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Application of the Case-Based Reasoning Method in the Expert System of Early Diagnosis of Polycystic Ovarian Syndrome

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Abstract: Polycystic ovarian syndrome (PCOS) is a hormone disorder experienced by women of childbearing age. Many women are not aware of the early symptoms of PCOS because they consider it is a normal thing in the menstrual cycle so they do not carry out any treatment and prevention. Case-Based Reasoning (CBR) is a major paradigm in automatic reasoning and machine learning. The objective of this study was to provide information (education) about the definition, common symptoms as well as solutions and prevention related to Polycystic Ovarian Syndrome before it becomes a chronic disease. The data collection was done by interview and observation, while the method used in this study was the Case-Based Reasoning (CBR) method, which is a problem-solving method that in finding a solution from a new case base, the system will search for a solution from an old case that had the same problem and had happened before. The result of this study is an expert system for early diagnosis of Polycystic ovarian syndrome based on the symptoms experienced by the patient.

Keywords: PCOS, CBR, Expert System, Menstrual Cycle, Polycystic Ovary.

1. INTRODUCTION

An adult woman experiences menstruation 12 to 13 times in one year. Normal menstruation involves the maturation of the neuroendocrine system. The menstrual cycle will be disrupted if one of the steps in the neuroendocrine system does not work properly. Hormonal imbalance caused by irregular menstrual cycles will cause long periods of menstruation to become irregular and can cause health problems related to fertility in women. The results of the Basic Health Research (RISKESDAS) in 2018 showed that 27.8% of women aged 10-59 years in Indonesia reported irregular menstruation in the past year. Meanwhile, data in Semarang Regency, especially the G&G Healthy clinic, showed that 21.95% of women experience irregular menstruation. One of the fertility problems caused by irregular menstruation is Polycystic ovary syndrome (PCOS). This polygenic disorder with various phenotypes is generally experienced by women of reproductive age. PCOS can affect a woman's ability to get pregnant and interfere with her quality of life [1].

Patients with PCOS experience hormonal imbalances in their bodies because they have higher than normal levels of androgens, which are commonly known as the male sex hormone [2]. A percentage of 70% of patients with PCOS are generally not diagnosed because some of the symptoms of PCOS are considered normal by women. If PCOS is not immediately detected and treated with the right steps, it will lead to several serious long-term diseases, such as diabetes, heart disease, stroke, endometrial cancer and depression. One of the most serious effects of PCOS is a woman's inability to conceive (infertility). PCOS causes irregular ovulation, resulting in abnormal menstrual cycles and an increased risk of disorders, one of which is gestational

diabetes.

The application of case-based reasoning (CBR) method is used as a support in determining the symptom status of patients with PCOS. This method uses reasoning that combines three core things, including: problem-solving, understanding and learning as well as integrating all of them with memory processing [3]. Moreover, the application of CBR in this case study is based on several studies that have similar cases and produce an accurate diagnosis for the final result. The CBR method is also broadly applied in other cases, such as a study conducted by Roki Hardianto, entitled "Expert System for Determining Personality Type of Primary School Students Using Case-Based Reasoning Methods." [4] This study focused on the final result process in the form of grouping personality types. In addition, this method was also applied in a similar case to determine the types of pests and diseases on tea plants, entitled "Expert System for Diagnosing Pests and Diseases in Tea Plants Using the Case-Based Reasoning Method on Android." [5] The final result of the study conducted by Agus Suryadi, Dasman Johan and Eka Lia Febrianti was a system that provides android-based expert solutions and control of pests/diseases in tea plants.

Based on the above background, to facilitate the early diagnosis process, an expert system for early diagnosis of Polycystic ovarian syndrome was created by applying the Case-Based Reasoning method. This study aimed to apply CBR calculations in PCOS early diagnosis applications. This system is expected to assist the public to find out information about PCOS and its symptoms, solutions and prevention of PCOS as well as to find out the percentage of possibilities of suffering from PCOS.

2. RESEARCH METHOD

In this section, we will explain further the process or stages in the application of the Case-Based Reasoning (CBR) method on the PCOS early diagnosis expert system. In general, the steps in implementing CBR included procedures of data collection, analysis, problem-solving methods, and system testing methods.

2.1. Data Collection Procedure

In this study, two data collection techniques were applied, consisting of observation and interviews. In the observation technique, it obtained knowledge about matters related to the topic to be studied (PCOS). Meanwhile, in the interview technique, an analysis was carried out to obtain potential problems and data related to the research topic and information needs from the field (research site).

Table 1. Table of Disease Data

Disease Code	Disease Name	Definition
P1	*Polycystic Ovarian Syndrome* (PCOS)	Polycystic ovarian syndrome (PCOS) is an endocrine disorder that affects the female reproductive system. Women with PCOS have a high risk of infertility. [6] Patients with PCOS tend to have excessive levels of masculine hormones (androgens) accompanied by disturbances in the menstrual cycle. This causes the ovaries to produce pockets filled with fluid in large quantities so that the egg cannot develop properly and fail to be released regularly.

Table 2 shows data on general symptoms of PCOS according to an expert in Reproductive and Infertility Endocrinology who is also a trainer and an active researcher at the Indonesian Center for Research and Reproduction, dr. Beeleoni, BMedSc, SpoG-KFER.

Table 2. Table of PCOS Common Symptoms Data

No.	Symptom code	Symptom
1	G01	Irregular menstrual cycles/periods
2	G02	Excessive/bleeding menstruation/periods

3	G03	Excessive growth of hair or fine hair on the face, back, stomach and chest
4	G04	Excessive acne on the face, chest and upper back
5	G05	Weight gain to obesity
6	G06	Baldness
7	G07	Blackened body skin in the folds of the body, such as the neck, groin and under the breast
8	G08	Excessive headaches
9	G09	Difficult to conceive

Table 3. Table of Solution Data

No.	Solution Code	Solution
1	S1	Changes in lifestyle, including: 1. Doing a calorie deficit to lose weight 2. Reduce consumption of foods containing sugar 3. Set a pattern of rest (sleep) and should not stay up late 4. Doing regular exercise
2	S2	Medication <administration of drugs> such as: 1. Drugs to overcome irregular menstrual cycles 2. Drugs to lower blood sugar levels 3. Drugs to stimulate ovulation 4. Drugs to reduce the growth of excessive fine hair.
3	S3	Operative action (operation)

2.2. Analysis

The analysis phase required data of constraints and data that would be a reference to solve the problem. The information obtained from the analysis served to become a foundation of knowledge of PCOS ranging from general information to solutions that would support the design of the system to suit the expert system application to be made. This stage was also used to determine the weight of the relation for calculating the similiarity value in the CBR method.

Table 4. Table of Symptom Value/Weight

No.	Code	Symptom	Value/Weight
1.	G01	Irregular menstrual cycles/periods	2
2.	G02	Heavy menstruation / heavy bleeding	3
3.	G03	Excessive growth of hair / fine hair on the face, chest/back areas	3
4.	G04	Excessive acne	3
5.	G05	Weight gain to overweight	2
6.	G06	Hair fall to baldness	3
7.	G07	Black skin in the folds of the body	2
8.	G08	Excessive headaches	1
9.	G09	Difficult to get conceive	2

Table 5. Table of Diagnosis Presentation

No.	Percentage	Notes
1.	0.1	Definitely not
2.	0.2	Almost certainly not
3.	0.3	Probably not
4.	0.4	Maybe not
5.	0.5	Slightly yes
6.	0.6	Maybe

7.	0.7	Probably
8.	0.8	Almost certainty
9.	1	Definitely

2.3. Problem Solving Method

Analyzing and finding solutions and prevention of PCOS is the goal of designing this expert system. This quantitative approach used Research and Development (R&D) as the research design. R&D is a stage to develop a new product or improve an existing product.

This expert system was developed through the application of the method with the waterfall model. The waterfall model is a model that provides a sequential software lifeflow approach starting from analysis, design, coding, and testing [7]. This method has 5 main stages, consisting of:

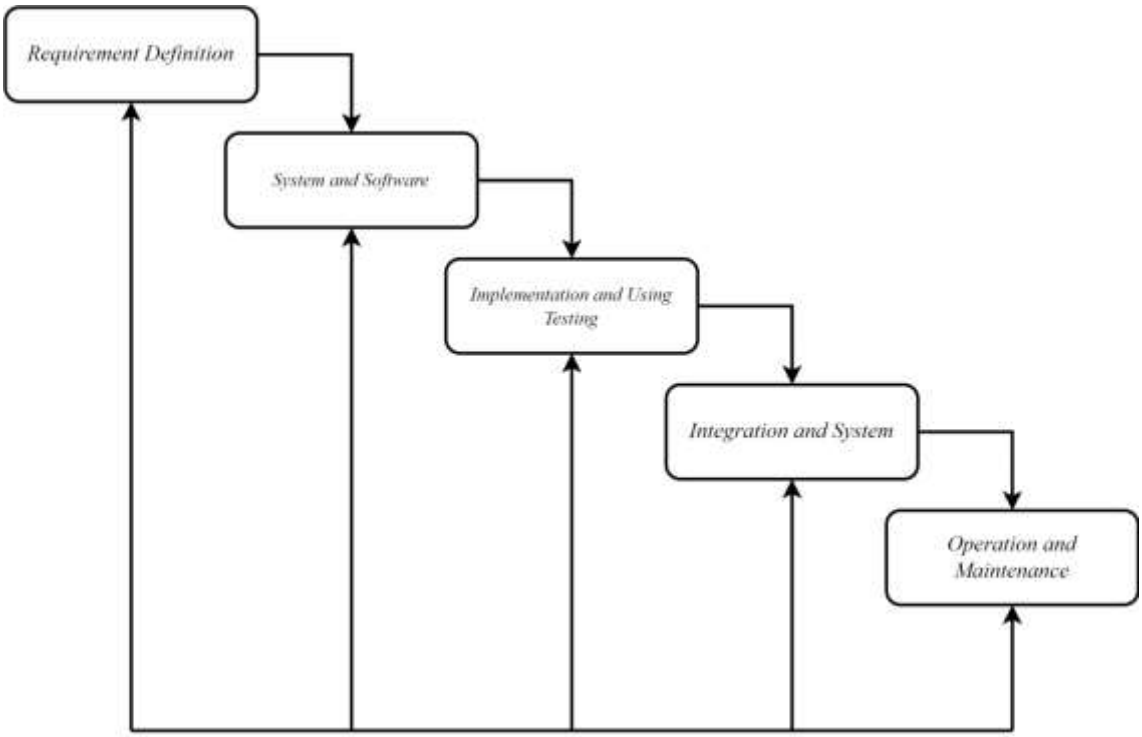

Figure 1. The Main Stages of the Waterfall Model

Notes:

1. *Requirement definition*, is an analysis stage consisting of field studies and literature studies.
2. *System and software design,* is the stage where researchers form an application design that will be made/developed based on the results of the analysis of the previous process.
3. *Implementation and unit testing*, is the realization stage of the design results in a program unit.
4. *Integration and system testing*, is a test of the system whether it meets the existing requirements or not and the application will be tested on the user whether an error occurs or not.
5. *Operation and maintenance*, is the stage where the system that has been tested by the user has no errors found and the system will go through the maintenance phase so that it runs optimally. [8]

2.4. System Method Test

The testing of the PCOS early diagnosis expert system was carried out using the Black Box Testing method. It is a method used to test applications without having to know the details of the application, such as the source code. [9] This test aims to check for missing/wrong functions, interface failures, external database errors and program initialization.

3. RESULTS AND DISCUSSION

This section will explain the discussion of the results of manual calculations in more detail using the CBR method along with making the system. The case-based reasoning (CBR) method is one method to build a system that works by diagnosing new cases based on old cases that have occurred and providing solutions to new cases based on old cases that have the highest similarity value. [10] The results obtained from these manual calculations will be compared with the results of calculations from the expert system that has been designed.

The CBR method has 4 stages: retrieve, reuse, revise and retain. [11] *Retrieve* means retrieving the old case base that is most similar/relevant to the new case. *Reuse* means reusing old case knowledge and information based on the weight of similarity that is most relevant to the new case. *Revise* means reviewing the proposed solution and testing it on real, new cases. *Retain* means to keep the knowledge part back to solve similar problems in the future.

The following is one of the data obtained during the data collection with the interview technique:

Table 6. Data on Symptoms Experienced by Patients

No.	Symptom	Answer
1.	Irregular menstrual cycles/periods	Yes
2.	Heavy menstruation / heavy bleeding	No
3.	Excessive growth of hair / fine hair on the face, chest/back areas	Yes
4.	Excessive acne	Yes
5.	Weight gain to overweight	Yes
6.	Hair fall to baldness	Yes
7.	Black skin in the folds of the body	Yes
8.	Excessive headaches	No
9.	Difficult to get conceive	Yes

Based on the data above, manual calculations will be carried out using the case-based reasoning (CBR) method with a rule base formulated with the nearest neighbor retrieval formula as follows:

$$Similiarity\ (problem, case) = \frac{s1 * w1\ + s2 * w2\ + \cdots + sn * wn}{w1 + w2 + \cdots + wn}$$

Notes:

S = similarity, if there is a similarity case in terms of the similarity, it will be graded 1, while if there is not, it will be graded 0.

W = weight (given weight).

Table 7. Table of Matching New Case Bases with Old Case Bases

No.	Symptoms of Old Case	Value/Weight Equation
1.	Irregular menstrual cycles/periods	1
2.	Heavy menstruation / heavy bleeding	0
3.	Excessive growth of hair / fine hair on the face, chest/back areas	1
4.	Excessive acne	1
5.	Weight gain to overweight	1
6.	Hair fall to baldness	1
7.	Black skin in the folds of the body	1
8.	Excessive headaches	0
9.	Difficult to get conceive	1

Notes:

If the symptoms are the same, it will be graded 1, If they are different, it will be graded 0.
Based on the equation of the symptoms above, the similiarity value will be searched using the formula:

$$Similiarity\ (problem, case)$$
$$= \frac{(s1 * w1) + (s2 * w2) + (s3 * w3) + (s4 * w4) + (s5 * w5) + (s6 * w6) + (s7 * w7) + (s8 * w8) + (s9 * w9)}{w1 + w2 + w3 + w4 + w5 + w6 + w7 + w8 + w9}$$
$$= \frac{(1 * 2) + (0 * 3) + (1 * 3) + (1 * 3) + (1 * 2) + (1 * 3) + (1 * 2) + (0 * 1) + (1 * 2)}{2 + 3 + 3 + 3 + 2 + 3 + 2 + 1 + 2}$$
$$= \frac{(2) + (0) + (3) + (3) + (2) + (3) + (2) + (0) + (2)}{21}$$
$$= \frac{17}{21}$$
$$= 0{,}8095 = 80{,}95\%$$

Based on the results of the case-based calculation above, the case has a similarity weight of 0.8095 or a percentage of 80.95%, the patients were diagnosed with severe PCOS disease with the predicate of Almost certainty. The predicate values for the percentage of diagnoses were matched with Table 5.
The PCOS early diagnosis expert system was created using the PHP (Hypertext Processor) programming language by applying the case-based reasoning (CBR) method. The following is a display of users who have successfully registered and carried out the PCOS diagnosis process by selecting the symptoms experienced.

Figure 2. Display of User Symptom Data Filling

On the diagnosis page, there are 9 common symptoms of patients with PCOS. Users can choose the symptoms according to what they are experiencing by clicking the checkbox provided. If the user has finished selecting the symptoms and clicking the diagnostic process button, the diagnostic results will be displayed as shown in Figure 3 below.

Figure 3. User's Diagnostic Results Display

On the page, there is a button that will display the calculation of the similiarity value. If the user clicks the button, the page display will be shown in Figure 4 below.

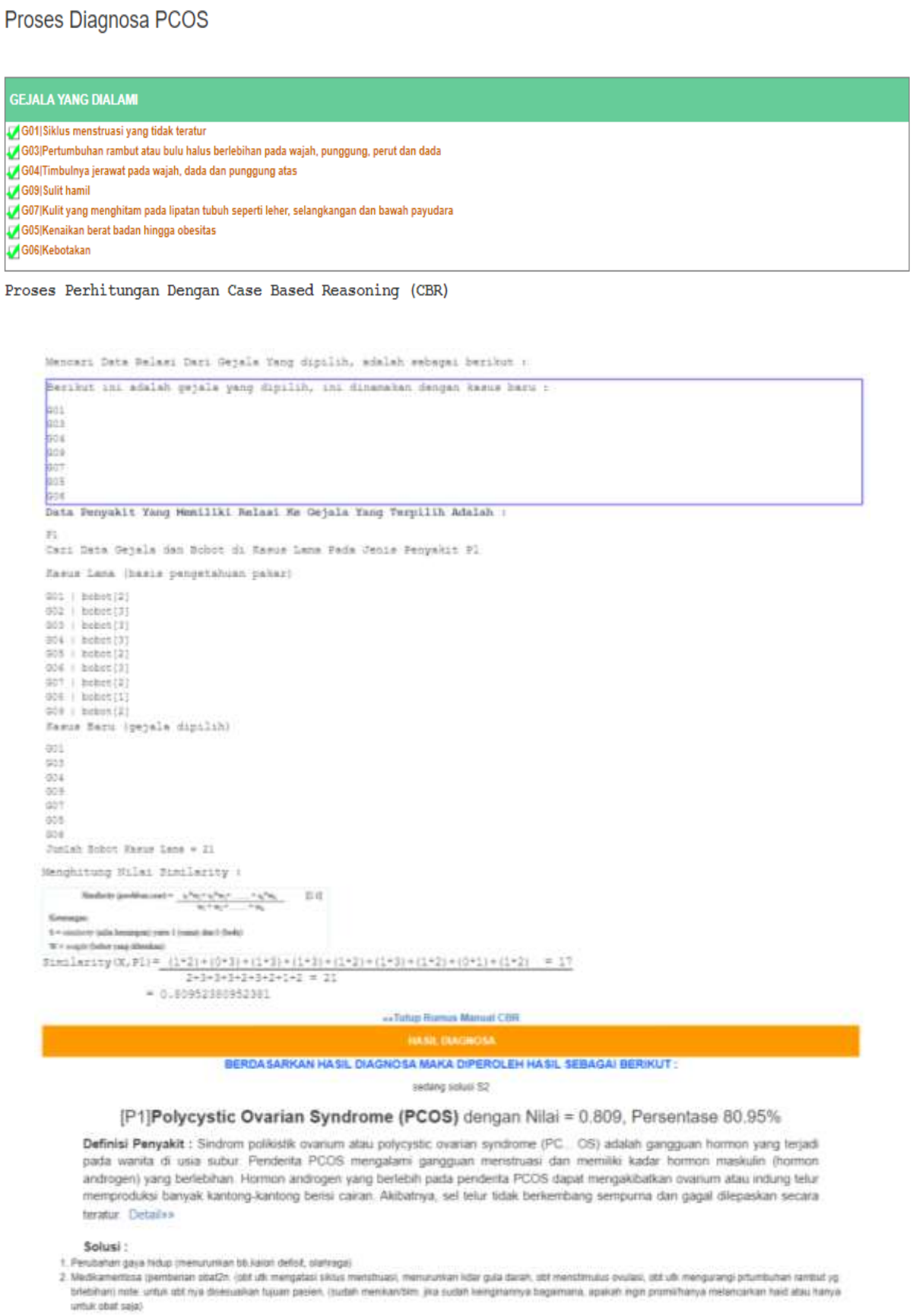

Figure 4. Display of Similiarity Value Calculation in Expert System

4. CONCLUSIONS AND SUGGESTIONS

The study using the Case-Based Reasoning (CBR) method was conducted as expected and can provide the right diagnosis. The results of this study provided a diagnostic presentation with complex accuracy with a presentation of 80%. The system built with the CBR method can be customized to some other cases in the future. Therefore, suggestions for this development are that other methods can be applied in the future as a comparison, and researchers need to have updated knowledge and information according to the latest developments in science.

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