The fuzzy Mamdani implementation to predict blood stock needs in blood transfusion unit of Palang Merah Indonesia (PMI) in Bandung district

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Abstract. Blood stock needs in blood transfusion unit of Palang Merah Indonesia in Bandung district are decreasing due to several things. To resolve this problem, a method to predict future blood stock needs is needed. With Fuzzy Mamdani method, the prediction results can be grouped into categories, those are stock in stock and fixed stock. Based on system testing and manual testing carried out in this study, it was found that Mamdani fuzzy had a high enough level of accuracy of 88.88% to predict blood stock needs in Blood Transfusion Unit of Palang Merah Indonesia in Bandung district.

1. Introduction
Blood is an important element for the human body, where blood is produced from what is consumed by humans themselves every day. According to KBBI (Big Indonesian Dictionary) blood is a liquid consisting of plasma, red and white cells that flow in human or animal blood vessels [1]. The PMI Association is a neutral and independent social humanitarian institution which was established with the aim of alleviating the suffering of fellow human beings, whatever by not distinguishing religion, nation, ethnicity, language, skin colour, gender, class and political views [2]. The PMI in Bandung District is one of the central PMI branches where there is a BTU (Blood Transfusion Unit), one of which is to collect donor blood from donors to be donated back to those in need, which previously has been through the examination and testing process so that it can be released from the disease.

So much blood needs both in hospitals, clinics or maternity homes make each BTU have to provide 4 blood groups including A, B, AB and O that are needed by other people both for the purposes of surgery or others. Besides that the problem that is often experienced by BTU PMI in Bandung District is the excess stock of certain groups of blood, for example in January blood type A is very much in stock so that it makes it difficult for officers to group blood, because each blood has different levels, other problems faced is a shortage of blood stock itself [3]. With the existence of this problem becomes a barrier for PMI officers to supply blood to hospitals and other agencies in need. This is a serious matter for BTU as the blood donor manager in the area. Because there are many things that are not beneficial for certain parties, predictions of blood stock can anticipate the problem in the future, so it is very helpful in making decisions. In the future the community will get information about blood donor activities so that the community can participate in these activities [4].

Prediction is one process for estimating something that might happen in the future, where data sources are obtained from information in the past and present owned by an agency. The purpose of the
prediction itself is that mistakes in the past can be minimized or reduced. Prediction does not have to have an answer level that is 100% close to true but tries to find opportunities or answers as close to what might happen in the future and for that BTU PMI in Bandung District requires a prediction of monthly blood stocks so that the income and demand for blood are appropriate [5].

The Mamdani method is often also known as the Max-Min Method. This method was introduced by Ebrahim Mamdani in 1975 [6]. Fuzzy Mamdani method is a method that maps an input into an output without ignoring the existing factors. This method is a mathematical framework that is used to present uncertainty, obscurity, inaccuracy, lack of information, and partial truth so that it is in accordance with the problems of fluctuating demand and uncertain production quantities [7]. This method has been widely used in predicting several case studies, including predicting the amount of palm oil production and gold price predictions. Therefore, fuzzy Mamdani is expected to be able to predict the blood stock requirements at BTU PMI in Bandung District.

Besides using the Mamdani method, other methods that are often used are the Sugeno method and the Tsukamoto method. For the Sugeno method, it is almost the same as the Mamdani method, but the Sugeno method is simpler because the system output is not in the form of a fuzzy set but in the form of constants or linear equations. While the Tsukamoto method for the calculation results is not detailed because the calculation results obtained are only in the form of an average value, even though the resulting output is the same as fuzzy Mamdani in the form of a set.

2. Methodology
The method used in this study is the prototype method. The following are the stages and processes contained in the prototype found in Figure 1 as follows:

![Prototype model](image)

**Figure 1.** Prototype model [8].

2.1. Communication
The developer and client meet and determine general goals, desired needs and an overview of the parts that will be needed.

2.2. Quick plan
The design is done quickly and represents all known aspects of the software, and this design is the basis for making prototypes.

2.3. Modelling quick design
Focusing on the representation of software aspects that can be seen by the user. Modelling quick design tends to make prototypes. The modelling method used in making this application is using Unified Modelling Language (UML).
2.4. Construction of prototype
Build a framework or design prototype of the software that will be built.

2.5. Deployment delivery & feedback
The prototype that has been created by the developer will be distributed to the user, to be evaluated, then the user will provide feedback that will be used to revise the software requirements that will be built. Repetition of this process continues until all needs are met.

3. Results and discussion

3.1. Fuzzy Mamdani discussion
An example of a calculation for fuzzy Mamdani to predict blood stock in a blood transfusion unit with blood type A.

3.1.1. Fuzzy set of blood type A
MUCH : > 500
MEDIUM : 300 < A < 500
LESS : < 300

Figure 2. Membership function graph of blood type A donor variable.

3.1.2. Membership function

\[
\mu_{\text{Less}} [x] = \begin{cases} 
1, & x \leq 300 \\
\frac{100 - x}{100}, & 300 < x < 400 \\
0, & x \geq 400, x \leq 300 \text{ or } x \geq 500 \\
0, & x \geq 400, x > 500 
\end{cases}
\]

\[
\mu_{\text{Medium}} [x] = \begin{cases} 
\frac{x - 300}{100}, & 300 < x \leq 400 \\
\frac{500 - x}{100}, & 400 < x < 500 \\
0, & x \leq 400 
\end{cases}
\]

\[
\mu_{\text{Much}} [x] = \begin{cases} 
\frac{x - 400}{100}, & 400 < x < 500 \\
1, & x \geq 500 
\end{cases}
\]
3.1.3. Application function implications. Function implication or formation of rules using the MIN method rule. In predicting this blood stock there are 27 rules that have differences in their functions.

3.1.4. Rule composition. Rule composition using MAX function, thus get final result as follows in Figure 3.

![Figure 3. Rule composition result.](image)

From Figure 3, result area is divided into 3 part, namely A1, A2 and A3. Then find a1 and a2 value as follows:

\[
\begin{align*}
\frac{a1 - 300}{200} &= \mu a1 \\
\frac{a1 - 300}{200} &= 1,2 \\
200 * 1,2 + 300 &= a1 = 540
\end{align*}
\]

\[
\begin{align*}
\frac{a2 - 300}{200} &= \mu a2 \\
\frac{a2 - 300}{200} &= 1,72 \\
200 * 1,72 + 300 &= a2 = 644
\end{align*}
\]

Thus, the membership function for the results of this composition is:

\[
\mu [Z] = \begin{cases} 
1,2, & Z \leq 540 \\
\frac{300 - Z}{200}, & 540 < Z < 644 \\
1,72, & Z \geq 644
\end{cases}
\]

3.1.5. Defuzzification. Defuzzification is the conversion process from fuzzy output to a crisp output. In this defuzzification the authors use the Centroid Method to get the output crisp value. In this method the value of the crisp is obtained from taking the centre point of the area. To get the crisp value using the centroid method, calculate the moment of each area as follows:

\[
M1 = \int_{300}^{540} (1,2) z dz = 120960
\]

\[
M2 = \int_{540}^{644} \frac{300 - Z}{200} z dz = 90357,97333
\]

\[
M3 = \int_{644}^{500} (1,72 ) z dz = (-141672,96)
\]

Then find the comprehensive area:
\[ A_1 = (540 - 300) \times 1.2 = 288 \]
\[ A_2 = \frac{(1.2 + 1.72) \times (644 - 540)}{2} \]
\[ = \frac{(2.92) \times (104)}{2} \]
\[ = 303.68 \]
\[ = 151.84 \]
\[ A_3 = (500 - 644) \times 1.72 = (-247.68) \]

The centre point can be obtained from:

\[ Z = \frac{M_1 + M_2 + M_3}{A_1 + A_2 + A_3} \]
\[ = \frac{120960 + (90357,97333) + (-141672,96)}{288 + 151,84 + (-247,68)} \]
\[ = \frac{69591,0133}{192,16} \]
\[ = 362,151401 \text{ (Less)} \]

3.2. Results of software testing

This blood stock prediction application will issue an information in the form of an order that will be used as a report by Blood Transfusion Unit of Palang Merah Indonesia (PMI) in Bandung District employees. The following is the display interface for predicting blood stock:

![Display Interface Predicting Blood Stock](image)

**Figure 4.** Display interface predicting blood stock.

4. Conclusions

Implementation of the Fuzzy Mamdani Algorithm for blood stock prediction systems has been successfully built and can be used. The Fuzzy Mamdani algorithm used in the blood stock prediction system has an accuracy rate of 88.88%. Inaccuracy of 11.12% because the data entered is random data that affects the calculation process.
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