Design of a Deep Learning-Based Psychological Counseling System for College Students' Mental Health

Ling Pan*, Haili Ma, Yongqiang Li
Zhengzhou Railway Vocational and Technical College
Zhengzhou, Henan, 451460, China
11054@zzrvtc.edu.cn

ABSTRACT

In response to the necessity of psychological counselling for college student's mental health, this paper proposes a psychological counselling and assessment system based on PGCapsNet. The system aims to achieve both college students' psychological health assessment and real-time online counseling, while improving the accuracy of predicting their mental health status. Having an experienced psychological counsellor is crucial for college students' mental health and crisis management. The simulation results demonstrate that compared to other models, using the PGCapsNet model can effectively improve the levels of precision, recall, F1-measure, and accuracy of the college student psychological counseling system, achieving 70%, 75%, 72%, and 74%, respectively. This validates the feasibility and superiority of this design. This paper discusses a novel algorithm that combines capsule networks and convolutional neural networks, incorporating dynamic routing algorithms and deep learning capabilities.

1. Introduction

With the call of the Party and the state, as well as the needs of social development, our education has achieved tremendous accomplishments. However, due to the enrollment expansion in many tertiary institutions, the number of students is increasing rapidly. At this time, for all students to acquire a good comprehensive literacy, it is essential to pay attention to their mental health. To facilitate the students' growth, universities should take effective measures to help them cope with increasing psychological pressure. Among these measures, psychological counseling services are particularly prominent [1], and they need to be widely promoted and improved, just like traditional educational methods and expert advice. As an important part of society, college students' mental well-being significantly impacts their future. During their university years, changes in their thoughts, emotions, behaviors, values, and other aspects will profoundly impact their future and may lead to many adverse

consequences. Due to today's development in society, job market changes have become more apparent, which poses great challenges to college students [3]. They need to have strong mental health to meet the demands of society. However, achieving a healthy mental state cannot be achieved overnight. They must conduct in-depth research and master relevant mental health theories to identify and address issues on time and attain a healthy mindset.

Currently, although colleges and universities have paid considerable attention to ideological and political education, they lack focus and fail to consider the mental health of college students fully. They have not provided them with sufficient attention, support, care, dignity, or concern, which has resulted in damage to their mental well-being. Therefore, in the design of the psychological counseling system for college students' mental health, this study should focus on the overall architecture of the system. The designed counseling system should have various classifications based on different usage scenarios, analyzing the psychological health assessment and online counseling system. The design will utilize the PGCapsNet model for the psychological counselling system for college student's mental health and verify the feasibility of the design through experiments to further improve our country's mental health counselling system.

2. Literature Review

With the advancement of technology, China's mental health services are rapidly emerging, although there is still much room for improvement. In today's world, many universities and institutions are dedicated to developing and enhancing the quality and efficiency of mental health services to meet people's needs for healthcare [4]. While many systems are available for psychological counseling, most still adopt traditional online browsing modes. To improve efficiency when providing counseling, it is essential to provide clients with detailed information about the counseling in advance and offer corresponding assistance when they visit [5]. The lack of this during the process leads to a severe lack of communication between teachers and students, hindering effective utilization during this period, even though students face many challenges in their learning. While some systems have recognized the severity of the issue and developed question-asking functionalities, they still fail to respond to students' inquiries [6] promptly. With increasing attention to the mental health of college students [7], more and more sub-institutions and experts are exploring and researching how to help and guide them better. Sub-I, such as Li and Wang, have creatively established a complete, sustainable, traceable record of college students' mental health, as well as a complete, sustainable, operational, predictable, adjustable psychological counseling experience by applying big data and the Apriori algorithm. This helps them better cope with and resolve their psychological distress. By introducing advanced technology for psychological health education and counseling management, we have successfully implemented a high-performance system that overcomes the limitations of traditional algorithms and significantly enhances the efficiency of the entire experience [8]. The research mentioned above, in designing the counseling system, did not integrate the overall and local feature extraction of the information extracted by the counseling system, resulting in insufficient accuracy in predicting mental states. Related research in the field of psychological counseling in foreign countries mainly focuses on service-oriented counseling. At the same time, online psychological counseling has developed rapidly abroad and has formed a well-established system [9]. With the development of 5G networks, smartphones, and other advanced wireless communication means, wireless internet has significantly progressed in recent years. However, even so, under this background, there are still many unknown areas in the digitalization of mental health education information, and this phenomenon is worth pondering. Through this project, we can gain a more comprehensive understanding of the current mental state of college students and make better use of this data to achieve a perfect integration of psychological education and IT. This is a cutting-edge and creative idea [10].

3. Design of a College Student Mental Health Consultation System Based on Deep Learning

3.1. System Software Hierarchy Architecture Design
The online real-time counseling module is essential for users to engage in psychological health counseling and receive replies from mental health experts. Its real-time nature characterizes

it. Since it involves direct conversation between individuals, it offers more flexibility in responding to psychological health inquiries [11,12]. The online real-time counseling module includes various functions, such as real-time consultation queries and online real-time counseling. However, a common issue with the online real-time counseling module is that the real-time conversation between users and mental health experts can be interrupted due to personal reasons or other factors. To avoid the loss of conversation information caused by users unintentionally exiting the conversation, the module allows users to establish new conversations within a certain time frame while loading historical counseling information to continue the conversation process from before exiting [13].

The user management department of the system includes multiple functions, such as account registration, personalized settings, and adding or changing account passwords. Currently, the system exclusively targets college students who need to input their student status and go through approval from relevant departments to access the necessary information and assistance. The main purpose of this application is to help college students acquire more information, such as professional counseling and online communication, and support on-demand appointment services anytime, anywhere. Additionally, the application has a rich knowledge base management and search tool, making it convenient for users to search for and utilize information.

Knowledge base maintenance is an important task that enables precise management of the content in the knowledge base, including operations such as deletion, addition, and updates. It can store knowledge resources in specific formats as needed. The system maintenance module covers multiple aspects, including web page, database, and security. The web page maintenance functionality aims to achieve real-time webpage content updates, while the database maintenance functionality provides users with comprehensive services regarding information and counseling records. Furthermore, the system security feature ensures data security and effectively prevents external attacks. The statistical analysis of this module can help college students accurately identify their problems and provide counseling teachers with more precise guidance and treatment plans.

3.2. CapsNet Model

To achieve a comprehensive assessment of college student's mental health, it is crucial to choose an appropriate evaluation algorithm. Considering the difficulty of extracting text features with traditional deep learning methods and the requirement for accuracy in psychological assessment, we refer to the research findings of Cha Meng and adopt the CapsNet network for evaluating psychological features. In the CapsNet structure, the convolutional layers are replaced by capsule layers. The presence of capsule layers enables the model to have spatially relative positional learning capabilities, resulting in more accurate position recognition. The model consists of primary and digit capsules, and a dynamic routing algorithm is used for communication between them. This algorithm ensures the integrity of pooled features in the network and improves the network's robustness to some extent. Weight involves multiplying the capsule vector u_i by the weight matrix w_{ij}.

$$\vec{u}_{j|i} = w_{ij} u_i \qquad (1)$$

In the digit capsule layer, the calculation formula for capsule S_j is:

$$\vec{s}_j = \sum_i c_{ij} \vec{u}_{j|i} \qquad (2)S$$

Where c_{ij} is the coupling coefficient, its value is obtained by applying the softmax operation to b_{ij}. This process ensures that the sum of all coefficients for capsule u_j is 1, and initializes b_{ij} to 0 (which makes all C_{ij} the same). The expression for the coupling coefficient is:

$$c_{ij} = \frac{\exp\left(b_{ij}\right)}{\sum_j \exp\left(b_{ij}\right)} \qquad (3)$$

In practice, the aforementioned CapsNet network still has room for improvement in text feature extraction and prediction accuracy. Therefore, a psychological assessment algorithm that combines local and global features is proposed. The specific process is illustrated in Figure 1. Using Eclipse, this layer can interact efficiently with users, allowing them to achieve the desired application effects through various operations. The platform can effectively adjust physical and simulated devices during development to build integrated scenarios. Intents, as a communication medium, can combine multiple components to achieve the functionality of an Android program. The performance of these components can be classified into activities, services, Broadcast Receivers, and other forms.
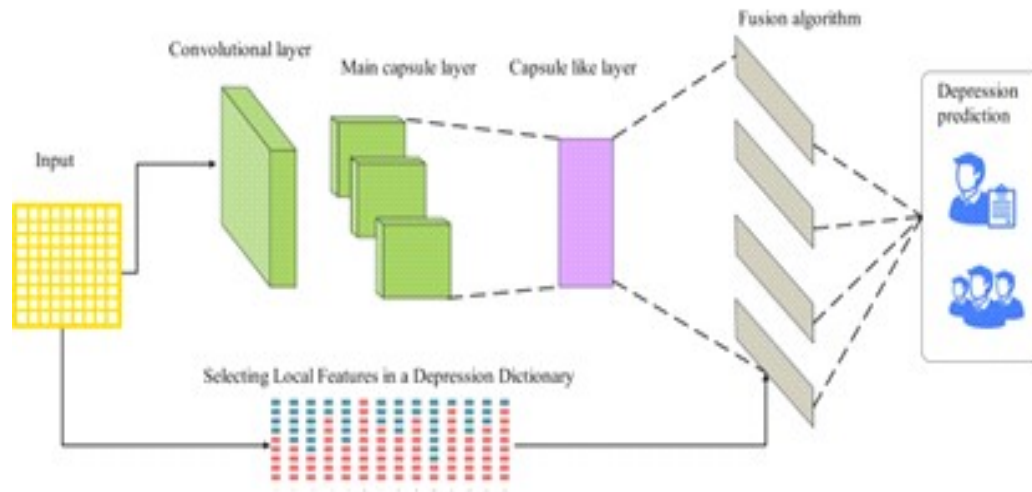

Figure 1. CapsNet Model Diagram

In the improved psychological assessment algorithm, text information is used as the input for psychological assessment. Extracting overall text features relies on the dynamic routing algorithm, while local features are extracted from the text database. After both sets of features are removed, they are fused using two strategies: max pooling and sum pooling. Typically, to improve efficiency, we use a client/server model to build the database for the counseling service system. It is divided into three layers: the presentation layer, the business logic layer, and the data layer. Effective isolation between these three layers ensures each component can be accessed efficiently. Adopting a 3-tier architecture, our psychological counseling service experience utilizes a three-tier client/server framework.

4. Experimental Design and Data Analysis

4.1. Database Design
The data obtained by the system is divided into two parts: the majority is used for training, while a smaller portion is used for experimental testing. The design utilizes 5-fold cross-validation as the method for data processing. After collecting user data, the information is divided into five equal parts that are mutually exclusive. Four parts are used for training, and the remaining is used for testing. Finally, the trained parameters are selected using a loss function to determine the optimal values. The designed model requires reasonable evaluation metrics as the basis for reliability. After verification, we found that the learning rate of the PGCapsNet model is superior to other models such as KNN, DNN, TextCNN, and BiRNN. Among them, PGCapsNet has the highest learning rate, reaching 0.01.

From a logical perspective, the database server and the application server are considered as two completely different combinations, while from a hardware perspective, they are seen as a complete system. Moreover, since client-side operations are performed through web browsers, we refer to their three-layer architecture as the Browser/Server architecture. We have employed state-of-the-art JSP technology, which enables dynamic connection to the data

base, significantly improving the reliability and availability of the system.

4.2. Training Results and Analysis

Two different strategies were used to fuse the processing results when performing local and overall feature processing. The max pooling and sum pooling strategies correspond to other evaluation parameters, corresponding to hyperparameters K and K, respectively β, Design evaluation parameters for the use of sum pooling strategy β By comparison, as shown in Figure 2, it can be seen that when $\beta = $ At 0.4, the model achieves the highest prediction accuracy.
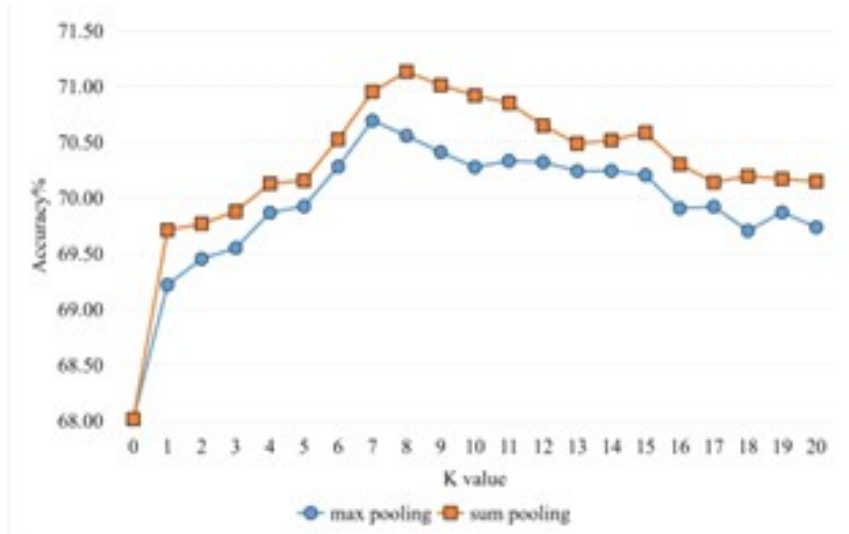

Figure 2. Model Accuracy K

A comparison was made for the hyperparameter K used in the local feature processing. As shown in Figure 2, it can be easily seen from the graph that the sum pooling strategy demonstrates significantly better prediction performance. Therefore, the sum pooling strategy was
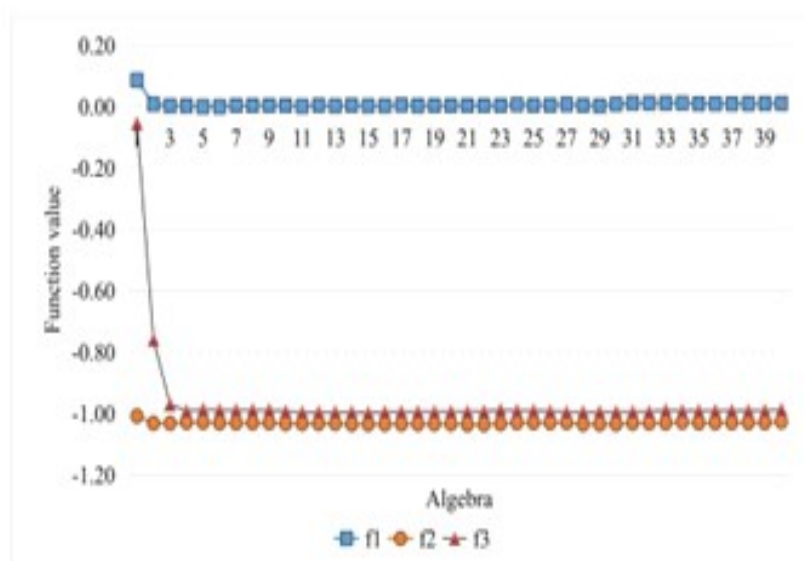

Figure 3. Convergence Curve of CBEA Calculation Functions f1~f8

chosen as the subsequent strategy for comparison. By comparing the accuracy, recall, overall evaluation metrics, and precision of multiple models, we can better understand the changes in the dataset. The obtained experimental results show that the PG-CapsNet *model used in the design performs better in all evaluation metrics, achieving an accuracy of 74% and demonstrating superior predictive performance for mental health status compared to other models. To illustrate the convergence of CBEA, we tracked the evolutionary process and plotted the corresponding evolution curves for all selected test functions. CBEA was evaluated 50 times, with each evolution consisting of 100 generations.*

According to Figure 3, regardless of whether the test function is in 2-dimensional or 10-dimensional space, CBEA quickly converges to the optimal solution. In particular, f3 approaches the optimal solution within 25 generations, indicating that CBEA exhibits good convergence. Experimental results have shown that functions within 30 generations can reach or approach the optimal solution. However, due to the limitations of the graph's details, the full extent of this result cannot be fully displayed.

5. Conclusions

In conclusion, the designed psychological counselling system, primarily based on the PGCapsNet *model utilizing capsule networks, enables faster and more accurate data recognition. It accurately extracts and interprets the collected counselling information while simultaneously completing real-time and non-real-time online counselling tasks. The system's overall performance is excellent and holds practical reference value for designing mental health counselling systems for college students. It is worth noting that although the designed psychological counselling system can fulfil the current stage of counseling tasks, it may not recognize emerging new forms of expression with the rapid development of internet culture. Therefore, future research should further optimize the predictive recognition system and update the database with new internet terms.*

After careful design, the system testing should start with comprehensive data analysis to identify any potential defects and take necessary measures for improvement, ensuring that the final test results align with the expected objectives. Through iterative implementation, we have ultimately achieved a stable and efficient system. The system has undergone meticulous design, extensive testing, and continuous refinement for different functional components to accomplish control tasks effectively. With our technology, the system has reached an outstanding level, providing students with high-quality psychological counseling and ensuring the efficiency of our workflow. Moreover, our engineering efforts have significantly reduced our investment while yielding good economic benefits. The system operates robustly through comprehensive evaluation and perfectly aligns with the expected design outcomes.

References

[1] Varga, M. A., Lanier, B., Biber, D., et al. (2021). Holistic Grief Effects, Mental Health, and Counseling Support in Bereaved College Students. *College Student Affairs Journal, 39*(1), 1-13.

[2] West, E. M., Moate, R., Baltrinic, E. R., et al. (2021). Counselor educators' perspectives on helpful learning for clinical mental health counseling students. *Counselor Education and Supervision, 60*(3), 235-250.

[3] Liu, Y. (2021). Research on Mental Health Intervention of College Students Based On Music Therapy. *Revista Brasileira de Medicina do Esporte, 27*(spe), 40-42.

[4] Ospina-Pinillos, L., Davenport, T. A., Ricci, C. S., et al. (2018). Developing a mental health eClinic to improve access to and quality of mental health care for young people: using participatory design as research methodologies. *Journal of Medical Internet Research, 20*(5), e188.

[5] Du, C., Yu, C., Wang, T., et al. (2022). Impact of virtual imaging technology on film and

television production education of college students based on deep learning and Internet of Things. *Frontiers in Psychology, 12*, 766634.

[6] Li, X., Shi, X. (2021). Design and Application of Mental Health Intelligent Analysis System for College Students Majoring in Physical Education. *Journal of Physics: Conference Series, 1852*(3), 032049 (7pp).

[7] Wang, T., Park, J. (2021). The Design and Execution of a Cognitive Sports Training System for the Mental Health Education of College Students. *Frontiers in Psychology, 12*, 634978.

[8] Wang, P. L., Li, Q., Guo, H. (2019). A research on deep learning model for face emotion recognition based on Swish activation function. *Journal of Image and Signal Processing,* 8(3), 110-120. recognition based on Swish activation function. *Journal of Image and Signal Processing, 8*(3), 110-120.

[9] Lei, Y., Belkacem, A. N., Wang, X., et al. (2022). A convolutional neural network-based diagnostic method using resting-state electroencephalograph signals for major depressive and bipolar disorders. *Biomedical Signal Processing and Control, 72*, 103370.

[10] Pandey, S., Sharma, S., Wazir, S. (2022). Mental healthcare chatbot based on natural language processing and deep learning approaches: Ted the therapist. *International Journal of Information Technology, 14*(7), 3757-3766.

[11] Du, F., Zhu, J. (2022). Mobile Terminal-Based Remote Counseling Education System for Middle School Students' Mental Health. In *International Conference on E-Learning, E-Education, and Online Training*. Cham: Springer Nature Switzerland, 351-364.

[12] Trappey, A. J. C., Lin, A. P. C., Hsu, K. Y. K., et al. (2022). Development of an empathy-centric counseling chatbot system capable of sentimental dialogue analysis. *Processes, 10*(5), 930.

[13] Zhao, L. (2018). Design and implementation of psychological counseling service system based on android. *In: Proceedings of the 2018 1st International Conference on Internet and e-Business*, 193-197.