ARTIFICIAL INTELLIGENCE'S ROLE IN PREDICTIVE ANALYTICS FOR PATIENT MENTAL HEALTH CARE

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ABSTRACT *The aim of this study is to analyze the use of AI in mental health care using case-based reasoning methods, which generate treatment solution recommendations from previously occurring cases.*

KEYWORDS Artificial intelligence, case-based reasoning, mental health

INTRODUCTION

Mental health conditions cause a great deal of distress or impairment; depression alone will affect 11% of the world's population. (Ariel Rosenfeld 2021) Anyone can become a patient with a mental health disorder if they experience unusual symptoms that interfere with their daily lives. (Katiyar 2022) The ramifications of these disorders ripple through communities, affecting individuals, families, and societies at large. The burden placed on healthcare systems, as well as the personal toll on those who suffer, are significant. Despite the growing awareness of mental health issues, access to timely and effective mental healthcare remains a significant challenge. (Shah 2022) Mental health is, by its very nature, a very complex sector, and the increasing demand for healthcare services coupled with limited resources has made addressing mental health issues challenging. (Cecula et al. 2021)

In recent years, artificial intelligence (AI)-based applications have rapidly been developed for research and diagnosis. (Liu et al. 2020) Artificial Intelligence (AI), particularly Machine Learning (ML) and Deep Learning (DL), offers significant advantages in this realm due to its outstanding capability to process, analyze, and interpret intricate, nonlinear, and high-dimensional data in various forms. (Xu et al. 2021) Such techniques can effectively discern hidden data patterns that might elude human analysts and use them to predict future events, making them an instrumental tool in aiding clinicians during the decision-making process in the digital health era. (Sharma and Chaudhary 2023)

Case-based reasoning (CBR) is a subset of artificial intelligence (AI) and cognitive science that models the reasoning process based on a stored master database of events. The solutions to new problems are derived by comparing similar patterns of data in the case base that fit new needs. The mechanism of formulating the solution is initiated with the computation of the similarity index for finding possible match solutions. The solution of the most similar case in the case base is fitted as the solution for the new case. (Venkatesh Raja et al. 2024)

AI's effective data analysis, pattern recognition, and automation capabilities can overcome the barriers to mental health patient care, potentially anticipating mental health disorders through early detection, health development management, and treatment recommendations. AI will help analyze the results based on the inputs already collected from mental health cases. The results obtained are in the form of diagnoses and recommendations for actions needed to address the diagnosis.

RESEARCH METHOD

Case-Based Reasoning (CBR) is the AI method that finds solutions and recommendations for mental health patient care. It is a type of machine learning that relies on analogical reasoning, which is the process of finding similarities between past situations and new ones. CBR works by retrieving similar past cases and adapting them to the current situation to decide or solve a problem. (Putri 2023).

This study employs a case-based method that provides solutions in the form of action recommendations based on previous cases. The similarity function used is the modified weighted average. The proposed method not only involves case components in the case base but also involves components in the evaluated case. Modification of the similarity function with weights can be done by dividing the sum of the same component weights between the new case to be resolved (C) and the i-th case in the case base K_i by the maximum of the number of components in C (eg: m) and components in K_i (eg: n), so that the similarity value T_i is obtained. (Mora L. et al. 2020)

$$T_i = \{\frac{\sum_{j=1}^{n} \text{the same component between } C \text{ and } K_i}{\sum_{j=1}^{n} \text{component weight } K_i}, \ m \leq n \ \frac{\sum_{j=1}^{n} \text{the same component between } C \text{ and } K_i}{\sum_{j=1}^{n} \text{component weight } K_i + \propto (m-n)}, \ m > n \quad (1)$$

The explanation of the four essential activities in case-based reasoning, namely retrieve, reuse, revise, and retention, is as follows:

1. **Retrieve** is the process of rediscovering cases that are similar to new ones that will be evaluated using the similarity function in equation (1).
2. **Reuse** involves utilizing stored information or knowledge from the case base to address case problems. The number of similar cases depends on the previously determined θ value.
3. **Revise** is to improve the proposed solution. We will also carry out revisions when a case no longer aligns with the current conditions.
4. **Retain** means to store knowledge that will later be used to solve problems in the existing case base.

Figure 1 describes the research method in this study. The research stages consist of (1) case data collection and literature study, (2) modeling, (3) model evaluation, and (4) model evaluations.

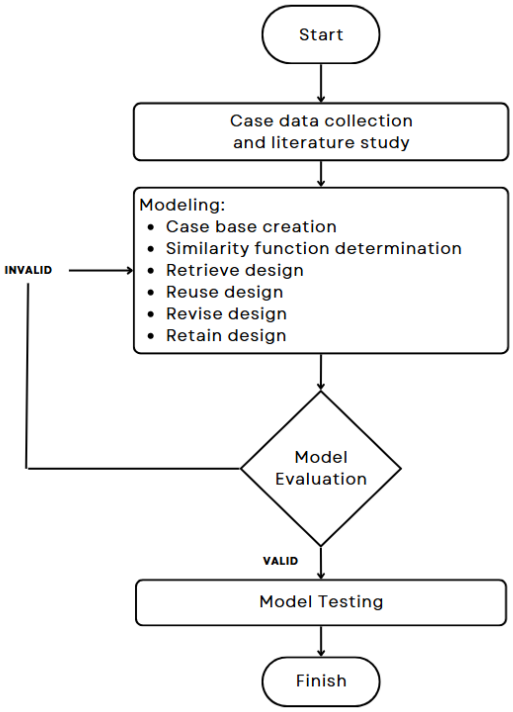

Figure 1. Research Method

1. Case Data Collection and Literature Study

The authors initiated their method by searching indexed databases such as PubMed/Medline (National Library of Medicine), Scopus, and other published articles featuring recent cases. In the review article, the authors extensively examine the use of AI in predictive analytics in healthcare, especially mental health. The authors selected mental health as a case because of its universality, affecting individuals ranging from children to the elderly.

The author took a month to collect cases related to mental health, what the symptoms are, what the types are, and how to handle them. The author collected cases through literature studies and focus group discussions with counselors. The authors examined various combinations of keywords, such as AI in medical diagnosis, AI applications in healthcare, AI in personalized medicine, and predictive analytics in healthcare. The author extracted data by filtering only publications that met certain criteria that were relevant to the topic to find out how AI plays a role in predictive analysis to help find solutions to existing cases.

2. Modeling

The formation of a case base. Counselors will store knowledge in the form of solved cases within the case base. The goal is to have at least 90 cases in the case base. We will later use this case as a guideline for problem solving. We will also determine a similarity function to assess the degree of similarity between the evaluated cases and those in the case base. This study will propose a modified weight average as a similarity function. Modeling continues by determining the retrieve, reuse, revise, and retain processes. Researchers will try several threshold values (θ) to determine the minimum similarity value. We will also discuss this value with the counselor to achieve optimal results.

3. Model Evaluation

At this stage, we will test the case-based reasoning model using new cases that are not part of the existing case base. We will divide the data set into two groups, training data and test data, according to specific proportions. We will also evaluate the test results based on their performance. We will measure the model's performance by comparing its recommendations with the counselor's actual solutions. At this stage, the goal is to form a classification model that counselors have tested.

4. Model Testing

We then subject the evaluated model to a usability test to see how well it matches actual cases, and whether the results of the predictive analysis using AI can provide recommendations for solutions that can help treat mental health patients. Usability testing involved 30 mental health patients and 5 counselors.

RESULT AND DISCUSSION

1. Case- Based Reasoning (CBR)

Case-Based Reasoning (CBR) is a method used to implement computer diagnostic systems in real-world applications. Cases collected from both focus group discussions and literature studies were then compiled into a total of 100 cases along with their solutions approved by the counselors, with the provision that 90 cases would be entered into the database and 10 cases would be used as trial cases that had not been entered into the database. We set the number of symptoms in the respondents' actual cases at 70.

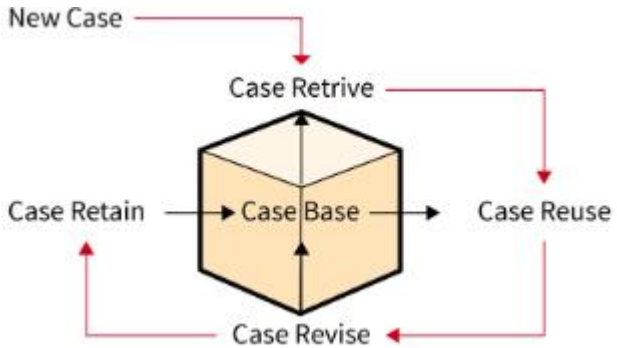

Figure 2. Case-Base Reasoning (CBR) Cycle

The CBR process typically involves four main steps: retrieve, reuse, revise, and retain. (Subhagata Chattopadhyay, Suvendu Banerjee, Fethi A. Rabhi n.d.)

a. **Retrieve**

In this retrieval process, the CBR method computes the similarity function of previously existing cases that are similar to new cases. The retrieval process is carried out by two processing steps in the database: problem recognition and problem similarity searches. We first conduct a manual calculation test using the similarity function in the case search algorithm, such as equation (1), before testing the system.

We chose the similarity calculation because it is pertinent to a case-based system that generates a similarity value between new cases and cases already in the case base. This study collected and evaluated 90 cases using the similarity function. The comparison results will be a reference for deciding

whether the solutions available through the system are relevant or not to the actual case.

b. **Reuse**

In the reuse stage, reusing old cases stored in the case base provides information or knowledge to solve problems. The number of similar cases depends on the threshold value (θ) that has been set previously. The similarity results between new and stored cases are usually between 0 and 1. A value of 0 means that the two cases are absolutely not similar, whereas a value of 1 means that they are absolutely similar. Therefore, we choose a middle-point value of 0.5 as the minimum requirement for similarity results to determine solution recommendations.

c. **Revise**

After developing a solution using past cases, the next step is to revise it to better suit the current problem. This involves modifying the solution based on current or newly available cases in order to improve the current solution to the problem. In some cases, the revision step may involve using machine learning algorithms to optimize the solution. The counselor is responsible for this revision, confirming the solution recommendations provided by the case-based reasoning results. If a case no longer fits the current conditions, the counselor will revise it.

d. **Retain**

The final step is storing the newly developed solution for future use. The goal is to improve the quality of the case base and the CBR process's effectiveness.

The counselor offers solutions that stem from recommendations generated by the case-based reasoning, which are based on the similarity scores of previous cases. The case base stores the new solution as knowledge, which subsequently aids in solving new case problems.

2. Demographics of Data Collection

We collected case studies related to mental health and the application of AI in health information technology. We also conducted a focus group discussion (FGD) with five counselors to identify new cases that had occurred or were currently trending.

After gathering 90 cases for the database, we chose 10 significant issues or topics frequently discussed by respondents in articles or on social media to serve as model testing cases. Based on the counselors' FGD results, we selected the cases and jointly determined the recommended solutions for each case. We collected the best solutions from each counselor into a database to serve as recommendations in the case-based system.

3. Calculation Process

The case-based reasoning method calculates solutions based on cases involving mental health issues.

a. In the first process, the patient enters a new case by sharing their experience with one of the counselors. The CBR will compare the patient's symptoms in the new case with those from previously stored old cases.

Table 1. Case Study

Case	Symptoms	Score
I feel like my friends don't like me because I'm quiet, I'm not confident to greet them first because I'm afraid of being ignored. So my relationship with my friends is limited to college purposes only	less of confidence	1
	fear of being ignored	1

b. The table below displays the calculation method incorporating similarity calculations.

Table 2. Case Similarity Calculation

Case Number	Case	Similarity = Total (1*weight of matching diagnoses) / Total Weight of Cases	Solution
C25	My boyfriend once cheated on me, which left me feeling insecure and less attractive, leading me to retreat.	½ = 0,5	Focus on building a better future, instill in yourself that you are the best, keep learning, and don't always look at the past. To get a lot of support, try to be open with your friends.
C28	I experienced bullying as a child, which persisted into my college years, leaving me unable to trust anyone. I lacked the self-assurance to communicate, fearing retaliation should I fail to blend in. I experienced a sense of disconnection.	½ = 0,5	Let go of the past and strive to maintain open communication with your friends in the present. Engage in activities you enjoy with them, and cultivate new friendships and experiences to boost your self-confidence.
C76	Despite my boss giving me the opportunity to perform my job, I lack confidence in my abilities, and many of my colleagues dislike me for accepting this opportunity. People frequently disregard my inquiries.	2/3 = 0,67	Be confident and focus on the job you get; prove it with achievements; and don't give up. You can learn alot from trusted colleagues.

The test results found three similar cases and met the minimum threshold value. Counselors have the freedom to select the most appropriate and relevant solution for the current real conditions, and they can also modify the selected solution to effectively address the problem.

4. Decide on a Solution

After receiving a new case, the counselor will present several relevant cases that are close to the minimum similarity value of 0.5 as a solution recommendation. The counselor can use the existing solutions, add more appropriate solutions, or create new solutions that fit the actual situation. For example, in the tested case, the counselor received several suggestions and then proposed the optimal solution, which is to *"concentrate on your current job, pursue your interests, and encourage your friends to join you. Be open and trusting, having more friends will boost your confidence as you become accustomed to interacting with others"*.

5. Result

Case-Based Reasoning (CBR) is effective in the field of mental health, especially in predictive analytics, because its approach resembles the way humans solve problems based on past experiences. There are several main reasons for this phenomenon to occur:

a. CBR draws conclusions based on previous cases that are similar to the current situation because mental disorders often have recurring symptoms or certain patterns. (B, Nanculef, and Mar 2019) (Li, Du, and Kumaraswamy, 2024)
b. Adapting solutions from previous cases is crucial in CBR, as each patient may exhibit variations in symptoms or treatment response, despite sharing the same diagnosis. (Bannour, Maalel, and Ghezala 2020) (Profile 2023)
c. CBR supports a more personalized approach to care because mental health is highly influenced by personal context (Stumpp and Sauer-Zavala 2022) (Menear et al. 2022) (Bolton et al. 2020)
d. With healthcare digitization increasing, large and diverse medical data is available for analysis, so CBR uses this large database to find patterns and make accurate predictions. (Paul et al. 2023) (Kasoju et al. 2023) (Limna 2023)
e. Individual interpretation often influences the subjective nature of mental health diagnoses. CBR helps reduce this uncertainty by providing concrete references from validated past cases, providing more objective evidence to support clinical decisions. (Schnell et al. 2021)(Kraus et al. 2021)
f. CBR continues to evolve over time, as each new case solved can be added to the database, enriching the knowledge base so that CBR becomes more accurate in its predictions as experience increases. (Schultheis, Zeyen, and Bergmann 2023)
g. In AI, especially in mental health prediction systems, CBR is often combined with other machine learning techniques to make models more complex and to learn more about the patterns behind a patient's mental state that might not be clear from looking at just one type of data. As a result, the use of CBR in AI for mental health prediction is not only logical but also provides very real benefits in terms of improving diagnostic accuracy and treatment effectiveness. As a result, the use of CBR in AI for mental health prediction is not only logical but also provides very real benefits in terms of improving diagnostic accuracy and treatment effectiveness. (Chekroud et al. 2021) (Schultheis et al. 2023) (Sun et al. 2023) (Tutun et al. 2023)

Case-Based Reasoning (CBR) is indeed a method within the broader category of artificial intelligence (AI). CBR excels in problem-solving scenarios, where it leverages past cases or experiences to understand and address new problems. The method has seen significant applications in healthcare, including predictive analytics for patient mental health care. (Pradeep, Caro-Martínez, and Wijekoon 2024)

In the context of mental health, AI, specifically CBR, has been used to predict and diagnose psychological disorders by comparing current patient data to previous cases. This approach allows for personalized treatment plans and more accurate predictions by leveraging similarities between cases. (Olawade et al. 2024) This research has shown that these AI-based systems, including those using CBR, have the potential to fill the gap left by traditional methods, such as manual evaluations or standard diagnostic tools. By leveraging large datasets and advanced

computational methods, CBR can offer more tailored insights to individual patients, leading to better mental health care outcomes.

CONCLUSION

Overall, the CBR method implements the role of AI in providing the best solution based on previous cases. The authors compiled cases from focus group discussions and literature studies into a database. The authors then used the CBR method to identify similarities between the newly emerged cases and cases previously stored in the case base. Counselors validated the model testing solution, ensuring that it was consistent with reality and served as a reference for addressing other mental health issues.

This study demonstrates the growing role of AI in predictive analysis for mental healthcare, with CBR being the primary method for improving the accuracy and relevance of predictions in this field. While there are alternative methods for developing AI for healthcare, not all of them produce solutions based on real-world case studies, such as using CBR. In the future, the role of AI will not only be predictive analysis of something, but it can also provide a way out of a problem.

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