Multimodal Depression Recognition Using Data Analysis and Machine Learning

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Background Information

Current world's development brings a faster life pace and competition relationship as well as an increasingly heavy social pressure. The possibility of getting mental illnesses climbs dramatically. Depression, in represent of the emotional illnesses, has been catching attention of the international society for a long time. The WHO cites the data from IHME, showing that the depression patients have increased from 0.17 billion in 1990 to 0.28 billion in 2019, which already affects 3.8% of the global population. For China, the depression has become the second largest disease that exerts burden to the health system.

The most popular depression screening method adopted by the international society is having a psychology doctor to ask the patients based on scales. And they will make their final decision based on the score got from the scales. But this process has strong subjectivity components, which makes the screening not that accurate. Also, some of the patients may be concerned about their personal information and thus try to lie when answering the questions raised by doctors. Based on these facts, it is crucial to find a biomarker-based screening method to assist the judgement done by doctors.

In recent years, the development of data analysis and machine learning algorithms enables many industries to solve some difficult issues due to lack of computation ability. And the field of multimodal depression recognition becomes a heated topic in psychology. Researchers have come up with algorithms and methods that effectively recognize whether the patients have potential danger of catching depression or not. By this analysis, the problem of depression recognition is transformed to a problem of classification in machine learning. Further topics like using regression to monitor the degree of depression can also be discussed.

Feature Engineering

As mentioned above, the word "multimodal" indicates that the depression screening process is based on a model with multiple features or parameters. In medical fields, these features are described using the word "biomarkers". Frequently seen biomarkers for depressed patients are the GPS information, like the position entropy and daily steps. Since the depressed patients tend to stay at home for a long time, thus they tend to have a smaller position entropy as well as less daily steps. Other information like the phone use and social media use can also reflect whether the patient is experiencing depressed mood,

Some body-related to features are also proved to be efficient indicators of depression. Heart Rate Variability, calculated based on the ECG signals collected either by wearable devices or professional apparatus, is a strong indicator for depression. Note that the ECG data is quite complicated and one must extract features out in pre-processing stage using signal processing techniques, like Fast Fourier Transformation and Frequency Domain Analysis. Similarly, the EEG signal collected from patient's brain can perform an even better prediction of depression symptoms. But regarding the difficulty and precision of EEG collection, the true power of it is still undiscovered.

During these feature engineering process, scientist have tried numerous parameters and

features and looked for potential relationship between depression symptoms and these biomarkers. Needless to say, many papers are published to argue that none of their parameters are strong enough to indicate the depression.

Algorithms Used

1. SVM (Support Vector Machine)

Support Vector Machine, as a strong classification, is widely used to classify whether a patient is depressed or not. Given the features and the input, the SVM will transform the data to higher dimension and then classify the data into two different hyper surfaces. By this method, the data are easily split apart. Literature revies show that SVM performs especially well when using the EEG signal to predict depression. The difficulty for this algorithm is to get the optimal parameters.

2. kNN (k – Nearest Neighbor)

k-Nearest Neighbor is one of the most classic classification algorithms with high performance. It uses the k nearest neighbors of the tested point to determine the proper class. The distance usually used is the kNN is the Euclidian distance. However, literatures propose a better distance for EEG classification, which is called the squared inverse distance

$$d_{weighted} = \frac{1}{d^2_{euclidian}}$$

The disadvantage is that the cost of calculation is relatively big.

3. Naïve Bayes

Naïve Bayes classification is another classic classification algorithm that use the Bayes' Theorem

$$P(l \mid X) = \frac{P(X \mid l)P(l)}{\sum_k P(X \mid k)P(k)}$$

We will train the model to gain the knowledge about the probabilities of the thesis: given observation X, what the class l should it be in. Then we will use these probabilities to choose the most proper class for new observations.

The disadvantage is that this model is really sensitive to outliers and we thus have to preprocess the data carefully enough. Unfortunately, the biomarkers for depression, especially EEG signals, are always full of outliers.

4. All kinds of NNs (Neural Networks)

The development of Neural Networks enables a better classification result. Current researchers are still investigating the usage of NNs in depression prediction. Some of the papers show that the prediction accuracy and reach 90% which is a huge improvement on other models. However, the training process is tough.

Conclusion

Nevertheless, the big trend of human-computer interface is aiming at property explain the working pattern of human brain. And then develop computer-based techniques to assist it for health care or entertainment. In this sense, the data analysis and machine learning will certainly play an important role in the process.