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Mapping COVID-19 in a Region Using IP Geolocation and Fuzzy Inference System

Anang Aris Widodo[1], Muslim Alamsyah[2]

[1,2]*Informatics Engineering Department, University of Merdeka Pasuruan, Indonesia*

[1]anangariswidodo@gmail.com (*)

[2]muslimalamsyah2@gmail.com

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Abstract— The spread of COVID-19, which is getting faster every day, has made people wary. If residents suffer from the symptoms and risks of COVID-19, they are afraid and ashamed because they feel ostracized by their neighbours, relatives, and families. It is a shame and fear of reporting that causes the transmission of COVID-19 to accelerate. Therefore, it is necessary to create a system that can answer the problem, namely a system that can detect first aid symptoms and risks of COVID-19 suffered by residents, so that residents know their health status without checking the health of the COVID-19 task force in each area. The system is made by reading the location of residents who report their health to know where they are and their health status. A method for reading the location of system users based on IP addresses is called IP Geolocation, which stands for Internet Protocol Geolocation. The determination of the health status of residents is in the category of Negative COVID-19, ODR, ODP, PDP, or Positive COVID-19 using the Fuzzy Inference System (FIS) method. The IP Geolocation and FIS results will be displayed on a map (google maps). Implementing this system will make it easier for the Government to monitor the spread of COVID-19 based on public reports and information. By testing using the black box method based on partition equivalence with seven facilities in the system, one mistake makes the facility a weakness of IP Geolocation.

Keywords— Mapping COVID-19, IP Geolocation, Fuzzy Inference System, FIS.

I. INTRODUCTION

IP Geolocation is the process of determining the geographic location of a person or group of people based on the IP address of that person or group [1]. Due to technological advancements in these areas, IP Geolocation is increasingly used in advertising, sales, and security today [2]. Geolocation identifies the real-world geographic location of a computer, mobile device, the visitor to an Internet-connected website, or otherwise. IP Address Geolocation data can include country, region, city, postal/postal code, latitude, longitude, and time zone [1]. One area that is currently becoming a global topic is the Corona Virus Disease (COVID-19) pandemic.

Coronaviruses (CoV) are a large family of viruses that cause mild to severe illnesses. At least two types of coronavirus are known to cause diseases that can cause severe symptoms, such as Middle East Respiratory Syndrome (MERS) and Severe Acute Respiratory Syndrome (SARS). Coronavirus Disease (COVID-19) is a new type of virus that has never been previously identified in humans. Coronavirus is zoonotic (transmitted between animals and humans). Research says that SARS was transmitted from civet cats to humans and MERS from camels to humans. Several known coronaviruses circulate in animals but have not been shown to infect humans [3]

The very fast spread of COVID-19 caused many fatalities, including in Indonesia in 2020. Due to the rapid spread of COVID-19, the Government urges the Government to hold social and physical distance to fight COVID-19 and suppress its spread. Many residents suffer from COVID-19 symptoms such as fever, sick throat, lungs feeling the pain to breathe, and most of them are people who return from cities that are infected with COVID-19. But these residents do not want to be honest with the local Government by conducting health checks or reporting to responsible parties such as RT / RW, villages, or sub-districts to get treatment according to the COVID-19 SOP (Standard Operating Procedure). Because this issue is one of the factors contributing to the spread of COVID-19 in Indonesia, residents should not feel ashamed if they encounter symptoms of COVID-19, as this will aid in the prevention of the disease's spread. It is critical to have the participation and compliance of residents with orders to avoid the spread of COVID-19.

For the above problems, it is necessary to implement a system to detect public health from the symptoms of COVID-19 without having to leave the house and be directly covered and connected to the COVID-19 task force in each area. These symptoms will be systemized on a computer-based basis with a combination of Fuzzy Inference System (FIS) and IP Geolocation. The Fuzzy Inference System (FIS) will be used to predict the results of the symptoms selected by residents to get the expected results, namely (ODR, ODP, Positive COVID-19). Meanwhile, IP Geolocation will be used to determine the location point of each user. The expected results from this research will be able to map user status (Covid-19 Negative, People At Risk (ODR), People Under Monitoring (ODP), Patients Under Supervision (PDP), or Positive COVID-19) on google maps. This system is expected to solve community problems. If residents are embarrassed to report when they suffer from COVID-19 symptoms, then this system can be an alternative for people to fill in data without anyone's knowledge. If a Negative COVID-19, ODR, ODP, PDP, or

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Positive COVID-19 is detected, a self-quarantine solution will be provided or treated/isolated in a designated hospital to handle COVID-19 patients.

II. RESEARCH METHODOLOGY

A. *Block Diagram System*

The system block diagram is made using the flow of making software, as shown in Figure 1.

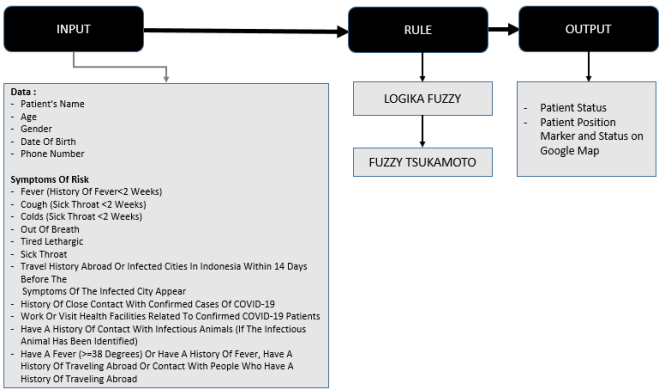

Figure 1. Global Block Diagram

B. *Fuzzy Tsukamoto Flow Process*

The stages of the Fuzzy Tsukamoto method used in this study consist of five main processes as presented in Figure 2 with the following steps:

Step 1 : Choose risk symptoms
Step 2 : Fuzzification by changing the scalar value to a fuzzy value
Step 3 : Calculates the alpha predicate with the MIN implication function
Step 4 : Calculates the z value or the consequent value of each rule and defuzzification
Step 5 : COVID-19 status output and marker position on Google Map

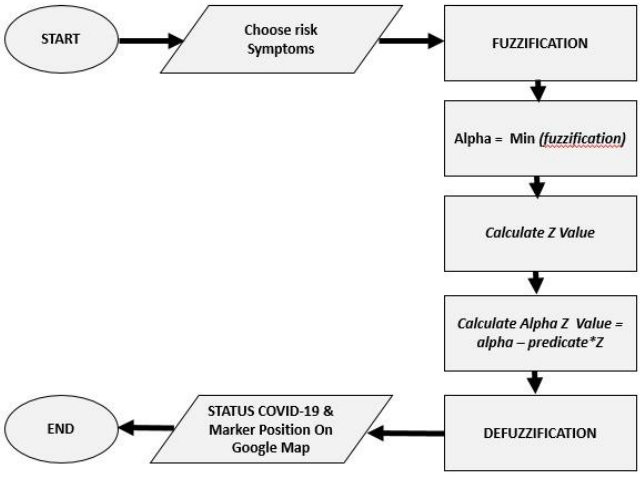

Figure 2. Tsukamoto Fuzzy Flowchart

C. *Problem Domain*

Fuzzy Inference System (FIS), according to [5], is a method used to map the input space based on the output space. In the Fuzzy Tsukamoto method, there is a rule in the form of IF-Then, which can be represented in a Fuzzy set with a monotonous membership function which produces something called a fuzzification process. The inference output from each rule is formed in crisp numbers based on -predicate. The final result is the weighted average used by defuzzification [6].

Based on this understanding, Fuzzy Tsukamoto, if applied to this research, is very suitable because the problem raised has an input in the form of symptoms and risks of COVID-19. At the same time, the output is the status of negative COVID-19, ODR, ODP, PDP, or Positive COVID-19 19. There are no ambiguous and qualitative results from these symptoms and risks, so applying the Fuzzy Tsukamoto method can eliminate ambiguous and qualitative results. Table I describes the signs, symptoms, and dangers associated with COVID-19. [7].

TABLE I.
COVID-19 SYMPTOMS AND RISK

Type	Symptoms/Risk
Symptom	Fever (History of Fever < 2 weeks)
Symptom	Cough (Sick Throat < 2 weeks)
Symptom	Colds (Sick Throat < 2 weeks)
Symptom	Out of breath
Symptom	Tired Lethargic
Symptom	Sick throat
Risk	History of travel abroad or infected cities in Indonesia within 14 days before symptoms of infected cities appear.
Risk	History of close contact with confirmed cases of COVID-19
Risk	Work or visit health facilities related to confirmed COVID-19 patients
Risk	Have a history of contact with infectious animals (if the infectious animal has been identified)
Risk	Have a fever (>=38 degrees) or have a history of fever, have a history of travel abroad or have contact with people who have a history of traveling abroad

The symptoms and risks presented in Table I refer to the Ministry of Health guidelines on preparedness for handling COVID-19. Based on the symptoms of risk, the output can be described as presented in Table II [7]. Table II refers to the Ministry of Health's guidelines on preparedness for handling COVID-19.

TABLE II
CITIZENS OUTPUT/STATUS ON COVID-19

Status	**Information**
Negative COVID-19	Not Suffering from COVID-19
ODR	People at Risk
ODP	People Under Surveillance
PDP	Patient Under Surveillance (suspect)
Positive COVID-19	Suffering from COVID-19

The data used in the form of symptoms, risks, and types of citizen status. Each status has different symptoms and risks. In this study, data on symptoms and risks obtained a total of 6 symptoms five risks with five types of status. Each status has rules based on existing symptoms and risks.

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Based on Figure 1 of the Fuzzy Tsukamoto flow chart, the stages of the Fuzzy Tsukamoto method can be described as follows:

1) Fuzzification: The formation of Fuzzy sets consists of input variables and output variables. The variable is divided into one or more Fuzzy sets. In this process, the input variables are symptoms and risks in COVID-19, while the output variables are the status of the patient (NEGATIVE, ODR, ODP, PDP, or POSITIVE). Each status has different symptoms and risks. Symptoms, age, and location are some of the parameters used in Fuzzy Logic. The membership function in Figure 3 is a membership function for all symptoms and risks used. The set membership function "Yes or No" includes Equation (1) and Equation (2).

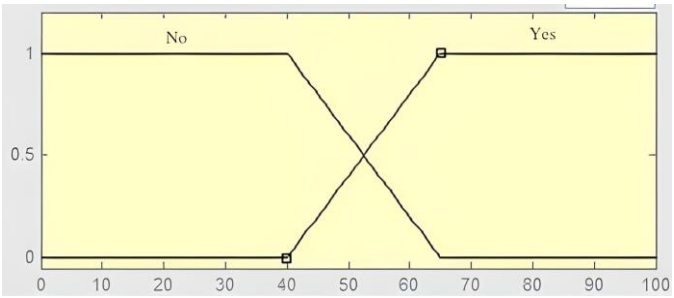

Figure 3. Membership Function of COVID-19 Symptoms and Risks

$$\mu No\ (x) = \begin{cases} 1 & (x \leq 40) \\ \frac{65-x}{25} & (40 < x < 65) \\ 0 & (x \geq 65) \end{cases} \quad (1)$$

$$\mu Yes\ (x) = \begin{cases} 0 & (x \leq 40) \\ \frac{x-40}{25} & (40 < x < 65) \\ 1 & (x \geq 65) \end{cases} \quad (2)$$

Where, μ variable is membership degree, and x variable is object set

2) Fuzzy Rule: The results of the fuzzification calculation are then inferred against the rule. The implication function of the Fuzzy Tsukamoto method is MIN. To calculate the alpha predicate must represent all existing rules using the MIN formula (fuzzification). An example of the rule used for COVID-19 status is:

- IF G1 Yes AND G2 Yes AND G3 Yes AND G4 Yes AND G5 Yes AND G6 Yes AND R1 Yes AND R2 Yes AND R3 Yes AND R4 Yes AND R5 Yes THEN Positive COVID-19.
- This formula can be implemented as MIN (G1 No, G2 No, G3 No, G4 No, G5 No, G6 No, R1 No, R2 No, R3 No, R4 No, R5 No). The G1 variable is Symptom-1; the G2 variable is Symptom-2; the G3 variable is Symptom-3; the G4 variable is Symptom-4; the G5 variable is Symptom-5, and the G6 variable is Symptom-6. The R1 variable is Result-1; the R2 variable is Result-2; R3 variable is Result-3; R4 variable is Result-4; R5 variable is Result-5; and R6 variable is Result-6.

Determining of this status by Fuzzy Inference System. The Following is the symptom. Make with implementation rules:

- IF G1 and X Result then False = PDP COVID-19
- IF G2 and X Result then False = Positive COVID-19
- IF G3 and X Result then True = Negative COVID-19
- IF G4 and X Result then False = ODP COVID-19
- IF G5 and X Result then True = PDP COVID-19
- IF G6 and X Result then False = Positive COVID-19

3) Defuzzification: The last step of the Fuzzy method stage is changing the value of the Fuzzy set to a firm or crisp value [8]. After obtaining the predicate alpha value, the next step is calculating the value of each consequent value of each rule or z value. Defuzzification is done by dividing the value of the sigma alpha predicate times z by the sigma alpha predicate.

D. IP *Geolocation*

IP Geolocation is the mapping of IP addresses to geographic locations with internet-connected devices. IP Geolocation aims at using a suitable IP address to determine a location, such as finding which city a host is in with a public IP. IP Geolocation has an essential role in network security, such as tracking fraud and cyber-attacks and extracting system logs for computer forensics. IP geolocation is widely applied in Internet commerce and security and cloud services [9].

In addition, many studies apply IP Geolocation. Whereas to find the geographic location of the IP address, IP Geolocation service is used, which is an essential mapping means. Currently, IP Geolocation services use many combinations of methods, such as the based-delay method, database-driven method, and topology-driven method. Some online IP Geolocation services such as ip-api.com, ip.taobao.com, and offline IP Geolocation services such as GeoLite2 and ipip.net. The test is carried out using city IP address data as a test set to perform comparative tests on several major IP address geolocation services. The test results say that the accuracy of online geolocation services is higher than offline geolocation services [10].

Research [11] stated that IP geolocation could be used to track the position of criminals who have committed crimes in cyberspace. By combining artificial intelligence, geographic information systems, and IP Geolocation, criminals in cyberspace can be detected because, so far, the perpetrators of crimes in the world are very difficult to detect. According to research [12], IP Geolocation has a weakness; the accuracy is not following reality. The difference is about 10 km from the actual position. For this reason, an update for IP Geolocation is made by using a new IP Geolocation approach. The approach used is to exploit geolocation resources fundamentally. But even though IP Geolocation has weaknesses, IP Geolocation is still in great demand by

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researchers because IP Geolocation is easy to implement into a system.

III. Result and Discussion

A. *Entity Relational Diagram* (ERD)

The ERD design for mapping COVID-19 sufferers uses IP Geolocation and the Fuzzy Inference System (FIS) as shown in Figure 4, while the relation table is presented in Figure 5.

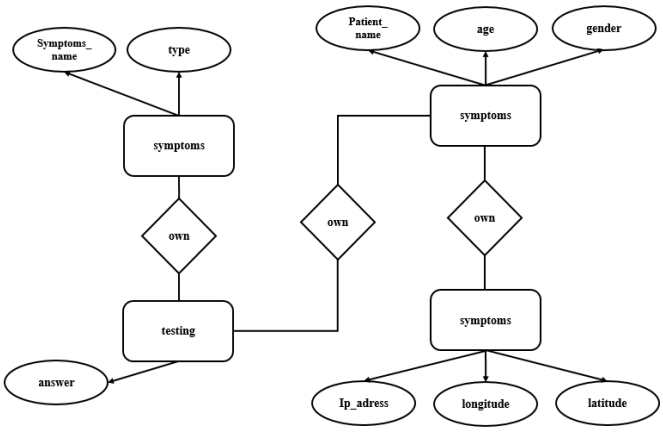

Figure 4. Entity Relational Diagram

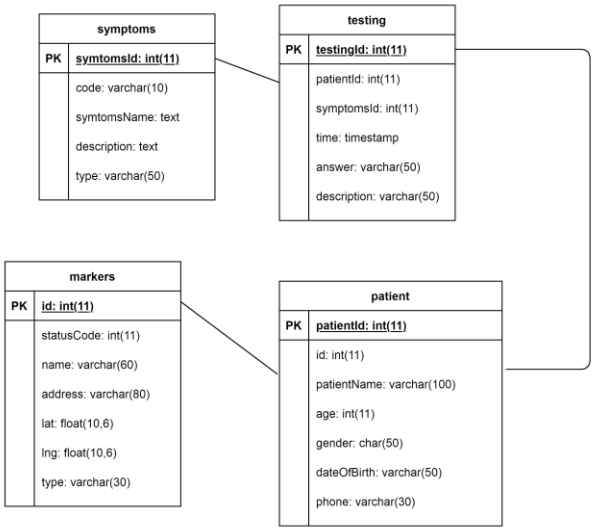

Figure 5. Table Relation

B. Implementation System

At the beginning of the system, the user will get a display to fill in the user's identity presented in Figure 6. the system contains a source code in the identity form that takes the user's IP address and its location to detect the user's position and address, as shown in Figure 6. The source code snippet in Figure 7 describes the source code for retrieving the API from the http://api address.ipinfodb.com/. The API is placed on the system user identity form to detect the user's IP address. After the location is detected, the system will take the user's longitude and latitude points at a marker on google maps, as shown in Figure 8.

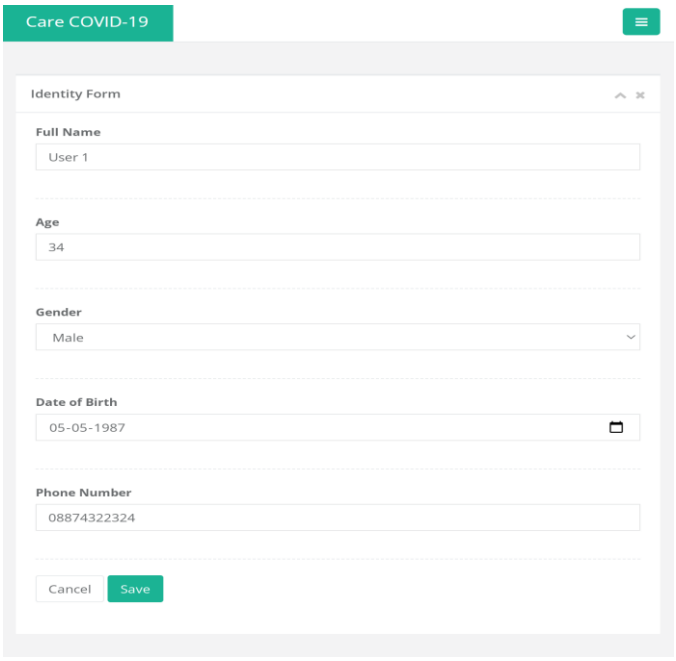

Figure 6 Patient Identity Form

Figure 7 describes the source code snippet for IP Geolocation technology. The point of longitude, latitude, area name, city name, country, and time can be known in real-time.

```
$statusCode='';
$ipAddress='';
$countryCode='';
$countryName='';
$regionName='';
$zipCode='';
$latitude='';
$longitude='';
$timeZone='';
$apikey='d186d95df69f7bbacd2839aeb51dd7cfa0a3ae3b0c21dac4f839fe3b1752ce6e';
$url = 'http://api.ipinfodb.com/v3/ip-city/?key='.$apikey.'&format=json&ip='.$ip;
$response = file_get_contents($url);
 $json_array=json_decode($response,true);
```

Figure 7. Source Code IP Geolocation

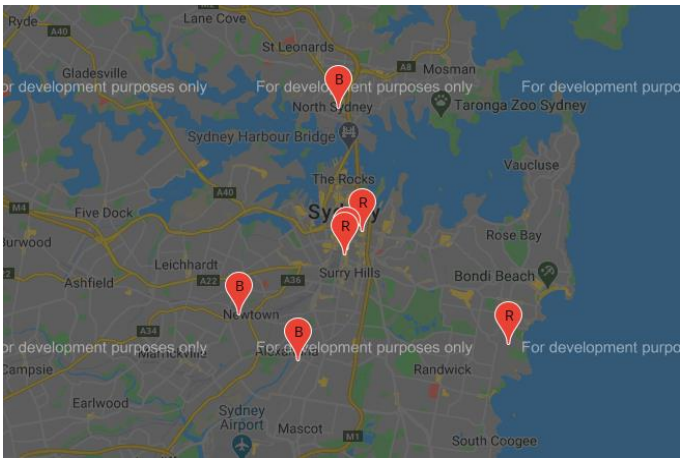

Figure 8. Marker Point on Google Maps

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If each user has got the longitude and latitude, the system will detect the name of the village, country, and IP address used by the user. The detected information will automatically enter the database when the user presses the save button after filling out the identity form. After filling in the identity form, the next step is to choose what symptoms and risks the user feel. The symptoms and risks, such as Table I, will be processed by the system using Fuzzy Tsukamoto to produce out the status of residents as in Table II. The symptom and risk selection form is shown in Figure 9.

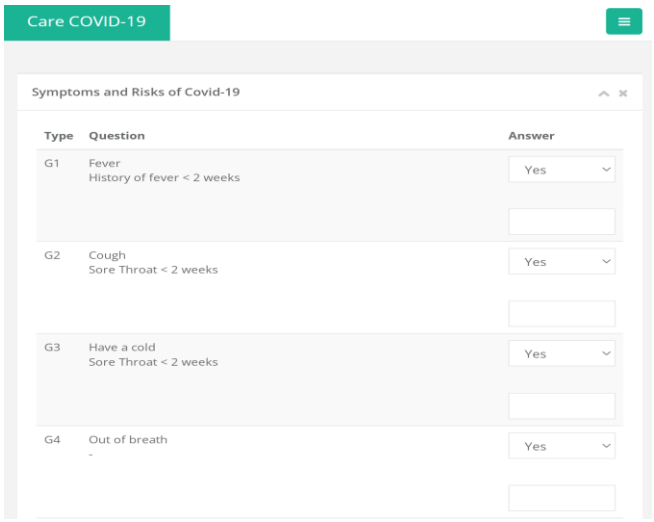

Figure 9. COVID-19 Symptoms and Risk Form

After the user gets the status results, the data will be entered into the google map, wherever the patient is with a Negative, ODR, ODP, PDP, or Positive status. This mapping can make it easier for the Government to monitor the spread of the COVID-19 pandemic, especially in East Java Province. Besides that, it can also facilitate embarrassed residents if they want to have health check-ups at the COVID-19 post in each area. The results are presented in Figure 10, while the implementation form of IP Geolocation which displays the results from Fuzzy Tsukamoto, is presented in Figure 11.

Figure 10. Results of Fuzzy Tsukamoto

Figure 10 shows the results when the user fills in the symptoms and risks. If you get the results as shown in Figure 10, then the user data has entered the map as shown in Figure 11.

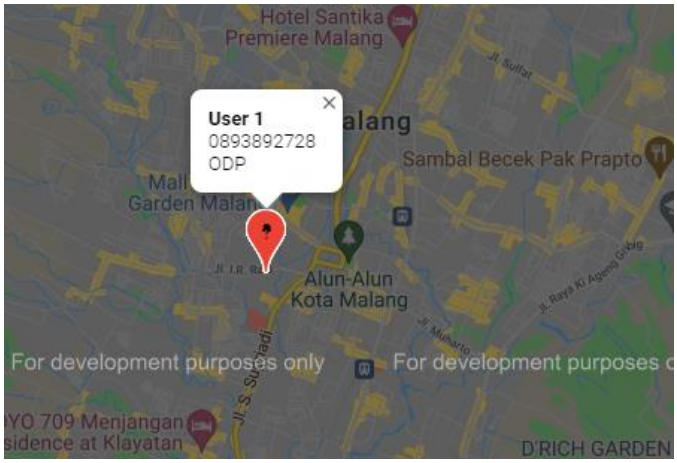

Figure 11. IP Geolocation and Fuzzy Tsukamoto results on Google Maps

The results of this study are expected to be an alternative for citizens to be honest with the Government, which is struggling against COVID-19. Many residents are embarrassed and dishonest in doing health checks because if the resident enters the status of ODP/ODR/PDP/Positive COVID-19, they will be temporarily isolated for fear of infecting other residents. Therefore, with this system to suppress shame so that citizens are honest with the Government about their health status, if it is proven that ODR / ODP / PDP / Positive COVID-19, the Government will alertly handle it according to the existing COVID-19 protocol.

The COVID-19 patient mapping system was tested before general users deployed it to figure out its flaws. The test findings revealed system flaws, allowing the user to strengthen those components. The test results are in the form of a test case table that serves to conclude whether the system is successful in testing or not. The test method used is a Black Box based on Equivalence Partitioning.

TABLE III
RESULT TESTING WITH BLACK BOX BASED

Id User	Test Description	Expected results	Test result	Conclusion
A01	Login by user level	The system can divide according to the user level	The system has successfully mapped according to the user level	Succeed
A02	The patient fills in the personal data form and chooses a map	Displays data according to the form for filling in personal data and a location map	The system successfully displays the patient's data and location	Succeed
B01	Patients choose the symptoms of COVID-19	Save user-selected symptom data	The system has succeeded in saving and searching with	Succeed

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Id User	Test Description	Expected results	Test result	Conclusion
			the FIS method to determine these symptoms, successfully categorizing the type of COVID-19 patient according to the rules.	
B02	The patient selects a location using a marker on a map	Displays the results of the marker according to the IP address used by the patient	The system can match the user's IP with the user's marker to be displayed in the results	Succeed
C01	The patient's medical record is recorded on the system admin page	Displaying each user's medical record	The system can display the results of the patient's medical record on the admin page	Succeed
C02	Patient location accuracy	Displays the exact location of the patient according to the location and position of the patient	Using IP Geolocation, the disadvantage is that there is a shift of several meters from the patient's position, so the resulting location on the map does not match the patient's position.	Not successful

IV. CONCLUSION

The results of this study can be an alternative for the Government to be faster in handling cases during the COVID-19 pandemic. This system can suppress the spread of COVID-19, because if there are residents who are embarrassed to carry out health checks, then with this system residents can find out their health status from the COVID-19 virus. The implementation of the system uses IP Geolocation to detect the presence of residents whose health status is detected from the COVID-19 virus, and the distribution of COVID-19 sufferers can be seen directly on the map (google maps). The system is able to find out the spread of COVID-19 based on information and reports from its citizens. After testing with a Black Box based on Equivalence Partitioning on the system, it can be concluded that an error was found in one of the menus, where Geolocation could not show the exact position of the COVID-19 patient according to the patient's position precision. There was a shift of several meters or even kilometers from the original position of the COVID-19 patient. Based on this, it can be concluded that the weakness of IP Geolocation is accuracy in determining the location, so from this weakness emerged a new technology, namely Global Positioning System (GPS). The system can be developed based on mobile (Android, iOS) in the future.

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