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

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 Kocourkova*et 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

[8].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 conclution of this work is described in Section 5.

2. Literature Review

According to Martin and Oxman (1998) [14], expert system is computer-based systemthat uses knowledge, facts and reasoning techniques in solving problems that usually cn 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].

$$CF(Rule) = MB(H, E) – MD(H, E)…..(1)$$

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.

Table 1. Certainty Factor Values

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

Almost certainly	0.8
Definitely	1.0

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(rule)
   = CF(user) * CF(expert)
2. Certainty factor for multiple premis rules:
   CF (A AND B) = Minimum (CF (a), CF (b)) * CF (rule)
   CF (A OR B) = Maximum (CF (a), CF (b)) * CF (rule)
3. Certainty factor for similar concluded rules:
   $CF_{COMBINE}$ (CF_1, CF_2) = $CF_1 + CF_2*(1-CF_1)$

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:

Table 2. Data Types and Episodes of Bipolar Disorder

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. s Data 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		Bipolar II Disorder		Unipolar Disorder	
Mania	Hypomania	Depppressive	Hypomania	Deppresive	
✓	✓		✓		G001
✓	✓		✓		G002
✓	✓		✓		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		
		BD01	BD02	BD03
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	✓	✓	✓

*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	0.6
G003	Evidence	1.0
G005	Evidence	0.6
G008	Evidence	0.6
G012	Evidence	1.0
G014	Evidence	0.8
G015	Evidence	0.6
G016	Evidence	1.0
G017	Evidence	1.0
G019	Evidence	0.6
G021	Evidence	0.6
G022	Evidence	0.6
G023	Evidence	1.0
G024	Evidence	1.0
G009	Evidence	0.6
G011	Evidence	1.0

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:

R1Not executed because evidence is not fact
R2Not 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 ; 1.0 ; 1.0] * 0.8
= 0.6 * 0.8
= 0.48

New Fact→ Episode:

X001 Hypothesis CF = 0.48

R4Not executed because evidence is not fact

R5Not 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) **AND** G024(CF=1.0)) **OR**(G016(CF=1.0) **AND** G017(CF=1.0) **AND** G019(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)) **OR** (G016(CF=1.0) **AND** G017(CF=1.0) **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)) **OR** (G016(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)) **OR** (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)) **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 ∩ G017 ∩ G021 ∩ G022 ∩ G011 ∩ G014 ∩ G015 ∩ G023 ∩ G024) ∪ (G016 ∩ 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 ; 0.6 ; 1.0 ; 0.8 ; 0.6 ; 1.0 ; 1.0] [1.0 ; 0.6 ; 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 * 0.6
= 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) **THENX003** (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 ; 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

R8Not executed because evidence is not fact

R9Not 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

X003	Hypothesis	CF7 = 0.42

Because R6 and R7 has the same hypothesis namely X003, then combine the value CF6 to value CF7:
CF = CF6 + CF7*(1-CF6)
= 0.36 + 0.42*(1-0.36)
= 0.78 * 0.64
= 0.6288

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

Iteration 2

Table 11. New Fact of Iteration 1 Namely Episode

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

Table 12. Value of CF Rules Level 2

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 * 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 ∩ X003)
= Min [0.48 ; 0.6288] * 1
= 0.48 * 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 * 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		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*(1-CF10)
= 0.336 + 0.48*(1-0.336)
= 0.816 * 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. 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:

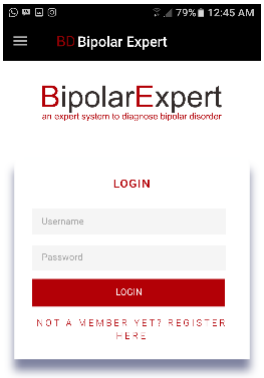

Figure 2. Form Login in Android Application

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:

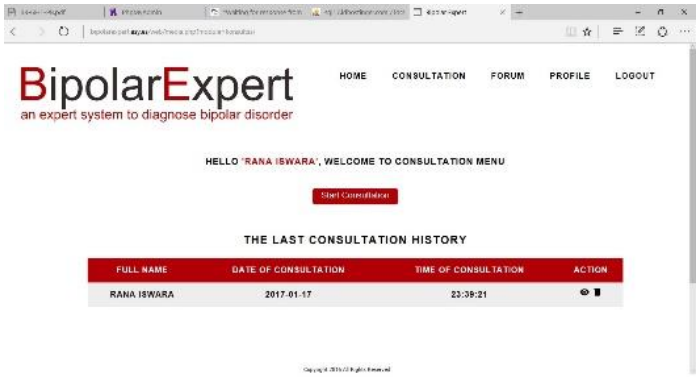

Figure 3. The front page of consultation menu based on Web

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:

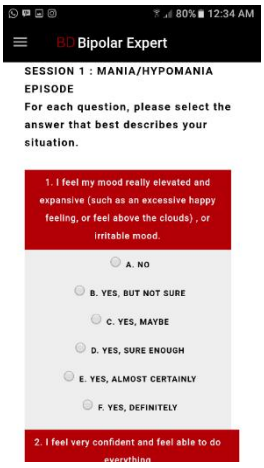

Figure 4. Question Form on Android Application

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:

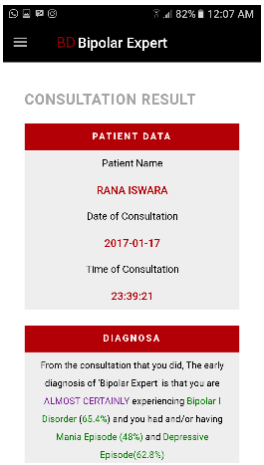

Figure 5. Early Diagnosis inConsultation Result Form on Android Application

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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