25 - 0{,}28\,(20)\\ &= 25 - 5{,}6 = 19{,}4\end{aligned}$$

[A3] IF Fewer Goods Out And Low Supply THEN Fewer Purchases, the calculation is:

$$\begin{aligned}\alpha 3 &= \mu\text{BarangKeluarSedikit} \cap \mu\text{PersediaanRendah}\\ &= Min\,(\mu\text{BarangKeluarSedikit} \cap \mu\text{PersediaanRendah})\\ &= Min\,(0{,}1\,;0{,}7)\\ &= 0{,}1\end{aligned}$$

$$\begin{aligned}z3 &= z\max - \propto 1\,(z\,max - z\,min)\\ &= 25 - 0{,}1\,(25-5)\\ &= 25 - 0{,}1\,(20)\\ &= 25 - 2 = 23\end{aligned}$$

[A4] IF Goods Come Out Few And Supply Is High THEN Purchases Decrease, the calculation is:

$$\begin{aligned}\alpha 4 &= \mu\text{BarangKeluarSedikit} \cap \mu\text{PersediaanTinggi}\\ &= Min\,(\mu\text{BarangKeluarSedikit} \cap \mu\text{PersediaanTinggi})\\ &= Min\,(0{,}1\,;0{,}28)\\ &= 0{,}1\end{aligned}$$

$$\begin{aligned}z4 &= z\max - \propto 1\,(z\,max - z\,min)\\ &= 25 - 0{,}1\,(25-5)\\ &= 25 - 0{,}1\,(20)\\ &= 25 - 2 = 23\end{aligned}$$

Then the value of Z can be found using the following formula:

$$= \frac{\alpha 1 * z1 + \alpha 2 * z2 + \alpha 3 * z3 + \alpha 4 * z4}{\alpha 1 + \alpha 2 + \alpha 3 + \alpha 4}$$

$$= \frac{0{,}7 * 11 + 0{,}28 * 19{,}4 + 0{,}1 * 23 + 0{,}1 * 23}{0{,}7 + 0{,}28 + 0{,}1 + 0{,}1}$$

$$= \frac{17{,}732}{1{,}18} = 15{,}0$$

From the calculation of the z value, it can be concluded that the purchase of goods for the following stock is 15 items.

3. Results and Discussion

3.1. Prototyping Building

In the next stage, according to the reference model used to make a prototype, making a prototype is done using the hypertext Preprocessor and Hypertext Markup Language for programming languages and using the MySQL for databases. The user for this application is the warehouse admin, who must enter some related data, such as stock data, demand data, and sales data.

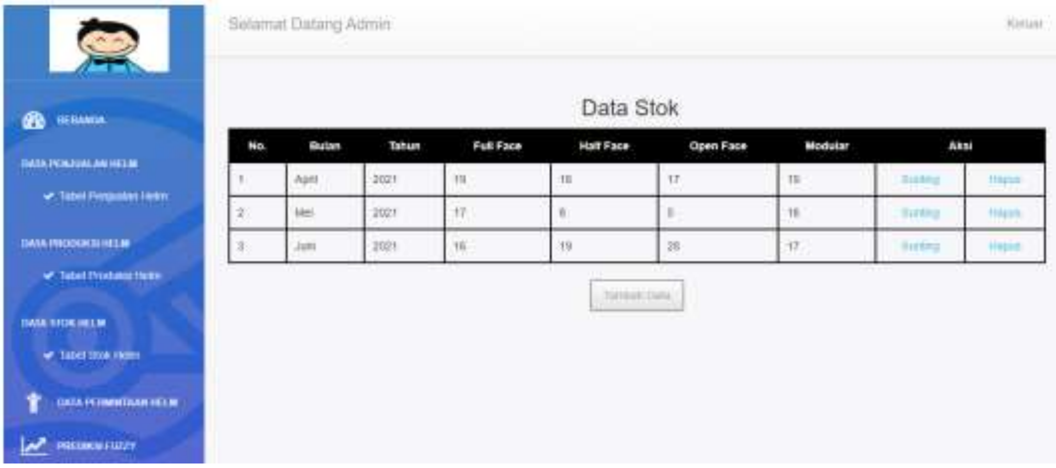


Fig 4. Stock Data

Inventory data displays sales data from April to June. The warehouse admin has input the data, and on this page, the admin can also add data back in the following month with the add data button.

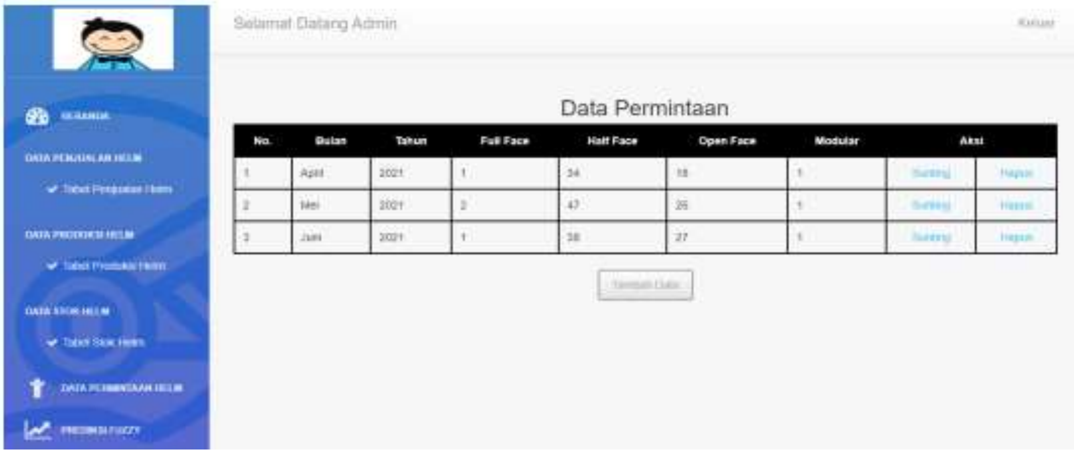


Fig 5. Goods Supply Data

Just like the stock of goods, the data for goods supply is also input by the admin according to the month that is input on the goods stock menu.

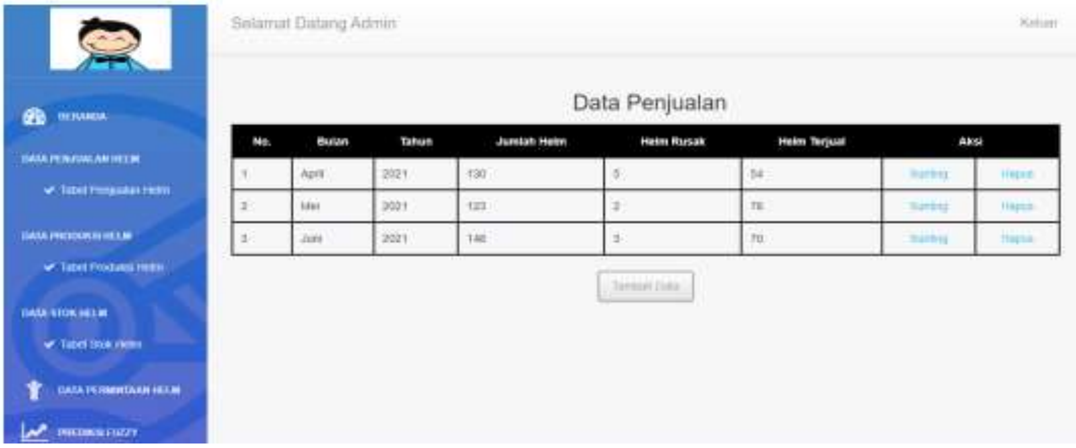


Fig 6. Goods Sales Data

The admin also inputs the sales data to match the modeling made in the design process so that it can produce relevant results.

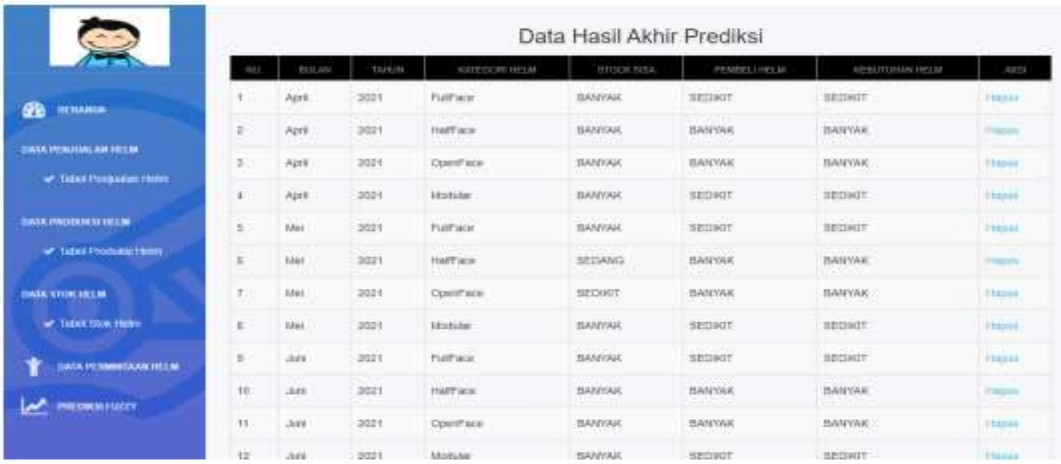


Fig 7. Prediction Final Result Data

On the data menu, the prediction results will display the number of items that need to be purchased for stock so that there are no vacancies or excess items in the warehouse and that it does not interfere with the business processes.

4. Conclusion

The Mamdani fuzzy algorithm for web-based inventory prediction has been successfully implemented. The built prototype model integrates web interface, data collection, fuzzification, rule base, fuzzy inference, defuzzification, and integration with web applications.

The results showed that the Mamdani fuzzy-based inventory prediction model could provide good inventory predictions. Using relevant fuzzy rules and appropriate inference methods helps generate accurate predictions.

A web-based inventory prediction system with the Mamdani fuzzy algorithm provides significant benefits in inventory management. Users can get better estimates of required inventory, optimize inventory, and reduce the risk of under or over-stock.

Using the Mamdani fuzzy algorithm in web-based inventory prediction can improve efficiency and accuracy in inventory management. By combining historical inventory data and relevant environmental factors, this system can generate better predictions and assist in making better decisions in inventory management.

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