SECTION: INFORMATION TECHNOLOGY AND CYBERSECURITY

NEURAL NETWORK DUAL ARCHITECTURE FOR DEPRESSION DETECTION USING CLOUD SERVICES

Tymofiiev Illia
Postgraduate student
Mazurets Oleksandr
Ph.D in Engineering Science, Associate Professor
Hardysh Daryna
Bachelor student
Molchanova Maryna
Teacher
Computer Science Department
Khmelnytskyi National University, Ukraine

In the conditions of the modern social and academic environment, pressure, stress and anxiety have become common phenomena that can lead to the development of depression. This is especially relevant in conditions of an intensive educational process, high demands and limited time for rest and self-regulation. Detecting depressive conditions in the early stages can significantly affect timely support and prevention of more serious mental disorders. With digitalization and widespread use of communication platforms, NLP becomes a powerful tool for monitoring the psychological state of students during the educational process. The development and implementation of modern methods for automated detection of depressive symptoms will help to timely identify people who need help and provide them with the necessary support to improve their mental health [1].

The task of diagnosing depression is a complex process and may differ from case to case. Depression has manifestations that are often expressed in writing. Taking into account the increase in the duration of online communication, the intelligent detection of a depressive state in text data is an actual direction of IT, and the early diagnosis and treatment of depression contribute to the improvement of the quality of life and prevent further complications.

Today, there are various methods of artificial intelligence that can be used to detect a depressive state in textual data [2]. The task of detecting a depressive state belongs to the tasks of classification [3, 4].

Among the NLP tools for the task of detecting a depressive state in textual data, there are two main approaches - an approach based on machine learning models and an approach using neural networks [5]. As for the approach based on machine learning models, this includes logistic regression, SVM, Naive Bayes, etc. [6, 7, 8].

For processing textual data, recurrent neural networks are most widely used, and a more modern approach is based on transformer models [9, 10]. This makes it

possible to better find hidden contextual dependencies, which is important for the task of detecting a depressive state [11].

The purpose of the work is the development of neural network dual architecture for depression detection using cloud services. Neural network dual architecture is based on the use of two parallel neural networks, each of which specializes in the analysis of different aspects of the text: syntactic and semantic.

The method of detecting a depressive state by means of NLP is designed to transform input data in the form of text and a trained neural network model into output data in the form of a numerical assessment of the presence of a depressive state.

The input data is a neural network model of a dual transformer architecture, consisting of a combination of BERT and GPT2 models, which are designed to analyze the syntactic and semantic context of user text [12]. The BERT model is used as a model for syntactic analysis of user text, and GPT2 is used for semantic analysis.

The first step is to tokenize the user text with the appropriate tokenizers of the BERT and GPT2 models.

The next step is the analysis of the tokenized text by neural networks BERT and GPT2, which takes place in parallel. The BERT model analyzes the text from the point of view of syntactic dependencies, and GPT2 - semantic ones.

The third step is to combine the results of both streams using a specialized fusion layer. As a result, a numerical assessment of the manifestation of a depressive state will be obtained.

The output data is a numerical assessment of the manifestation of a depressive state in the user text.

To identify the depressive state associated with learning in educational institutions, it was proposed to use a neural network of dual architecture, which combines the simultaneous possibility of syntactic and semantic content.

The input data is a dataset containing 2 classes - texts containing manifestations of depression associated with studying in educational institutions, and texts without manifestations of depression.

First, all the texts of the dataset are tokenized. Tokenization is done by BERT and GPT2 models. Further, the tokenized texts are transformed into a training sample, divided into 10% validation data and 90% training data.

Tokenized texts are submitted to the input of previously trained BERT and GPT2 models for the purpose of their retraining [13, 14]. These models work in parallel, and after receiving outputs in the form of vectors, they are combined in a fully connected layer [15]. This layer processes the concatenated vector, producing a final vector of logits, which is then used to calculate the loss function and predict the results.

According to the results of the loss function, the weights of the neural networks are updated by performing a reverse pass in the direction of reducing the error [16].

To investigate the effectiveness of the proposed method, a software complex was developed, consisting of a laptop implemented in the cloud environment "Google Colab" [17] for learning a neural network and a web interface that uses a trained neural network model of dual architecture [18, 19]. The web interface is implemented using the "PyCharm" programming environment and the use of the "Flask" microframework [20].

The neural network was trained for 2 epochs due to the lack of computing power (more than 40 GB of RAM is required). However, the results of the study indicate the sufficiency of the epochs spent. The result of the value of the loss function by epoch is shown in Figure 1.

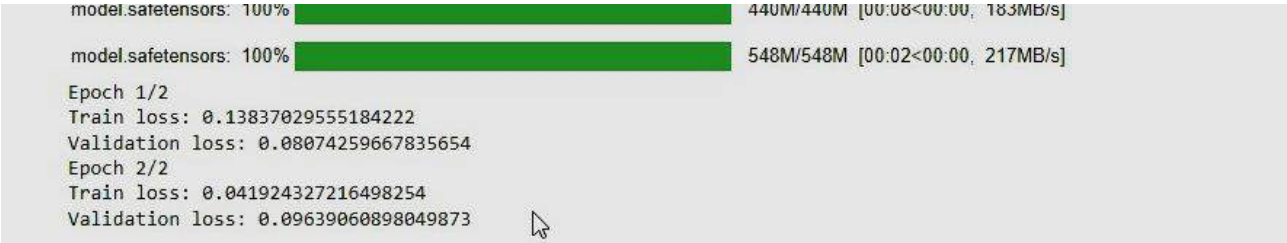

Figure 1. Dual architecture neural network learning metrics.

To conduct experiments with the trained model, a web interface was created, an example of its use is shown in Figure 2.

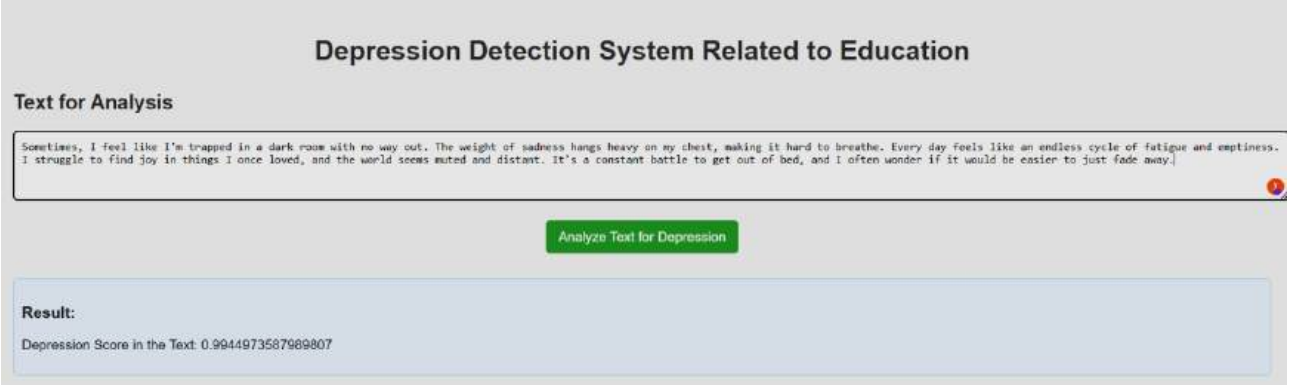

Figure 2. A web interface for detecting a depressive state.

Therefore, a neural network dual architecture was designed to detect a depressive state. Neural network dual architecture is based on the use of two parallel neural networks, each of which specializes in the analysis of different aspects of the text: syntactic and semantic.

The scheme of formation and training of a neural network model of dual architecture, which combines the simultaneous possibility of syntactic and semantic content, is presented. A method of detecting a depressive state by means of NLP was developed, which is designed to transform input data in the form of text and a trained neural network model of dual architecture into output data in the form of a numerical assessment of the presence of a depressive state. The proposed method differs from analogues in that it combines a two-stream architecture, which is based on the use of two parallel neural networks, each of which specializes in the analysis of different aspects of the text - syntactic and semantic. The stream of syntactic analysis is aimed at identifying the syntactic structure of the text, and the stream of semantic analysis is aimed at understanding the content and context of the text. After processing the text by each stream, the results are combined at the level of a higher layer, which allows taking into account both the details of the language structure and the general content of the text for a more accurate definition of the depressive state.

Experiments were conducted using the developed software, which testify to the correctness of the proposed approach.

References

1. Prediction of Depression Using Machine Learning and NLP Approach. URL: https://link.springer.com/chapter/10.1007/978-981-16-4863-2_15.
2. Depression and Suicide Analysis Using Machine Learning and NLP. URL: https://iopscience.iop.org/article/10.1088/1742-6596/2161/1/012034/meta.
3. Zalutska O., Molchanova M., Sobko O., Mazurets O., Pasichnyk O., Barmak O., Krak I. Method for Sentiment Analysis of Ukrainian-Language Reviews in E-Commerce Using RoBERTa Neural Network. CEUR Workshop Proceedings, 2023, vol. 3387. Pp. 344–356.
4. Nazarov V., Molchanova M. Information System for Detecting Abusive Speech in Audio Content by Means of Natural Language. Proceedings of V International Scientific and Practical Conference «Modern strategies of global scientific solutions». December 27-29, 2023. Stockholm, Sweden, International Scientific Unity. Pp. 132-135.
5. Mazurets O., Molchanova M., Klimenko V., Prosvitliuk M Practice Implementation of Neural Network Model BART-Large-CNN for Text Annotation. Prospects of Scientific Research in the Conditions of the Modern World. Proceedings of XXVII International scientific and practical conference. June 12-14, 2024. Rotterdam, Netherlands. 2024. Pp. 97-102.
6. Mazurets O.V., Sobko O.V., Molchanova M.O., Zalutska O.O., Yurchak A.V. Practical Implementation of Neural Network Method for Stress Features Detection by Social Internet Networks Posts. Global Science: Prospects and Innovations. Proceedings of the II International Scientific and Theoretical Conference «Scientific Review of the Actual Events, Achievements and Problems». May 31, 2024. Berlin, Federal Republic of Germany: International Center of Scientific Research. 2024. Pp. 160-167.
7. Sobko O., Mazurets O., Didur V., Chervonchuk I. Recurrent Neural Network Model Architecture for Detecting a Tendency to Atypical Behavior Of Individuals by Text Posts. Theoretical and Practical Aspects of Modern Research. Proceedings of XXVI International scientific and practical conference. June 5-7, 2024. International Scientific Unity. Ottawa, Canada. 2024. Pp. 113-117.
8. Krak I., Zalutska O., Molchanova M., Mazurets O., Bahrii R., Sobko O., Barmak O. Abusive Speech Detection Method for Ukrainian Language Used Recurrent Neural Network. CEUR Workshop Proceedings, 2024, vol. 3688. Pp. 16-28.
9. O. Barmak, I. Krak, O. Mazurets, S. Pavlov, A. Smolarz, W. Wojcik, Research of efficiency of information technology for creation of semantic structure of educational materials. Advances in Intelligent Systems and Computing, 2020, vol. 1020, pp. 554–569.
10. Barmak O., Mazurets O., Krak I., Kulias A., Method for automated test tasks creation for educational materials. CEUR Workshop Proceedings, 2020, vol. 2711, pp. 309–320.
11. Slobodzian V., Kovalchuk O., Molchanova M., Sobko O., Mazurets O., Barmak O., Krak I. Text Data Vectorization Model of Ukrainian-Language Internet Communication Content. CEUR Workshop Proceedings, 2022, vol. 3171, pp. 561–571.

12. Slobodzian V., Molchanova M., Kovalchuk O., Sobko O., Mazurets O., Barmak O., Krak I. An Approach Based on the Visualization Model for the Ukrainian Web Content Classification. 2022 12th International Conference on Advanced Computer Information Technologies, ACIT 2022. 2022. pp. 400-405.
13. Zharnovskyi O., Sobko O., Klimenko V. Intelligent System for Neural Network Detection of Fake Document Images for Automated Personality Identification. Proceedings of IV International Scientific and Practical Conference «Innovative research and perspectives of the development of science and technology». January 29-31, 2024. Stockholm, Sweden. 2024. Pp. 337-343.
14. Novak Y., Mazurets O. Practical Application of Method of Automated Personal Identification by Fingerprints Using Convolution Neural Networks. Proceedings of V International Scientific and Practical Conference «Modern strategies of global scientific solutions». December 27-29, 2023. Stockholm, Sweden, International Scientific Unity. 2023. Pp. 136-140.
15. Mazurets O., Sobko O., Vit R., Pasternak V. Practical Approach for Detection by Deep Learning of Target Objects of Subject Area Based on Semantic Connectivity Indicators in Audio Database. Proceedings of XXIV International Scientific and Practical Conference «Modern Scientific Challenges are the Driving Force of the Development of Scientific Research». May 22-24, 2024. Bruges, Belgium. International Scientific Unity. 2024. Pp. 91-96.
16. Mazurets O., Zalutska O., Tyschenko O., Bohdanova A. An Approach to Using MobileNet CNN-model for Gesture Recognition. Proceedings of XXIII International Scientific and Practical Conference «Problems of Science and Technology: the Search for Innovative Solutions». May 15-17, 2024. Munich, Germany. 2024. Pp. 59-64.
17. Mazurets O. V., Klimenko V. I., Molchanova M. O., Sultanov A. V. Object-Oriented Intelligent System for Neural Network Detection of Sugar Crystallization Zones. Global Science: Prospects and Innovations. Proceedings of the 10th International scientific and practical conference. Cognum Publishing House. Liverpool, United Kingdom. 2024. Pp. 198-207.
18. Mazurets O., Molchanova M., Klimenko V., Klopotivskyi D. Datalogic Model for Image Recognition by Convolutional Neural Network Using Cloud Services. Proceedings of XXII International Scientific and Practical Conference «Modern Scientific Research: Theoretical and Practical Aspects». May 8-10, 2024. Oslo, Norway. 2024. Pp. 64-68.
19. Molchanova M., Mazurets O., Klimenko V., Kuflevsky Ev. Object-oriented model for neural network damage detection of mail packages. Proceedings of XIV International Scientific and Practical Conference «Solving Scientific Problems Using Innovative Concepts». March 13-15, 2024. Copenhagen, Denmark. 2024. Pp. 58-62.
20. Kovalchuk O., Slobodzian V., Sobko O., Molchanova M., Mazurets O., Barmak O., Krak I., Savina N. Visual Analytics-Based Method for Sentiment Analysis of COVID-19 Ukrainian Tweets. Book Chapter. Lecture Notes on Data Engineering and Communications Technologies. 2023. Vol. 149. pp. 591–607.