Journal of Physics:
Conference Series

Diagnosis of Facial Skin Disease in Expert System Using Fuzzy Sugeno Method

Journal of Physics: Conference Series **1898** (2021) 012021 doi:10.1088/1742-6596/1898/1/012021

Diagnosis of Facial Skin Disease in Expert System Using Fuzzy Sugeno Method

S M Hardi[1*], D P D Siregar[1] and Elviwani[1]

[1] Faculty of Computer Science and Information Technology, Universitas Sumatera Utara Padang Bulan 20155 USU, Medan, Indonesia.

*vani.hardi@usu.ac.id

Abstract. Structure of human skin is the largest structure in the human body. Skin has many function for human body. The importance of skin care is done to provide beauty to the skin, especially facial skin care, how important facial care can be seen by number of beauty clinics that are used to help treat skin beauty. Various kinds of facial skin problems, one of problem were facial acne which can interfere with beauty of facial skin. Most people oftenly uneducated how to treat acne which is often inappropriate. Usually, sufferers will go directly to the doctor or beauty clinic. Problem often occurs is high cost of consulting with experts and long distance between user's location and nearest doctor's clinic, so needed an application that can help users to be able to consult about skin diseases on the face. In these researches, researchers focused on problem of acne on facial skin by implementing an expert system using Sugeno fuzzy method. Results obtained from these researches is kind of acne and severity based on the symptoms input by user. This application expert system implemented with mobile app and having an accuracy rate of 75% from 100% by testing results of experts and results by system.

1. Introduction

Skin is the largest part of organ in the body. Skin is the most important organ outside the human body which is supple and soft [3,4,5]. There are so many people which think healthy skin is unimportant part for caring [3]. Eventhough with healthy skin can avoid threat of germs, bacteria, and viruses [3]. As we get older so many problems related with healthy skin such as freshness of the skin usually begins fade away, quality of the skin deteriorates, and skin dead cells hard for regeneration and cause many various skin diseases. Skin diseases on face especially acne can be divided into 3 levels: Severe, mildly severe, mild [3]. The first step is usually done by people by going to the doctor because of people are more entrusted to an expert or doctor [3,5]. The problem that often occurs today is the high cost of consulting with experts and long distance between user's location and nearest doctor's clinic.

Based on problems, an application is needed to replace a doctor or expert on problem to provide information that can diagnose skin diseases on the patient's face by using an expert system application. In this research, reasoning system used to solve problems is using fuzzy logic. Fuzzy logic is input values expressly converted by fuzzification unit to the corresponding fuzzy values [1,2,8]. Measurement results that have been calculated then processed by reasoning unit, which by using knowledge base unit, produces a fuzzy set as its output [1]. Final step is done by defuzzification unit, which is to translate the output set into a firm value [2]. Main objective to be achieved in this research is to design an expert system application in the health sector, diagnosis of skin diseases on face. This application is used to diagnose skin diseases on face using Sugeno fuzzy method and this application is based on Android so people can use it easily [2].

2. Method

2.1. Expert System

Expert system is a computer program system that uses certain fields of science to provide solutions to problems in that field [6,7]. Knowledge base in expert system is separate from inference engine. This separation is for the development of the system freely in accordance with the development of knowledge. Inference Engine, namely reasoning in an expert system or commonly called the brain of an expert system in the form of software. In these researches, there were some steps that can be done for implemented expert system for diagnose skin disease. Below architecture of these research can be seen in Figure 1.

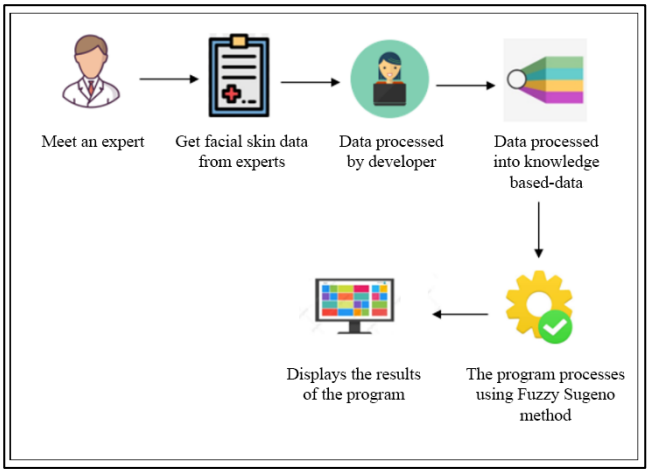

Figure 1. Architecture of expert system in diagnose acne skin.

In these research process, data collection process was carried out by conducting interviews with expert, in this case a dermatologist. Data obtained from experts then be processed into a knowledge base using a computer system. The system display design process is made by paying attention to the use of a good user interface. Results from knowledge base then processed using Sugeno fuzzy method to obtain results in the form of the name of acne disease and severity of disease.

2.2. Fuzzy Sugeno

Sugeno fuzzy method reasoning is almost same as Mamdani fuzzy reasoning method which is often known as Max-Min method, it's just that system output is not a fuzzy set, but rather a constant. To get output (results) on Sugeno method, there are 4 steps as follows:

1. Formation of fuzzy set, which determines the variables associated in the process to be determined.
2. Compile a knowledge base, namely rules in the form of fuzzy implications stating betweenfunction of input variable with output variable.
$$If\ x\ is\ A\ and\ y\ is\ B, then\ z\ =\ f\ (x,y)$$
3. Composition of the rules, fuzzy set solution is obtained by taking the minimum value of the rule, then using that value to modify the fuzzy region and apply it to the output using the operator or (union). In general, it can be written as follows :
$$\mu_{sf}[x_i] = \min(\mu_{sf}[x_i], \mu_{kf}[x_i]) \quad ; \quad i = 1,2,3 \dots, N$$
4. Affirmation, a fuzzy set obtained from the composition of fuzzy rules, while resulting output is a real number. If composition of the rules uses Sugeno method, defuzzification (Z *) is carried out by finding centered mean values:
$$Z^* = \frac{\sum_{i=1}^{N} a_i z_i}{\sum_{i=1}^{N} \alpha_i} \quad ; \quad i = 1,2,3 \dots, N.$$

α_i is the output value in sequence to-i.

z_i is the degree of membership of the output value in sequence to -*i*.
n is the number of rules used.

3. Result and Discussion

3.1. Analysis Data

For applying Fuzzy Sugeno method there is data that must be needed and weight value of each symptom data. Data used in this system include: size of acne, color of acne, amount of ichor, number of acne, pain in acne, and shape growth of acne. Table of symptoms can be seen in Table 1.

Tabel 1. Symptoms table of Acne Skin Disease.

No	Parameter	Information
1	Acne Size	Acne sizes vary, the bigger acne then gets worse
2	Acne Color	The color of acne can be diagnosed the type of acne as each type has different colors
3	Ichor	Ichor here can also be sebum due to people sometimes do not understand the difference ichor and sebum
4	Number of acne	Amount of acne can help in acne diagnosis.
5	Pain in acne	Severe acne can be painful
6	Appearance of acne	Acne can grow on surface and under skin

From data of disease symptoms in following Table 1, a membership function diagram is formed. Membership function can be presented as follows as figure 2

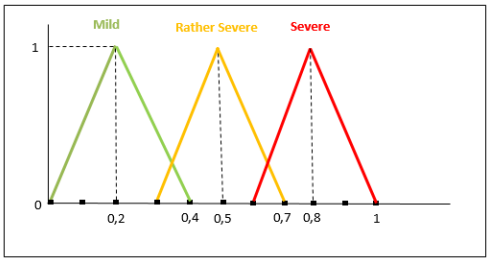

Figure 2. Symptom Membership Function.

Based on assumptions of the experts and application of fuzzy logic, interval range divided into 3 categories, mild with a range ($0.0 \leq a \leq 0.4$), somewhat severe with a range ($0.3 \leq a \leq 0.7$), and severe with a range ($0.6 \leq a \leq 1$). Following is a table of values for symptoms of facial skin disease can be seen in Table 2.

Table 2. Description table of Weight from Disease Symptoms.

Code	Description Weight of Disease Symptoms	Value
G1	Small acne	0,15
G2	Medium acne	0,5
G3	Big acne	0,8
G4	Black acne	0,15
G5	White acne	0,5
G6	Reddish acne	0,8
G7	Invisible Ichor	0.15
G8	Ichor	0,5
G9	Ice Ichor	0,8
G10	Grow one spot acne	0,15
G11	Some acne grow around face	0,5
G12	Acne grow cluster	0,8

G13	Acne not hurt when touched	0,15
G14	Acne hurt when touched	0,5
G15	Very hurts when acne touched (Inflamed)	0,8
G16	No lumps	0,15
G17	Lumps	0,5
G18	Lumps under skin	0.8

Severity of disease divided into 4 categories: mild with a range ($0 \leq a \leq 25\%$), somewhat severe with a range ($25.1\% \leq a \leq 50\%$), severe with a range ($50.1\% \leq a \leq 75\%$), very severe ($75.1\% \leq a \leq 100\%$). Range of intervals can be seen in Figure 3.

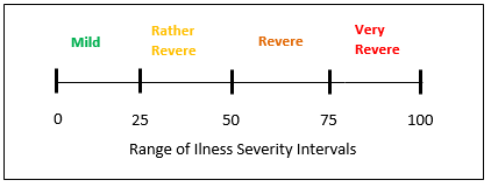

Figure 3. Interval Range of Severity of Disease.

Following is value of severity from each disease that has been obtained from experts. Can be seen in Table 3.

Table 3. Value of Severity of Disease According to Experts.

Code	Disease	Information
P1	Blackhead	Mild
P2	Whitehead	Mild
P3	Submarine	Severe
P4	Sandpaper	Rather Severe
P5	Papule	Severe
P6	Pustules	Severe
P7	Nodules	Severe
P8	Cyst	Awfully

Based on table 3, can seen severity of acne obtained from interviews with experts and acne specialist books provided by experts. From list of diseases above, rules are made for the symptoms that have been obtained from experts. Following rules are made based on diseases that number 8 above, which can be seen in Table 4.

Table 4. Disease Rules Table.

Rules(*to*)	Symptoms *(If)*	Disease(*the*n)
1	G1, G4 G7, G10, G13, G16	P1
2	G1, G5, G8, G11, G13, G17	P2
3	G3, G6, G8, G10, G15, G18	P3
4	G3, G6, G8, G11, G15, G18	P3
5	G1, G4, G7, G10, G13, G17	P4
6	G1, G4, G7, G11, G13, G17	P4
7	G2, G5, G8, G11, G14, G17	P5
8	G2, G6, G8, G11, G14, G17	P6
9	G3, G6, G9, G10, G15, G18	P7
10	G3, G6, G9, G12, G15, G17	P8

3.2. Results

There are three menus that are displayed diagnosis page, information page, and the page. On the top right there is also a button to go to the page about. Main page display can be seen in Figure 4. Based on figure 5 can be seen diagnosis page which user asked to answer questions from symptoms that are experienced. Diagnosis results on system are derived from calculations and weighted values that have been determined and entered into a computer program. Weight from value of disease symptoms can be seen in table 2. Result of diagnosis can be seen in Figure 6.

Figure 4. Display Main Page.

Figure 5. Symptoms Page Display.

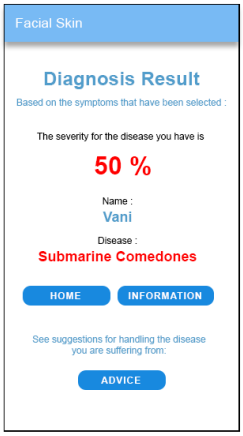

Figure 6. Results.

Following is an example of a case given by an expert to test Sugeno fuzzy method. Examples of cases that will be used are Papule disease (P4) can be seen in Table 5.

Table 5. Examples of Cases of Papule Disease (P4).

Symptom Code	Description of Symptoms	Value
G2	Medium acne	0,5
G5	Colored white	0,5
G8	Ichor	0,5
G11	Some acne grow around face	0,5
G15	Very hurts when acne touched (Inflamed)	0,8
G17	Lumps	0,5

Following are steps used in Takagi-Sugeno-Kang Fuzzy Infrence System method:

1. Formation of a set of Fuzzy / Fuzzyfication, these processes are processes to change a numerical variable (non-fuzzy variable) into form of a weighted value, minimum and maximum interval of selected symptom into a linguistic variable (fuzzy variable) with fuzzyfication formula so that the fuzzy value is obtained.
   First step is to calculate the value of b (the middle value of the minimum limit and maxismum) of each category from interval range in Figure 3 which contains severity of mild, rather severe, severe with by following formula:

$$b = \frac{\sum a \; to \; b}{n}$$

Second step is the fuzzification process, where users choose the symptoms "G2, G5, G8, G11, G15, G17". In the symptom "G2, G5, G8, G11, G17" has a weight value of 0.5 and the symptoms of "G15" has a weight value of 0.8. Furthermore, fuzzification process is carried out with equation formula. Calculate symptoms with a weight value of 0.5.

$$\begin{cases} 0 \\ \frac{x - 0,3;}{0,5 - 0,3;} \\ \frac{0,7 - x;}{0,7 - 0,5;} \end{cases}$$

$$x \leq 0,3 \text{ or } x \geq 0,7$$
$$0,3 \leq x \leq 0,5$$
$$0,5 \leq x \leq 0,7$$

Then fill value 0.5 into fuzzification process
x=0,5 , then (0,5-0,3) / (0,5-0,3) = 2 / 2 = 1
x=0,5 , then (0,7-0,5) / (0,7-0,5) = 2 / 2 = 1
1 / 1 = 1
Fuzzification result for a weight value of 0.5 is 1. Then, calculate symptoms with a weight value of 0.8. Using same formula, then fill value 0.8 into fuzzyfication process.
x=0,8 , then (0,8-0,6) / (0,8-0,6) = 2 / 2 = 1
x=0,8 , then (1-0,8) / (1-0,8) = 2 / 2 = 1
1 / 1 = 1
Fuzzyfication results for weight value of 0.8 are 1

2. Application of function implications
Examples formation of premise rules in this expert system are IF symptoms = G2 AND G5 AND G8 AND G11 AND G15 AND G17 then disease = P4. Based on rules that have been formed at the stage of knowledge acquisition, as many as 8 rules are obtained.

3. Defuzzification, these processes is final process of fuzzy logic where after fuzzyfication is performed on each selected symptom, then symptoms are processed according rules of implication function that has been made so that the disease results are obtained. Following is defuzzyfication process, which is as follows.

$$WA = \frac{(F.G2 \text{ X } B.G2) + (F.G8 \text{ X } B.G8) + (F.G11X \text{ } B.G11) + (F.G15 \text{ X } B.G15) + (F.G17 \text{ X } B.G17}{F.G2+F.G8+F.G11+F.G15+F.G17}$$

$$= \frac{(1 \text{ X } 0,5)+(1 \text{ X}0,5)+(1\text{X}0,5)+(1\text{X}0,5)+(1\text{X}0,8)+(1\text{X}0,5}{1+1+1+1+1+1}$$

$$= \frac{3,3}{6}$$

$$= 5, 5$$

Severity of disease = 0.55 x 100% = 55%.
Based on results of manual calculation above, final result is 55%. Next process is weight value used in manual calculation in the program to the system to begin diagnostic testing. Diagnosis can be seen in Figure 6.
Figure 6 display diagnostic results obtained from system are same as results of manual calculations. Then it can be concluded that system being built can work very well. System evaluation is done by comparing the diagnosis results from experts with the diagnosis results from the system. Can be seen in the following Table 6.

Table 6. Comparison of Experts and Systems.

Code	Severity of expert	Information	Severity of system	Information
P1	(0,0% - 25%)	Mild	(0,0% - 23%)	Mild

P2	(0,0% - 25%)	Mild	(23,1% - 29%)	Mild
P3	(25% - 50%)	Rather Revere	(29,1% - 35%)	Rather Revere
P4	(25% - 50%)	Rather Revere	(35,1% - 40%)	Rather Revere
P5	(25% - 50%)	Rather Revere	(40,1% - 45,43%)	Rather Revere
P6	(50% - 100%)	Revere	(44,44% - 56%)	Revere
P7	(50% - 100%)	Revere	(56,1% - 70%)	Revere
P8	(50% - 100%)	Revere	(70,1% - 100%)	Revere

From testing by system and testing from experts obtained accuracy of severity from diagnosis of acne skin diseases on face is 75%. So it can be concluded that Sugeno fuzzy method can be applied to expert systems and can diagnose acne skin diseases on the face.

4. Conclusion

Based on the test results, it can be seen that the Sugeno fuzzy method can be implemented in producing diagnoses of facial diseases where in this study focuses on the classification of types of acne and its severity so that it can be seen that these systems can be initial treatment by using these expert systems. Test results using system and direct testing with experts obtained the accuracy of 75%.

Reference

[1] Abdullah, Azian Azamimi., & Khairunizam, Wan. 2018. Development of Fuzzy Expert System for Diagnosis of Diabetes. International Conference on Computational Approach in Smart Systems Design and Applications (ICASSDA).

[2] Salman, A, Lina, Y & Simon, C. 2014. Computational Intelligence Method for Early Diagnosis Dengue Haemorrhagic Fever Using Fuzzy on Mobile Device. http://www.epj-conferences.org or http://dx.doi.org/10.1051/epjconf/20146800003.

[3] P. K. Buxton, "ABC of Dermatology. Jolly & Barber Ltd,Great Britain. Pp 1-30, 1991.

[4] Wasitaatmadja, Sjarif M (ed.). 2018. Akne. Jakarta:Badan Penerbit FKUI.

[5] Asghar, M Z1, et all. 2011. Diagnosis of Skin Diseases using Online Expert System. (IJCSIS)International Journal of Computer Science and Information Security, Vol. 9, No. 6, June 2011.

[6] Hardi S M, Surbakti F P, & Elviwani. 2020. Expert System for Detection Glaucoma Disease Using Certainty Factor Method. ICAISD 2020. Journal of Physics: Conference Series 1641012100 IOP Publishing doi:10.1088/1742-6596/1641/1/012100.

[7] Hardi S M, Triwiyono A, & Amalia. 2020. Expert System for Diagnosing Osteoarthritis with Fuzzy Tsukamoto Method. ICAISD 2020. Journal of Physics: Conference Series 1641 (2020) 012107 IOP Publishing doi:10.1088/1742-6596/1641/1/012107.

[8] Damayanti, A., Maimunah, S., & Pratiwi, A. B. (2019, August). Fuzzy modeling network type 2 and principal component analysis for the diagnosis of diabetic retinopathy. In *Journal of Physics: Conference Series* (Vol. 1306, No. 1, p. 012020). IOP Publishing.