Expert System Application for Diagnosing of Bipolar Disorder with Certainty Factor Method Based on Web and Android

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Abstract - The purpose of this research is to design and develop software engineering of expert system based on web and android that is capable of diagnosing Bipolar Disorder to get the same level of solution and information with the expert. The expert system application has been developed by using PHP as the web programming language and by using Java with the Web View method as the android programming, and by using MySQL as the databases. This research used analytical method of certainty factor based on the user answers for the questions asked by this expert system. The result showed that the user condition related with bipolar disorder and completed with suggestion of solution medical or treatment and the list of psychiatrist. The conclusion of this research is certainty factor method evidently could give result in the form of early diagnosis and could provide the consistent and effective solutions.

1. Introduction
About 20-30 years ago, the central pillar of psychiatry was schizophrenia. Today’s interest has turned to a new paradigm – bipolar disorder [1]. Bipolar disorder (BD) has traditionally been thought of as an episodic condition, characterized by periods of hypomania/mania and depression [2]. The term of BD taken of this disorder character that could change the bipolar patient’s mood suddenly between two polar (bipolar), sadness and happiness. Generally, the normal people can feel the mood high and the mood low. But, it’s different with the bipolar people, the changing of their mood are so sudden and extreme. One time, people with bipolar disorder could feel so enthusiastic and spirited (mania). However, when their mood changes to a low mood, bipolar people could be so depressive, pessimist, hopeless, even they could have the desire of suicide (depressive)[3]. Bipolar disorder is characterized by the occurrence of at least one manic or mixed-manic episode during the patient’s lifetime. Most patient also, at other times, have one or more depressive episodes. In the intervals between these episodes, most patients return to their normal state of well-being [4].
BD is considered to be one of the most disabling psychiatric disorders, associated with a suicide rate approximately 20-30 times that of the general population [5]. According to Kocourkovaet al. (2009) [6], approximately 87%-98% of suicide case has done by individual with several types of mental disorder like mood disorder, anxiety disorder, bipolar disorder and depressive. Research findings from Dr. Ghanshyam Pandey with team from University of Illinois, Chicago, is 9 of 17 teenagers who died because suicide have history of mental disorder. One of mental disorder which could take someone leading to the suicide decision is Bipolar Disorder [7].

The diagnostic process of bipolar disorder is still very difficult and rare. It caused there are many people who doesn’t realize that they have been indicating of bipolar disorder, even there are some people already feel it, however they are ashamed to consult to psychologist or psychiatrist.
Therefore, it takes an expert system that could help to early diagnose bipolar disorder independently and able to give the right solutions. Even, an expert system is able to be an experienced assistant to psychologist or psychiatrist for making decision appropriately and accurately. The implementation of expert system is many used in psychology because expert system is regarded as storage to save expert knowledge in particular area in a computer program, so that, decision could be given in reasoning intelligently [9]. The basic of expert system is how to move the knowledge possessed by an expert into a computer and how to infer or make decisions based on that knowledge [10].

In the face of problem, frequently found answer that doesn't have certainty, one of them is the problem in making a diagnosis of a disease. The uncertain result is caused by two factors, namely the uncertain rules and the uncertain user answer of a question posed by system. In the end, it will be found many possibilities for diagnosis [9]. Certainty factors are one of the methods that can be used to deal with uncertainty. The advantage of this method is that it can deal with uncertainty which is subjective in nature because its modeling is based on expert’s idea [11]. The measurement using certainty factors only once by processing only two data so that the accuracy of data is reliable [12].

The concept of certainty factor is proposed to accommodate the uncertainty of an expert who is often thought of analyzing information with phrases such as “may”, “likely”, “almost certainly” and so on [13]. Therefore, this research will develop an expert system for diagnosing of bipolar disorder with certainty factor method. In order of this system can be used effectively and efficiently, then the system will be developed by two bases of operating system, namely based on website by using PHP programming language and based on Android by using Java programming language, and by using MySQL database.

The rest of this paper is organized as follow. Section 2 describes related works on malnutrition. Section 3 describes proposed method. Section 4 describes results and following by discussion. Finally, the conclusion of this work is described in Section 5.

2. Literature Review

According to Martin and Oxman (1998) [14], expert system is computer-based system that uses knowledge, facts and reasoning techniques in solving problems that usually can only be solved by an expert in a particular field.

The concept of certainty factor is proposed by Shortliffe and Buchanan in 1975 to accommodate the uncertainty of an expert. An expert, (e.g. doctor) is often thought of analyzing information with phrases such as “may”, “likely”, “almost certainly”. For accommodating this case, we could use certainty factor to describe confidence level of expert to the problems being faced. The following is formula of net belief method that is proposed by E.H. Shortliffe and B.G. Buchanan [15].

\[
\text{CF}(\text{Rule}) = \text{MB}(H, E) - \text{MD}(H, E) \ldots (1)
\]

Description:

CF (Rule) = certainty factor
MB (H, E)= measurement of belief to hypothesis H, if given evidence E (between 0 and 1)
MD (H, E)= measurement of disbelief to hypothesis H, if given evidence E (between 0 and 1)

Value of CF(Rule) is be obtained of term interpretation from expert, which is changed to specific value based on Table 1.

| Uncertain Term       | CF    |
|----------------------|-------|
| Definitely not       | -1.0  |
| Almost certainly not | -0.8  |
| Probably not         | -0.6  |
| Maybe not            | -0.4  |
| Unknown              | -0.2 to 0.2 |
| Maybe                | 0.4   |
| Probably             | 0.6   |
The following is the description of some combinations of certainty factor to any conditions [10]:

1. Certainty factor for single premise rules:
   \[ CF(H, E) = CF(E) * CF(\text{rule}) = CF(\text{user}) * CF(\text{expert}) \]

2. Certainty factor for multiple premises rules:
   \[ CF(A \text{ AND } B) = \text{Minimum}(CF(a), CF(b)) * CF(\text{rule}) \]
   \[ CF(A \text{ OR } B) = \text{Maximum}(CF(a), CF(b)) * CF(\text{rule}) \]

3. Certainty factor for similar concluded rules:
   \[ CF_{\text{COMBINE}}(CF_1, CF_2) = CF_1 + CF_2 \times (1 - CF_1) \]

According to DSM-IV-TR [16], Bipolar disorder is characterized by the occurrence of one or more mania or hypomania episode. Mania or hypomania episode is often replaced by severe depressive episode.

3. Methodology

The following is the method or sequence of research done in this research which consists of 9 stages namely:

a. Defining the Scope of the Problem
b. Problem Analysis
c. Setting Goal
d. Literature Review
e. Data Collection
f. Data Analysis
g. Software Design
h. Implementation
i. Testing

4. Result and Discussion

4.1 Data Analysis

Data analysis is aimed to limit the findings in order to make the data be more organized and meaningful. Data collection is done by doing interview with the expert, namely psychiatrist and from another reference. The following is data which is obtained by the research:

| Level of Rules | Codes of Types & Episodes of Bipolar Disorder | Types & Episodes of Bipolar Disorder |
|----------------|---------------------------------------------|-------------------------------------|
| Level 1        | X001 Mania Episode                           |
|                | X002 Hypomania Episode                       |
|                | X003 Depressive Episode                      |
| Level 2        | BD01 Bipolar I Disorder                      |
|                | BD02 Bipolar II Disorder                     |
|                | BD03 Unipolar Disorder                       |
Table 3. Data Relation of Types and Episodes of Bipolar Disorder

| Codes of Bipolar Disorder Types | Codes of Episodes |
|--------------------------------|-------------------|
|                                | X001 | X002 | X003 |
| BD01                           | ✓    | ✓    | ✓    |
| BD02                           | –    | ✓    | ✓    |
| BD03                           | –    | –    | ✓    |

Table 4. sData Symptoms

| Codes of Symptoms | Symptoms |
|-------------------|----------|
| G001              | Feeling of excited excessive which is abnormally, persistently elevated, expansive, or irritable mood. |
| G002              | Inflated self-esteem or grandiosity |
| G003              | Decreased need for sleep |
| G004              | More talkative than usual or pressure to keep talking |
| G005              | Flight of Ideas or subjective experience that thoughts are racing |
| G006              | Distractibility, as reported or observed |
| G007              | Increased in goal-directed activity (either socially, at work or school, or sexually) or psychomotor agitation |
| G008              | Excessive involvement in activities that have a high potential for painful consequences (i.e., engaging in unrestrained buying sprees, sexual indiscretions, or foolish business investments) |
| G009              | Symptoms are felt to be quite heavy till its interfere with the daily activities (at school/work/relationship with others). |
| G010              | Presence of delusions or hallucinations |
| G011              | Patient is not regularly consuming drug or narcotic, and patient doesn’t have hyperthyroid disease. |
| G012              | Symptoms are lasting at least 1 week |
| G013              | Symptoms are lasting at least 4 days |
| G014              | Depressed mood most of the day, nearly everyday, as indicated by either subjective report (e.g., feels sad, empty, or hopeless) or observation made by others (e.g., appears tearful) |
| G015              | Markedly diminished interest or pleasure in all, or almost all, activities most of the day, nearly every day |
| G016              | Significant weight loss when not dieting or weight gain, or decrease or increase in appetite nearly every day. |
| G017              | Insomnia or hypersomnia nearly every day |
| G018              | Psychomotor agitation or retardation every day (observable by others; not merely subjective feelings of restlessness or being slowed down) |
| G019              | Fatigue or loss of energy nearly every day |
| G020              | Feelings of worthlessness or excessive or inappropriate guilt nearly every day |
| G021              | Diminished ability to make a decision, to think or concentrate, or indecisiveness every day |
| G022              | Recurrent thoughts of death (not just fear of dying), recurrent suicidal ideation without a specific plan, or a suicide attempt or a specific plan for committing suicide |
| G023              | Patient is not having temporary grief (such as death of people who loved) |
| G024              | Symptoms are lasting at least 2 weeks |
### Table 5. Data Solutions

| Codes of Solutions | Solutions                        |
|-------------------|----------------------------------|
| S001              | Mood Stabilizer                  |
| S002              | Antidepressant                   |
| S003              | Antipsychotic                    |
| S004              | Benzodiazepine                   |
| S005              | Cognitive Behaviour Therapy (CBT)|
| S006              | Psychoeducation                  |
| S007              | Family Therapy                   |
| S008              | Group Therapy                    |
| S009              | Electroconvulsive Therapy (ECT)  |
| S010              | Transcranial Magnetic Stimulation|

### Table 6. Data Relation of Types, Episodes and Symptoms of Bipolar Disorder

| Types of Bipolar Disorders | Codes of Symptoms |
|---------------------------|-------------------|
| Bipolar I Disorder        |                   |
| Mania                     | ✔                  |
| Hypomania                 | ✔                  |
| Depressive                | ✔                  |
| Hypomania                 | ✔                  |
| Depressive                | ✔                  |
| G001                      |                   |
| Bipolar II Disorder       |                   |
| Mania                     | ✔                  |
| Hypomania                 | ✔                  |
| Depressive                | ✔                  |
| Hypomania                 | ✔                  |
| Depressive                | ✔                  |
| G002                      |                   |
| Unipolar Disorder         |                   |
| Mania                     | ✔                  |
| Hypomania                 | ✔                  |
| Depressive                | ✔                  |
| Hypomania                 | ✔                  |
| Depressive                | ✔                  |
| G003                      |                   |
| G004                      |                   |
| G005                      |                   |
| G006                      |                   |
| G007                      |                   |
| G008                      |                   |
| G009                      |                   |
| G010                      |                   |
| G011                      |                   |
| G012                      |                   |
| G013                      |                   |
| G014                      |                   |
| G015                      |                   |
| G016                      |                   |
| G017                      |                   |
| G018                      |                   |
| G019                      |                   |
| G020                      |                   |
| G021                      |                   |
| G022                      |                   |
| G023                      |                   |
| G024                      |                   |

### Table 7. Data Relation of Types and Solutions of Bipolar Disorder

| Codes of Solutions | Solutions                  | Codes of Types of Bipolar Disorder |
|--------------------|----------------------------|-----------------------------------|
| S001               | Mood Stabilizer            | ✔                                 |
| S002               | Antidepressant             | ✔                                 |
|                    |                            | BD01 BD02 BD03                     |
|                    |                            | ✔                                 |
|                    |                            | ✔                                 |
|                    |                            | ✔                                 |
4.2 Process Analysis

Inference method is used in problem solving in this expert system for diagnosis bipolar disorder is certainty factor. By interviewing an expert, the researcher is getting the value of CF based on value of table 1.

Iteration 1

Table 8. Fact of Symptom Selection by User Answers

| Fact   | Value of CF User |
|--------|------------------|
| G001   | Evidence         |
| G003   | Evidence         |
| G005   | Evidence         |
| G008   | Evidence         |
| G012   | Evidence         |
| G014   | Evidence         |
| G015   | Evidence         |
| G016   | Evidence         |
| G017   | Evidence         |
| G019   | Evidence         |
| G021   | Evidence         |
| G022   | Evidence         |
| G023   | Evidence         |
| G024   | Evidence         |
| G009   | Evidence         |
| G011   | Evidence         |

Table 9. Value of CF Rules Level 1

| Rule Level 1 | Value of CF Rules Level 1 |
|--------------|---------------------------|
| R1           | CF R1 = 0.6               |
| R2           | CF R2 = 0.7               |
| R3           | CF R3 = 0.8               |
| R4           | CF R4 = 1                 |
| R5           | CF R5 = 0.9               |
| R6           | CF R6 = 0.6               |
| R7           | CF R7 = 0.7               |
| R8           | CF R8 = 0.8               |
| R9           | CF R9 = 1                 |

The explanation of rule level 1 of the new facts:

R1 Not executed because evidence is not fact
R2 Not executed because evidence is not fact
R3IF G001(CF=0.6) AND G003(CF=1.0) AND G005(CF=0.6) AND G008(CF=0.6) AND G009(CF=0.6) AND G011(CF=1.0) AND G012(CF=1.0) THEN X001 (CF = 0.8)

CF3 (X001.G001 ∩ G003.G005 ∩ G008 ∩ G009 ∩ G011 ∩ G012)
= Min [0.6 ; 1.0 ; 0.6 ; 0.6 ; 0.6 ; 0.6 ; 0.6] * 0.8
= 0.6 * 0.8
= 0.48

New Fact→ Episode:
X001 Hypothesis CF = 0.48

R4 Not executed because evidence is not fact
R5 Not executed because evidence is not fact

R6 IF(G016(CF=1.0) AND G017(CF=1.0) AND G019(CF=0.6) AND G021(CF=0.6) AND G011(CF=1.0) AND G014(CF=0.8) AND G015(CF=0.6) AND G023(CF=1.0)) OR (G016(CF=0.7)) THEN X003 (CF = 0.6)

CF6(X003. (G016 ∩ G017 ∩ G019 ∩ G021 ∩ G011 ∩ G014 ∩ G015 ∩ G023 ∩ G024) ∪ (G016 ∩ G017 ∩ G019 ∩ G022 ∩ G011 ∩ G014 ∩ G015 ∩ G023 ∩ G024) ∪ (G016 ∩ G021 ∩ G017 ∩ G022 ∩ G011 ∩ G014 ∩ G015 ∩ G023 ∩ G024) ∪ (G016 ∩ G019 ∩ G021 ∩ G022 ∩ G011 ∩ G014 ∩ G015 ∩ G023 ∩ G024) ∪ (G017 ∩ G019 ∩ G021 ∩ G022 ∩ G011 ∩ G014 ∩ G015 ∩ G023 ∩ G024) ∪ (G017 ∩ G019 ∩ G021 ∩ G022 ∩ G011 ∩ G014 ∩ G015 ∩ G023 ∩ G024))
= Max [Min [1.0 ; 1.0 ; 0.6 ; 0.6 ; 1.0 ; 0.8 ; 0.6 ; 1.0 ; 1.0] [1.0 ; 1.0 ; 0.6 ; 0.6 ; 1.0 ; 0.8 ; 0.6 ; 1.0 ; 1.0] [1.0 ; 1.0 ; 0.6 ; 0.6 ; 1.0 ; 0.8 ; 0.6 ; 1.0 ; 1.0] [1.0 ; 0.6 ; 0.6 ; 1.0 ; 0.8 ; 0.6 ; 1.0 ; 1.0] [1.0 ; 0.6 ; 0.6 ; 1.0 ; 0.8 ; 0.6 ; 1.0 ; 1.0] * 0.6
= Max [0.6 ; 0.6 ; 0.6 ; 0.6] * 0.6
= 0.6 * 0.6
= 0.36

New Fact→ Episode:
X003 Hypothesis CF = 0.36

R7IF G016(CF=1.0) AND G017(CF=1.0) AND G019(CF=0.6) AND G021(CF=0.6) AND G022(CF=0.6) AND G011(CF=1.0) AND G014(CF=0.8) AND G015(CF=0.6) AND G023(CF=1.0) AND G024(CF=1.0) AND G009(CF=0.6) THEN X003 (CF = 0.7)

CF7(X003.G016 ∩ G017 ∩ G019 ∩ G021 ∩ G022 ∩ G011 ∩ G014 ∩ G015 ∩ G023 ∩ G024 ∩ G009)
= Min [1.0 ; 1.0 ; 0.6 ; 0.6 ; 1.0 ; 0.8 ; 0.6 ; 1.0 ; 1.0 ; 0.6] * 0.7
= 0.6 * 0.7
= 0.42

New Fact→ Episode:
X003 Hypothesis CF = 0.42

R8 Not executed because evidence is not fact
R9 Not executed because evidence is not fact

Table 10. New Fact of Rule Level 1 Namely Episode

| New Fact | Value of CF |
|----------|-------------|
| X001     | Hypothesis  | CF3 = 0.48 |
| X003     | Hypothesis  | CF6 = 0.36 |
Because R6 and R7 has the same hypothesis namely X003, then combine the value CF6 to value CF7:
\[
CF = CF6 + CF7 \times (1 - CF6)
\]
\[
= 0.36 + 0.42 \times (1 - 0.36)
\]
\[
= 0.78 \times 0.64
\]
\[
= 0.6288
\]

**New Fact → Episode:**
X001 Hypothesis CF = 0.48
X003 Hypothesis CF = 0.6288

**Iteration 2**

| New Fact | Value of CF |
|----------|-------------|
| X001     | Hypothesis  | CF3 = 0.48 |
| X003     | Hypothesis  | CF6 = 0.49 |

| Rules Level 2 | Value of CF Rules Level 2 |
|---------------|---------------------------|
| R10           | CF R10 = 0.7              |
| R11           | CF R11 = 1.0              |
| R12           | CF R12 = 1.0              |
| R13           | CF R13 = 0.8              |

The explanation of rule level 2 of the new facts:

**R10** IF X001(CF=0.48) THEN BD01 (CF=0.7)
\[
CF10 (BD01.X001) = 0.48 \times 0.7
\]
\[
= 0.336
\]

**New Fact → Types of Bipolar Disorder:**
BD01 Hypothesis CF = 0.336

**R11** IF X001 (CF=0.48) AND X003 (CF=0.49) THEN BD01(CF=1)
\[
CF11 (BD01.X001 \land X003) = \text{Min}[0.48 ; 0.6288] \times 1
\]
\[
= 0.48 \times 1
\]
\[
= 0.48
\]

**New Fact → Types of Bipolar Disorder:**
BD01 Hypothesis CF = 0.48

**R12** Not executed because evidence is not fact

**R13** IF X003 (CF=0.6288) THEN BD03(CF=0.8)
\[
CF13 (BD03.X003) = 0.6288 \times 0.8
\]
\[
= 0.503
\]

**New Fact → Types of Bipolar Disorder:**
BD03 Hypothesis CF = 0.503
Table 13. New Fact of Iteration 2 Namely Types of Bipolar Disorder

| New Fact | Hypothesis | Value of CF |
|----------|------------|-------------|
| BD01     | Hypothesis | CF10 = 0.336 |
| BD01     | Hypothesis | CF11 = 0.48  |
| BD03     | Hypothesis | CF13 = 0.503 |

Because R10 and R11 has the same hypothesis namely BD01, then combine the value CF10 to value CF11:

\[ CF = CF10 + CF11 \times (1 - CF10) \]

\[ = 0.336 + 0.48 \times (1 - 0.336) \]

\[ = 0.816 \times 0.664 = 0.654 \]

**New Fact → Types of Bipolar Disorder:**

BD01  Hypothesis    CF = 0.654
BD03  Hypothesis    CF = 0.503

**The Result**

Type of bipolar disorder which are owned by user is Bipolar I Disorder with value of certainty is 0.654 or 65.4%, and had and/or having manic episode with value of certainty is 0.48 or 48% and depressive episode with value of certainty is 0.6288 or 62.88%.

4.3 **System Design by using UML**

As the tools for the design for this expert system, the UML diagram which is used has 7 types, such as:

a. Use Case Diagram
b. Class Diagram
c. Sequence Diagram
d. Communication Diagram
e. State Chart Diagram
f. Activity Diagram
g. Deployment diagram.

4.4 **Implementation and Testing**

4.4.1 **Homepage Expert System for Diagnosing Bipolar Disorder Form**

The frontpage home contains a glimpse of the sub-menu of the expert system based on website, such as Bipolar Disorder menu, FAQ menu and Login menu, as can be seen in Figure 1 below.

![Figure 1](image)

**Figure 1.** The front page of the proposed expert system based on Web

4.4.2 **Login Form**

All of actor in this system must be logged in to be able to use others feature, such as consultation feature for *member*, management data user feature for administrator. The login form as shown in Figure 2 below:
4.4.3 Front Page of Consultation Form
In this form, member need to click "Start Consultation" to proceed to questions as can be seen in Figure 3 below:

Figure 3. The front page of consultation menu based on Web

4.4.4 Question Form
Member who have registered and logged, they can consult with the system as can be seen in Figure 4 below:

Figure 4. Question Form on Android Application
4.4.5 Consultation Result
Consultation results will appear, after users have been answered all of questions displayed by the system on Figure 4, as can be seen in Figure 5 below:

Figure 5. Early Diagnosis in Consultation Result Form on Android Application

5. Conclusion
Bipolar disorder is considered to be one of the most disabling psychiatric disorders, associated with a suicide rate approximately 20-30 times that of the general population. Understanding and knowledge about bipolar is needed to reduce the percentage of suicides and to reduce impact of bipolar disorder symptoms which are ruining people’s daily life. With the rapid technological advancement, the result of thinking and training of intelligent human beings, has developed a technology that is able to adopt the human thought process and the way that artificial intelligence or Artificial Intelligence (AI). Artificial Intelligence (AI) has a wide range of applications, one of which is an expert system that is capable of resolving problems such as an expert. We successfully implemented an expert system with certainty factor method for diagnosing bipolar disorder. Knowledge is obtained through questions posed to a psychiatrist and from Diagnostic and Statistical Manual of Mental Disorders 5th Edition. Value of certainty factor taken based on member answers on questions posed by system. When all the questions concerned has been completed, it will show the result of consultation. With the application of this system, member can consult for getting bipolar diagnosis and get a solution. This system can be used by member, expert and administrator. In this system also includes important information about bipolar disorder and forum page for member and expert. This application is designed only for diagnosing bipolar disorder, so the future is expected to be added with another mental disorders.

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