

Increasing Diagnosing Hydrocephalus Using Case-based Reasoning (CBR)

Yogi Piko Rio Randes¹, Sarjon Defit², Rini Sovia³

Abstract

Hydrocephalus is a medical condition characterized by the accumulation of cerebrospinal fluid in the brain, which can lead to increased intracranial pressure and neurological disturbances. Early and accurate diagnosis is crucial for medical professionals to determine the type of hydrocephalus the patient has and provide the appropriate solution. This study aims to develop a Case-Based Reasoning (CBR) system to assist healthcare providers in diagnosing hydrocephalus more effectively. With this system, medical professionals can identify the type of hydrocephalus based on the symptoms experienced by the patient and receive recommendations based on previous cases. The research method used in this study is Case-Based Reasoning (CBR), an experience-based approach that relies on documented cases to solve new problems by comparing them to similar past cases. Data for this study were obtained from Andalas University Hospital and consultations with experts. The dataset used includes 19 hydrocephalus symptom data points and two main classifications of hydrocephalus: congenital hydrocephalus and acquired hydrocephalus. The results show that the CBR method has an accuracy rate of 63.15% in diagnosing congenital hydrocephalus and 44% in diagnosing acquired hydrocephalus. Although the accuracy rate still requires improvement, this study demonstrates that the CBR method has significant potential as a tool to assist in diagnosing hydrocephalus. The system can provide analysis based on historical data and help healthcare providers make more informed decisions. This study emphasizes that CBR can be an alternative to expert systems in hydrocephalus diagnosis. However, to improve accuracy and reliability in clinical practice, further testing with a larger dataset and integration with other artificial intelligence methods is needed. With further development, this system has the potential to become a more precise diagnostic tool and be more widely implemented in the medical field.

Keywords:

CBR, Diagnosis, Hydrocephalus, Accuracy.

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1. Introduction

Hydrocephalus is a medical condition characterized by the accumulation of cerebrospinal fluid in the brain's ventricles, which can lead to increased intracranial pressure and various neurological complications. This condition can occur in both newborns and adults, with symptoms varying depending on age and severity. Early detection and accurate diagnosis are crucial to preventing more severe consequences, such as developmental disorders, motor impairments, or even death. Currently, the

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diagnosis of hydrocephalus relies on clinical examinations by medical professionals and imaging techniques such as CT scans or MRIs. However, the limited availability of medical experts and uneven distribution of medical facilities can pose challenges in the diagnostic process. Therefore, an artificial intelligence-based system is needed to assist medical professionals in identifying this disease more quickly and accurately [1].

CBR is an artificial intelligence technique that mimics human problem-solving by utilizing knowledge gained from previous experiences to address new problems. In the context of medical diagnosis, CBR operates by matching a new patient's symptoms with historical cases stored in a database. Each case typically consists of symptoms, diagnosis, and treatment information. When a new case is introduced, the system calculates the similarity between the new input and the stored cases using various similarity measures. The most similar past cases are retrieved, and their solutions are adapted and proposed for the new case. This method allows healthcare systems to make informed decisions, especially in complex scenarios where a complete rule-based approach might be insufficient or infeasible [16].

Implementing CBR in disease diagnosis offers several advantages, including adaptability, continuous learning, and explainability. Since CBR systems learn from new cases over time, their performance and accuracy can improve as more data becomes available. Additionally, CBR systems are transparent, allowing clinicians to review and understand the rationale behind a given diagnosis or recommendation by referencing similar historical cases. This interpretability is crucial in clinical decision-making, where trust and accountability are essential. Recent studies have demonstrated the effectiveness of CBR in diagnosing diseases such as cancer, diabetes, and respiratory conditions, thereby supporting its applicability in intelligent healthcare systems [17].

The author conducted a study on the Case-Based Reasoning method for identifying hydrocephalus to help the public understand the type and solution for hydrocephalus they are experiencing. The research aims to design an expert system to reduce medical treatment delays that may lead to fatal risks for hydrocephalus patients. Additionally, it seeks to apply the Case-Based Reasoning method to provide knowledge and awareness about hydrocephalus symptoms, causes, effects, and treatments, as well as how an online expert system using the Case-Based Reasoning method can identify hydrocephalus and offer solutions and preventive measures. By implementing CBR, the system can deliver more efficient diagnostic results and offer appropriate treatment recommendations based on previous case experiences. The expert system for hydrocephalus identification using Case-Based Reasoning can compare system results with expert diagnoses, obtaining accuracy values from multiple patient data as a testing method.

2. Related Works

The Case-Based Reasoning (CBR) analysis method can be applied to heart rate analysis to determine whether a person's heart condition is normal or if there is a cardiovascular disorder. The physical activity recommendations provided by the system are determined based on the individual's heart condition. If the Resting Heart Rate (RHR) is within the range of 60-100 (under certain conditions), it is considered normal. If it is below 60, there is suspicion of a cardiovascular disorder called bradycardia. Conversely, if it is above 100, it indicates a cardiovascular disorder known as tachycardia. The analysis of the obtained Target Heart Rate (THR) value serves as a reference for recommending physical activity to users [1].

Other research has also successfully implemented the Case-Based Reasoning method to diagnose disorders in the human digestive system. Out of 83 test data, the

system showed an accuracy of 96.39% with a similarity value of 0.89, producing 20 data points with 100% accuracy and only 3 misdiagnoses. Additionally, this research successfully designed and developed an expert system capable of diagnosing 12 types of diseases based on 54 symptoms [2].

Another study using the Case-Based Reasoning method found that past cases had a similarity value of 42.51%, and the certainty factor (CF) calculation diagnosed chronic suppurative otitis media with a confidence level of 40% [3]. CBR is a method used to solve problems by utilizing past experiences to address new issues while considering the similarities between previous problem solutions. A database system is built to store revisions of new problem solutions [4]. Case-Based Reasoning (CBR) is also an approach to developing systems that function by diagnosing new cases based on past case experiences. This system provides solutions to new cases by referring to old cases with the highest similarity level [5].

A study on expert systems for diagnosing cardiovascular diseases in the elderly showed that the Case-Based Reasoning method could be used in an expert system to diagnose cardiovascular diseases and calculate the likelihood of having a cardiovascular condition. By applying the Case-Based Reasoning method in diagnosing cardiovascular diseases in the elderly, accurate certainty value calculations can be achieved [6]. Other research has shown that the Case-Based Reasoning (CBR) method has significant potential in supporting early diagnosis and disease management of dementia. The developed system can analyze and compare patient symptoms and medical histories with previously documented cases, enabling faster and more accurate diagnostic recommendations. The implementation of CBR in a web-based expert system for dementia diagnosis, developed using PHP and MySQL, has proven effective [7].

Previous research using expert systems with the Case-Based Reasoning method for diagnosing infectious diseases in infants introduced an innovative expert system for diagnosing children's diseases using Case-Based Reasoning. The CBR model results identified the highest case values, including loose or watery stools, inability or reluctance to drink, diarrhea lasting 14 days or more, black-colored stools, and blood in the stool, with an identified value of 0.863636364 [8]. The Case-Based Reasoning method has also been used to diagnose Typhoid Fever in an established system. This system can address problems related to Typhoid Fever diagnosis and provide output on the severity level based on two conditions: mild Typhoid Fever and chronic Typhoid Fever. This method is considered appropriate for determining the severity level of Typhoid Fever based on patient symptoms [9].

An expert system study diagnosing Zika disease using the Case-Based Reasoning method showed that this method could be used to determine similarity values to assess the certainty of a Zika diagnosis. The Case-Based Reasoning and Certainty Factor methods were used to calculate the CF value, diagnosing Zika disease with a 97% confidence level, confirming that the patient was infected with Zika [10]. Another study on an expert system application for diagnosing diseases in broiler chickens demonstrated that it could assist farmers in diagnosing diseases with high accuracy. Additionally, the expert system could display diagnosis results based on the Case-Based Reasoning method [11]. Research in the livestock sector also showed that implementing an Expert System with the Case-Based Reasoning method for diagnosing betta fish diseases in a web-based system was successful. This system helps users accurately and efficiently identify diseases in betta fish based on past cases, providing a beneficial solution for betta fish enthusiasts and breeders in detecting and treating diseases more quickly and effectively [12].

3. Proposed Method

Artificial Intelligence (AI) is defined as intelligence exhibited by an artificial entity, typically a computer. Intelligence is created and embedded into a machine (computer) to perform tasks similar to human capabilities [13]. Artificial Intelligence (AI) is a multidisciplinary field aimed at automating activities that currently require human intelligence. Humans and AI can collaborate to make decisions that are less influenced by personal values [14]. Artificial Intelligence is a computer system capable of performing tasks that typically require human intelligence. AI processes include learning, reasoning, and self-correction, similar to how humans analyze before making decisions. AI is a technology widely adopted in the Industry 4.0 era. AI can connect every device, allowing users to automate all devices remotely without being physically present [15].

The research methodology is a conceptual framework containing systematic stages carried out by the author in the study. In this research, the Case-Based Reasoning method is used, as shown in Figure 1.

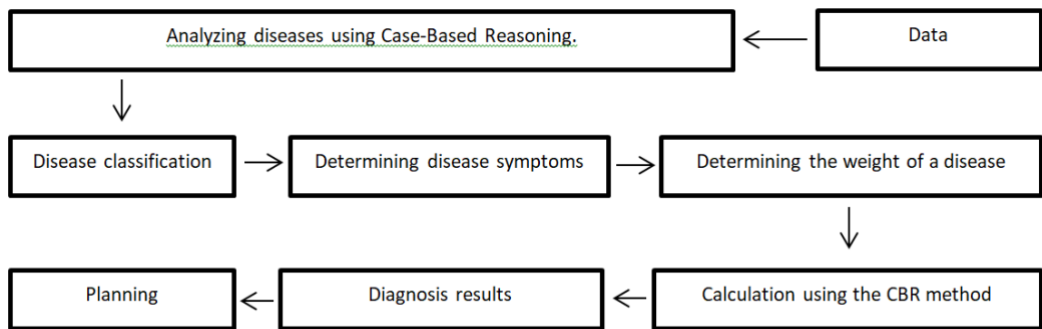


Fig. 1 Research Stages

Fig. 1 illustrates the stages of research, starting with data collection, analyzing diseases using the Case-Based Reasoning method, classifying diseases, determining disease symptoms, assigning disease weights, followed by calculations using the CBR method, leading to diagnosis results, and finally system design.

4. Experimental Setup

4.1 Data Collection

In this study, the data collection process was conducted through in-depth interviews and discussions with experts who have expertise and experience in the relevant field. This approach was chosen to obtain information that is not only accurate but also rich in perspectives based on the direct understanding and experience of experts. By involving experts, the collected data is expected to provide a strong foundation for analyzing the issues being studied and producing more comprehensive and applicable findings.

4.2 Case-Based Reasoning Process

The Case-Based Reasoning (CBR) method consists of four main stages: retrieve, reuse, revise, and retain. This system generally relies on the knowledge base it possesses. The

knowledge base is derived from previously diagnosed case symptoms by experts and is calculated based on their similarity to new cases. Based on this similarity level, the system diagnoses hydrocephalus according to its disease classification.

- a. The retrieval process involves searching for similarities between a new case and cases stored in the knowledge base. At the beginning of the diagnosis process, the user inputs all the symptoms they are experiencing at once without needing to answer multiple questions. The user will then receive the diagnosis results. The system performs weighting by matching each symptom with those in the knowledge base. The similarity weight processing stage carried out by the system is calculated using the following formula:

$$\text{Similarity} = \frac{s_1*w_1 + s_2*w_2 + \dots + s_n*w_n}{w_1 + w_2 + \dots + w_n} \quad (1)$$

- b. Reuse Process
In the reuse process, the solution provided is the one with the highest similarity weight between the existing knowledge base and the new case.
- c. Revise Process
This process is carried out to refine the proposed solution and then test it on real cases (simulation). It is necessary to further improve the solution so that it fits the new case accurately.
- d. Retain Process
The retention process involves storing parts of the experience that may be useful for solving future problems.

4.3 System Analysis

At this stage, an analysis is conducted on how the expert system for diagnosing hydrocephalus will be designed. This expert system will be developed in the form of a website.

4.4 System Design

The design process begins with collecting relevant data and facts to support system development through consultations with experts. Next, the design phase is carried out, which is divided into model design and interface design.

The Unified Modeling Language (UML) model design in this study includes the use case diagram, class diagram, sequence diagram, collaboration diagram, state chart diagram, activity diagram, and deployment diagram. The interface design refers to the system development plan based on the workflow of the previously designed model.

The steps in designing the hydrocephalus expert system for child patients include:

- a. For members/patients: Member/patient dashboard, latest news page, instructions page, consultation guide, login consultation page, consultation page, and final diagnosis results page.
- b. For admin users: Home page, symptoms table, disease data table, case data table, news management table, user settings table, admin data, patient data, and consultation data.

5. Result and Analysis

In the Results and Discussion section, the analysis stages carried out are explained in detail. The results of this study are as follows:

5.1 Symptom Data

The classification of hydrocephalus obtained from experts can be seen in Table 1 below:

Table 1: Hydrocephalus Classification Data

| Classification Code | Disease Name |
|---------------------|----------------------------------|
| P01 | <i>Hydrocephalus kongintenal</i> |
| P02 | <i>Hydrocephalus Aicured</i> |

Meanwhile, the symptoms of hydrocephalus can be seen in Table 2 below:

Table 2. Symptoms of Hydrocephalus

| Symptom Code | Symptom Name |
|--------------|--|
| G01 | Abnormal head enlargement |
| G02 | Tense fontanelle |
| G03 | Downward-looking eyes |
| G04 | Delayed walking ability |
| G05 | Nausea and vomiting |
| G06 | Seizures |
| G07 | Irritability |
| G08 | Drowsiness, difficulty staying awake or waking up |
| G09 | Poor coordination |
| G10 | Muscle stiffness |
| G11 | Poor appetite |
| G12 | Headache |
| G13 | Head pain upon waking up |
| G14 | Blurred vision |
| G15 | Frequent confusion |
| G16 | Difficulty controlling urination and bowel movements |
| G17 | Speech disorder |
| G18 | Neck pain |
| G19 | Memory decline |

5.2 Process Analysis

Based on interviews with experts, symptom classification can be divided into three categories:

- a. Mild symptom classification with a parameter weight (w): 1

- b. Moderate symptom classification with a parameter weight (w): 3
- c. Severe symptom classification with a parameter weight (w): 5

Below is the table of symptom data and hydrocephalus weights

Table 3. Symptom Data and Hydrocephalus Weights

| Symptom Code | Symptom Name | Disease Code | | Symptom Weight |
|--------------|--|--------------|------|----------------|
| | | P0 1 | P0 2 | |
| G01 | Abnormal head enlargement | √ | √ | 5 |
| G02 | Tense fontanelle | √ | | 5 |
| G03 | Downward-looking eyes | √ | | 3 |
| G04 | Delayed walking ability | √ | | 3 |
| G05 | Nausea and vomiting | √ | √ | 5 |
| G06 | Seizures | √ | √ | 5 |
| G07 | Irritability | √ | √ | 1 |
| G08 | Drowsiness, difficulty staying awake or waking up | √ | √ | 5 |
| G09 | Poor coordination | √ | √ | 3 |
| G10 | Muscle stiffness | √ | √ | 1 |
| G11 | Poor appetite | √ | √ | 1 |
| G12 | Headache | √ | √ | 1 |
| G13 | Head pain upon waking up | | √ | 5 |
| G14 | Blurred vision | | √ | 5 |
| G15 | Frequent confusion | | √ | 3 |
| G16 | Difficulty controlling urination and bowel movements | | √ | 1 |
| G17 | Speech disorder | | √ | 3 |
| G18 | Neck pain | | √ | 3 |
| G19 | Memory decline | | √ | 3 |

5.3 CBR Method Analysis

From the data, a new case has been identified as shown in the following table:

Table 4. New Case

| Code | Experienced Symptoms | Weight |
|------|--|--------|
| G01 | Abnormal head enlargement | 5 |
| G02 | Tense fontanelle with visible head veins | 5 |
| G03 | Downward-looking eyes | 3 |
| G05 | Delayed walking ability | 3 |
| G06 | Seizures | 5 |
| G09 | Poor coordination | 3 |
| G13 | Head pain upon waking up | 5 |
| G16 | Difficulty controlling urination and bowel movements | 1 |

| Code | Experienced Symptoms | Weight |
|------|----------------------|--------|
| G17 | Speech disorder | 3 |

The results for the CBR method according to its steps are as follows:

a. Retrieve Process

The calculation for congenital hydrocephalus cases is as follows:

$$\begin{aligned}
 \text{Similarity}(x,x) &= \frac{s_1*w_1+s_2*w_2+\dots+s_n*w_n}{w_1+w_2+\dots+w_n} \\
 &= \frac{(1*5)+(1*5)+(1*3)+(1*3)+(1*5)+(1*3)+0+0+0}{5+5+3+5+3+5+1+5+3+1+1+1} \\
 &= 0.6315 \\
 &= 63.15 \%
 \end{aligned}$$

From the calculation of the case above, there is a similarity with a previous case, resulting in a similarity score of 63.15%.

The calculation of the hydrocephalus Aicured case is as follows:

$$\begin{aligned}
 \text{Similarity}(x,x) &= \frac{s_1*w_1+s_2*w_2+\dots+s_n*w_n}{w_1+w_2+\dots+w_n} \\
 &= \frac{(1*5)+0+0+0+(1*5)+(1*3)+(1*5)+(1*1)+(1*3)}{5+5+5+1+5+3+1+1+1+5+5+3+1+3+3+3} \\
 &= 0.44 \\
 &= 44 \%
 \end{aligned}$$

From the calculation of the above case, there is a similarity with a previous case, resulting in a similarity calculation of 44%.

b. Reuse Process

Based on the results of the similarity calculation, the case identified with the highest similarity weight corresponds to congenital hydrocephalus, achieving a similarity score of 63.15% when compared to the existing knowledge base. This result indicates that, among all retrieved historical cases, the symptoms and characteristics of the new patient most closely align with those observed in previous instances of congenital hydrocephalus. The similarity score is computed using a weighted similarity function, typically considering symptom match, severity, duration, and other clinical parameters, enabling the CBR system to provide a quantified measure of relevance between cases.

In the reuse phase of the CBR cycle, the system selects and proposes the solution associated with the historical case that has the highest similarity score. This solution may include a preliminary diagnosis, recommended diagnostic tests, and treatment plans that were successfully applied in the matching past case. By relying on the most relevant case, the system ensures that the proposed diagnostic and therapeutic actions are

evidence-based and contextually appropriate, thus improving the reliability and precision of clinical decision-making. This method not only reduces diagnostic time but also enhances consistency in handling complex or rare conditions such as congenital hydrocephalus, where expert experience may be limited.

c. Revise Process

This refinement process, known as the revision phase in the CBR methodology, is essential to ensure that the proposed solution is appropriately tailored to the specifics of the new case. After identifying the most similar historical case and reusing its solution, the system or expert evaluates the applicability and accuracy of this solution through simulation or real-world testing. This phase involves validating the diagnostic hypothesis and recommended interventions against actual patient outcomes or simulated scenarios to detect any discrepancies or mismatches. If inconsistencies are identified, the solution is iteratively modified to better fit the clinical context of the new case, ensuring a higher degree of precision and reliability. Such adjustments may involve recalibrating symptom weightings, integrating new diagnostic data, or consulting additional expert knowledge. The goal is to optimize the system's learning process, enabling it to adapt to diverse medical cases and continuously improve its performance in future diagnoses.

d. Retain Process

The retain process is the final phase of the CBR cycle, in which the system incorporates the newly validated and refined solution into its knowledge base for future reference. This process involves several critical steps, including indexing, where the new case and its solution are categorized using key features or attributes for efficient retrieval; integration, where the case is systematically merged into the existing database structure; and extraction, which involves identifying and storing essential knowledge derived from the case. By retaining this newly acquired case, the system enhances its problem-solving capabilities, enabling it to recognize and respond more effectively to future problems that exhibit similar patterns or characteristics. This continuous learning mechanism ensures the CBR system becomes progressively more robust and accurate over time, fostering improved decision support, particularly in domains such as medical diagnostics, where case variability is high and historical insight is invaluable.

6. Conclusion

This study demonstrates the potential of the CBR method as a computational approach to support medical professionals in diagnosing hydrocephalus. Utilizing data collected from Andalas University Hospital and validated through expert consultation, the system incorporated 19 symptom variables and classified hydrocephalus into two primary types: congenital and acquired. The diagnostic system achieved an accuracy of 63.15% for congenital hydrocephalus and 44% for acquired hydrocephalus. These results reflect the system's initial capability to identify patterns in clinical cases and suggest relevant diagnostic pathways based on historical case similarity.

Despite the promising findings, the accuracy levels, particularly for acquired hydrocephalus, indicate the need for further enhancement of the model. Future work should focus on expanding the case database, refining the similarity computation algorithms, and integrating additional clinical parameters to improve diagnostic precision. Moreover, rigorous testing in broader clinical settings is essential to validate the generalizability and robustness of the CBR approach. With continued development, the

system holds the potential to become a valuable diagnostic aid in neurology, contributing to faster, experience-driven, and data-informed clinical decision-making.

Acknowledgment

The author would like to express sincere gratitude to Universitas Putra Indonesia YPTK Padang and the Faculty of Computer Science for their support in conducting this research. Special thanks go to the thesis advisor for their invaluable guidance, insightful feedback, and continuous encouragement throughout the research process. The author also extends appreciation to Rumah Sakit Universitas Andalas for providing the necessary data and resources for this study. Additionally, heartfelt thanks to family, colleagues, and friends for their unwavering support and motivation. Finally, the author acknowledges all individuals and organizations whose contributions, directly or indirectly, have helped in the completion of this research.

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