Jurnal E-Komtek
Vol. 8, No. 2 (2024) pp. 538-550
https://jurnal.politeknik-kebumen.ac.id/index.php/E-KOMTEK
p-ISSN : 2580-3719 e-ISSN : 2622-3066

Case Based Reasoning System for Tourette Syndrome Disease Detection

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https://doi.org/10.37339/e-komtek.v8i2.2232

Published by Politeknik Piksi Ganesha Indonesia

Artikel Info
Submitted:
28-11-2024
Revised:
21-12-2024
Accepted:
23-12-2024
Online first :
28-12-2024

Abstract

Tourette Syndrome is a neurological disease that has a dangerous impact on the survival of children under 18 years of age. Tourette's is a disorder of the brain and nervous system (neurology) that causes a person to behave in tics or behave in behavior that makes movements and or sounds suddenly and repeatedly, to making aggressive movements such as hurting oneself or hurting others. Patients with Tourette Syndrome and specialist doctors are interviewed to get a complete picture of the symptoms, the structure for detecting Tourette Syndrome disease, and validation of the results. The expert system case based reasoning approach is applied with weighting in the diagnosis and calculation in the form of an accumulation formula that can produce accurate results, exposure percentages, and first aid that must be carried out with small computing resources without being constrained by the dataset.Based on the results of testing on 10 patients accompanied by experts, this system can detect and fully classify patients with Tourette's syndrome.

Keywords: *Tourette Syndrome; Expert System; Case Based Reasoning; Disease Detection System; Tourette Classification.*

Abstrak

Tourette Syndrome adalah penyakit neurologis yang memiliki dampak berbahaya terhadap kelangsungan hidup anak-anak di bawah usia 18 tahun. . Tourette adalah gangguan pada otak dan sistem saraf (neurologi) yang menyebabkan seseorang melakukan tics atau perilaku berupa gerakan dan/atau suara secara tiba-tiba dan berulang, hingga melakukan gerakan agresif seperti menyakiti diri sendiri atau orang lain. Pasien dengan Tourette Syndrome dan dokter spesialis diwawancarai untuk mendapatkan gambaran lengkap mengenai gejala, struktur untuk mendeteksi penyakit Tourette Syndrome, serta validasi hasilnya. Pendekatan sistem pakar berbasis penalaran kasus (case-based reasoning) diterapkan dengan pembobotan dalam diagnosis dan perhitungan dalam bentuk formula akumulasi yang dapat menghasilkan hasil yang akurat, persentase eksposur, serta pertolongan pertama yang harus dilakukan dengan sumber daya komputasi yang kecil tanpa terhambat oleh dataset.Berdasarkan hasil pengujian pada 10 pasien yang didampingi oleh para ahli, sistem ini dapat mendeteksi dan mengklasifikasikan secara penuh pasien dengan Tourette Syndrome.

***Kata-kata kunci**: Sindrom Tourette; Sistem Pakar; Case Based Reasoning; Sistem Deteksi Penyakit; Klasifikasi Tourette.*

1. Introduction

Tourette Syndrome (TS) is a complex neuropsychiatric condition characterized by tics, which are sudden, repetitive, and stereotypical motor movements that affect certain muscle groups such as (head-turning, blinking, throat clearing, humming), coprolalia, and obsessive-compulsive disorder [1]. TS involves at least two motor tics and at least one vocal tics for one year or more [2] and usually occurs starting at the age of 4-6 years [3]. A neuropsychiatric condition that is unique in that it is at the interface between neurology (movement disorders) and psychiatry (behavioral disorders) [4], [5].

Tourette's syndrome is a disease of considerable concern, according to data from the U.S. National Child Health Survey, parents report that 0.3% of their children and adolescents between the ages of 6 and 17 have been diagnosed with TS [6]. Globally, the prevalence of TS is 0.7% in children and adolescents and 0.5–0.6% in adults, according to a systematic review and meta-analysis [7]. In Asia, For the years 2007 through 2015, the incidence and prevalence of TS and chronic tic disorder (TS/CTD) were estimated using the Taiwan National Insurance Research Database [8]. Throughout this time, TS/CTD prevalence rose. TS/CTD has an annual incidence rate that rises during childhood and adolescence but falls during adulthood. It is estimated that 1.37% of schoolchildren in China between the ages of 6 and 16 have tic disorders, lower than all other recent studies [9]. In 2020, the census in the U.S. has at least 350,000 – 450,000 people suffering from Tourette's disease, both children and adults [2]. Based on these problems, a tool is needed to help detect Tourette's syndrome, so that a person who suffers from this disease can immediately get treatment from a specialist. Research that automatically detects Tourette syndrome has not been done much, Barnabei conducted research using a wearable device to monitor a Tourette patient, but could not detect it in the early stages [10], Another study was conducted by Wu who tried to detect a person suffering from Tourette syndrome by taking pictures and applying the Unsupervised Visual Feature Learning approach, the accuracy rate was given at 86%, but the obstacle obtained was the limitation of the data source which could increase the value of false positives and false negatives [11]. The research to detect Tourette's syndrome did not stop there, some studies were conducted by researchers using videos like Tang's, but unfortunately, there were no evaluation results that showed how accurate the approach was [12], Wu applied the 3D Convolution Network, to detect tics in a given video [13], This is similar to what Schappert did to detect Tourette's syndrome through the video presented [14]. However, this study's limitation is the limited source of datasets, which can affect the results when implemented in different environments. The expert System approach used to detect Tourette Syndrome becomes the novelty of the research conducted.

Expert systems have been widely used as an approach to detecting various diseases with satisfactory results because it is close to an expert doing the initial detection of a person suffering from a disease, such as pneumococcal prognosis [15], heart disease [16], diagnose autism disorders in children [17], [18], mental health [19], eye disease[20], detecting schizophrenia [21], early detection and diagnosis of central nervous

disease [22], screening of borderline personality disorder [23], blood disease [24], dan detecting symptoms of game addiction [25], However, until now no one has raised the case of Tourette Syndrome, considering that this disease is considered comorbid. This research will contribute in the form of techniques for detecting and classifying Tourette syndrome with a case-based reasoning approach that is directly supervised and validated by experts.

The rest of the paper is organized as follows: Section II represents the methodology of the research conducted. Section III explains the design of the expert system in the research and describes our assessment, results, and discussion. Section IV concludes the paper and future work.

2. Method

2.1 Case-Based Reasoning

Case-based Reasoning (CBR) is an expert system problem-solving approach predicated on past solutions to cases that are similar to current cases. Moreover, it is said that the CBS method concentrates on resolving issues and managing novel circumstances by considering prior experiences comparable to the current circumstances. On a technical level, CBS attempts to gather comparable cases from the past with novel issues and adjusts the solution to fit the new case **[26]**.

Several studies with case-based reasoning techniques are quite widely carried out, such as for the identification of engine failures in cars **[27]**, student performance prediction **[28]**, or for disease detection such as nutritional identification of toddlers[29], and acute respiratory infections diagnosis **[30]**, but no one has discussed Tourette Syndrome yet.

2.2 Research Stages

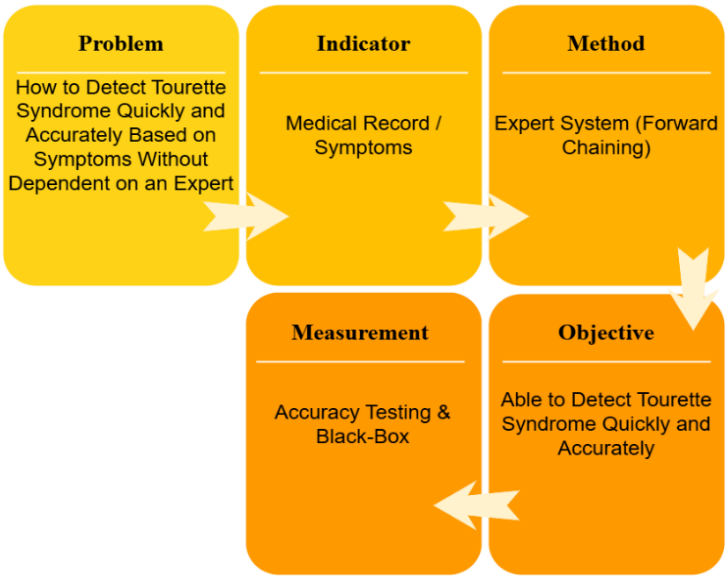

Figure 1. Research Framework

Figure 1 above, shows the framework of thinking in this study, the problem is how to detect Tourette syndrome quickly and accurately without depending on an expert based on the symptoms that appear.

Symptoms that appear can be seen from medical records or based on the symptoms felt directly by answering diagnostic questions asked to the user. The method used is an expert system approach using a case-based reasoning approach, to ensure that the results obtained from accuracy testing are carried out by comparing the prediction results with the actual value. At the same time, the feature is tested using black-box.

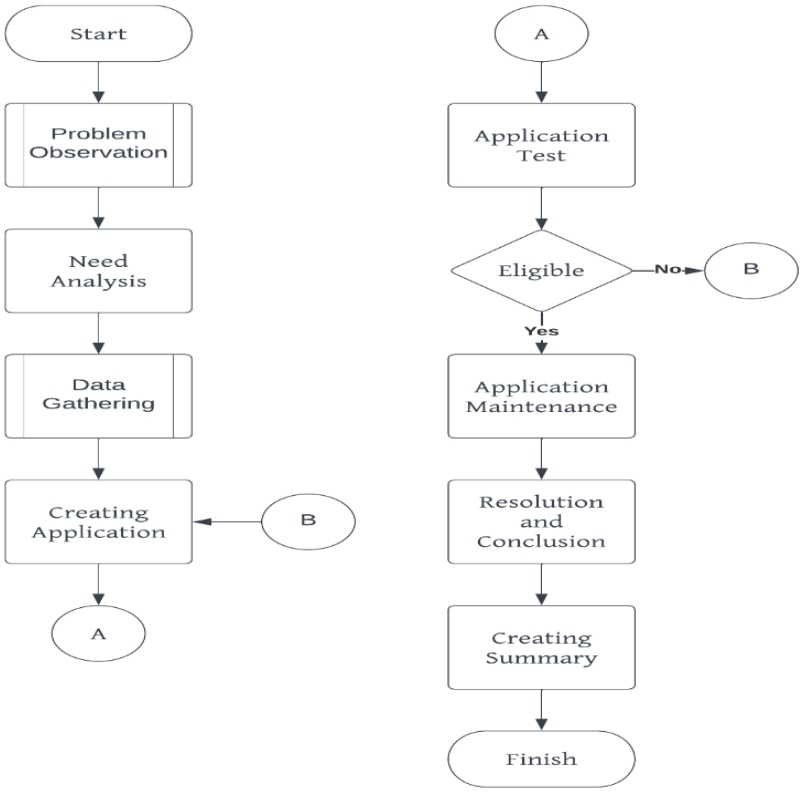

Figure 2. Research Flowchart.

The problem raised in this study is how to apply the case-based reasoning approach to detect Tourette Syndrome, the results are in the form of a technique to detect Tourette Syndrome with the case-based reasoning approach, and an application that is a tool for implementing the technique. The observations made will produce understanding, problems, and solutions that will be taken in solving problems. Next, an analysis of needs in the steps to create a Tourette Syndrome detection application such as disease data needs, frameworks, and the scope of the database to be used.

The next stage of collecting data to support the disease detection application is data observation from RSPON (National Brain Center Hospital) to interviews with general practitioners, pediatricians, neurologists, and one of the patients with Tourette Syndrome. Application Test is the process of testing an application to check the functionality, and accuracy of the approach used. Eligible Conditioning if the application is eligible or not. If the application is not feasible, then the application will be re-created in the application creation process by considering the elements that are not feasible in the running of the application.

3. Results and Discussion

3.1 Expert System Design

The case-based reasoning method applied in this study is one of the approaches in the expert system. It requires at least two components: the knowledge base and the inference engine.

3.1.1 Knowledge-Based

Case-based reasoning is an approach that learns from previous cases, which is then studied and used as a basis to provide solutions to the current case, so that to gain knowledge from past cases, a table of symptoms and weights is made to detect someone with Tourette syndrome based on the results of interviews with general practitioners and pediatricians, 10 questions with 3 variations of answers are formulated. Each question has a different weight of answers that will determine which classification a person will fall into, as shown in **Table 1.**

Table 1. Symptoms Table

No	Questions	Weight		
		Y	S	N
1	Is the initial condition characterized by the person blinking suddenly, unintentionally, or spontaneously?	1	0.5	0
2	Does the body in question move suddenly and involuntarily or spontaneously over time? Examples: Shoulder raises, hand movements, kicks, and others.?	2	1	0
3	Does the person concerned speak suddenly and unintentionally? Examples: Calling, shouting, whistling, clearing, and others.	2	1	0
4	Does the person concerned move and or speak spontaneously every day?	2	1	0
5	Can the spontaneous movement and/or voice experienced by the person concerned be more triggered by a very happy, angry, or sad mood?	1	0,5	0
6	Can spontaneous movements and/or voices experienced by the person concerned be more subdued if the mood is stable?	1	0,5	0
7	Has the person concerned experienced spontaneous movement and speech in more than 1 (one) year?	2	1	0
8	Does the person concerned begin to experience spontaneous movement and speech under 18 (eighteen) years?	2	1	0
9	Is the spontaneous movement and speech caused by the person concerned taking medication or experiencing medical action?	0	1	2
10	Does the person have any other neurological disorders?	1	0,5	0

Table 1 above shows a list of questions that are used as rules to detect and classify a person with Tourette's syndrome. The questions are divided into 2 groups, the first group is question number 2,3,4,7,8,9, and the second group is question number 1,5,6,10. The answer consists of three answers, yes, sometimes, and no.

This study requires 3 options suggested by experts which are converted into different weights for each given fact and will be reasoned by the inference engine.

3.1.2 Inference Engine

This section has the role of performing reasoning based on predetermined rules by reading the input given based on predetermined weights. Users will be asked questions one by one, after the answer is obtained, then it is converted into a value based on the answer submitted, and a calculation is carried out to calculate the amount of value as the basis for classification with the following equation.

$$\text{tow} = 100\% \times \left(\frac{3}{4} \times \text{twa} + \frac{1}{4} \times \text{twb}\right) \quad (1)$$

Notes:

- twa = Total weight for question group 1 with a maximum score of 12.
- twb = Total weight for question group 2 with a maximum score of 4.
- The highest weight is 2, and the lowest is 0.
- tow = Total overall weight

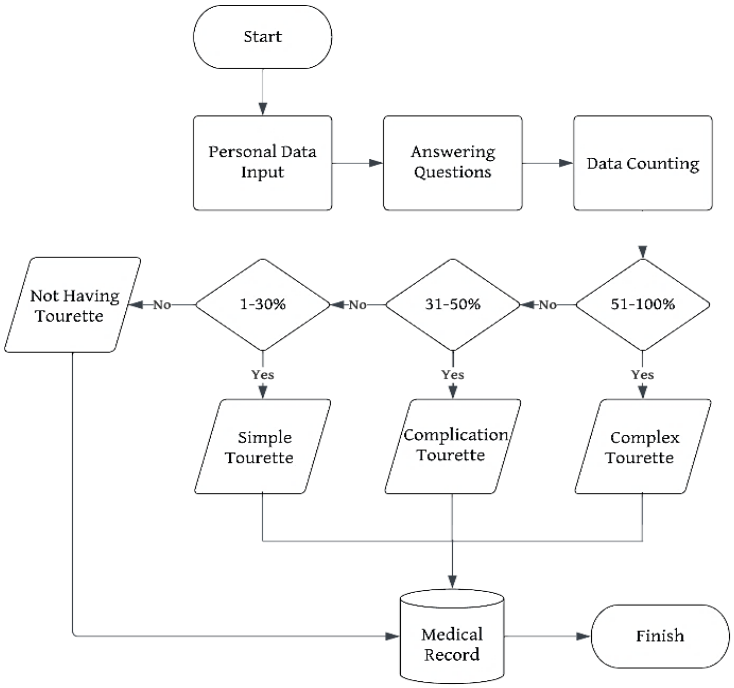

Figure 3. Flowchart of Detection System.

Figure 3 above explains how to classify the detection results with the following stage details. The registration process is carried out by filling in personal data from the user. Answering questions, this stage is the process of answering the questionnaires which correspond to the symptoms felt by the user, questionnaires are collected from the results of interviews with general practitioners, and pediatricians.

Data Counting is calculated to group valid data with symptom indicators that are a reference. At the classification stage, it is divided into 4, namely Complex Tourette 51-100%, displaying the percentage of people who are most likely to have severe Tourette Syndrome. Displaying suggestions for actions that can be taken is to consult a doctor for neurological treatment such as Psychotherapy to Deep Brain Simulation (DBS).

Tourette Complication 31-50%, showing the percentage of people who are likely to have Tourette Syndrome who are complicated by other diseases that cause hyperactivity, also showing suggestions for action to be taken. Displaying suggestions for actions that can be taken is to consult a doctor to ask for treatment such as Topiramate (Anticonvulsant), Botulinum Toxin Injection (Botox) to Pskiotherapy. Simple Tourette 1-30%, showing the percentage of people who are likely to have mild Tourette Syndrome. Displaying suggestions for actions that can be taken are providing support in stabilizing emotions or participating in a support group, to consulting with a doctor to ask for Fluoxetine (Antidepressant). Not Having Tourette 0%, displays the percentage and information that people may not have the syndrome but are allowed to have a healthy lifestyle such as exercise and eating a 4 healthy 5 perfect diet. Finally, record the results of filling out the questionnaire in a database which can later be accessed for medical purposes.

3.2 Application Implementation (if any)

3.2.1 System Design

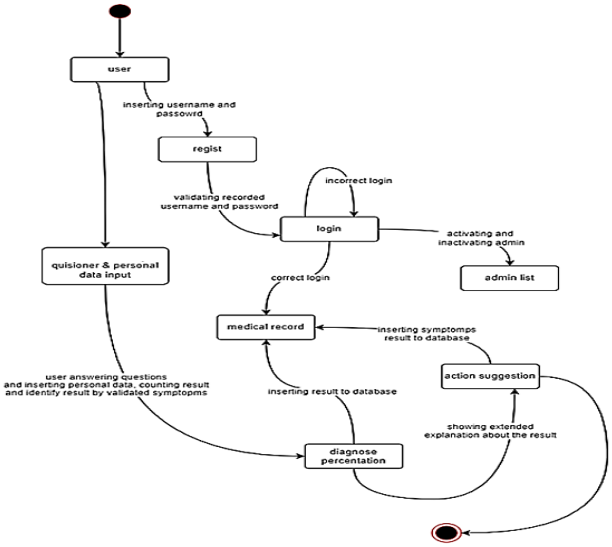

Figure 4. State Diagram of the System.

In Figure 4 above, a state diagram shows 2 users, namely users and admins. On the admin user, you will be directed to fill in the username and password for the Registration stage. As for consumer users, they will be directed to fill in the personal data and questionnaire to start the diasonization process. At login, if entering the username and password is incorrect, the admin will be redirected to enter the account until it is correct. After success, the admin will be directed to be able to access the Medical Record and Admin List. Admin List In this process, admins will be able to view, activate, and deactivate admins who have been registered in the system.

Users will also be asked to fill in personal data and fill in any diagnostic questions that are suffered in this process. Diagnosis presentation, after the identification process is carried out, the diagnosis will be displayed in the form of a percentage. Action suggestions, in addition to getting percentage artist results, consumer users will also be shown a review of actions suggested by experts. Medical record, after all processes are successfully implemented, all data collection results will be entered into the Medical Record database which will later be accessible for review.

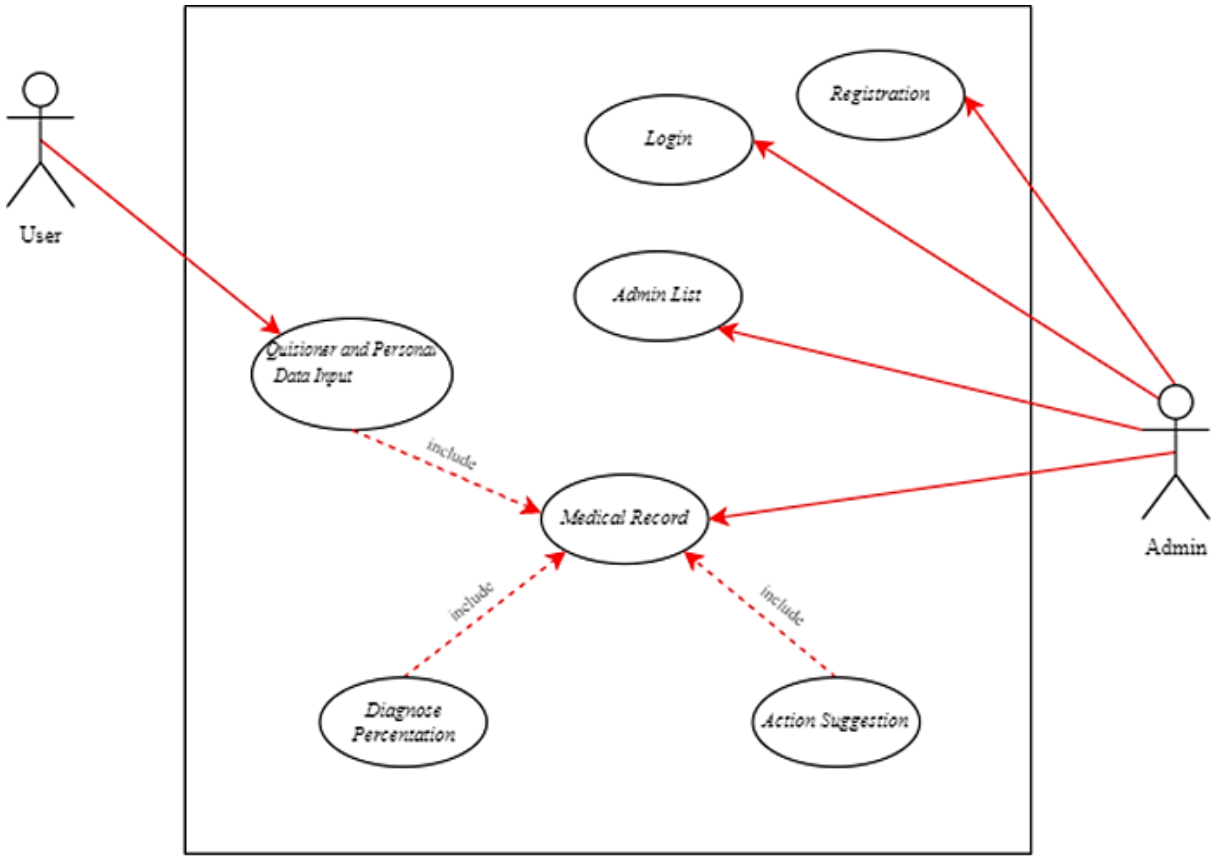

Figure 5. Use case of the system.

Figure 5 shows the use case of the system created, consisting of 2 users, admin, and user, a user can directly diagnose through the existing system, and the data can be seen by the admin as a tool for evaluation.

3.2.2 System Mockup

Here are the results of the software implementation.

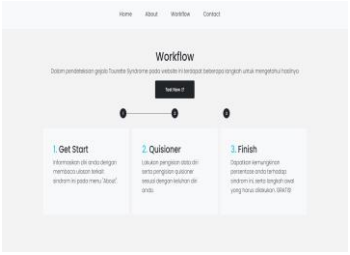

Figure 6. Landing page of Tourette syndrome detection.

Figure 6 shows landing page start with the the workflow of using the Tourette syndrome detection expert system application.

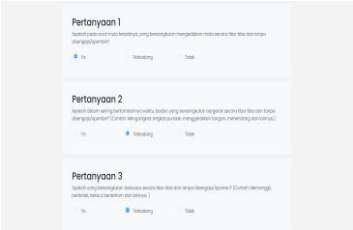

Figure 7. Question answering mechanism for detecting Tourette syndrome

Figure 7 shows the questions that must be answered by the user with three choices, where each choice has a different weight based on expert advice, the results will be processed by the inference engine to obtain a conclusion.

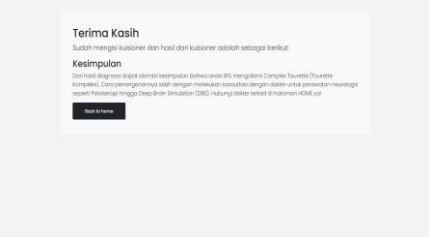

Figure 8. Detection results and suggestions for Tourette syndrome detection

Figure 8 above shows an example of the results of the detection of Tourette Syndrome and the recommendations given depending on the classification of the patient.

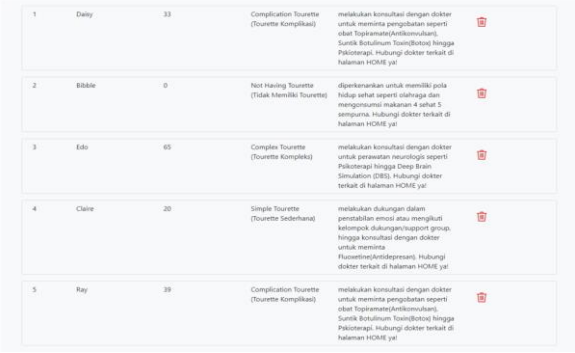

Figure 9. Results of detection and suggestion of Tourette syndrome detection for several patients

Figure 9 shows data records on several people to test the system's ability to detect and classify patients. Testing of the system was carried out on ten patients with Tourette syndrome accompanied by a pediatrician, the results showed that the system could detect and be able to classify correctly in all trials, this is a good thing considering that classification in a patient is not easy to do.

To be able to prove the accuracy of the calculations carried out in the system, the accuracy test applied in this system is in the form of a comparison of manual calculations with data that has been contained in the system. The following is a comparison of the calculations in question : It is known from the calculation that a user gets an accumulation of 2 types of questions with a total Total Weight A (twa) as question number 2,3,4,7,8,9, all filled with the highest weight choice, and Total Weight B (twb) as question number 1,5,6,10 filled with the lowest weight choice.

Meanwhile, if calculated manually, it is found that:

Questions and weights answered:

1(0), 2(2), 3(2), 4(0), 5(0), 6(0), 7(2), 8(2), 9(2), 10(0)

Total: Weight A (2,3,4,7,8,9) :

$2 + 2 + 2 + 2 + 2 + 2 = 12$

Weight B (1,5,6,10) :

$0 + 0 + 0 + 0 = 0$

So, accumulate weights A and B:

- $12 \times \frac{3}{4} = 9$
- $0 \times \frac{1}{4} = 0$
- $(0 + 9)$
- 90%

A value of 90% above indicates the level of accuracy of a person suffering from Tourete syndrome, black box testing is imposed directly on Tourete syndrome sufferers under the supervision of the experts mentioned above to ensure that the system can work properly, there are 9 features tested to ensure that the system can work properly, on the home page, personal data input, questionnaire, results button, register, login, dashboard, medical record, admin list, the results show that the system has passed the black-box test. This research is not research that aims to produce a model by studying previous datasets such as several studies that have been conducted previously which have been mentioned in the introduction as research gaps. Limitations in the dataset have a big influence and require large computing resources. This research applies discrete equations so that the expected value is 100% successful and requires fewer computing resources.

The results of the Medical Record can be useful for health workers in reviewing the recorded syndrome to conduct further research. Of course, the system that is made is validated directly by experts while still using the diagnosis and calculation process obtained from the validation of related experts so that the system can operate reliably.

4. Conclusion

This research contributes to the technique of detecting and classifying a person suffering from Tourette syndrome with an expert system approach using case-based reasoning. The results obtained show that the system can work well according to the data that has been recorded from the medical records that we got from the doctors interviewed. The Case-based reasoning method used in this study can produce a system that has good accuracy to help the community in detecting and classifying Tourette Syndrome.

In determining the diagnosis that is prepared in the form of a questionnaire and its weight as a knowledge base to get a symptom from the user where this questionnaire is validated directly by experts, both a general practitioner and a pediatrician to ensure that the diagnostic questions given are valid. The user can operate the system by answering each question given, and the results will show the level of classification of a person with Tourette's syndrome, complete with explanations and recommended actions.

In future research, it can be done by raising other types of comorbid diseases so that it can help the public to detect the syndrome from the beginning, it can also be done by using other approaches so that the results given can be better.

5. *Acknowledgement*

We would like to express our deepest gratitude to the Institut Teknologi PLN through the Institute for Research and Community Service, for supporting this research and funding it so that this research can be carried out.

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