Implementation of Expert System to Diagnose Pregnancy Disorders using Fuzzy Expert System Method

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ABSTRACT

The process of problem analysis can be carried out by a computer system that has included a knowledge base and a set of rules from an expert, known as an expert system. One of the problems that the expert system can solve is to diagnose pregnancy disorders. This study aims to determine how to design an expert system by adopting a doctor's expertise with the fuzzy expert system method. The data used in this study were 46 data obtained from the medical records from Tugurejo Hospital in Semarang City. The variables used were general symptoms and pregnancy disorders. The result of this research is the implementation of the fuzzy expert system to diagnose pregnancy disorders. The level of system accuracy generated from the scenario of 26 data as training data and 20 data as test data is equal to 95%.

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1 Introduction

Maternal Mortality Rate (MMR) compared to live births in Indonesia required special attention to detecting early pregnancy disorders. There are nearly 20,000 deaths in Indonesia due to complications during pregnancy or childbirth each year (Lisbet, 2016). Based on data from the 2015 Indonesian Demographic and Health Survey (IDHS) by the Survey Implementing Agency (SIA), the Maternal Mortality Rate (MMR) in Indonesia is 305 deaths per 100,000 live births. It is relatively high because it exceeds the predetermined target of 102 deaths per 100,000 live births (Ministry of Health Republic of Indonesia, 2020). Understanding the behavior of prenatal care (antenatal care) is vital for knowing the health effects of infants and mothers (Afrian & Putra, 2015). Many doctors will not examine the patient until the age of 8 weeks old pregnancy unless the patient has a medical condition, had problems with a previous pregnancy, or have symptoms that should be checked (Rayyane, 2013). Prediction is essential to know an event in the future by recognizing patterns from past events, and then humans can prepare everything that will happen (Setiyowati, Alamsyah, & Muslim, 2019). One of the branches of computer science that can help human performance is an expert system, a sub-field of artificial intelligence. Expert systems as intelligent storage systems for human expert knowledge have been widely used to solve various problems as human experts do (Maylawati, Darmalaksana, & Ramdhani, 2017). An expert system is a computer system that has entered the knowledge base and rules used to solve problems like an expert (Insani, Alamsyah, & Putra, 2018). The expert system can diagnose a disease that can help users diagnose a condition (Agusta, Arini, & Arifudin, 2020). The purpose of an expert system is not to replace the role of humans but to present human knowledge in a system form so that it can be used by many people (Muslim, Kurniawati, & Sugiharti, 2015).

This Pregnancy Diagnosis Expert System was created using a website platform. The website's page will be accessible via a URL which is usually called the homepage (JavaCreativity, 2014). PHP

stands for Personal Home Page, which is the standard language used in the world of websites. PHP is a programming language in the form of a script placed on a web server (Peranginangin, 2006). Building a web-based system would require a database to store the data in the system (Pramesti, Arifudin, & Sugiharti, 2016). Apart from using PHP as a programming language, this pregnancy diagnosis system also utilizes the Laravel framework. Laravel is an MVC (Model-View-Controller) framework with bundles, migration, and Artisan CLI (Command-Line Interface) (Gunawan, Lawi, & Adnan, 2016). Pregnancy is a normal function of the body and part of a woman's life phase (Ashari, 2015).

Based on the description above, this study aims to implement an expert system to diagnose pregnancy disorders using the fuzzy expert system method and determine accuracy in diagnosing pregnancy disorders.

2 Methods

2.1 Fuzzy Expert System

A fuzzy expert system is a computer program that provides an expert in providing solutions using a fuzzy logic knowledge base (Prasetiya & Irawan, 2012). The fuzzy expert system has characteristics compared to other expert systems, wherein this fuzzy expert system has a confusion of linguistic assessment (Klir & Yuan, 1995).

2.2 Process Design

The steps for designing an expert system process for diagnosing pregnancy disorders are shown in Figure 1.

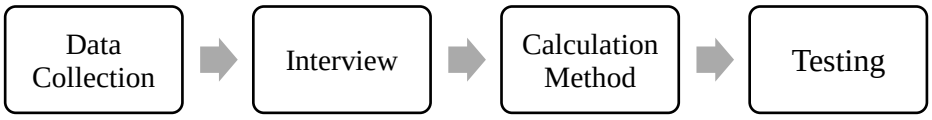

Figure 1. Steps for making an expert system

A flowchart of the fuzzy expert system can be seen in Figure 2.

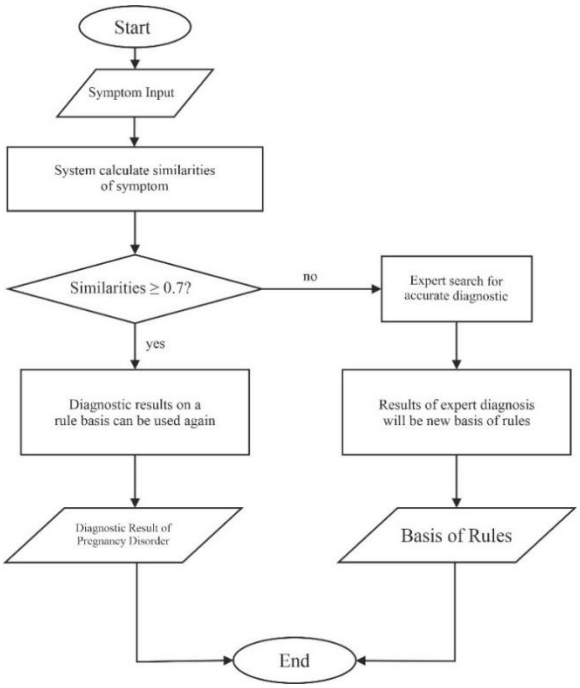

Figure 2. Flowchart of Fuzzy Expert System

2.3 System Development

The system design is carried out using the Waterfall Model approach. This model is often used by system analysts in general (Roviaji & Muslim, 2017). The waterfall method consists of several stages of the software development process, namely analysis needs, design, implementation, testing, and maintenance (Hardyanto *et al.*, 2017).

1) The requirements analysis phase defines the entire software format, identifies all requirements, and outlines the system being created (Nugroho & Arifudin, 2015).
2) The design stage is application design, including interface design and database structure design (Putra, 2015). Creating an attractive web-based application program must be designed in advance to achieve the results under predetermined goals.
3) The implementation stage is designing software that is realized as a series of programs or program units (Muslim, 2012).

The testing phase is to test whether the system is ready and fit for use. The tester can determine a set of input conditions and perform tests on the functional specifications of the program (Purwinarko & Sukestiyarno, 2015).

3 Results and Discussion

3.1 Results

3.1.1 Data Collection

The data used in this study are the results of 46 medical records from patients in 2017 who experienced pregnancy disorders at the Tugurejo Regional General Hospital, Semarang. The data used are in the form of symptoms experienced by patients at Tugurejo Hospital and the diagnosis results from the doctor in charge.

3.1.2 Interview

The interview stage was carried out with an obstetrician who was a doctor at the Tugurejo Regional Hospital. The interview data generated from each patient's symptoms with pregnancy disorders, symptoms, and weights are shown in Table 1.

Table 1. Disorders analysis of pregnancy, symptoms, and weight

Symptoms	Pre Eclampsia	Inpartu	Premature rupture	Placenta Previa	Blighted Ovum	IUFD
Abdominal Contractions	0,3	0,3	0,3			0,3
Heartburn	0,6			0,3		
Mucus in the birth path		0,6	1	0,6		
Blood in the birth path		0,6	0,6	1	1	0,6
The liquid in the birth path			1	0,6		0,3
Out of the amniotic fluid		0,6		0,3		
Spots		0,3			1	
Fetal movement is felt		0,6		1		
Fetal movement not felt						1
High tension	1					
Blurred vision	1					
Dizzy	0,6					
Nausea	0,6		0,3		1	
Heavily liquid comes from the birth path			1			
Headache	0,6					
Stomach pain				0,6	0,6	
Fetus absent						1

3.1.3 Calculation Method

1) Fuzzification

The data testing through fuzzification, based on data presented in Table 1, the weight value based on the variable input and output is divided into one or more sets of fuzzy-like symptoms that can be seen in Figure 3.

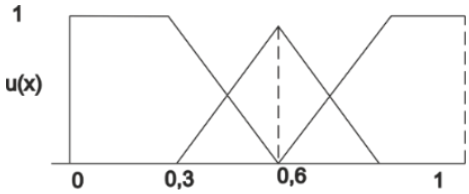

Figure 3. Fuzzy set

Data on this fuzzy set can be categorized to describe the level of symptoms experienced by patients, as shown in Table 2.

Table 2. Values of severity level category

Category	Weight
Rarely	0,3
Sometimes	0,6
Often	1

2) Basic of Rules

The basis of the rule is written in the form of if-then (IF-THEN), which can be said to be a two-part implication relationship, namely the premise (if) and the conclusion (then). If the premise part is fulfilled, the decision will also be proper.

Rule 1:
IF High tension, often
AND Blurred vision, often
AND Dizziness, sometimes
AND Nausea, sometimes
THEN Pre-Eclampsia
Rule 2:
IF Spots, rarely
AND Fetal movement felt, occasionally
AND The birth path is bleeding, sometimes
AND Some cubes are out, often
THEN Inpartu
Rule 3:
IF The birth canal discharge, often
AND The birth path is bleeding, sometimes
AND Mucus in the birth path, often
AND Heavily liquid comes from birth path, often
THEN Premature rupture of membranes
Rule 4:
IF Fetal movement is felt, often
AND The birth canal discharge, sometimes
AND The birth path is bleeding, often
AND Abdominal pain, sometimes
THEN Placenta Previa

Rule 5:
IF Spots, often
AND The birth path is bleeding, often
AND fetus doesn't thrive, sometimes
AND Vomits, often
THEN Blighted Ovum
Rule 6:
IF Fetal movements are not felt, often
AND The birth canal discharge, rarely
AND fetus absent, often
AND Fetal heart is not beating, often THEN IUFD

3) Rules Component

It is necessary to calculate the fuzzy value based on the symptoms inputted by the patient to determine the type of pregnancy disorder suffered. To find the value of suitability or instance entered by the patient's symptoms are:

1. Rarely abdominal contractions;
2. Sometimes the birth canal bleeds;
3. Occasionally feels pain in the stomach.

Then according to the category values in Table 2, the symptoms entered by patient B= {0,3/a1, 0,6/a2, 0,3/a3}. Then the suitability value is calculated using the following formula:

$$R\big(B(ai), Uj(ai)\big)| = \text{Max}\left(0{,}1 - \frac{C|\mu B(ai) - \mu Uj(ai)|}{\mu Uj(ai)}\right) \quad (1)$$

With the provisions $\mu Uj(ai) \neq 0$

$$R\big(B(ai), Uj(ai)\big) = 0 \text{ with the provisions of } \mu Uj(ai) = 0 \quad (2)$$

The formula above can be obtained the conformity generated each patient's symptoms inputted to the symptoms that exist in the knowledge-based for each disease that has the symptoms.

4) Defuzzification

After calculating the value of symptoms between symptoms that are inputted with existing knowledge-based symptoms, then the next step is the sum of the pregnancy disorder suitability values, so the fuzzy conditional probability value can be calculated from the data above as follows:

$$P(B, U_1) = \frac{1x1}{3} = \frac{1}{3} = 0{,}33 \quad (3)$$

$$P(B, U_2) = \frac{0x1}{3} = \frac{0}{3} = 0 \quad (4)$$

$$P(B, U_3) = \frac{0{,}5x1}{3} = \frac{0{,}5}{3} = 0{,}16 \quad (5)$$

$$P(B, U_4) = \frac{0{,}5x1}{3} = \frac{0{,}5}{3} = 0{,}16 \quad (6)$$

$$P(B, U_5) = \frac{0x1}{3} = \frac{0}{3} = 0 \quad (7)$$

$$P(B, U_6) = \frac{1x1+1x1+1x1}{3} = \frac{3}{3} = 1 \quad (8)$$

From the results obtained from the above calculations, the final results are as follows:

$$P(B, U_1) = 0{,}33 \text{ x } 100\% = 33\% \quad (9)$$

For pre-eclampsia pregnancy disorders with low probability.

$$P(B, U_1) = 0{,}33 \text{ x } 100\% = 33\% \quad (10)$$

For pregnancy disorders, premature rupture of the membranes and placenta previa with less probability.

$$P(B, U_6) = 1 \text{ x } 100\% = 100\% \quad (11)$$

For IUFD, pregnancy disorders occur with great possibilities and are accompanied by an explanation or intrauterine fetal death or IUFD is the condition of the fetus died in the womb after 20 weeks gestation. Some cases of IUFD cannot be prevented, but the risk can be reduced by paying attention to the causative factors and taking appropriate preventive steps.

3.1.4 Testing

After testing 46 medical record data from patients at Tugurejo Hospital Semarang, by dividing 26 data as training data and 20 data as test data, the results of the system accuracy were 95%, as can be seen in Table 3.

Table 3. Data testing results

Data tested	Compatible Data	Incompatible Data	Accuracy
20	19	1	95%

From the test results of 20 test data on 26 training data using the system made, 19 training data is accurate with the diagnosis from the doctor in charge, and one data is inaccurate because the system uses a calculation basis based on strict rules.

3.2 Discussion

The system is made using the platform website that dynamically with the framework laravel, making the data in the system can be accessed and modified when there are developments concerning pregnancy interruption following the user's needs. Users can enter symptoms on the website on the diagnosis page. The diagnosis page showed experienced signs that have been selected and will display the diagnosis and calculation results as shown in Figure 4.

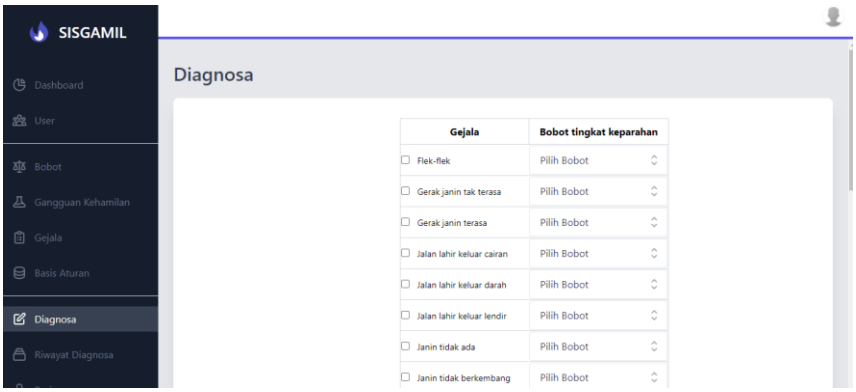

Figure 4. Diagnosis page

After the user makes a diagnosis, information on pregnancy disorders will appear based on the symptoms and weights that have been inputted by the user, as can be seen in Figure 5.

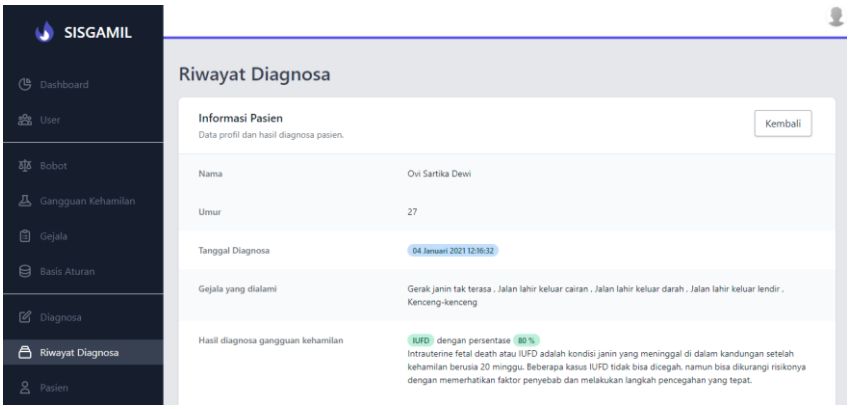

Figure 5. Diagnosis result page

Based on testing and implementation of the system, diagnosis of pregnancy disorders using the fuzzy expert system is adequate for diagnosing disorders of pregnancy. The flexibility of a web-based pregnancy disorder diagnosis system can be accessed and operated using a web browser. With the determination of the rule base, the calculation of rule components based on the input of pregnancy disorders symptoms in the medical records of Tugurejo Hospital, and the results of expert diagnosis with an accuracy level of 95%, development still can improve system accuracy. Currently, the system can only diagnose pregnancy disorders, including pre-eclampsia, labor, premature rupture of membranes, placenta previa, blighted ovum, and IUFD (Intrauterine fetal death).

4 Conclusion

The implementation of the Fuzzy Expert System in diagnosing pregnancy disorders using medical record data from Tugurejo Hospital, Semarang City, has been conducted. The Fuzzy Expert System that has been developed comprises some several stages, namely fuzzification, basis rule, rule component, and defuzzification. After implementing 46 medical record data from Tugurejo Hospital Semarang with a scenario of 26 data as training data and 20 data as test data successfully diagnosed correctly, it can be seen that the system accuracy rate is 95%.

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