Jurnal Mantik, 7 (2) (2023), ISSN 2685-4236 (Online)

Published by: Institute of Computer Science (IOCS)

Jurnal Mantik

Journal homepage: www.iocscience.org/ejournal/index.php/mantik

Implementation of adaptive neuro fuzzy inference system (ANFIS) in diagnosing obsessive compulsive disorder (OCD)

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ARTICLE EI NFO

Article history:

Accepted Aug 22, 2023
Revised Aug 25, 2023
Accepted Aug 29, 2023

Keywords:

ANFIS;
Expert system;
OCD

ABSTRACT

Obsessive Compulsive Disorder (OCD) is a condition characterized by repetitive thoughts that encourage sufferers to do repetitive actions with the intention of reducing anxiety. People who experience OCD require assistance from specialist doctors to ensure appropriate treatment and avoid delays in treatment. However, the imbalance between the number of specialist doctors and sufferers can lead to prolonged consultation waiting times. In addition, the high costs incurred for consultations are also an obstacle for sufferers. Therefore, this research aims to develop a system that can diagnose OCD disease using the Adaptive Neuro Fuzzy Inference System (ANFIS) method. This system was designed on a website-based platform using the Python programming language with the help of the Flask framework and MySQL as the database. It is expected that this system will help people who experience OCD in the process of diagnosing OCD disorders.

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1. INTRODUCTION

Obsessive Compulsive Disorder (OCD) is a health disorder that can affect various age ranges (Berberich & Hoffmann, 2022; Grant & Chamberlain, 2022; Mahjani et al., 2021). It is characterized by the emergence of recurring disturbing thoughts (obsessions) (Pan et al., 2023). These repetitive thoughts cause repeated actions to be done in an effort to relieve distress and anxiety (Metin et al., 2020). According to WHO data in 2017, Obsessive Compulsive Disorder (OCD) affects around 2% to 3% of the world's population(Endres et al., 2022; Erliksson et al., 2020; Robbins et al., 2019) . However, 40% of OCD sufferers do not take their treatment(Karaya ğ iz et al., 2022).

Treatments that are commonly carried out for sufferers of Obsessive Compulsive Disorder (OCD) include cognitive behavior, psychotherapy, and drug therapy (Karaya ğiz et al., 2022). In addition, OCD sufferers prefer to conceal their experienced symptoms because they feel ashamed. This is because there is a stigma stating that OCD is a mental illness and makes sufferers worry that there will be rejection and judgment for their behavior, causing delays in the diagnosis of treatment (Saragih & Adawiyah, 2020). In an effort to prevent delays in the diagnosis of OCD, the sufferers should get help from experts in their field (Rohana et al., 2022). However, there is an imbalance between experts and specialists considering the large number of sufferers which causes them have to wait a longer time to carry out consultations or treatment. In addition, the relatively expensive consultation fees are an obstacle for sufferers in consulting with specialist doctors (Kurnia, 2021). Therefore, a system is required that can take knowledge from experts and put it into a computer, which is often known as an artificial intelligence-based system to make a diagnosis of Obsessive-Compulsive Disorder (OCD).

Several previous studies have reviewed expert systems in the process of disease diagnosis, one of which is research by Rosana, Wijaya, and Bimantoro which discussed the use of the Dempster Shafer method to diagnose skin health problems. The results of this study resulted in an expert system application that has the ability to identify possible diseases that are being experienced based on the symptoms described by the patient (Rosana et al., 2020). Another study conducted by Ayudia raised the topic of an expert system that examined the diagnosis of disease conditions caused by excessive MSG intake through the ANFIS method (López-Santana et al., 2019; Panda et al., 2022). ANFIS is the result of a combination of a fuzzy logic system and an artificial neural network (Irawan & Sugiono, 2020). This merging occurs because fuzzy logic has limitations in terms of learning. It is only able to draw conclusions, while artificial neural networks, on the other hand, are capable of learning but do not have the ability to conclude (Nompunu et al., 2018). Therefore, the results of this study mentioned that an expert system capable of diagnosing disease conditions were caused by excessive consumption of MSG and providing appropriate solutions.

According to these description, this study implemented an Artificial Neural Network (ANFI) using the Adaptive Neuro Fuzzy Inference System (ANFIS) approach for the diagnosis of Obsessive-Compulsive Disorder (OCD) (Amato et al., 2013; Dastres & Soori, 2021; Falwadiya & Dhingra, 2022; Hagenauer & Helbich, 2022). The decision to use this system in this study is because the neuro-fuzzy system combines the advantages of fuzzy inference systems and artificial neural networks (Nompunu et al., 2018). By utilizing the fuzzy inference method, data can have a clear value so that it is possible to anticipate the results of a disease diagnosis that is in accordance with the symptoms encountered (Ayudia, 2020).

The results of this study indicate that there are various methods of diagnosing obsessive-compulsive disorder. One of the results of the backward chaining process shows that the results of application testing are by the knowledge of experts. Testing the application system uses black box testing, which shows all the functions in the application can run as expected (Raharja et al., 2021). This research is different from previous research, in this study, this research was carried out through the development of a website -based platform using the Python programming language and the Flask framework and applying MySQL as a database. It is expected that this study is able to provide assistance to people who experience OCD in the process of diagnosing Obsessive-Compulsive Disorder (OCD).

2. RESEARCH METHOD

2.1 Expert System Architecture

The expert system consists of two crucial elements, namely the development environment and the consulting environment. The development environment plays a role in integrating expert knowledge into the knowledge base and is used by expert system designers. On the other hand, the consulting environment is for users to carry out consultations and gain knowledge from experts (Sandhiyasa et al., 2022). Figure 1 illustrates the components in the Consulting Environment and Development Environment.

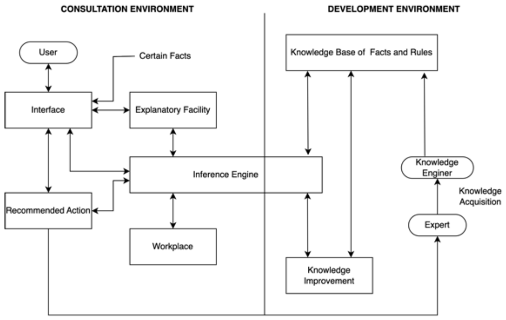

Figure 1Expert System Architecture

2.2 Flow Chart

The flow diagram contained in Figure 2 illustrates the entire flow contained in the system. There are two parties who have access permission to this system, namely administrators and users. Admin is responsible for data management, including information about types of OCD disorders and related symptom data. Meanwhile, the user can do an analysis by entering the symptoms experienced and observing the results of the OCD diagnosis through the ANFIS method.

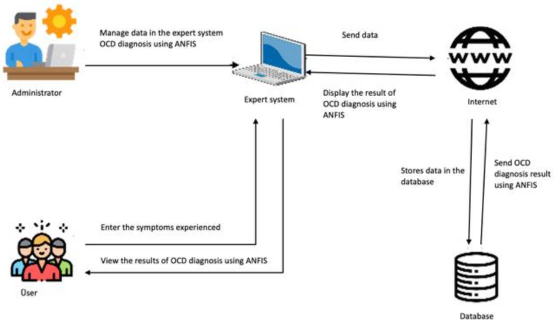

Figure 2Flowchart

2.3 Types of OCD Disorders

The types of Obsessive Compulsive Disorder (OCD) in this study were divided into five types of disorders, namely *checkers, washers and cleaners, orderers, obsessionals, and hoaders* which can be shown in Table 1 (Rohana et al., 2022) .

Table 1Types of OCD Disorders

OCD Disorder Codes	Type of OCD Disorder
WC	Washer and Cleaner
C	Checker
OR	Orderer
OB	Obsessional
H	Hoaders

2.4 Symptoms of OCD

The 17 symptoms of OCD used are listed in Table 2 below [5].

Table 2OCD symptoms

Symptom Code	Symptom
G1	Constantly unwanted repetitive thoughts.
G2	The emergence of thoughts that produce anxiety and interfere with the smooth

	activity.
G3	Relieve anxiety by taking repeated actions to reduce it.
G4	Practice the repetitive action for an hour each day.
G5	Experiencing fear of contamination by dirt or microbes.
G6	Often doubt whether the stove has been turned off or the door has been locked.
G7	Has a strong drive to keep things running in harmony and order.
G8	Feeling overwhelmed when seeing items that are messy or mismatched in color selection.
G9	Doing the act of cleaning body parts or objects that are considered dirty repeatedly.
G10	Check many times to make sure whether the stove has been turned off or the door has been locked.
G11	Arrange items in such a way that they face a uniform or parallel direction in terms of color.
G12	Perform calculations based on a special pattern.
G13	Having thoughts of wanting to commit violence and imagining violent images (such as hurting yourself or others)
G14	Experiencing an enormous burden of constantly having unpleasant sexual images in the mind.
G15	Performing repetitive mental actions, such as silently repeating a prayer, word, or phrase in your mind.
G16	Excessive emotional attachment to objects or goods in terms of grooming.
G17	Likes to collect old or low-value items in the belief that they will someday be useful.

2.5 Expert Weight

Determination of weight determination for expert CF is used in calculations using the ANFIS method. The weights are shown in Table 3 (Ayudia, 2020).

Table 3. Weight Determination for Expert CF

No	Information	Weight
1	No	0
2	Uncertain	0.2
3	Unlikely	0.4
4	Possible	0.6
5	Likely	0.8
6	Definitely	1

2.6 Disease Rules

Based on the symptoms experienced by the sufferer, the system will display the type of OCD disorder experienced. Information about the variations of OCD disorders that will be displayed will match the guidelines applied and can be found in Table 4.

Table 4. Rule on OCD Disorders

rules	Symptom		OCD Disorder Codes
1	IF G1 AND G2 AND G3 AND G4 AND G5 AND G9		WC
2	IF G1 AND G2 AND G3 AND G4 AND G6 AND G10		C
3	IF G1 AND G2 AND G3 AND G4 AND 7 AND G8 AND G11	THEN	OR
4	IF G1 AND G2 AND G13 AND G15		OB
5	IFG16 AND G17		HOR

2.7 Adaptive Neuro Fuzzy Inference Systems (ANFIS)

Neuro fuzzy, or often referred to as Adaptive Neuro Fuzzy Inference System (ANFIS), belongs to the neuro fuzzy group which is part of a hybrid system in the realm of soft computing. This idea involves combining at least two soft computational methods to produce a more efficient algorithm [9]. The ANFIS algorithm is organized in a series of five stages: Fuzzification (Step 1), Fuzzy Process (Step 2), Calculation of Weights (Step 3), Aggregation (Step 4), and Defuzzification (Step 5). ANFIS is a method that uses learning algorithms to adapt rules based on a set of data. By utilizing a fuzzy inference system, data is converted into linguistic values, making it possible to predict disease diagnoses based on detected symptoms (Ayudia, 2020).

a. Layer 1:

Layer has the role of the input layer, which contains concrete values for each input.

b. Layer 2:

The second layer is formed by one or more labeled fixed nodes, which produce an output based on all input signals. This layer is also considered a fuzzy value (Lestari Sirait et al., 2018). The formula used in layer 2 is found in Equation 1 (Ayudia, 2020).

01,i = μ A,1 (x), untuk i = 1,2 dan (1)
01,i = μ B,1-2(y), untuk i = 1,2

c. Layer 3

The third layer is the result of combining all the fuzzy values which will create the activity function of nodes 1 and 2. The formula used in layer 3 is found in Equation 2 and Equation 3 (Triana, 2020).

$$W_{t1} = \frac{w1}{w1 + w2} \quad (2)$$

$$W_{t2} = \frac{w2}{w1 + w2} \quad (3)$$

d. Layer 4

The fourth layer is the output of the neuro fuzzy system. In order to calculate the output value of this neural network, the formulation listed in Equation 4 is used (Syrian, 2020).

ϖ fi = ϖ 1 (pix +qiy +ri) (4)

Information:
W1: Normalized sending power from layer 3
highest priority, (q1,r1,s1,t1,u1 initial value)

e. Layer 5

The final layer, after obtaining the results from the confidence factor of the CF rule, refers to the confidence factor value which is calculated by dividing the total value of the fourth layer by the total value of the third layer (Lestari Sirait et al., 2018). So that in the explanation above, the ANFIS process can run on an expert system if the user chooses a predetermined symptom condition.

Diagnosis of OCD disorders was done using the ANFIS algorithm. In this context, the user experiences thought symptoms that arise and causes anxiety that interferes with activities (G2), and then relieves the anxiety through repeated actions to relieve oneself (G3). The steps in the ANFIS algorithm are as follows:

a. The user selects a symptom

The symptoms experienced by users are G2 and G3 which can be seen in Table 5.

Table 5. Case Studies and Expert Weights

Patient	Selected Symptoms	Description of Selected Symptoms	Weight based on description of Symptoms
1	G2	Almost possible	0.4
	G3	Possible	0.6

The weight values of 0.4 and 0.6 are obtained based on the results of changes in the values of the selected symptoms to the expert CF weight values which can be seen in Table 3.

b. Determine the Values of X1 and X2

Before performing calculations in layer 1, the values of X1 and X2 are required, where X1 in this study has a value of 0.25 and X2 has a value of 0.15. The range values X1 and X2 have a range of 0 to 1. This is because ANFIS is a set of membership degrees (Ayudia, 2020).

c. Retrieval of CF Values according to the Symptoms selected is presented in the results of Table 5. It means that the crips values entered into the first layer are G2 and G3. The crips value to be entered is shown in Table 6.

Table 6Value on Layer 1

Selected Symptoms	Weight Based on Description of Symptoms
G2	0.4
G3	0.6

d. Priority Calculation at Layer 2

Layer 2 consists of nodes that have been labeled, and the output result is the multiplication of all signals originating from Layer 1 which represent the strength of the rule (Lestari Sirait et al., 2018) to calculate layer 2 where it contains fuzzy values resulting from the formula in Equation 1.

With x (or y) input to node I. So it is obtained:

$$Value\ of\ Fuzzy_1 = \frac{0.25}{(0.4 + 0.6)} = 0.25$$

$$Vaue\ of\ Fuzzy_2 = \frac{0.15}{(0.4 + 0.6)} = 0.15$$

Because layer 3 requires the maximum and minimum values from the results of layer 2, which are used as W1 and W2 (Triana, 2020), then the values W1 = 0.25 and W2 = 0.15.

e. Calculating Values of W_{t1} and W_{t2} at Layer 3

Each node in this layer is a defined node and is represented as N. Node 1 calculates the ratio between the strength of the i-th rule and the total comparative strength of all rules (Triana, 2020). At this stage, layer 3 calculations were carried out using activation functions 1 and 2 using Equation 2 and Equation 3 (Triana, 2020) so that the values W_{t1} and W_{t2} obtained are as follows:

$$W_{t1} = \frac{0.25}{0.25+0.15} = 0.625$$

$$W_{t2} = \frac{0.15}{0.25 + 0.15} = 0.375$$

The result values of W_{t1} and W_{t2}will be used as input from Layer 4.

f. Calculating Values of W1f1 and W1f2 Layer 4

In this layer, the adaptive layer of neuroran was used. The formula used is in Equation 4. Because the values in the first layer only consist of 2, the values W1f1 and W1f2 will only use one parameter set, namely pix.

W1f1 = Wt1 (pix)

W1f2 = Wt2 (pix)

So that is obtained:

W1f1 = 0.625 * (0.25 * 1 + 0.25 * 1) = 0.3125

W1f2 = 0.375 * (0.15 * 1 + 0.15 *) = 0.1125

g. Layer 5

Layer 5 is used as output/conclusion from the characteristics of the symptoms that have been approved by the user. In order to determine the conclusions obtained, it takes the total value of layer 4 divided by the total value of layer 3. So that it produces the following equation.

$$\text{f(kesimpulan)} = \frac{Total\ Nilai\ Layer\ 4}{Total\ Nilai\ Layer\ 3}$$

$$= \frac{0.3125 + 0.1125}{0.625 + 0.375} = \frac{0.425}{1} = 0.425$$

To obtain a percentage, the result is multiplied by 100%. Thus, the results obtained are 42.5%. So it can be concluded that the user is infected with the type of interference with the type of *washer* and *cleaner* (WC).

3. RESULTS AND DISCUSSIONS

In this step, the findings from the research that has been carried out is explained. The findings include the presentation of the application interface and the results of manual accuracy tests, as well as diagnostic evaluations from experts that have been carried out.

3.1 Implementation Results

The impact of the implementation of this study is manifested in the form of a web platform for expert systems, providing convenient access for users. This platform has two types of users, namely administrators and users.

In Figure 3, it presents the login page, which is the first display when the user wants to access the system. Within this page, the user is asked to fill out a login form by providing a username and password.

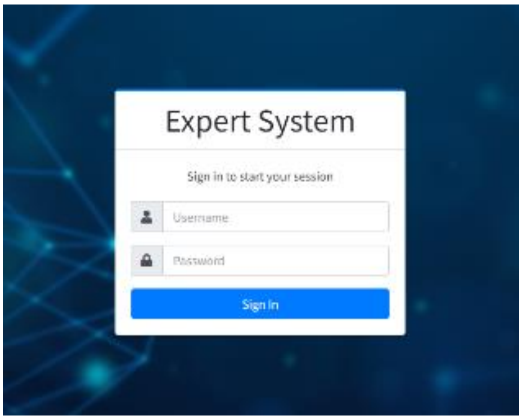

Figure 3Login Page

Figure 3 shows the admin dashboard page that is displayed after the admin logs in. Admin can manage user data, OCD disorders, symptoms, rules, and can perform analysis.

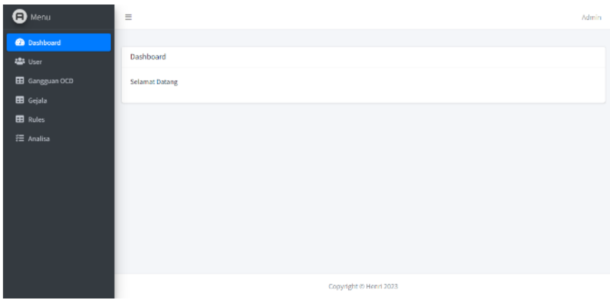

Figure 4Admin Dashboard page

Whereas Figure 4 shows the user dashboard page that is displayed after the user logs in. The users can carry out analysis related to the symptoms they are experiencing.

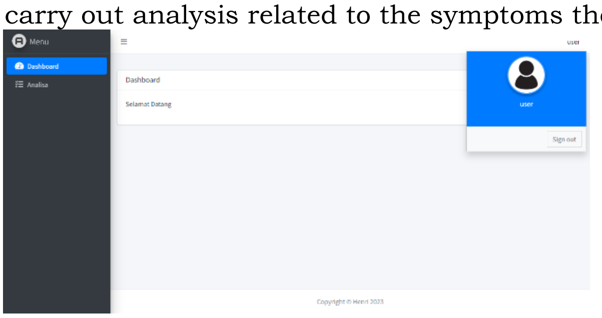

Figure 5User Dashboard page

Figure 5 shows the display of the OCD disorder page which shows information about various disorders and their identification codes. Admins can manage data such as adding, changing, and deleting OCD disorder data.

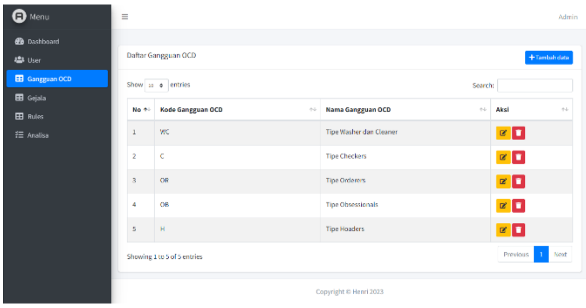

Figure 6OCD Disorders Page

Figure 8 depicts a symptom page that contains information about the symptoms experienced by people with OCD. Administrators have the ability to manage this information, including adding, changing, and deleting symptom data.

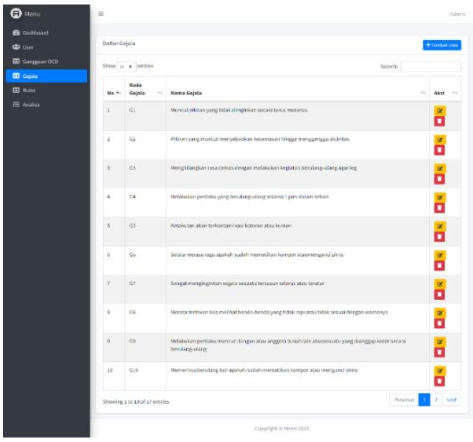

Figure 7Symptoms Page

Figure 7 shows the rules page that is used to display information on the types of OCD disorders. Admin can manage data rules, such as adding, changing, and deleting data.

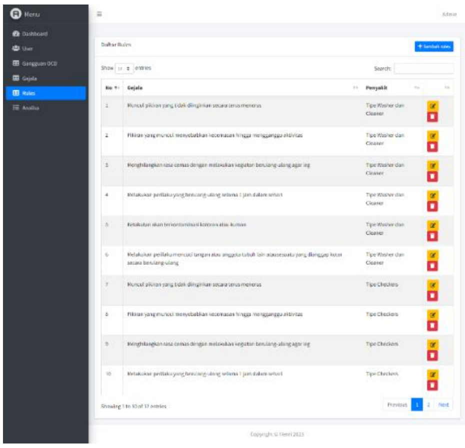

Figure 8Rules page

Figure 8 shows an analysis page related to OCD symptoms. The user must fill in the patient's name and select the symptoms felt. Then, the user can click the analysis button to receive the analysis results.

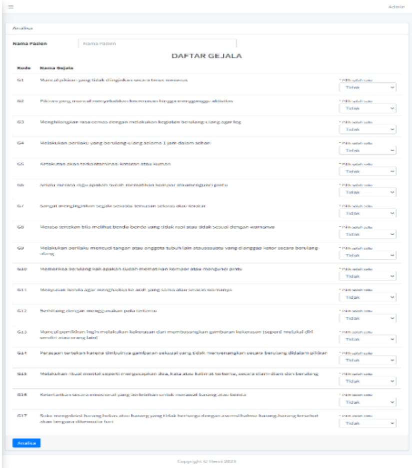

Figure 9Analysis Menu

The results of the analysis are shown in Figure 9 by displaying information in the form of the patient's name, diagnosis of the type of disease, and the percentage.

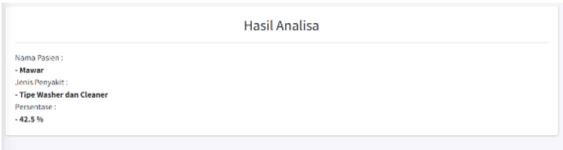

Figure 10Analysis Results

3.2 Accuracy Testing

In the accuracy assessment stage, two forms of testing are implemented, namely testing the accuracy of the expert system through manual calculations and also testing the accuracy of the expert system through diagnosis by experts (Robbins et al., 2019). The series of trials is described as follows:

a. Testing the Accuracy of Expert Systems through Manual Calculations

The trial was carried out by comparing the results of the diagnosis manually through the ANFIS method with the results of the diagnosis produced by this program. In this case, an example is provided of a user who experiences thoughts that trigger anxiety and interfere with activities (G2) and overcomes anxiety with repeated actions to relieve it (G3). The trial results are documented in Table 7.

Table 7Diagnostic Tests on Manualization and Programs

No	Symptoms Experienced	Manualization Results	Program Results
1	G2 and G3	Obtain a percentage of 42.5% with *washers* and *cleaners* type of OCD diagnosis	Obtain a percentage of 42.5% with *washers* and *cleaners* type of OCD diagnosis

Based on Table 7, the test results on manualization and on the program show the similar results as the symptoms experienced by users, namely G2 and G3 get 42.5% with a diagnosis of *washer* and *cleaners type OCD.*

b. Testing Expert System Accuracy through Evaluation by Experts

In this phase, a comparison was made between testing the accuracy of the expert system and evaluation by an expert. Expert judgment was obtained from dr. Fitriyana

Astuti Sp. KJ. The results of testing the accuracy of the expert system and evaluation by experts are shown in Table 8.

Table 8Testing the Expert System with Expert Diagnoses

No	Symptoms Experienced	Expert System Results	Expert Diagnostic Results	Information
1	G2 and G3	*Washer* and *cleaners* types of OCD disorders	*Washer* and *cleaners* types of OCD disorders	Suitable
2	G1, G2, and G13	*Washer* and *cleaners* types OCD disorders	*Washer* and *cleaners* types of OCD disorders	Suitable
3	G2, G3, G4, and G10	*Checker* type of OCD disorder	*Washer* and *cleaners* types of OCD disorders	Not Suitable
4	G6, G8, and G10	*Checker* type of OCD disorder	*Checker* type of OCD disorder	Suitable
5	G1, G13, and G17	*Washer* and *cleaners* types of OCD disorders	*Washer* and *cleaners* types of OCD disorders	Suitable
6	G2 and G5	*Washer* and *cleaners* types OCD disorders	*Washer* and *cleaners* types of OCD disorders	Suitable
7	G1, G7, and G8	*Orderer* type of OCD disorder	*Orderer* type of OCD disorder	Suitable
8	G2, G3, and G12	*Washer* and *cleaners* types of OCD disorders	*Washer* and *cleaners* types of OCD disorders	Suitable
9	G2 and G17	*Washer* and *cleaners* types of OCD disorders	*Washer* and *cleaners* types of OCD disorders	Suitable
10	G1, G7, G8, and G16	*Orderer* type of OCD disorder	*Orderer* type of OCD disorder	Suitable

From the results of testing the accuracy of the system based on expert judgment, it was found that out of a total of 10 data tested, as many as xx data had accurate diagnostic results or were in accordance or suitable with the results of the system. The level of accuracy is calculated using the following method:

$$Accuration = \frac{Right\ Test\ Result}{All\ data}\ x\ 100\% \qquad (5)$$

$$Accuration = \frac{9}{10}\ x\ 100\% = 90\%$$

Based on the calculation of the level of accuracy, the results obtained an accuracy of 90%.

3.3 Discussion

Adaptive Neuro Fuzzy Inference System algorithm is used in diagnosing website-based Obsessive Compulsive Disorder (OCD) using the Python programming language with the Flask framework and MySQL as the database. The results of the research are in the form of an expert system that can diagnose OCD based on the symptoms experienced by the user. In this study, two accuracy tests were carried out, namely testing the accuracy of the expert system with manual calculations and testing the accuracy of the expert system with expert diagnosis. The results on testing the accuracy of the expert system with manual calculations show the similar results with no difference. Meanwhile, the results of expert system testing with expert diagnoses based on the 10 data tested obtained an accuracy of 90%.

4. CONCLUSION

Based on the results of the conducted research, the conclusion is drawn that the implementation of the Adaptive Neuro Fuzzy Inference System (ANFIS) algorithm in diagnosing Obsessive Compulsive Disorder (OCD) through a website-based approach, utilizing the Python programming language with the Flask framework and MySQL as the database, is capable of conducting diagnoses based on experienced symptoms and generating diagnostic results in accordance with the ANFIS algorithm. The accuracy testing results of the expert system, when compared to manual calculations, show the similar results, with a percentage of 42.5% for diagnosing OCD subtypes of *'washer'* and *'cleaners'* during the experiment with symptoms G2 and G3 selected by the user. Meanwhile, accuracy testing results of the expert system when compared to expert diagnosis, from a total of 10 tested data points, achieved an accuracy rate of 90%. This research implies that this research has a high level of accuracy and can be a reference for knowledge about how to diagnose. Future research is expected to carry out ongoing research to improve accuracy.

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