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MODEL APPLICATION BASED ON FUZY LOGIC TSUKAMOTO WITH CERTAINTY FACTOR FOR EARLY DIAGNOSIS ON CORONA VIRUS (COVID-19)

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ABSTRACT

COVID-19 is a new type of infectious disease caused by the coronavirus that first appeared due to an outbreak in Wuhan, China in December 2019. The process of controlling and preventing COVID-19 by calibrating early diagnosis in Non-Suspect Cases, Suspect Cases, and Close Contacts is still in doubt. In addition, COVID-19 also has many symptoms that make the diagnosis process by direct diagnosis by medical personnel and without involving technology often quite difficult. So, a model application is needed that can help and facilitate doctors and medical personnel in making an initial diagnosis of COVID-19. So, to overcome uncertainty problems such as lack of information, inaccuracy, doubt, and incomplete truth, this study applies a model by implementing Fuzzy Tsukamoto with Certainty Factor. In this study using variables such as traveling, body temperature, close contact, symptoms and diseases. Where each of these variables has a fuzzy set, namely very sure, sure, fairly sure, a little sure, don't know, and no for all symptoms, except for body temperature symptoms, which have cold, normal, and hot fuzzy sets. In addition, there are 17 rules that are formed for the diagnosis. The evaluation results using the Fuzzy Logic Tsukamoto method with Certainty Factor on the real diagnosis of health workers on 30 data samples can produce an accuracy of 80%. As such, this study has the potential to make a positive contribution to supporting the early diagnosis of COVID-19 patients, in the hope of reducing hesitation and enabling faster decision-making in the management of such cases.

Keywords: *Corona Virus (COVID-19), Early Diagnosis, Fuzzy Logic Tsukamoto*

1. INTRODUCTION

COVID-19 is a new type of infectious disease caused by the coronavirus that first came from an outbreak in Wuhan, China in December 2019 [1]. COVID-19 broke out in almost all countries including Indonesia and caused the world community to panic, as a result the World Health Organization (WHO) established COVID-19 as a global pandemic and tried to make appropriate regulations to limit the spread of the virus and conduct early detection/diagnosis of COVID-19 symptoms faster and earlier [2]. From the stipulated regulations, the Ministry of Health issued Guidelines for the Prevention and Control of COVID-19, with number HK.01.07 / MENKES / 413/2020, which divides into 4 (four) categories, namely Suspect Cases, Non-Suspect Cases, Close Contacts and Probable Cases [3].

Diagnosis is the process of choosing various options to achieve certain goals, but in making a diagnosis, there are often problems of uncertainty such as lack of information, imprecision, doubt, and incomplete truth [4], As in the process of early diagnosis of COVID-19 symptoms by classifying into several categories such as the categories of Non-suspect Cases, Suspect Cases and Close Contacts. In addition, covid-19 also has many symptoms that make the diagnosis process by direct diagnosis by medical personnel and without involving technology often becomes quite difficult. So, a model application is needed that can help and facilitate doctors and medical personnel in early diagnosis of COVID-19.

The Tsukamoto method is the most suitable method for determining diagnoses because it can handle uncertainty problems such as lack of information, imprecision, doubt, and incomplete truth [4]. In addition, the use of tsukamoto fuzzy in diagnosis cases has good performance, this is supported by previous research conducted by Yuniarti, Sigit, and Rofiq (2020) [5] which discusses the application of fuzzy tsukamoto in hypoxemia, hypothermia, hypertension, and diabetes disease detection tools. The result of this research is that it can produce 100% accuracy with 20 data used.

Although in previous studies it produced good accuracy, when the model application only uses tsukamoto fuzzy it can have difficulty in handling existing rules. So, from these problems, this research has the novelty to use a combination of fuzzy tsukamoto and certainty factor. In addition, there is a certainty factor (CF) method that can overcome uncertainty when making decisions. CF and tsukamoto methods both contain uncertainty; the difference is that CF rules have expert belief values while the tsukamoto fuzzy method does not have expert belief values but has several rules that look for the largest value with OR and the smallest value with AND to find the calculation. CF can be used to show whether the facts that occur are considered uncertain or certain in the form of a matrix [6], thus the use of tsukamoto fuzzy and certainty factor can enable incorporation based on expert knowledge, and can flexibly accept input from experts without involving a complicated learning process [7].

Based on the description above, this research will create a Fuzzy Tsukamoto-based model application with CF to perform early diagnosis of COVID-19. The use of Tsukamoto fuzzy logic is done by combining the defuzzification results with the results of CF to get the final diagnosis results. Where linguistic variables are resolved using tsukamoto fuzzy and absolute variables are resolved with CF. In addition, Fuzzy tsukamoto and certainty factor have good tolerance for imprecise data and are able to handle such data so that the processed data can produce more accurate results [8].

2. LITERATURE REVIEW

There are several studies that become references for this research, namely as follows:

The first study conducted by Pradana, Bachtiar, Widasari (2022) [9] which discusses the detection of psychological conditions by applying tsukamoto fuzzy. This research applies the method to Internet of Things (IoT) based e-learning. The result of this research is that it can produce a model with an accuracy of 84.01%.

The second related research conducted by Agusta, Arini, and Arifudin (2020) [10] which discusses the application of fuzzy logic and certainty factor methods for the diagnosis of chronic kidney disease. The data used in this research comes from UCI and is implemented on a system using the Laravel framework. The results of this study are generated from 400 data obtained 92.25% accuracy for fuzzy logic. While for certainty factor 97.25%, and 99% for the combination of fuzzy logic and certainty factor.

The third related research conducted by Shi et al., [11], which discusses the occurrence of rapid acquisition and widely conducted X-ray and CT scans to provide evidence to radiologists increasing the need for proper diagnosis and treatment for patients suspected of having COVID-19. However, it takes a long time for doctors to diagnose because medical images, especially chest CT, consist of hundreds of slices. In addition, as COVID-19 is a new disease, the symptoms are similar to other pneumonias, which requires radiologists to accumulate a wealth of experience for effective diagnosis. Therefore, it is highly recommended to use media images to assist AI diagnosis. This method can use segmentation results for diagnosis. This research is already good but for the advanced phase of early diagnosis based on the author's research.

The application of tsukamoto fuzzy is also applied to IoT to control flooding. The research was conducted by Riansyah, Kurniadi, and Saebani (2020) [12]. The use of the Tsukamoto fuzzy method is carried out on the intelligent control system of the water catchment pond pump in real time. So that this can prevent and reduce human error that causes flooding. One of the Iot tools used is using Wemos D1 mini which is connected to an ultrasonic sensor. The results of this study are that the system was successfully built by applying a red pomba indicator, which means the status is inactive and the indicator will turn green if the pump is active and here the tsukamoto fuzzy process works.

The fifth related research conducted by Suryana et al., [13] discusses how professionals can diagnose COVID-19 early by combining patient cases such as PDP, ODP, and Non-Suspect, which will be validated with lab test results to determine whether the patient is positively or negatively infected. The results show that 114 PPD, 36 PDP, and 2 NON have an average CF of 98.25%, 91.38%, and 40%. It is expected that the author's research will have a higher accuracy rate.

Further research was conducted by Ashidiqi, Widaningrum and Karaman [14]. The research discusses the implementation of certainty factor to diagnose dyslexia in children. The result of this research is a system for detecting dyslexia successfully built and based on the test results, it can be concluded that the system has a low level of

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risk and performs as expected because the cyclomatic complexity ranges from 2 to 6.

The seventh related research conducted by Setyaputri et al., [15]. This study uses confidence factors to determine the diagnosis of ENT diseases with four data samples. The results showed that patient A suffered from sinusitis with a confidence value of 0.917, patient B suffered from cerumen (earwax) with a confidence of 0.951, and patient C suffered from otitis externa (OE) with a confidence value of 0.951. According to the researcher, based on the two previous studies, the resulting percentages still need to be validated because the number of data samples is not enough.

3. RESEARCH METHODOLOGY

3.1 Frame of Mind

COVID-19 or Corona Virus Desease has spread to almost all countries around the world and caused public anxiety. Based on the above background, this research will carry out early diagnosis of COVID-19 patients quickly so that they can be treated quickly in accordance with WHO standards. It is hoped that rapid and early detection can slow down or reduce the number of COVID-19 sufferers and reduce the spread of the virus. The framework in this study can be illustrated in the following in Figure 1.

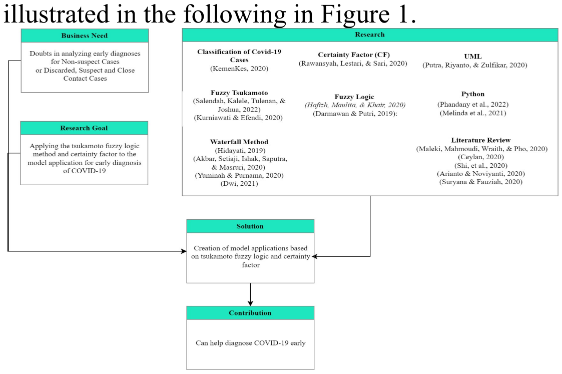

Figure 1: Research Framework

In the first framework carried out is an analysis of business needs, namely the problem of doubt in analyzing early diagnoses for Non-suspect or Discarded Cases, Suspect Cases and Close Contacts, then finding research objectives, namely applying the tsukamoto fuzzy logic method and certainty factor in model applications for early diagnosis of COVID-19, then research on journals as a literature study. After that, finding a solution is to create a model application based on tsukamoto fuzzy logic and certainty factor. Furthermore, it was found that the contribution of research is that it can help diagnose early COVID-19.

3.2 Research Stages

The following in Figure 2 are the research stages used in this study.

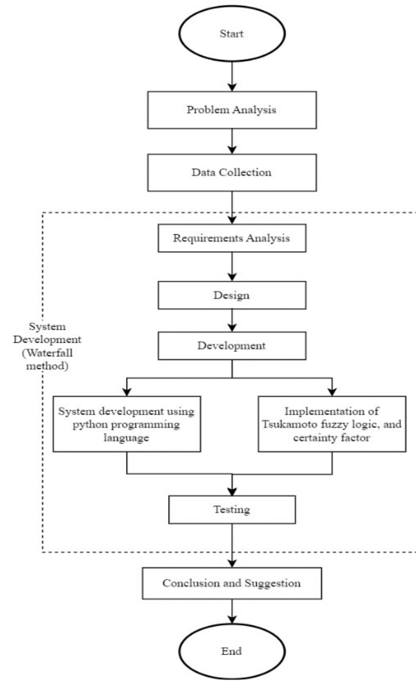

Figure 2: Research Stages

3.3 System Design

3.3.1 Problem Analysis

To find out if the patient has COVID-19, they must go to the hospital for treatment, so that the doctor can confirm whether the patient has contracted COVID-19. When the patient comes for treatment, the patient must register and wait for the queue. The process takes quite a long time. In addition, the doctor's diagnosis can be wrong because the symptoms of COVID-19 can be in the form of flu, cough, and other diseases. This can happen if the symptoms felt by the patient are only the flu but the doctor diagnoses the patient with COVID-19, it will have an impact on the patient to be isolated, and this is certainly detrimental to the patient. Therefore, a model application for the diagnosis of COVID-19 is an alternative for early diagnosis. Based on the problem analysis, this research proposes to build a website-based COVID-19 early diagnosis model application so that it can facilitate patients in early diagnosis of COVID-19. The following are important features that will be implemented:

a. Dashboard, to display if the admin and user actors have successfully logged in.
b. User, admin can manage user data such as adding, editing, deleting.

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c. Covid-19 Case, the admin can manage COVID-19 case data consisting of add, edit, and delete.
d. Symptoms, the admin can manage COVID-19 symptoms consisting of add, edit, and delete symptoms.
e. Rules, the admin can manage COVID-19 rules consisting of add, edit, and delete rules.
f. History, admin can see the results of the analysis.
g. Analyze, all actors can perform analysis and see the results of the analysis.

3.3.2 Data Collection

Data are collected by looking at reports or records from health workers based on interviews with patient cases. There is an option to conduct interviews directly or indirectly, for example by telephone or other means of communication with health workers' diagnosticians when patients seek treatment at puskesmas, clinics, hospitals or other health facilities. In collecting data, the author collaborates with several health workers who deal directly with COVID-19 cases. The data tested were 30 samples of data that were not adrift of age, gender and patient location. The data used as a sample reference is based on diagnosis 1 or diagnosis 2 from health workers for patients who seek treatment or are interviewed at health care facilities.

3.3.3 System Development

In this research, system development uses the waterfall method [16]. The stages in the waterfall development method are requirement analysis, design, development, and testing.

a. *Requirement Analysis*
   This stage is carried out to process the data obtained in the previous stage, such as functional requirements analysis and non-functional requirements analysis, and there is an analysis of the tsukamoto fuzzy method, as well as the certainty factor.
b. *Design*
   At this stage, the design of the system to be built using the Unified Modeling Language (UML) such as use case diagrams, activity diagrams, and class diagrams, as well as interface design.
c. *Development*
   After the design process has been completed, the next stage is the development stage. For this reason, at this stage, system development is carried out, system development by applying the Fuzzy Logic Tsukomoto and Certainty Factor methods to the system with coding using the python programming language and using the flask framework.
d. *Testing*
   After developing the system by applying these methods, an evaluation is then carried out using eight golden rules, five measurable human factors, black box testing, UAT.

3.3.4 Conclusion and Suggestion

At this stage, conclusions will be drawn on this research and provide useful suggestions so that they can be used for further research as input material.

3.4 Variable

The variables used in this study consist of input variables, and output variables. Input variables consist of traveling, body temperature, close contact, and symptoms. Meanwhile, the output variable is disease.

3.5 Hypothesis

The hypotheses in this study regarding the development of tsukamoto fuzzy logic for early diagnosis of COVID-19 are:
Does the application of tsukamoto fuzzy logic and certainty factor in the early diagnosis of COVID-19 get good results?

H0: The application of tsukamoto fuzzy logic and certainty factor in the early diagnosis of COVID-19 does not get good results.

H1: The application of tsukamoto fuzzy logic and certainty factor in the early diagnosis of COVID-19 gets good results.

3.6 Population and Sample

There are 398 populations from the data collection results, but in this study 30 samples were used.

3.7 Merging Result

Analysis is carried out to obtain a fact based on the research method carried out. The data obtained is then analyzed using fuzzy tsukamoto and certainty factor. The analysis in this study was carried out with two methods, namely using the tsukamoto fuzzy method and certainty factor. The results of the calculation of the fuzzy tsukamoto value and the final result of the certainty factor will be summed up to get the final result.

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Then the final results will be evaluated by calculating the accuracy of the results of the detection of patient classification of Non-suspect Cases, Suspect Cases and Close Contacts using the tsukamoto fuzzy logic method after being combined with the certainty factor against the real diagnosis of health workers.

4. RESULTS AND DISCUSSION

4.1 Construction Model

4.1.1 Use Case Diagram

The following in Figure 3 is a use case diagram that has 2 actors and several use cases schemes. Actors in this use case diagram are admin, and user. These actors interact with the model and will be processed which can produce an analysis for early diagnosis of COVID-19.

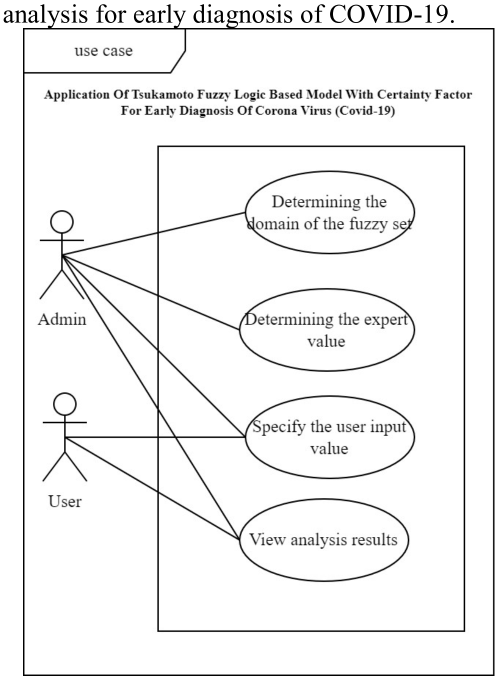

Figure 3: Use Case Diagram

4.1.2 Class Diagram

In Figure 4 Below is a class diagram that describes the database design for early diagnosis of COVID-19. From the diagram below shows the structure, attributes, relationships in each object in the decision support system. There are tables rule base, FuzzyandCFCombination, fuzzy membership, decision, covid-19, linguisticVariable, limitValue. The rule base table has a relationship to the FuzzyandCFCombination table, where many rulebases are for one fuzzylogic, the fuzzymembership table has a relationship to FuzzyandCFCombination, where many fuzzymemberships are for one fuzzylogic, the FuzzyandCFCombination table has a relationship with the table with the covid-19 table has a relationship to the decision table, the LinguisticVariable table and the LimitValue table has a relationship to FuzzyMembership with an aggregate function.

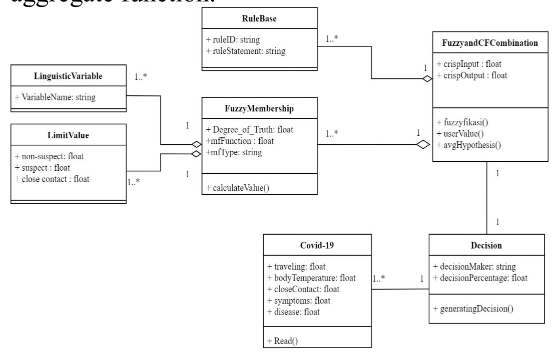

Figure 4: Class Diagram

4.1.3 Activity Diagram

In Figure 5 is an activity diagram flow that shows the process carried out by the model. First, the process of inputting rules and datasets, then the Tsukamoto fuzzy process and certainty factor are carried out to produce an output in the form of a COVID-19 diagnosis.

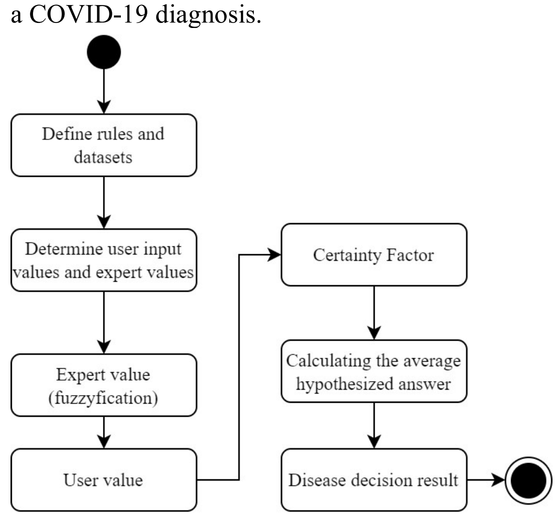

Figure 5: Activity Diagram

4.1.4 Define & Analyze Variables

The following Table 1 and Table 2 are a list of variables used in this study. These variables come from the "COVID-19 Management Guidelines" that have been processed [17]. The variables in this study consist of input variables, and output variables. Input variables are traveling, body temperature, close contact, symptoms. Meanwhile, the output variable is disease. Influence diagrams are used to see the influence of the components in the mathematical model.

Table 1: Complete Variable

Input	Variable Name	Description

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Variables	Travelling (G01)	Has the patient traveled within the last 14 days?
	Body Temperature (G04)	Fever with a temperature > 38 C or fever in the last 14 days
	Close Contact (G13)	Direct physical contact with possible or confirmed patients (such as shaking hands, holding hands, etc.)
	Symptoms other than G01, G04, and G13	Symptoms felt by patients other than traveling, body temperature, and close contact
Output Variable	Disease	Used to output diagnosis results in the form of NON, KE, and SUS

Table 2: Variable with Fuzzy Set

	Nama Variabel	**Himpunan Fuzzy**
Input Variables	Travelling (G01)	Very sure
		Sure
		Fairly Sure
		A little sure
		Don't know
		Not sure
	Body Temperature (G04)	Cold
		Normal
		Hot
	Close Contact (G13)	Very sure
		Sure
		Fairly Sure
		A little sure
		Don't know
		Not sure
	Symptoms other than G01, G04, and G13	Very sure
		Sure
		Fairly Sure
		A little sure
		Don't know
		Not sure
Variabel Output	Disease	NON
		KE
		SUS

4.1.5 Mathematical Model of Variables

The following in Table 3 is the expert value. While Table 4 is the value of the user table [18].

Table 3: *Input Variables*

Input Variables	**Himpunan Fuzzy**	**Scope of the Universe**	**Domain (Fuzzy Value)**
Travelling (G01)	Very sure	0-1	1
	Sure		0.8
	Fairly Sure		0.6
	A little sure		0.4
	Don't know		0.2
	Not sure		0
Body Temperature (G04)	Cold	0-36.5	0-1
	Normal	36-38.5	
	Hot	37.5-38.5	
Close Contact (G13)	Very sure	0-1	1
	Sure		0.8
	Fairly Sure		0.6
	A little sure		0.4
	Don't know		0.2
	Not sure		0
Symptoms other than G01, G04, and G13	Very sure	0-1	1
	Sure		0.8
	Fairly Sure		0.6
	A little sure		0.4
	Don't know		0.2
	Not sure		0

Table 4: User Table Value

No	**Description**	**User Value (MD)**
1	Very sure	1
2	Sure	0.8
3	Fairly Sure	0.6
4	A little sure	0.4
5	Don't know	0.2
6	Not sure	0

Specifically, for symptom G04, the MD value will be 0 if the temperature is <38 and 1 ≥38.

4.1.6 Rule Base

Rule here is a provision given by an expert to be acquired in the algorithm used. There are 17 rules set which can be seen in Table 5 below.

Table 5: Rule Base

Rule	Travelling	Body Temperature	Close Contact +	Symptoms	Patient Classification
1.	No	< 38 C	No	- Dry cough - Nasal congestion - Sneezing - sneezing	NON
2.	No	< 38 C	No	- The RT-PCR	NON

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				test results of individuals considered as suspected cases had 2x negative results within 2 days continuously with an interval of more than twenty-four hours. - People who have been in close contact and have passed fourteen days of quarantine	
…	…	…	…	…	…
17.	No	< 38 C	Yes	- Directly treat probable or confirmed cases without the use of appropriate PPE.	KE

4.1.7 Model Calculation Result

To test the algorithm used, a case study will be appointed which can be seen in Table 6.

Table 6: Case Study

Patient	Nur Aliyah
Travelling (G01)	A little sure
Body Temperature (G04)	38.2
Close Contact	A little sure
Symptoms	G10
	G2
	G5
Patient Answer Description	Don’t know
	Fairly Sure
	Very sure
Doctor's Decision	SUS

The algorithms used are the Fuzzy Tsukamoto and Certainty Factor algorithms. In the combination of Tsukamoto with Certainy Factor there is a difference in determining the classification. Where the CF value will be as an a-predicate and CF_combination will be as a Z value.

a. Determining User and Expert Input Values
The first step is to provide user input values (MD) and expert values (MB). In Table 3 acts as an expert value (MB) which will be processed through Tsukamoto and in Table 4 acts as a user input value (MD).

b. Expert Value (MB)
Expert values are obtained from the results of the fuzzification process carried out. The fuzzification process is carried out to convert the value in user input into a fuzzy set that has been previously determined in Table 4. Based on user input in Table 5, the values obtained can be seen in Table 7.

Table 7: Fuzzyfication Result User Input

Input Variables	Fuzzy set	µ (Fuzzy Value)
Travelling (G01)	A little sure	0.4
Close Contact (G13)	A little sure	0.4
G02	Don’t know	0.2
G06	Fairly Sure	0.6
G012	Very sure	1

For body temperature (G04), the fuzzification process will follow the research conducted by Romadhon, Indra, & Novita (2023) [19]. Where body temperature is categorized into 3 namely Cold, Normal and Hot. Based on this, 3 fuzzyfication equations are obtained for G04.

$$\text{Dingin}[x] = \begin{cases} 1 & ;\ x \le 36 \\ \dfrac{36.5 - x}{36.5 - 36} & ;\ 36 \le x \le 36.5 \\ 0 & ;\ x \ge 36.5 \end{cases}$$

$$\text{Normal}[x] = \begin{cases} 0 & ;\ x \le 36 \text{ atau } x \ge 38.5 \\ \dfrac{x - 36}{36.5 - 36} & ;\ 36 \le x \le 36.5 \\ \dfrac{38.5 - x}{38.5 - 37.5} & ;\ 37.5 \le x \le 38.5 \\ 1 & ;\ 36.5 \le x \le 37.5 \end{cases}$$

$$\text{Panas}[x] = \begin{cases} 0 & ;\ x < 37.5 \\ \dfrac{x - 37.5}{38.5 - 37} & ;\ 37.5 \le x \le 38.5 \\ 1 & ;\ x \ge 38.5 \end{cases}$$

Based on this, if visualized as a curve, the results of the curve visualization will be obtained as shown in Figure 6.

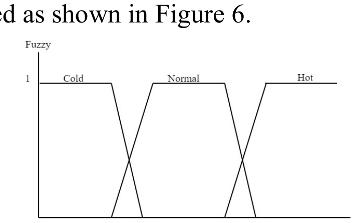

Figure 6: G04 Curve Visualization

Based on the G04 value in Table 6, it has a value of 38.2. So, this process will be searched

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based on cold, normal, and hot curves. Later, the largest fuzzyfication value will come out as output G04 [19].

Table 8: fuzzyfication value G04

Category	Fuzzyfication
Cold	0
Normal	0.3
Hot	0.7

Based on Table 8, the fuzzyfication output value is in the heat category with the largest fuzzyfication value of 0.7. So that the fuzzyfication value for all symptoms can be as in Table 9.

Table 9: Fuzzyfication value of all patient symptoms

Input Variables	Domain	µ (Fuzzy Value)
Travelling (G01)	Not sure	0
G04	38.2	0.7
Close Contact (G13)	A little sure	0.4
G02	Don't know	0.2
G06	Don't know	0.2
G012	Fairly Sure	0.6

c. Determining the User Input Value (MD)
Based on the value of Table 6, if the value of evidence e is changed to MD in Table 3, the results can be seen in Table 10.

Table 10: User Answer Convert Value

No	Symptoms	Convert User Data into User Value
1	G01	0.4
2	G04	1
3	G13	0.4
4	G10	0.2
5	G02	0.6
6	G05	1

In Table 5 which is the rule of the disease if made visual on CF which can be seen in Figure 7.

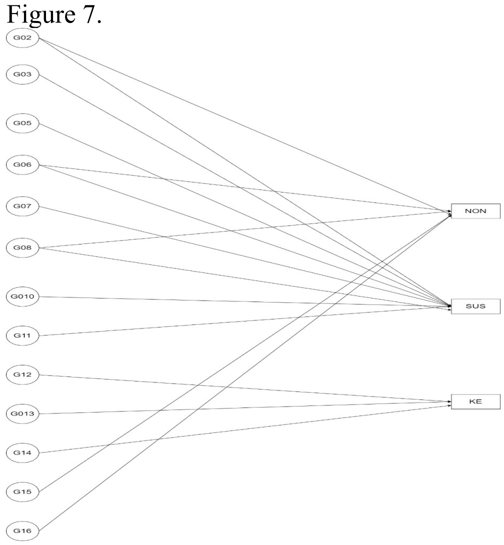

Figure 7: Visual CF

It was found that, the distribution of these symptoms was in 3 diseases to be determined. To facilitate reading the results, the following results can be seen in Table 11.

Table 11: Disease Distribution Against Symptoms

No	Symptoms	Distribution of Disease Classification
1	G01	NON, SUS, and KE
2	G04	NON, SUS, and KE
3	G13	NON, SUS and KE
4	G10	SUS
5	G02	SUS and NON
6	G05	SUS

The certainty factor stage will consist of two progresses, namely calculating the uncertainty factor (CF[H,E]_i) and calculating the hypothesis (CF_combination).

d. Calculating the Uncertainty Factor (CF)
To calculate the uncertainty factor using equation (1). Before calculating the formula, it is necessary to separate the symptoms based on the disease in Table 11 and the results obtained can be seen in Table 12.

$$CF[H,E]_i = CF[H] * CF[E] \quad (1)$$

Description:
CF[H] = User input value (MD)
CF[E] = Expert value (MB)

Table 12: Symptoms of the Disease

Disease	Symptoms
NON	G01
	G04
	G13
	G02
KE	G01
	G04
	G13
SUS	G01
	G04
	G10
	G02
	G05

After separating symptoms based on disease, the uncertainty factor value can be calculated which can be seen in Table 13.

$$CF[NON, G01]_1 = 0.8 * 0.8 = 0.16$$
$$CF[KE, G01]_1 = 0.8 * 0.8 = 0.16$$
$$CF[SUS, G01]_1 = 0.8 * 0.8 = 0.16$$

$$CF[NON, G04]_2 = 0.7 * 1 = 0.7$$
$$CF[KE, G04]_2 = 0.7 * 1 = 0.7$$
$$CF[SUS, G04]_2 = 0.7 * 1 = 0.7$$

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Previously, it was explained that the expert evidence value (CF[E]) comes from Tsukamoto inference.

Table 13: Uncertainty Factor Results

Disease	Symptoms	CF(H,E)
NON	G01	0.16
	G04	0.7
	G13	0.16
	G02	0.36
KE	G01	0.16
	G04	0.7
	G13	0.16
SUS	G01	0.16
	G04	0.7
	G10	0.04
	G02	0.36
	G05	1

e. Calculating the Hypothesis (CF Combination)
After getting the value of the uncertainty factor for the hypothesis (disease) given evidence from the user and expert sides. Then, the next hypothesized conclusion value is calculated using the formula (2) [20]. Based on the formula above, the following results are obtained.

$$CF_{Kombinasi} = CF[H,E]_i + CF[H,E]_j * (1 - CF[H,E]_i) \quad (2)$$

Description
$CF[H,E]_i$ = The value of the uncertainty factor of the initial symptom in a hypothesis
$CF[H,E]_j$ = The value of the uncertainty factor of the next symptom in a hypothesis
Based on the formula above, the following results are obtained.

$$CF_{Kombinasi}CF[NON,G01]_1 = CF[NON,G00]_1 + CF[NON,G01]_2 * (1 - CF[NON,G00]_1)$$
$$CF_{Kombinasi,NON} - 0 + 0.16 * (1 - 0) - 0.16$$
$$CF_{Kombinasi}CF[NON,G04]_1 = CF[NON,G01]_1 + CF[NON,G04]_2 * (1 - CF[NON,G01]_1)$$
$$CF_{Kombinasi,NON} = 0.16 + 0.7 * (1 - 0.16) = 0.748$$

$$CF_{Kombinasi,}CF[KE,G01]_3 = CF_{Kombinasi}CF[KE,G00]_1 + CF[KE,G01]_3 * (1 - CF_{Kombinasi}CF[KE,G00]_1)$$
$$CF_{Kombinasi,}CF[KE,G01]_3 = 0 + 0.16 * (1 - 0) = 0.16$$
$$CF_{Kombinasi.}CF[KE,G04]_3 = CF_{Kombinasi}CF[KE,G01]_1 + CF[KE,G04]_3 * (1 - CF_{Kombinasi}CF[KE,G01]_1)$$
$$CF_{Kombinasi,}CF[KE,G04]_3 = 0.16 + 0.7 * (1 - 0.16) = 0.748$$

$$CF_{Kombinasi,}CF[SUS,G01]_3 - CF_{Kombinasi}CF[SUS,G00]_1 + CF[SUS,G01]_3 * (1 - CF_{Kombinasi}CF[SUS,G00]_1)$$
$$CF_{Kombinasi,}CF[SUS,G01]_3 = 0 + 0.16 * (1 - 0) = 0.16$$
$$CF_{Kombinasi.}CF[SUS,G04]_3 = CF_{Kombinasi}CF[SUS,G01]_1 + CF[SUS,G04]_3 * (1 - CF_{Kombinasi}CF[SUS,G01]_1)$$
$$CF_{Kombinasi,}CF[SUS,G04]_3 = 0.16 + 0.7 * (1 - 0.16) = 0.748$$

Table 14: Combination CF Result

Disease	Symptoms	CF(H, E)	Combination CF
NON	G01	0.16	0.160
	G04	0.7	0.748
	G13	0.16	0.788
	G02	0.36	0.865
KE	G01	0.16	0.160
	G04	0.7	0.748
	G13	0.16	0.788
SUS	G01	0.16	0.160
	G04	0.7	0.748
	G10	0.04	0.758
	G02	0.36	0.845
	G05	1	1.000

f. Average Hypothesis Answer
Furthermore, after obtaining the CF value of the combination of each disease, the probability uses Tsukamoto deffuzification as before where CF(H,E) (is α) and CF Combination (is Z value), this is supported by research conducted. In this study, it combines the CF and Fuzzy Sugeno methods where the output of the combination will be defuzzified and can use equation (3) [21].

$$Z = \frac{\sum \text{CF(H,E)} * \text{CF Kombinasi}}{\text{CF(H,E)}} \quad (3)$$

So, based on the formula above, the following results are obtained.

$$Z_{NON} = \frac{\sum 0.16 * 0.16 + 0.7 * 0.748 + 0.16 * 0.788 + 0.36 * 0.865}{0.16 + 0.7 + 0.16 + 0.36} = 71.49\%$$

$$Z_{KE} = \frac{\sum 0.16 * 0.16 + 0.7 * 0.748 + 0.16 * 0.788}{0.16 + 0.7 + 0.16} = 66.21\%$$

$$Z_{SUS} = \frac{\sum 0.16 * 0.16 + 0.7 * 0.748 + 0.04 * 0.758 + 0.36 * 0.845 + 1 * 1}{0.16 + 0.7 + 0.04 + 0.36 + 1} = 83.35\%$$

Table 15: CF Conclusion Result

Disease	**Combination CF**
NON	71.49%
KE	66.21%
SUS	83.35%

In certainty factor, to determine the diagnosis is taken based on the CF value of the largest combination of diseases. So, based on Table 15 that patient Nur is diagnosed as SUS disease.
Based on the diagnosis results in Table 15, when compared with the doctor's diagnosis results (which can be seen in Table 6), the results in Table 16 are obtained.

Table 16: Diagnosis comparison results

Patient	**Fuzzy Decision + Certainty Factor**	**Doctor's Decision**
Nur Aliyah	SUS	SUS
Probabilitas	83.35%	

In Table 16, it states that the results of the Certainy Factor and Fuzzy algorithms for doctor diagnosis are similar. The results display the diagnosis, namely SUS.

4.1.8 Model Implementation

The evaluation stage is carried out to test how well the algorithm used performs on the problems raised. The evaluation conducted will focus on the accuracy value using the following formula [22]

$$Accuracy = \frac{Total\ Correct}{Total\ Data} * 100\% \quad (4)$$

Based on the test results using 30 samples, the results are shown in Table 17.

Table 17: Algorithm's correct result on doctor's decision

	Tsukomato + CF Description - Doctor
Total Correct	24

Based on the results above, the accuracy results of the algorithm used are obtained

$$Accuracy_{Tsukamoto+CF} = \frac{24}{30} * 100\% = 80\%$$

Based on the accuracy results, it can be concluded that the combination of tsukamoto fuzzy and certainty factor produces 80% accuracy. In addition, the method is also implemented into the system. Here in Figure 12 is a display of the implementation of the diagnosis results.

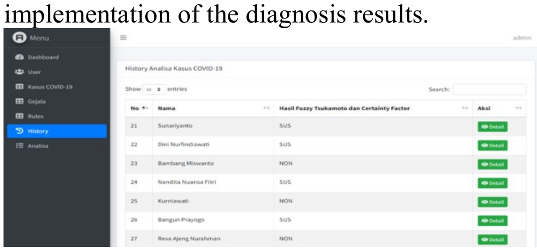

Figure 8: Diagnosis Results with System Implementation

4.2 Model Verification and Validation

Verification is to test existing theories to create new knowledge [23]. The number of variables used in the calculation is 5 [17]. The number of processes in tsukamoto fuzzy and *certainty factor* is 5, namely determine user input values and expert values, expert value (fuzzification), user value, certainty factor, Calculating the average hypothesized answer. While validation is done to check the suitability of the model compared to the real system being modeled [24]. Based on the model verification and validation process that has been carried out, it can be concluded that the model has been verified and validated correctly.

5. CONCLUSION

Based on the results of manualization calculations and trials related to the COVID-19 early diagnosis program, it can be concluded, this study creates a Fuzzy Tsukamoto-based model application with Certainty Factor which is then compared with real patient history data that has been classified by expert diagnoses, then the final results will be evaluated by calculating the accuracy of the patient classification detection results. The variables in this study consisting of the classification of COVID-19 cases, symptoms and rules come from the "COVID-19 Management Guidelines" which have been processed [17]. In this study using variables such as traveling, body temperature, close contact, symptoms and diseases. Where each of these variables has a fuzzy set, namely very sure, sure, fairly sure, a little sure, don't know, and no for all symptoms, except for body temperature symptoms, which have cold, normal, and hot fuzzy sets. In addition, there are 17 rules that are formed for the diagnosis.

Evaluation carried out by calculating the accuracy of the detection results of the classification of patients with NON, KE and SUS cases using 30 data samples and the tsukamoto fuzzy method with certainty factor against real diagnoses of health workers can produce an accuracy of 80%.

This research has shortcomings because the system used is expert-based, so that when some symptoms vary, and to determine rules that can overcome uncertainty can be difficult and an expert in their field is needed.

The following suggestions for further research in the development of early diagnosis of COVID-19 for diagnostic decision making are that further research can consider adding separate access for an expert who can manage the necessary data and add parameters according to the needs in future situations. Model optimization methods can also be added to produce a more optimal model.

REFRENCES:

[1] Y. Hao, T. Xu, H. Hu, P. Wang, and Y. Bai, "Prediction and analysis of Corona virus disease 2019," *PLoS One*, vol. 15, no. 10 October, 2020, doi: 10.1371/journal.pone.0239960.

[2] C. R. Zahara, *Minda Mahasiswa Indonesia: Psikologi Masyarakat Indonesia di Tengah COVID-19*. Aceh: Syiah Kuala University Press, 2020. [Online]. Available: https://books.google.co.id/books?hl=id&lr=&id=ytgNEAAAQBAJ&oi=fnd&pg=PA59&dq=COVID-19+mewabah+hampir+di+semua+negara+termasuk+Indonesia+dan+menyebabkan+masyarakat+dunia+panik,+akibatnya+World+Health+Organization+(WHO)+menetapkan+COVID

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[3] Rokom, "Kemenkes Kenalkan Istilah Probable, Suspect, Kontak Erat dan Terkonfirmasi COVID-19," *Kemkes*, 2021. https://sehatnegeriku.kemkes.go.id/baca/rilis-media/20200714/2834469/kemenkes-kenalkan-istilah-probable-suspect-kontak-erat-dan-terkonfirmasi-covid-19/

[4] R. Meenakshi, A, *Fuzzy Matrix: Theory and Applications*. MJP Publishers, 2019. [Online]. Available: https://books.google.co.id/books?id=4aacDwAAQBAJ&printsec=frontcover&source=gbs_ge_summary_r&cad=0#v=onepage&q&f=false

[5] H. Yuniarti, R. Sigit, and M. A. Rofiq, "Penerapan Fuzzy Tsukamoto pada Alat Deteksi Penyakit Hipoksemia, Hipotermia, Hipertensi, dan Diabetes untuk Health Care Kiosk," *J. Appl. Informatics Comput.*, vol. 4, no. 2, pp. 163–173, 2020, doi: 10.30871/jaic.v4i2.2643.

[6] E. P. Gunawan and R. Wardoyo, "An Expert System Using Certainty Factor for Determining Insomnia Acupoint," *IJCCS (Indonesian J. Comput. Cybern. Syst.*, vol. 12, no. 2, p. 119, 2018, doi: 10.22146/ijccs.26328.

[7] H. Kurniawan, Gustientiedina, Y. Desnelita, and Gusrianty, "Implementasi Metode Fuzzy Logic Untuk Aplikasi Diagnosa Penyakit Pencernaan Manusia," *Indones. J. Comput. Sci.*, vol. 11, no. 1, pp. 209–218, 2022, doi: 10.33022/ijcs.v11i1.3035.

[8] C. Fadhilah, N. Nunsina, and R. Siregar, "Intelligent Decision Support System in the Selection of Children's School Types Based on IQ, SQ, and EQ in Aceh," *J. Informatics Telecommun. Eng.*, vol. 6, no. 1, pp. 189–199, 2022, doi: 10.31289/jite.v6i1.7340.

[9] F. Pradana, F. A. Bachtiar, and E. R. Widasari, "Fuzzy Tsukamoto Implementation to Detect Physiological Condition on IoT-Based e-Learning Users," *Int. J. Inf. Educ. Technol.*, vol. 12, no. 7, pp. 663–667, 2022, doi: 10.18178/ijiet.2022.12.7.1668.

[10] A. Agusta, F. Y. Arini, and R. Arifudin, "Implementation of Fuzzy Logic Method and Certainty Factor for Diagnosis Expert System of Chronic Kidney Disease," *J. Adv. Inf. Syst. Technol.*, vol. 2, no. April, pp. 61–68, 2020.

[11] F. Shi *et al.*, "Review of Artificial Intelligence Techniques in Imaging Data Acquisition, Segmentation, and Diagnosis for COVID-19," *IEEE Rev. Biomed. Eng.*, vol. 14, pp. 4–15, 2021, doi: 10.1109/RBME.2020.2987975.

[12] A. Riansyah, D. Kurniadi, and Saebani, "Fuzzy Tsukamoto Implementation on Internet of Things to Control Flooding," *J. Transform.*, vol. 17, no. 2, p. 171, 2020, doi: 10.26623/transformatika.v17i2.1700.

[13] M. F. Suryana, F. Fauziah, and R. T. K. Sari, "Implementasi Sistem Pakar Menggunakan Metode Certainty Factor Untuk Mendiagnosa Dini Corona Virus Desease (COVID-19)," *J. Media Inform. Budidarma*, vol. 4, no. 3, p. 559, 2020, doi: 10.30865/mib.v4i3.2132.

[14] A. S. Ashidiqi, I. Widaningrum, and J. Karaman, "Implementation of The Certainty Factor Method in The Expert System For Early Diagnosis of Dyslexia in Childhood," *INTENSIF J. Ilm. Penelit. dan Penerapan Teknol. Sist. Inf.*, vol. 7, no. 1, pp. 18–32, 2023, doi: 10.29407/intensif.v7i1.18433.

[15] K. E. Setyaputri, A. Fadlil, and S. Sunardi, "Analisis Metode Certainty Factor pada Sistem Pakar Diagnosa Penyakit THT," *J. Tek. Elektro*, vol. 10, no. 1, pp. 30–35, 2018, doi: 10.15294/jte.v10i1.14031.

[16] R. A. Purba, "Application design to help predict market demand using the waterfall method," *Matrix J. Manaj. Teknol. dan Inform.*, vol. 11, no. 3, pp. 140–149, 2021, doi: 10.31940/matrix.v11i3.140-149.

[17] E. Burhan *et al.*, *Pedoman Tatalaksana COVID-19*. 2022.

[18] Y. K. Kumarahadi, M. Z. Arifin, S. Pambudi, T. Prabowo, and K. Kusrini, "Sistem Pakar Identifikasi Jenis Kulit Wajah Dengan Metode Certainty Factor," *J. Teknol. Inf. dan Komun.*, vol. 8, no. 1, pp. 21–27, 2020, doi: 10.30646/tikomsin.v8i1.453.

[19] M. E. Romadhon, H. Y. Novita, and J. Indra, "Implementasi Fuzzy Logic Tsukamoto pada Deteksi Kondisi Badan Berdasarkan Suhu Tubuh," *Sci. Student J. Information, Technol. Sci.*, vol. 4, no. 1, pp. 57–65, 2023.

[20] B. Harpad and R. Andrea, "JURNAL MEDIA INFORMATIKA BUDIDARMA Analisis Perbandingan metode Teorema Bayes dan CF dalam Mendiagnosa Gejala Penyakit Demam

Berdarah Dengue," vol. 7, pp. 1898–1907, 2023, doi: 10.30865/mib.v7i4.6776.

[21] Y. S. Nugroho and A. B. Granada, "Android-Based Decision Support System To Determine Appropriate Time for Rice Cultivation in Agricultural Land of Cengklik …," *J. Tek. Inform.*, vol. 3, no. 1, pp. 123–132, 2022, [Online]. Available: http://jutif.if.unsoed.ac.id/index.php/jurnal/article/view/149%0Ahttp://jutif.if.unsoed.ac.id/index.php/jurnal/article/download/149/53

[22] N. L. W. S. R. Ginantra, C. P. Yanti, G. D. Prasetya, I. B. G. Sarasvananda, and I. K. A. G. Wiguna, "Analisis Sentimen Ulasan Villa di Ubud Menggunakan Metode Naive Bayes, Decision Tree, dan K-NN," *J. Nas. Pendidik. Tek. Inform.*, vol. 11, no. 3, pp. 205–215, 2022, doi: 10.23887/janapati.v11i3.49450.

[23] Siregar, A. Zuliyanti, and N. Harahap, *Strategi Dan Teknik Penulisan Karya Tulis Ilmiah Dan Publikasi*. Yogyakarta: CV Budi Utama, 2019. [Online]. Available: https://books.google.co.id/books?hl=id&lr=&id=Vr2iDwAAQBAJ&oi=fnd&pg=PR5&dq=A.+Z.+Siregar+dan+N.+Harahap,+Strategi+Dan+Teknik+Penulisan+Karya+Tulis+Ilmiah+Dan+Publikasi,+Yogyakarta:+CV+Budi+Utama,+2019.+&ots=7ZFRRnQMSb&sig=wGzEwzWee7jL0pUW4r7_YwDsYt0&redi

[24] B. M. Sopha and S. Sakti, *PEMODELAN DAN SIMULASI BERBASIS AGEN UNTUK SISTEM KOMPLEKS SOSIO-TEKNIKAL: Konsep, Metode, dan Aplikasi*. Yogyakarta: Gadjah Mada University Press, 2021. [Online]. Available: https://books.google.co.id/books?hl=id&lr=&id=wKJKEAAAQBAJ&oi=fnd&pg=PA18&dq=validasi+dilakukan+untuk+memeriksa+kesesuaian+model+dibandingkan+dengan+sistem+nyata+yang+dimodelkan&ots=g0zh5PgpBO&sig=SQGHC7klVQaNZX2RiCXDcHpPPjw&redir_esc=y#v=onepage&q&f=false