Design and Development of Fuzzy Logic Application Mamdani Method in Predicting The Number of Covid-19 Positive Cases in West Java

E F Yogachi, V M Nasution and G Prakarsa

Faculty of Technology and Informatics, Universitas Informatika dan Bisnis Indonesia, Jalan Soekarno-Hatta 643, Bandung 40285, Indonesia.

*Email: egafaradhiyogachi@gmail.com

Abstract. The increase in covid-19 positive patients is unpredictable which results in being unprepared in dealing with Covid-19 cases. People in monitoring and patients under supervision are the category that is breastfed to be covid-19 positive patients after passing the incubation period for 14 days. Artificial intelligence used to predict the increase in cases of covid-19 positive patients is fuzzy logic. The fuzzy logic method used in this study is the mamdani method. The enter variables used are the increase in ODP, PDP, and Covid-19 positive with 3 sets of low, medium, and high respectively. While the output variable is a positive prediction 14 days later. The curve used for fuzzification needs is a linear curve. The method of composition of the rules used is the MAX function and defuzzification using Centroid.

1. Introduction

In line with the development of information technology, the technology’s ability to solve problems, among them the development of applications that can predict things. One example of an app that can predict something is an app that uses fuzzy logic. Fuzzy logic is a logic that can be used to analyze problems containing uncertainty, one example of the prediction process [1]. Fuzzy logic is a science that studies uncertainty. Fuzzy logic is considered capable of mapping an input into an output without ignoring existing factors. Fuzzy logic is believed to be very flexible and has a tolerance to existing data [2].

The mamdani method is one of the methods found in fuzzy logic. There have been several previous studies that used fuzzy logic with mamdani methods in terms of predicting things. In ref [3], system has an accuracy of 81.1% in predicting the procurement of hospital household appliances with the fuzzy logic of mamdani method. In ref [4], the predicts amount of rubber production using fuzzy logic mamdani method, has an accuracy rate of 87.82706% and error rate reaches 12.17294%. Pramana (2016) conducted a study predicting the number of dengue fever cases in Malang regency using fuzzy logic mamdani method with error rates for sub-districts in lowlands of 6%, medium plains by 12%, and plateaus of 14% [5]. There is also research comparing the fuzzy logic of Tsukamoto, Sugeno, and Mamdani methods in predicting the number of new student applicants of the Faculty of Science and Technology of Sunan Gunung Djati Bandung State Islamic University conducted irfan et al., (2018)
with the conclusion of mamdani method has a smaller error rate of 19.76% compared to Tsukamoto method of 39.93% and Sugeno by 86.41% [6]. Based on the studies mentioned, it can be concluded the mamdani method has a small error rate because it is close to 0% and a large accuracy rate because it is close to 100% in predicting cases. The mamdani method also has the lowest error rate compared to the tsukamoto and sugeno methods on predicting.

Coronavirus pandemic 2019 (Covid-19) is an ongoing problem from 200 countries in the world. Covid-19 has been identified as the cause of the outbreak of infectious respiratory diseases in Wuhan, China. As of March 31, 2020, there were 719,758 confirmed cases worldwide. The number of Covid-19-related deaths also reached 33,673 worldwide. Indonesia confirms there are 1,528 cases of Covid-19 and 136 deaths related to the disease [7].

Covid-19 pandemic causes many hospitals around the world to have difficulty both management and infrastructure advice in providing services as patient numbers soar in a short period of time. Starting from the first case until now, there has been an increase and decrease in the number of patients infected with coronavirus. On Monday, March 9, 2020, the West Java Provincial Health Office acknowledged the lack of Covid-19 treatment facilities at 52 Regional General Hospitals (HOSPITALS) in West Java Province to closely monitor covid-19 positive patients cannot be predicted so that treatments such as providing services, facilities, and medical personnel cannot be predicted. Therefore, an application is needed that can predict the number of covid-19 positive cases 14 days later to help the Task Force team accelerate the handling of Covid-19 in West Java Province in order to provide appropriate policies for the handling of the provision of services, facilities, and medical personnel.

According to Abudi et al. (2020) there are 4 (four) mentions of covid-19 related people to help the government and health authorities analyze their patients, namely People in Supervision (ODP), Patients In Supervision (PDP), People Without Symptoms (OTG), and positive Covid-19 [8]. People who are categorized as ODP, PDP, and OTG have a positive chance of becoming Covid-19 because the 3 categories have the characteristics of people infected with coronavirus. Therefore, the government recommends that ODP, PDP, and OTG conduct self-quarantine for 14 days. Indicators that result in an increase in covid-19 positive patients are the increase in ODP, PDP, and covid-19 positive. These indicators can be divided into three groups: low, medium, and high. The three groups can make sets on ODP, PDP, positive case, and positive cases 14 days later for fuzzy logic needs. The argument is reinforced by research conducted in Mexico state examining the rise of Covid-19 using a combination of fractal dimension and fuzzy logic dividing the set on variable increases in covid-19 positive cases in the world into no group namely low, medium, and high [9]. Other research, namely the application of Fuzzy Tsukamoto in seeking the percentage of risk level hanger enter maintenance makes the research results better in terms of the process of calculation speed, accuracy of percentage results and accuracy in decision making [10].

Covid-19 case data in West Java Province such as data on the number of People in Monitoring (ODP), Patients Under Supervision (PDP), and the number of patients confirmed by the Covid-19 virus are recorded and informed on the Pikobar website. Pikobat is the information and coordination center of Covid-19 West Java Province. In addition to the covid-19 case information feature, pikobar also provides donation or social assistance, pretical info, and news about Covid-19 in West Java.

2. Background Theory

Fuzzy logic is an improvement from boolean logic that introduces the concept of partial truth. Where classical logic states that anything can be expressed in binary terms (0 or 1, black or white, yes or no), fuzzy logic replaces boolean truth with the level of truth. Therefore fuzzy logic can allow membership values between 0 and 1, black and white, and in linguistic form, uncertain concepts such as "little", "half" and "many". Fuzzy logic was first developed by Lotfi A. Zadeh an Iranian American scientist from the University of California at Berkeley [11].
The basis of fuzzy logic is the fuzzy set theory. In fuzzy set theory, the role of membership degrees as a determinant of the existence of elements in a set is very important. Membership value or membership function degree is the main feature of reasoning with the fuzzy logic [12]-[13].

2.1. Fuzzy Membership

Kusumadewi and Purnomo (2010) explains that on a crisp set, the membership value of an item \( x \) in a relationship, often written with \( \mu_A[x] \), has the possibility, i.e. [14]:

- One (1), which means that an item is a member of a set, or Zero (0), which
- Means that an item is not a member of a set.

Sometimes the resemblance between fuzzy membership and probability raises confusion. Both have values at intervals of \([0, 1]\), but the interpretation of the values differs greatly between the two cases. Fuzzy membership provides a measure of an opinion or decision, while probability indicates a proportion to the likeness of an outcome of true value in the long run. The fuzzy set has 2 attributes, namely:

- Linguistics, i.e. naming a group that represents a particular state or condition using natural language, such as: YOUNG, PAROBAYA, and TUA.
- Numeris, which is a value (number) that indicates the size of a variable, such as: 40, 25, 50, etc.

There are several things to know in understanding the fuzzy system, namely [14]:

- A fuzzy variable, a fuzzy variable is a variable to be discussed in a fuzzy system. Examples: age, temperature, demand, etc.
- A fuzzy set, a fuzzy set is a group that represents a particular condition or state in a fuzzy variable. For example, the age variable, divided into 3 sets of fuzzy, namely: YOUNG, PAROBAYA, and TUA.
- The talk universe, the talk universe is the whole value that is allowed to be operated in a fuzzy variable. The talking universe is a set of real numbers that always rise monotonously from left to right. The value of the conversation universe can be either positive or negative. Sometimes the value of this universe of talks is not limited to its upper limit. For example, the universe talks to an age variable: \([0, +\infty)\).
- Domains, fuzzy set domains are the entire allowed value in the talk universe and can be operated in a fuzzy set. As with the universe of talks, domains are a monotonous set of real numbers from left to right, domain values can be both positive and negative numbers. Examples of fuzzy set domains:

  - YOUNG = \([0, 45]\)
  - MIDDLE-AGED = \([35, 55]\)
  - OLD = \([45, +\infty)\)

2.2. Membership Functions

A membership function is a curve that shows the mapping of data input points into their membership values that have intervals between 0 and 1. One way that can be used to get membership value is through a function approach. There are several functions that can be used, namely as follows [14]:

2.2.1. Linear Representation

Mapping input to membership degrees on linear representation is described as a straight line. This form is simplest and a good choice to approach a less obvious concept. There are 2 linear fuzzy set
states. First, the set increas starts at a domain value that has zero membership degrees (0) moving right towards a domain value that has a higher membership degree (See Figure 1).

**Figure 1. Linear Curve Rise**

![Linear Curve Rise Diagram]

Membership functions:

\[ \mu[x] = \begin{cases} 
0; & x \leq a \\
(x - a)/(b - a); & a < x < b \\
1; & x \geq b 
\end{cases} \quad (1) \]

Description:
- \( x \) = the value of the domain to be searched for membership degree.
- \( a \) = a domain value whose membership degree is equal to 0.
- \( b \) = a domain value whose membership degree is equal to 1.

Second, it is the opposite of the first. A straight line starts from the domain value with the highest membership degree on the left side, then moves downhill to a domain value that has a lower membership degree (See Figure 2).

**Figure 2. Linear Curve Down**

![Linear Curve Down Diagram]

Membership functions:

\[ \mu[x] = \begin{cases} 
(b - x)/(b - a); & a < x < b \\
0; & x \geq b 
\end{cases} \quad (2) \]

Description:
- \( x \) = the value of the domain to be searched for membership degree.
- \( a \) = a domain value whose membership degree is equal to 1.
- \( b \) = a domain value whose membership degree is equal to 0.
2.2.2. Trapezoidal Curve Representation

The representation of the trapezoidal curve is basically like a triangular shape, only there are some dots that have a membership value of 1. A representation of the trapezoidal curve can be seen in Figure 3.

![Figure 3. Phi Bell Curve](image)

2.3. Fuzzy Set Base Operation

As with conventional sets, there are several specially defined operations for combining and modifying fuzzy sets. Membership value as a result of operation of 2 sets is often known as fire strength \( \alpha \) predicate [15]-[16]. There are 3 basic operators created by Zadeh, namely:

- **Operator AND**, this operator relates to intersection operations on the set. \( \alpha \)-predicate as a result of operation with the OPERATOR AND is obtained by taking the smallest membership value between elements on the relevant sets.
- **Operator OR**, operator ini berhubungan dengan operasi union pada himpunan \( \alpha \)-predicate sebagai hasil operasi dengan operator OR diperoleh dengan mengambil nilai keanggotaan terbesar antar elemen pada himpunan-himpunan yang bersangkutan.
- **Operator NOT**, this operator relates to complementary operations on the set. \( \alpha \)-predicate as a result of operations with the NOT operator is obtained by subtracting the membership value of the element on the corresponding set from 1.

2.4. Fuzzy Inference System (FIS) Mamdani Method

According to Kusumadewi & Purnomo (2010), mamdani method is often also known by the method name Max-Min. This method was introduced by Ebrahim Mamdani in 1975. To get output it takes 4 stages [14]:

- The formation of the Fuzzy Set, on the mamdani method, both input variables and output variables are divided into one or more fuzzy sets.
- Application Function Implications, on the mamdani method, the implication function used is Min.
- The composition of the Rules, unlike mononton reasoning, if the system consists of several rules, then inference is obtained from the set and correlation between rules. There are 3 methods used in performing fuzzy inference systems, namely: max, additive and probabilistic OR (probor).
- Defuzzification is a fuzzy set derived from the composition of fuzzy rules, while the resulting output is a number in the domain of the fuzzy set. So if given a fuzzy set in a certain range, it should be able to take a certain crisp value as output.
3. Methodology

The research method used by the authors in this study used a descriptive method, which is to explain and describe data related to the current state, the relationship between emerging variables, and the differences in existing facts and their impact on conditions. Descriptive methods also aim to compare what can be done to get the most suitable solution. The Figure 4 show the explanations of the research methods conducted in this study.

Figure 4. Research Methods

The stage of problem identification aims to know the problem that is being experienced in the research. At this stage spelled out what problems were raised for research. The issues raised will then be reviewed and obtained information related to the issue.

Furthermore, the authors conducted a literature study to look for references to existing problems and support the research conducted. By looking for some good materials from books, scientific journals, and research results related to the application of fuzzy logic using mamdani method.

The Third Stage is to perform the data collection stage is the author's activity of collecting the data needed for application development. The data collection technique performed by the author is an observation on the website of pikobar. The purpose of this observation is to obtain data used for
application development, namely in the form of data on the number of ODP, the number of PDP, and the positive amount of Covid-19.

The Fourth phase is the analysis and planning phase is the beginning of the implementation of the system development method rapid application development (RAD) in this study. Activities to plan needs include system planning and analysis. At this stage the author analyzes all the needs that have been collected before to understand the nature of the program to be built. Then the author defines the needs of the application to be built in the form of user characteristics, data needs, and functional and non-functional needs. After the needs of the system have been defined, the authors created a fuzzy logic model of mamdani method on predicting an increase in the number of positive cases of Covid-19 14 days later. Based on prior studies on prediction using the fuzzy logic of the mamdani method and the limitations of the author's ability, the study used linear representation for membership functions, the MAX (Maximum) method for the method of rule composition, and the centroid (Composite Moment) method for the defuzzification method. The design architecture used to design the applications used in this study was Object Oriented Analysis and Design (OOAD), so the authors used Unified Modelling Language (UML) to create a software design object model. The UML diagrams to be created are use case diagrams, class diagrams, sequence charts, and state diagrams. The author only created the four diagrams because they are the main diagrams that are quite used for applications that are not very large. At this stage also the author creates a prototype in the form of an application mockup to be built. After the fuzzy logic was created, the authors then tested the results of the mamdani method in predicting covid-19 cases with field sample data.

The last stage of this research is the implementation and testing phase is the advanced stage of rad implementation, namely construction and cut over. Construction is the author's activity of implementing the user model into an application. Applications are built using java programming languages with Netbeans and MySQL tools for database management. If during the application development stage there is a discrepancy with the needs of the application that has been defined in the stage of planning the need then a model and prototype improvement is carried out at the user model stage. If the application built at the construction stage is in accordance with the needs of the application that has been defined at the stage of planning the need, then the next step is to test the application or cut over. The testing method that the authors did on this study was the black-box method. At this stage, a comparison of the calculation of prediction results using the application built on this study with data on the number of covid-19 positive cases that have occurred to look for the error rate.

4. Results and Discussions

This study uses fuzzy logic model with mamdani method for the process of calculating the percentage prediction of the increase in the number of positive cases of Covid-19. The fuzzy logic model of the mamdani method that suda created, will then be applied into the application. Mamdani method consists of 4 stages namely the formation of fuzzy sets, application of implication functions, composition of rules, and affirmation (defuzzification). This activity will explain the stages of the implementation of fuzzy logic mamdani method to predict the positive increase of COVID-19 up to the example of the case.

The first thing to do in creating a fuzzy logic model is to make the determination of the speaker universe to be a fuzzy set. The variables needed to be used as crisp inputs are the number of percentage increases in ODP, PDP, and Positive Covid-19. While the crisp output is the amount of positive percentage increase. Data collection conducted by authors with vulnerable time from March 6, 2020 to May 6, 2020 obtained on the website pikobar. In search of the number of odp, PDP, and Positive covid-19 increases, the calculation of odp, PDP, and Positive each day is reduced by the data of the amount recovered and died on the date to be calculated. The data is processed to look for a percentage increase each day and look for the minimum and maximum values to be domain for each variable that has been set, and is searched for the middle value of each domain (see Table 1).
Table 1. Speaker Universe

| Variable                        | Set   | Domain                        |
|---------------------------------|-------|-------------------------------|
| Increase in ODP                 | Low   | [1,60; 20,35]                 |
|                                 | Medium| [1,60; 20,35; 48,85; 67,60]   |
|                                 | High  | [48,85; 67,60; ∞]             |
| Increase in PDP                 | Low   | [1,29; 16,58]                 |
|                                 | Medium| [1,26; 16,58; 47,56; 62,86]   |
|                                 | High  | [47,56; 62,86; ∞]             |
| Increase in Positive Cases      | Low   | [5,19; 27,43]                 |
|                                 | Medium| [5,19; 27,43; 33,32; 55,56]   |
|                                 | High  | [33,32; 55,56; ∞]             |
| Increase in Positive Cases of Covid-19 14 Days Later | Low | [5,19; 24,13] |
|                                 | Medium| [5,19; 24,13; 29,75; 34,95]   |
|                                 | High  | [29,75; 34,95; ∞]             |

4.1 Formation of Fuzzy Associations

The first stage of the fuzzy logic of the mamdani method is the formation of a fuzzy set. Based on Table 1, a curved representation of each variable is made to know the membership functions of each set. The curve representation of each variable can be seen in Figures 5-8.

![Figure 5. Increase in ODP set](image)

![Figure 6. Increase in PDP set](image)

![Figure 7. Increase in Positive cases set](image)
4.2 Function Implications

The method used in the implication function in the mamdani method is the min method. The final rule of the fuzzy inference system in this study was established by combining existing sets, then the authors analyzed which rules had occurred based on the field data already collected. The final rules of the fuzzy inference system in this study can be seen in Table 2.

| No. Rules | IF ODP | AND PDP | AND Positive | THEN Predictions |
|-----------|--------|---------|--------------|------------------|
| R1        | Low    | Low     | Low          | Low              |
| R2        | Low    | Low     | Low          | Medium           |
| R3        | Low    | Low     | Medium       | Low              |
| R4        | Low    | Low     | Medium       | Medium           |
| R5        | Low    | Low     | High         | Medium           |
| R6        | Low    | Medium  | Low          | Low              |
| R7        | Low    | Medium  | Low          | Medium           |
| R8        | Low    | Medium  | Medium       | Medium           |
| R9        | Low    | Medium  | Medium       | High             |
| R10       | Low    | Medium  | High         | Low              |
| R11       | Low    | Medium  | High         | Medium           |
| R12       | Low    | High    | Low          | Low              |
| R13       | Low    | High    | Low          | Medium           |
| R14       | Low    | High    | Medium       | Low              |
| R15       | Low    | High    | Medium       | Medium           |
| R16       | Low    | High    | High         | Low              |
| R17       | Low    | High    | High         | Medium           |
| R18       | Medium | Low     | Low          | Low              |
| R19       | Medium | Low     | Low          | Medium           |
| R20       | Medium | Low     | Medium       | Low              |
| R21       | Medium | Low     | Medium       | Medium           |
| R22       | Medium | Low     | High         | Low              |
| R23       | Medium | Low     | High         | Medium           |
| R24       | Medium | Medium  | Low          | Low              |
The results of the implications function are as follows:

[R3] IF ODP Low AND PDP Low AND POSITIVE Medium THEN PREDICTIONS Low

\[ \alpha - predikat = \mu_{ODP_{Low}} \cap \mu_{PDP_{Low}} \cap \mu_{PositiveMedium(50)} \]
\[ = \min(0.55; 0.86; 0.25) \]
\[ = 0.25 \]

[R4] IF ODP Low AND PDP Low AND POSITIVE Medium THEN PREDICTIONS Medium

\[ \alpha - predikat = \mu_{ODP_{Low}} \cap \mu_{PDP_{Low}} \cap \mu_{PositiveMedium(50)} \]
\[ = \min(0.55; 0.86; 0.25) \]
\[ = 0.25 \]

[R5] IF ODP Low AND PDP Low AND POSITIVE High THEN PREDICTIONS Medium

The table below shows the implications for each rule:

| No. Rules | IF ODP  | AND PDP | AND Positive | THEN Predictions |
|-----------|---------|---------|--------------|------------------|
| R25       | Medium  | Medium  | Medium       | Low              |
| R26       | Medium  | Medium  | Medium       | Medium           |
| R27       | Medium  | Medium  | High         | Low              |
| R28       | Medium  | Medium  | High         | Medium           |
| R29       | Medium  | High    | Low          | Low              |
| R30       | Medium  | High    | Low          | Medium           |
| R31       | Medium  | High    | Medium       | Low              |
| R32       | Medium  | High    | Medium       | Medium           |
| R33       | Medium  | High    | High         | Low              |
| R34       | Medium  | High    | High         | Medium           |
| R35       | High    | Low     | Low          | Low              |
| R36       | High    | Low     | Low          | Medium           |
| R37       | High    | Low     | Medium       | Low              |
| R38       | High    | Low     | Medium       | Medium           |
| R39       | High    | Low     | High         | Low              |
| R40       | High    | Low     | High         | Medium           |
| R41       | High    | Medium  | Low          | Low              |
| R42       | High    | Medium  | Low          | Medium           |
| R43       | High    | Medium  | Medium       | Low              |
| R44       | High    | Medium  | Medium       | Medium           |
| R45       | High    | Medium  | High         | Medium           |
| R46       | High    | Medium  | High         | High             |
| R47       | High    | High    | Low          | Low              |
| R48       | High    | High    | Low          | Medium           |
| R49       | High    | High    | Medium       | Medium           |
| R50       | High    | High    | Medium       | High             |
| R51       | High    | High    | High         | Medium           |
| R52       | High    | High    | High         | High             |
$\alpha - predikat = \mu_{ODP Low} \cap \mu_{PDP Low} \cap \mu_{PositiveHigh}$

$= \min(\mu_{ODP Low}(10), \mu_{PDP Low}(3.45), \mu_{PositiveHigh}(50))$

$= \min(0.55; 0.86; 0.75)$

$= 0.55$

[R8] IF ODP Low AND PDP Medium AND POSITIVE Medium THEN PREDICTIONS Medium

$\alpha - predikat = \mu_{ODP Low} \cap \mu_{PDP Medium} \cap \mu_{PositiveMedium}$

$= \min(\mu_{ODP Low}(10), \mu_{PDP Medium}(3.45), \mu_{PositiveMedium}(50))$

$= \min(0.55; 0.14; 0.25)$

$= 0.14$

[R9] IF ODP Low AND PDP Medium AND POSITIVE Medium THEN PREDICTIONS High

$\alpha - predikat = \mu_{ODP Low} \cap \mu_{PDP Medium} \cap \mu_{PositiveHigh}$

$= \min(\mu_{ODP Low}(10), \mu_{PDP Medium}(3.45), \mu_{PositiveHigh}(50))$

$= \min(0.55; 0.14; 0.25)$

$= 0.14$

[R10] IF ODP Low AND PDP Medium AND POSITIVE High THEN PREDICTIONS Low

$\alpha - predikat = \mu_{ODP Low} \cap \mu_{PDP Medium} \cap \mu_{PositiveHigh}$

$= \min(\mu_{ODP Low}(10), \mu_{PDP Medium}(3.45), \mu_{PositiveHigh}(50))$

$= \min(0.55; 0.14; 0.75)$

$= 0.14$

[R11] IF ODP Low AND PDP Medium AND POSITIVE High THEN PREDICTIONS Medium

$\alpha - predikat = \mu_{ODP Low} \cap \mu_{PDP Medium} \cap \mu_{PositiveMedium}$

$= \min(\mu_{ODP Low}(10), \mu_{PDP Medium}(3.45), \mu_{PositiveMedium}(50))$

$= \min(0.55; 0.14; 0.75)$

$= 0.14$

[R20] IF ODP Medium AND PDP Low AND POSITIVE Medium THEN PREDICTIONS Low

$\alpha - predikat = \mu_{ODP Medium} \cap \mu_{PDP Low} \cap \mu_{PositiveMedium}$

$= \min(\mu_{ODP Medium}(10), \mu_{PDP Low}(3.45), \mu_{PositiveMedium}(50))$

$= \min(0.45; 0.86; 0.25)$

$= 0.25$

[R21] IF ODP Medium AND PDP Low AND POSITIVE Medium THEN PREDICTIONS Medium

$\alpha - predikat = \mu_{ODP Medium} \cap \mu_{PDP Low} \cap \mu_{PositiveMedium}$

$= \min(\mu_{ODP Medium}(10), \mu_{PDP Low}(3.45), \mu_{PositiveMedium}(50))$

$= \min(0.45; 0.86; 0.25)$

$= 0.25$

[R22] IF ODP Medium AND PDP Low AND POSITIVE High THEN PREDICTIONS Low

$\alpha - predikat = \mu_{ODP Medium} \cap \mu_{PDP Low} \cap \mu_{PositiveHigh}$

$= \min(\mu_{ODP Medium}(10), \mu_{PDP Low}(3.45), \mu_{PositiveHigh}(50))$

$= \min(0.45; 0.86; 0.75)$

$= 0.45$

[R23] IF ODP Medium AND PDP Low AND POSITIVE High THEN PREDICTIONS Medium

$\alpha - predikat = \mu_{ODP Medium} \cap \mu_{PDP Low} \cap \mu_{PositiveHigh}$

$= \min(\mu_{ODP Medium}(10), \mu_{PDP Low}(3.45), \mu_{PositiveHigh}(50))$
Based on the results of the rule implications function, the MAX method is used to perform the composition between all the following rules:

**Variable Output Increase in Positive cases Covid-19 14 Days Later**

- **Low**
  \[\alpha_{-predikat} = \mu_{ODPMedium} \cap \mu_{PDPMedium} \cap \mu_{PositiveMedium} = \min(\mu_{ODPMedium}(10), \mu_{PDPMedium}(3.45), \mu_{PositiveMedium}(50)) = 0.45\]

- **Medium**
  \[\alpha_{-predikat} = \mu_{ODPMedium} \cap \mu_{PDPMedium} \cap \mu_{PositiveMedium} = \min(\mu_{ODPMedium}(10), \mu_{PDPMedium}(3.45), \mu_{PositiveMedium}(50)) = 0.14\]

- **High**
  \[\alpha_{-predikat} = \mu_{ODPMedium} \cap \mu_{PDPMedium} \cap \mu_{PositiveMedium} = \min(\mu_{ODPMedium}(10), \mu_{PDPMedium}(3.45), \mu_{PositiveMedium}(50)) = 0.14\]

4.3 Composition Rules

Based on the results of the rule implications function, the MAX method is used to perform the composition between all the following rules:

- **Low**
  \[\text{Variable Output Increase in Positive cases Covid-19 14 Days Later} = \text{MAX}(R3; R10; R20; R22; R27) = \text{MAX}(0.25; 0.14; 0.25; 0.45; 0.14) = 0.45\]

- **Medium**
  \[\text{Variable Output Increase in Positive cases Covid-19 14 Days Later} = \text{MAX}(R4; R5; R8; R11; R21; R23; R26; R28) = \text{MAX}(0.25; 0.55; 0.14; 0.14; 0.25; 0.45; 0.14; 0.14) = 0.55\]

- **High**
  \[\text{Variable Output Increase in Positive cases Covid-19 14 Days Later} = \text{MAX}(R9) = \text{MAX}(0.14) = 0.14\]

Based on the calculation of the composition of the rules, the resulting area of the composition is formed as in Figure 9.

Based on Figure 9, it can be seen the resulting area is divided into 3 sections namely A1, A2, A3, A4, and A5. Then the author looks for the values a1, a2, a3, and a4 as follows:

\[a1 = 0.45 \times (24.13 - 5.19) + 5.19 = 13.71\]
\[a2 = 0.55 \times (24.13 - 5.19) + 5.19 = 15.61\]
\[a3 = 34.95 - (0.55 \times (34.95 - 29.75)) = 32.09\]
\[a4 = 34.95 - (0.14 \times (34.95 - 29.75)) = 34.22\]
4.4 Defuzzification

The affirmation method used by the author is the centroid method. For that first the author calculates the moments for each area as follows:

\[
M1 = \int_{0}^{13.71} (0.45)z \, dz = 42.29
\]
\[
M2 = \int_{13.71}^{32.09} \frac{z - 5.19}{24.13 - 5.19} \, dz = 13.96
\]
\[
M3 = \int_{15.61}^{34.22} (0.55)z \, dz = 216.18
\]
\[
M4 = \int_{32.09}^{34.95} \frac{34.95 - z}{34.95 - 29.75} \, dz = 24.22
\]
\[
M5 = \int_{34.22}^{34.95} (0.14)z \, dz = 3.53
\]

Then calculated the area of each area:

\[
A1 = 13.71 \times 0.45 = 6.17
\]
\[
A2 = \frac{1}{2} \times (15.61 - 13.71) \times (0.55 - 0.45) + ((15.61 - 13.71) \times (0.45)) = 0.95
\]
\[
A3 = (32.09 - 15.61) \times 0.55 = 1.17
\]
\[
A4 = \frac{1}{2} \times (34.22 - 32.09) \times (0.55 - 0.14) + ((34.22 - 32.09) \times (0.14)) = 0.73
\]
\[
A5 = (34.22 - 32.09) \times 0.14 = 0.1
\]

After the moment and the area of each area are finished, then the next step is to calculate the centre point as the final result of the calculation of the fuzzy logic of the mamdani method. This central point is used as the predicted value of Increase in Positive cases covid-19. The calculation of the central point is as follows:
5. Conclusions

The results of this study to predict the percentage increase in covid-19 positive cases in West Java Province use fuzzy logic mamdani method with membership function in the form of Linear Curve and Trapezoid. The enter variables used are Increase in ODP, PDP, and Positive Covid-19 with 3 sets of low, medium, and high, respectively. Medium the output variable is a positive prediction 14 days later. The method of composition of the rules used is the MAX function and defuzzification using Centroid.

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\[ z = \frac{42.29+13.96+216.18+24.22+3.53}{6.17+0.95+1.17+0.73+0.1} = \frac{300.17}{9.12} = 32.91 \]
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