DETECTING DEPRESSION FROM SOCIAL MEDIA USING A DEEP LEARNING BASED APPROACH

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This Report Presented in Partial Fulfillment of the Requirements for the Degree of Bachelor of Science in Computer Science and Engineering

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APPROVAL

This Project titled "Detecting Depression from Social Media using A Deep Learning Based Approach", submitted by Mahmudul Hasan Mahedi, ID No: 172-15-10051, Sabiqun Nahar Any, ID No: 172-15-9971, and Akash Roy ID No: 172-15-9967 to the Department of Computer Science and Engineering, Daffodil International University, has been accepted as satisfactory for the partial fulfillment of the requirements for the degree of B.Sc. in Computer Science and Engineering and approved as to its style and contents. The presentation has been held on 31 MAY 2021.

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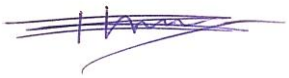

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We hereby declare that this project has been done by us under the supervision of **Professor Dr. Md. Ismail Jabiullah, Professor, Department of CSE,** Daffodil International University. We also declare that neither this project nor any part of this project has been submitted elsewhere for award of any degree or diploma.

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ABSTRACT

Unhappiness, feeling low, losing interest and excitement in daily life activities and it continues for a long time, causes depression. Depression can affect all types of age like young, adult and also child. Some signs and symptoms of depression are badly mood swings, loss of interest in daily life activities, less movement and speed, always feeling guilty and worthless, too much sleeping or Insomnia etc. Most of the people hesitate to talk about mental health. Nowadays depression is a common problem in our daily life. According to WHO, more than 264 million people are suffering from depression. The second major reason of death is suicide in the whole world and the age range is 15-29 years old and every year nearly 800000 people committed suicide due to depression. Researchers applied too many approaches to detect depression. But it is hard to understand someone's emotions from social media. In this paper, a Bangla dataset collected from Facebook to detect depression. LSTM, CNN, Combined CNN-LSTM are applied to detect depression from text. Later, performance comparisons are shown of these three architectures. Hope that it will help psychologists and the other researchers in their work based on depression. It will help to prevent harmful behaviors which occur due to depression.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

CHAPTER 1
Introduction

1.1 Introduction

Depression is a serious mental disorder which affects our thoughts, emotions and actions. Day after day the situation gets worse. Depression is a long-term problem. According to the World Health Organization, there are currently more than 264 million people of all ages in the world suffering from this depressive disorder [11]. Many people suffer from depression due to lack of relationship or disagreement with parents, friends or other close people. Many suffer from depression when they accept mental or physical humiliation. Death of a nearby per- son increases the risk of depression in many cases. Sometimes biochemical substances become deficient in people's brain and depression can occur. Sadly, depression is a disease that many people do not understand, or do not want to admit. Most of the people's share their feelings through posts or comments on social sites like Facebook, Twitter, Instagram. From those comments we are able to detect depression through sentiment analysis. In this pandemic situation due to COVID-19, it is more preferable and much easier to do sentiment analysis by collecting data from online sites than to collect data directly from people. We have collected Bangla comments from Facebook. We have tried to find out the feelings (Depressed or Not depressed) from those comments through a specific system. Researchers have been using various methods to analyze sentiment. Machine learning and deep learning techniques are being used widely for emotion or sentiment analysis from data. The effectiveness of data increases with the use of Deep learning techniques. We have given priority to deep learning for our work. There are many architectures that can be used for depression detection like- Long-short-term-memory (LSTM), Bidirectional Lstm (BiLSTM), Convolutional neural network (CNN), Recurrent neural network(RNN). We used LSTM, CNN and Combined CNN-LSTM architecture for depression detection in our work.

1.2 Motivation

People become depressed under the pressure of various events in our daily life. Many of us can overcome this situation and many of us can't. Those who can't, suffer mental distress day after day, their daily activities are disrupted and they are forced to live a stagnant life. Then it becomes a disease. This type of disease is more prevalent in certain types of personality (anxiety, small things seem big). There must be some purpose behind any work. One of the reasons we are doing our project is to understand people's sentiments through social media. Whether a person is mentally depressed or not is often understood in the status or comments given by him. In this project, we have collected comments from different types of social sites and tried to determine whether those comments are depressed or not depressed. Besides, there has been very little work on this topic on Bengali language. We are trying to determine the accuracy of the project by collecting Bangla comments from different social sites and applying different algorithms on it.

1.3 Rational of the study

There has been a lot of work on depression before. But detecting depression through social media comments was a challenging topic for us. A person's psychological condition is largely revealed through his comments. In the age of modern technology, a person expresses his thoughts through his status or comments on social sites. We have collected the comments from various social sites in our research and tried to detecting depression applying various algorithms on them. This research will help other researchers for analyzing depression in the future.

1.4 Research Questions

- How will this work help other researchers?
- Is this work beneficial for general people?
- How technology helps us for this project?
- What is the future work of this project?
- Why did we do this work?
- Why are we working with Bangla comments?

1.5 Expected Output

For a human being, depression is a major mental disorder. This is a serious issue. Overcoming depression is a very challenging thing for normal person.

We applied LSTM, CNN and combined CNN-LSTM on our dataset. We got the algorithms accuracy in the form of percentages. This will help us to detect depression from common people's Bengali comments.

1.6 Report Layout

- The following report is arranged in the subsequent manner. This report has 6 chapters. Each chapter has different subparts which are described in detail.
- In chapter 1, we discussed Introduction, Motivation, Rationale of the Study, Research Questions, Expected Output, Project Management and Finance, Report Layout.
- In chapter 2, Related Works, Research Summary, Scope of the Problem and Challenges are described.
- In chapter 3, Research Subject and Instrumentation, Data Collection Procedure, Statistical Analysis, and Implementation Assessments are discussed.
- In chapter 4, Experimental Setup, Experimental Results & Analysis and Discussion are discussed.
- In chapter 5, we discussed about the Impact on Society, Impact on Environment, Ethical Aspects and Sustainability.
- In chapter 6, discussion about the Summary of the Study, Conclusions and Implication for Further Study are given.

CHAPTER 2
Background

2.1 Introduction

Depression is a very familiar word to today's generation. But those who suffer from depression go through a lot of difficult situations. And depression is a mental illness like ten common physical problems. So it is very important to be aware of and diagnose depression. Previously, a lot of work has been done on depression detection. Many foreign researchers have been working on their own languages and on their own platforms. There has been more work in sentiment analysis than depression. Among them, there is very little work to detect depression in Bengali language. So we prefer to detect depression from comments of Bengali language. In this phase, we have tried to highlight the work of depression detection of various researchers on social media comments or status. The work of depression detection of various researchers on social media comments or status are discussing.

2.2 Related Works

Many analysts around the world have tried to increase the accuracy of depression detection. A few work has been done so far on the topic of depression. Some of them are described below.

In [1] authors applied LSTM for detecting depression from social media in Bangla Language. The authors used 5000 Bangla tweets. From the dataset they only used 984 depressives and 984 non-depressive tweets to balance the dataset and they excluded ambiguous and incomplete tweets. After applying LSTM in their dataset they found best accuracy 86.3.

The authors [2] did their work for predicting suicidal sentiment. They collected data which are written in Arabic from social sites like Twitter, Facebook etc. They built a CNN model to find out the specific suicidal notes from the dataset. Their CNNs model found the highest legibility was 82.14%, the second one was 77.04% and the third accuracy was 74.23%.

Researchers [3] used facebook comments to specify depression problems. They collected data using NCapture for their dataset. They processed their dataset by using LIWC2015. The authors used KNN classifiers. For their test set, they found Corse KNN as the best performing model that used evaluation matrix parameters like F- measure and precision recall.

In [4] researchers applied GRU for analyzing depression on a small dataset of Bangla. Each time they trained their model, they divided their data set into 80% training, 10% validity, and 10% test sets. They utilized tensor flow for implementation in their model. They got the best accuracy of 75.7%.

In [5] a team of Chinese researchers used a Chinese Microblogging site to collect their data for their dataset to predict depression. They used different time periods and windows for their work. The researchers worked with the registered users of Sina Weibo who were active in Sina Weibo site. They created an online questionnaire session which was composed by CES-D. They fixed a time period for the questionnaire session. The authors collected Sina Weibo user's data for their research with observation of two months. They used a software which is Chinese text analyzer named "Wen Xin" for processing the texts which were collected from Weibo Posts. They applied different features, Model Matrix and different kinds of observation windows on their dataset. They got accuracy from 63% to 82% for the classification models. From their experiment they also can predict the current situation depression.

The authors [6] worked with Machine Learning to detect depression from social media. They applied NLP, SVM, Naive Bayes algorithms to detect depression. They worked with twitter and facebook users for their dataset. They created a depression percentage table to measure the depression level and find out the depression condition of the users whom they worked with. Researchers tracked 100 twitter user's posts for 1 week. They found that 65% of them were depressed and 35% of them were non-depressed through their post. They also worked with 50 facebook user's 1 year posts and got 38% users were depressed and the rest were not. The researchers got accuracy of 74%, precision of 100% and recall of 60% 0f Naive Bayes.

The researchers [7] used Emotion AI for detecting depression. The result was presented through F1-score, Accuracy and Confusion matrix. They used Twitter API for their

database. They collected 1000 tweets for their dataset. They applied Naive Bayes and SVM algorithms in their dataset for their work purpose. The researchers got 83% accuracy on Multinomial Naive Bayes where SVMs accuracy was 79%.

Authors [8] discussed an approach for predicting depression from social media. There they used two classes for predicting depression. Later machine learning techniques applied for analyzing activities of depression prediction. Principal component analysis and SVM used as their classifier. From them SVM followed by a radial basis function shows a good accuracy.

The researchers [9] applied two methods named SVM and Naive Bayes on USC for classification. They classified their dataset as Depressed and Not-Depressed. Researchers got the accuracy of 57% on SVM and 63% on Naive Bayes.

In [10] authors did a survey using twitter dataset for analysis of sentiment. They did a relative study on different methods and approaches with twitter dataset. They compared the accuracy of Naive Bayes, SVM, Maximum-Entropy, Unigram, etc. algorithms and created a table based on algorithms and accuracy. It can be seen from the papers reviewed above, the researchers used LSTM, CNN, KNN, GRU, NLP, Naive Bayes, SVM architectures to make predictions from the depression dataset. In our paper we used LSTM, CNN and Combined CNN LSTM architectures on Bangla dataset which were collected from social media to detect depression.

2.3 Research Summary

We created a data set by collecting various Bangla comments from Facebook, Twitter. We used different algorithms and compared it in that dataset. We used the dataset for detecting depression. Three models used in our work. They are LSTM, CNN, Combined CNN-LSTM. Many researchers using a single model for their work.

We chose this work because in the modern age people express most of their emotions on social sites and through this work we can understand whether the comment given by a person is actually depressed or not depressed. We tried to explain which comment is depressed and which is not depressed through algorithm. After applying them, we found out which algorithm has the best accuracy. This is the main purpose of our work. This explain how useful the models can be for a dataset. We divided the dataset into two part.

Then we used the model and got the best accuracy. This is the summary of our research work.

2.4 Scope of the Problem

The emotional state of a person is a matter of many details. A person's surroundings have a profound effect on his thinking. This effect sometimes has an adverse effect on his mental health. So we tried to use people's mental state in our work through social media. In our work, we collected the comments on people's social sites and tried to divide them into two categories (Depressed and Not Depressed). In this way, we created a dataset by collecting Bangla comments from sites like Facebook, Twitter. We tried to determine their accuracy by applying various algorithms on that dataset. It is also possible to understand his mental state. We have tried to create a system by which a person's mental state (depressed or not depressed) can be informed through a comment or status made on social media. This work will help other researchers in this regard and we hope that many psychiatrists will be able to use the updated version in their own medical work.

2.5 Challenges

We do this work with online based data. When we collected data from different sites on the online platform, we had to face several challenges. Since it was a covid situation, it was not possible for us to work directly in the physical field. Also below are the challenges we have faced:

- Collecting quality data was tough.
- Since we are working on Bangla comments, it was a difficult aspect to select the appropriate Bangla comments.
- Many times there are unfinished comments, spelling and punctual problems. And these problems are comparatively more in Bengali comments. So this was also a quiet challenging issue.
- There has been less work on depression in the Bengali language, so we have received very few previous works related to this work. But others work on other languages had been supported.
- Some comments had to be omitted because they did not carry any emotional word.

CHAPTER 3

Research Methodology

3.1 Introduction

In this chapter we will discuss what algorithms, methods we used and how we worked in our work. We must have knowledge about when we work with any algorithm. It is important to have a prior idea of how an algorithm works on a data set and its potential output. We will also discuss in this chapter what technologies and instruments we have used in our work. From data collection to data pre-processing, leveling implementation, everything will be discussed. How to detect depression through data mining and its processes are discussed in this chapter.

Figure 1 exhibits workflows and others describe as below.

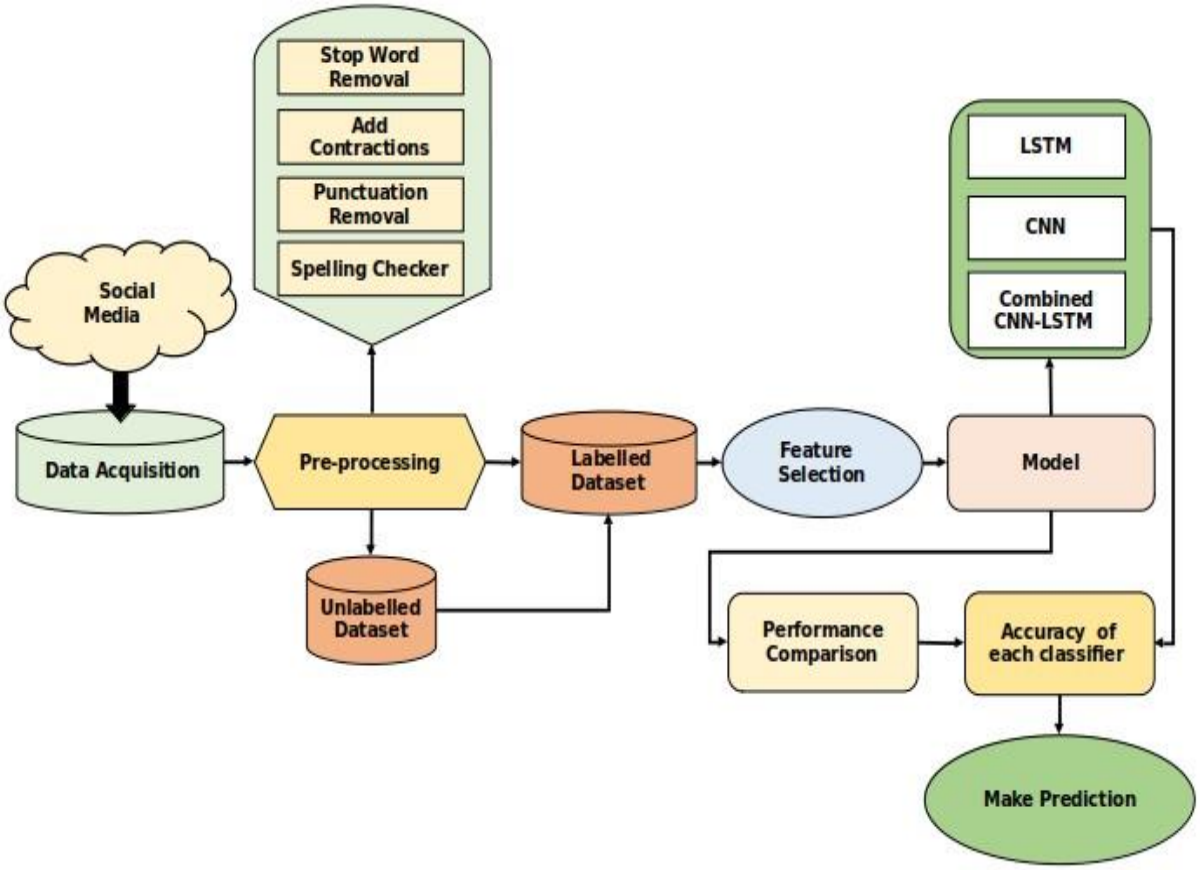

Figure 1: Workflow of depression detection system.

3.2 Research Subject and Instrumentation

Depression is a major problem in today's society. We tried to detect depression by collecting data from social media. We used deep learning algorithms for our work. Our main focus of research work was Emotion Detection field. Topic of our research is "Detecting Depression from Social Media using A Deep Learning Based Approach". It consists field of Natural Language processing system.

We used some software and hardware instruments. Names of the instruments are below:

- 7 th generation core i5-7200U, 3.1 GHz with RAM 8 GB
- NVIDIA® GeForce® 940MX 2 GB DDR3 Graphics
- 1 TB 5400 rpm

Developing tools-

- Python 3
- Numpy
- NLTK
- Tensor flow with GPU 2.2.0 version
- Windows 10
- Google Colab
- Google Chrome Browser

3.3 Data Collection Procedure

Now-a-days Depression affects people very badly. Now-a-days Depression affects very badly. In total 2000 Bangla data collected from Facebook for detecting depression. Some steps are followed to fit the data in the proposed required architecture. Data collection, Tokenization and Data processing were one of them. The steps are discussed in detail below.

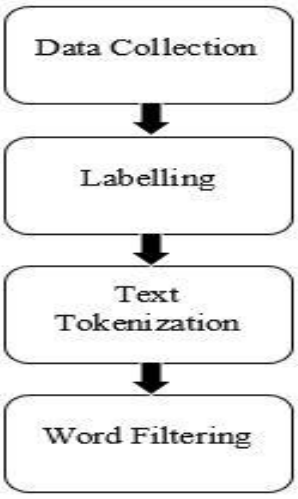

Figure 2: Data Collection Procedure

Data Collection: Data collection means collecting data in a structured way for the necessity of work. In data collection procedure, we chose a method for collecting data and sources from where can collect our expectable data. We must store the collecting data in a dataset. After exploring those data, we can get a specific result from the dataset. For our data collection, we have used social media (Facebook, twitter) as a source. Here, we used web scraping techniques. In this way, we can ensure the reliability of the data. It is a useful technique. We took 2000 ordinary Bangla comments from Facebook and stored them on a dataset.

Data Processing: Data processing is the process of transforming raw data or information into a certain format and making it suitable, so that machine can understand. Data processing helps to make more accurate and reliable decisions. 2000 Bangla Comments are collected from the Facebook. At first, we started to check all the collected comments and removed all character except Bangla. Secondly, we checked word spelling and find some wrong spelling. We corrected them. Then we removed unnecessary spaces, punctuation marks from the comments. After all this, we labeled a total of 2000 Bangla comments in our dataset for depression detection. For making the dataset more appropriate, we have categorized it into 2 sections- Depressed and Not-depressed. Within 2000 labeled data- 963 is depressed and 1037 is not depressed. For better accuracy, we balanced our dataset and took 1000 Depressed and 1000 Not-depressed comments.

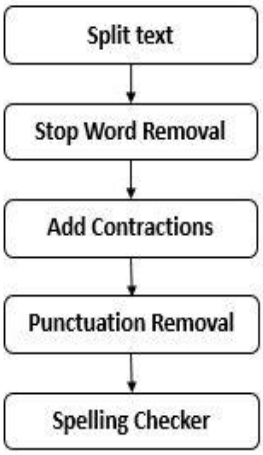

Figure 3: Data Processing System

Table-1 shows a sample of our dataset.

Table 1: Sample Dataset

Data	Label
মন থেকে চাইলে মিলবে আর পেয়েও যাবেন।	**Not_depressed**
চিন্তাভাবনা শেষ ভরসা।	**Depressed**
মন ও চিন্তা ভাবনার মিল দুইটাই দরকার।	**Not_depressed**
কোন যাতনায় কাঁদবে তুমি, মরবে মরার আগে।	**Depressed**
আপনার সাথে দেখার করার খুব ইচ্ছা হয়।	**Depressed**
যার পাতিলে ভাত নাই তার জন্য লকডাউন ও নাই।	**Depressed**
আমি হার মানতে চাইনি।	**Not_depressed**
পিছিয়ে পড়লে মন খারাপ করা যাবে না।	**Not_depressed**
হারাবে পথ আর্তনাদের বৃষ্টি রাতে।	**Depressed**
আমি কি ভুলিতে পারি ?	**Depressed**
সুস্থ থাকুন - ভালো থাকুন সবাই।	**Not_depressed**
যেখানে হারিয়ে যায় চোখের সীমারেখা।	**Not_depressed**
কিছুই পারলাম না জীবনে।	**Depressed**
ভালো চায়ের জন্য অনেক দূরের পথ পাড়ি দিতেও আমি রাজি আছি।	**Not_depressed**
নিস্তব্দ নদীর কাছে, আমি এক স্বপ্নচারিতা।	**Depressed**

Tokenization: Tokenization is a way of transmitting tactful data through an API call or batch with some special procurator called as token. Token replaced the original data with the same length and format. In this paper, Keras tokenizer used to encode the words as numerical values or numbers and take them as input.

Word Embedding: This paper based on a Bangla text dataset. Word embedding is an important and powerful way to represent texts and documents. Word embedding is a process where a word has a similar meaning for the similar illustration. In deep learning this approach is used as a key of revolution for representation of words and documents. Pretrained word embedding is that process where embeddings are trained on large dataset and saved for other works. Pretrained embedding gives more accuracy on a dataset. In our paper we used pretrained embeddings ”bnword2vec” for better accuracy with less time.

3.4 Implementation Assessments

At present the methods of deep learning are developing very fast. There are many models to work in deep learning. Those models are used for different tasks. Such as, CNN is used for image processing related work. For our dataset we used LSTM, CNN and Combined CNN-LSTM models. Their description is given below.

Long Short Term Memory: LSTM is an architecture that has a memory attached. That memory remembers and makes decisions based on the previous data that was received as input. This architecture is very suitable for written data input. This architecture has the ability to capture the feelings of a sentence. LSTM architecture can work well with large sequences of data. LSTM can hold previous activities for a long time which RNN can’t. Lstm works using 3 gates. It uses input gate to take input. It uses ot and forget gate ft to control the quantity of information in the previous memory. The output gate is used to give the output.

In order to use LSTM architecture, at first we used collected text as input. We fed those inputs to the embedding layer. We added pre trained word2vec with 300 dimensions to the embedding layer. An activation function ReLU used into the embedding layer. Then A dropout of 0.25 rate was added to avoid overfitting. We used the hidden layer of Lstm

which was 128 in size. Then used ReLU activation function of the fully connected layer of size 128. After using the ReLU activator, again we added a dropout of 0.25 rate. Finally, we used the softmax function to separate the Depressed or Not-depressed comments from the input.

We can see the working process of LSTM in figure 4 given below.

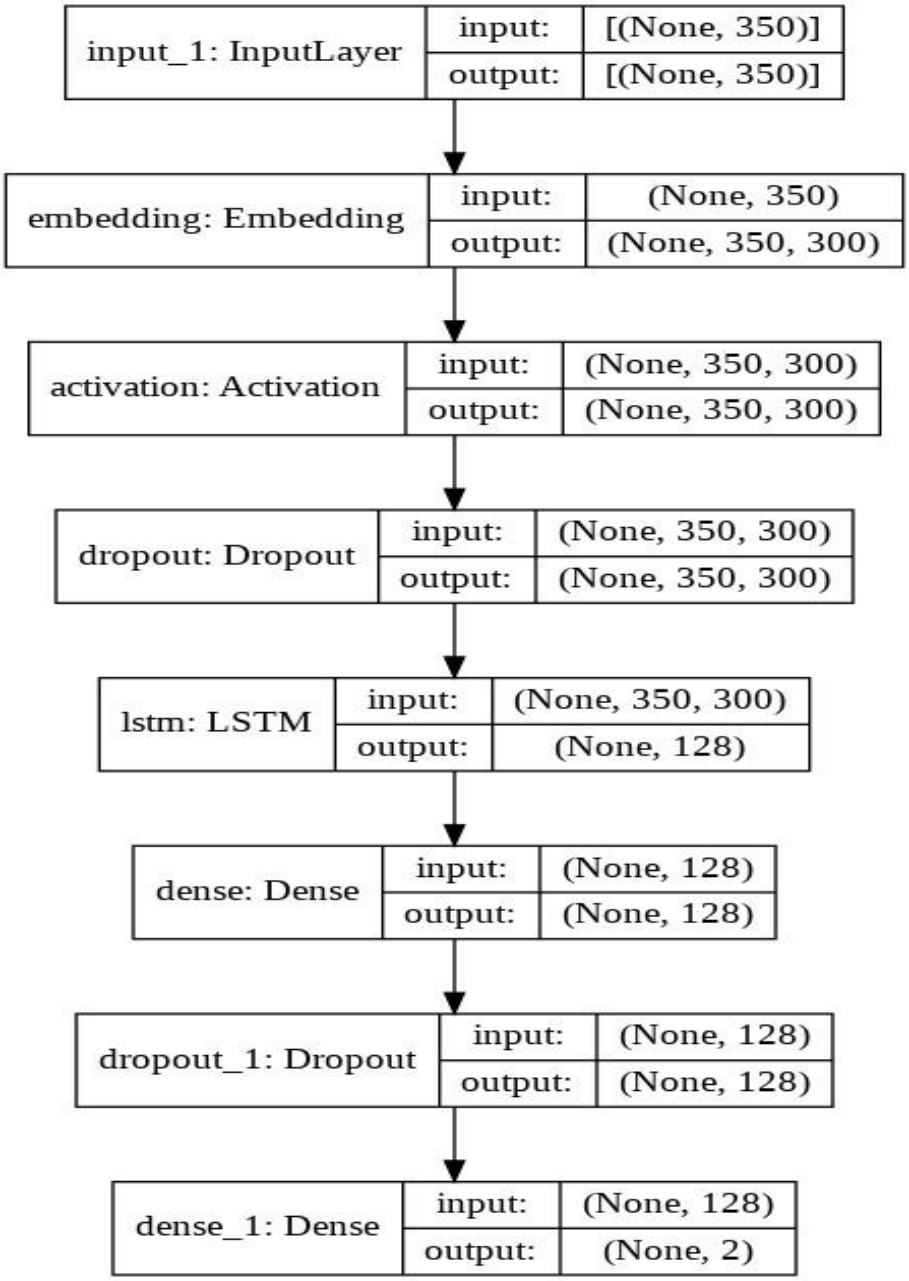

Figure 4: Working process of LSTM

Convolutional Neural Network: CNN architecture is basically used for image associated work. However, at present it is also being used for various purposes of NLP [12]-[13]. We used CNN architecture in our work. The description of its working process on our paper is given below:

We can see the working process of CNN in figure 5 given below.

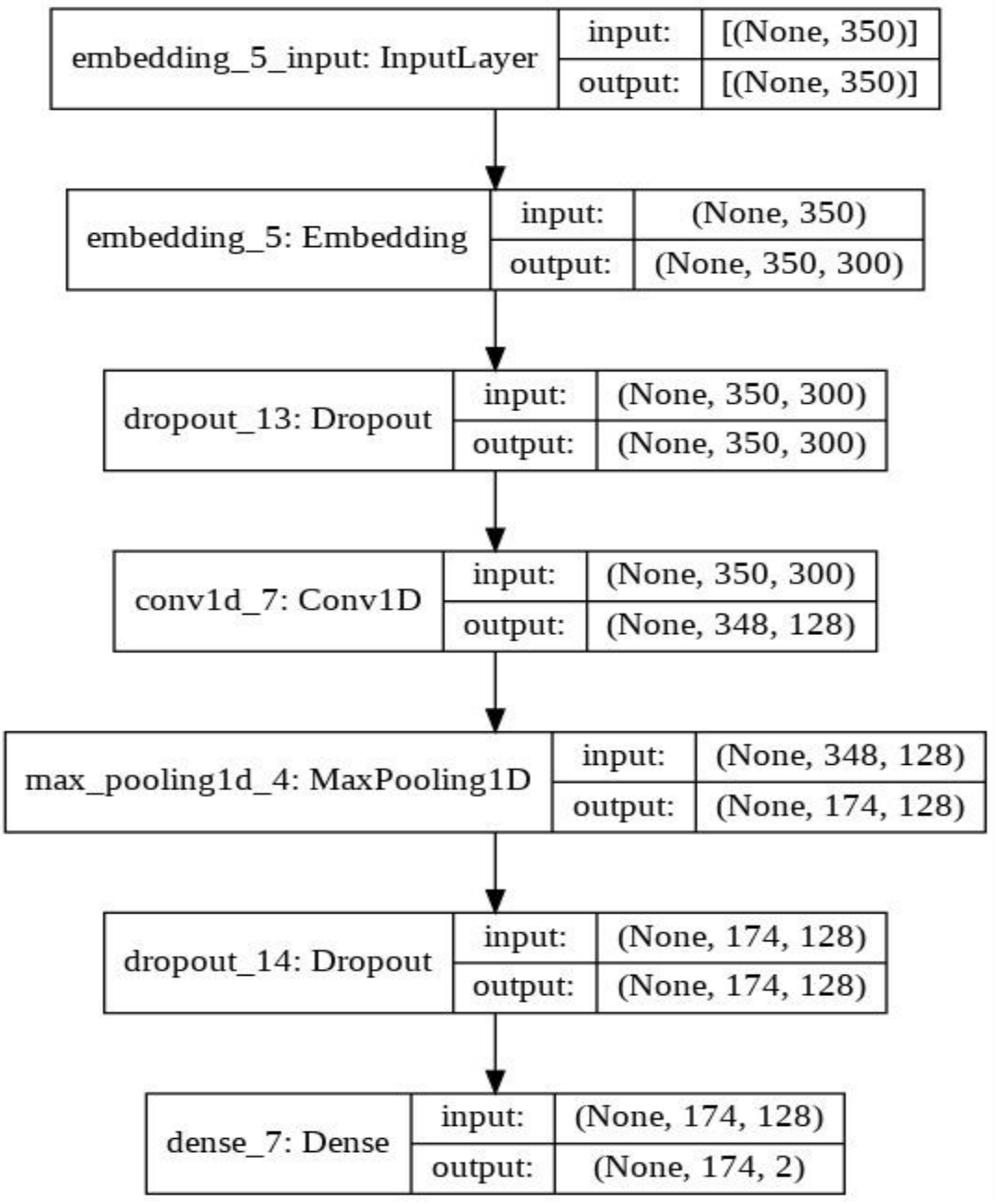

Figure 5: Working process of CNN

First we fed the input text into the embedding layer as a matrix. Then we added the 300 dimension pretrained word2vec to the embedding layer. Then added ReLU activation function to the embedding layer. To reduce the over fitting, a dropout of 0.25 rate added. We added a Convolutional layer of 128 filters, kernel size 3 3 and padding ”Valid” to provide the function map from the input and used activation function relu. To increase computation power, dimensionality needs to reduce. For this, we used Max pooling layer.

After using Max pooling layer, again we added a convolutional layer of 256 filters keeping the kernel size and padding the same. We applied a Global Max pooling layer to generate global value. We added a dropout of 0.3 rate. Then we added the fully connected layer of 256 in size. We used the activation function relu again here. Then we used the drop out of 0.25 rate again for avoiding the over fitting problem. Finally, we used the softmax function for classification which differentiate the Depressed and Not-depressed comments.

Combined CNN-LSTM: Combined CNN-LSTM architecture improves the accuracy of text classification [14]-[15]. Combined cnn-lstm architecture used for predicting sequence issues with some spatial input. Combined CNN-LSTM works using CNN layer with the help of LSTM for characteristic extraction of data.

At first, our collected text data was fed into the embedding layer as input. Then we used the activation function relu. We used a drop out of 0.25 rate. Then we added a CNN convolutional layer of 128 filters, kernel size 3 3, padding being valid and the relu activation function added. Again we used another cnn convolutional layer whose filter size was 256 but kernel size and padding was the same as before. We added relu activation here also. After using the convolutional layer, we used a max pooling layer. It was used to reduce the dimension which increases the computation power. We added a lstm layer size of 256. Then we used a fully connected layer of 256 dimension and added relu activation. To reduce the problem of overfitting, we used a drop out of 0.25 rate again. Finally, we used the softmax function like the previous architectures for classification.

We can see the working process of Combined CNN-LSTM in figure 6 given below.

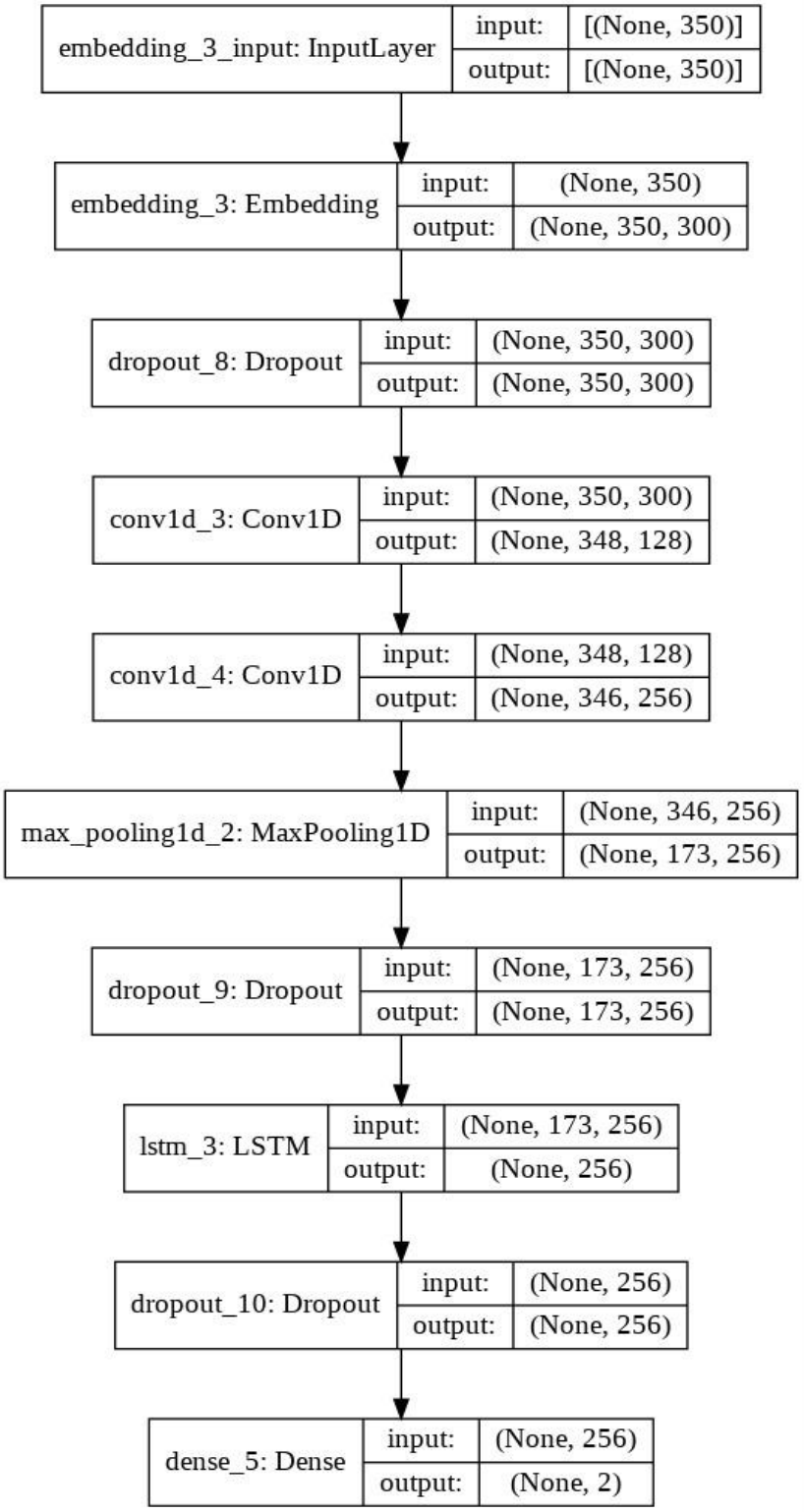

Figure 6: Working process of Combined CNN-LSTM

Classification results of these algorithms given below.

Table 2: Classification Result

Text	CNN Prediction	LSTM Prediction	Combined CNN-LSTM Prediction	Classification Result
ভুল যেমনি মানুষকে সিখায় । তেমনি ভলোবাসা মানুষকে কাদায়	Not Depressed	**Depressed**	Not Depressed	**Depressed**
বাহ উজ্জ্বল ভবিষ্যৎ দেখতেছি এখন	**Not Depressed**	Depressed	**Not Depressed**	**Not Depressed**
দীর্ঘসূত্রিতা ও আলস্যকে প্রশ্রয় দেবেন না। যখন যা করা প্রয়োজন, তখনই তা করুন	**Not Depressed**	**Not Depressed**	**Not Depressed**	**Not Depressed**
কাউকে ভালবেসে তাকে কষ্ট দিলে সে নিজে ও কষ্ট পায়	**Depressed**	Not Depressed	**Depressed**	**Depressed**
জানি ফিরবেনা এই মনের নিড়ে তবুও অপেক্ষায় থাকবো সারা জীবন ধরে	**Depressed**	**Depressed**	**Depressed**	**Depressed**

CHAPTER 4

Experimental Result and Discussion

4.1 Introduction

Our research topic is " Detecting Depression from Social Media using A Deep Learning Based Approach." Depression is a person's mental state. Depression causes a normal person cannot able to lead his normal life. They become discouraged in her aesthetic life. The purpose of our research is to determine whether an ordinary person is depressed or not depressed which we can find out by their comment on social sites. We used several algorithms in our research to detect depression. We tried to detect depression using LSTM, CNN and Combined CNN-LSTM algorithm. Our research will help to determine the mental state (depressed or not depressed) of a person from the Bengali comments made on social media.

4.2 Experimental Setup

Our main purpose is to determine depressed or not from the comments given by people on social media. That's why we collect Bangla comments from social sites. Then we created a dataset. Spelling checker, punctuation removal, add construction have been used to make the dataset correct. We used pandas, numpy library for data pre-processing. This is the setup of our work in which various algorithms have been applied for better results. Tokenization, word embedding, tensor have been used to get best accuracy.

4.3 Experimental Results and Analysis

Hyper-Parameter Tuning: To upgrade a selected variable that is defined Hyper-Parameter Tuning is used. The defined variable known as the hyper-parameter metric. For our work purpose we used some predefined parameters in our architecture which were called hyper-parameters. These parameters helped our architecture to work smoothly. First of all, we tuned the parameters properly to work in our architecture. Word embeddings trained using word2vec that had 5000 vocabularies. To gain the accuracy of our architecture we used batch size 128, epochs 75 and learning rate 0.001 as the hyper-parameters.

Result Comparison and Analysis: We used 80% of our collected data for training. The rest of data used for testing. We defined the Hyper Parameters into the architecture. Then we started compiling the architectures. We applied Adam optimizer and binary cross entropy loss function to compile our architectures. Then we used .fit( ) technique to start the training. For validation, we fraction-ed the dataset into 15% within this technique. After training all the architectures we got the best accuracy 95.50% from CNN.

Table 3 shows the classification report of LSTM architecture. Here we can see that the average of Precision is 0.65 which is better than the average of Recall and f1-score. The average of Recall and f1-score is same. The average of Recall and f1-score is respectively 0.64 and 0.64. In case of Depressed, the Precision is 0.62, Recall is 0.66 and f1-score is 0.64. The Precision, Recall and f1-score of Not depressed is respectively 0.68,0.62 and 0.65. The Precision and f1-score of Not depressed is better than Depressed. But the Recall of Depressed is better than Not depressed.

Table 3: Classification Report of LSTM

Architecture	**Precision**	**Recall**	**f1-score**
Depressed	0.62	**0.66**	0.64
Not-depressed	**0.68**	0.62	**0.65**
Average	0.65	0.64	0.64

In Table 4 the classification report of CNN is shown. In the case of CNN architecture, the average of Precision, Recall and f1-score is respectively 0.69,0.67 and 0.68. Here is also the average of Precision is bit better than Recall and f1-score like LSTM architecture. For Depressed, the Precision is 0.66, Recall is 0.73 and f1-score is 0.69. For Not depressed, the Precision is 0.74, Recall is 0.62 and f1-score is 0.67. Here, the Precision of Not depressed is much better than Depressed. But the Recall and f1-score of Depressed is better than Not depressed.

Table 4: Classification Report of CNN

Architecture	**Precision**	**Recall**	**f1-score**
Depressed	0.66	**0.73**	**0.69**
Not-depressed	**0.74**	0.62	0.67
Average	0.69	0.67	0.68

In Table 5 the classification report of Combined CNN-LSTM architecture is shown. From the Combined CNN-LSTM architecture, we get the average of Precision is 0.67 which is best. The average of Recall and f1-score is respectively 0.66 and 0.66, both are same here also like LSTM. The precision, Recall and f1-score of Depressed is 0.65, 0.60 and 0.62 and the Precision is 0.69, Recall is 0.71, f1-score is 0.70 for Not depressed. In this architecture, the Precision, Recall and f1-score is much better for Not depressed.

Table 5: Classification Report of Combined CNN-LSTM

Architecture	**Precision**	**Recall**	**f1-score**
Depressed	0.65	0.60	0.62
Not-depressed	**0.69**	**0.71**	**0.70**
Average	0.67	0.66	0.66

The table 6 below shows average precision, recall, f1-score of LSTM, CNN, Combined CNN-LSTM.

Table 6: Average Comparison of precision, recall and f1-score

Architecture	**Precision**	**Recall**	**f1-score**
LSTM	0.65	0.64	0.64
CNN	**0.69**	**0.67**	**0.68**
Combined CNN-LSTM	0.67	0.66	0.66

Table 7 shows the performance comparison of our applied architectures. Three architectures were used. They are LSTM, CNN and Combined CNN-LSTM. We got accuracy 94.29% using LSTM. We also used a combination architecture of CNN and LSTM and got accuracy 94.69%. But we got the best accuracy 95.59% from CNN.

Table 7: Performance Comparison of Architectures

Architecture	**Technique**	**Top accuracy**
LSTM	word2vec	94.23%
CNN	word2vec	**95.50%**
Combined CNN-LSTM	word2vec	94.69%

4.4 Discussion

The outcome of any work depends on how the work is done step-by-step. From data collection to data preparation, data processing, applying algorithms to dataset, after doing all these things properly we can see the best output or results. Since we worked with Bangla Comment, it has not been possible to set our data on a very large scale. We have used 1000 Depressed and 1000 Not Depressed Bangla Comment to balance the dataset. We found Deep Learning Methods Suitable for our work. We applied three algorithms- LSTM, CNN, Combined CNN-LSTM on the data set of this work. We got accuracy 94.23% in LSTM and 94.69% accuracy in Combined CNN-LSTM. But we got the best accuracy 95.50% from CNN. It would be possible to get better accuracy if we could work with bigger dataset. In future, we will achieve better accuracy by working on larger dataset.

CHAPTER 5

Impact on Society, Environment and Sustainability

5.1 Impact on Society

Every work has some effect on the society. With our research, everyone from teenagers to adults can benefit mentally. Nowadays, everyone from teenagers to adults use social media. Due to which they directly or indirectly express their thoughts through comments or status. If we can verify those comment properly, we can determine which comment is depressed or not depressed, then we can be aware of a person's mental state. Depression is a disorder that is affecting more and more people. And if depression can be detected through social media comments, I hope it will contribute to the development of a depressed patient's mental state.

5.2 Impact on Environment

When a person suffers from depression, he loses his sense of well-being compared to ordinary people. He has a detrimental effect on the environment as well as himself. In many cases, a person becomes more and more smoker when he or she is depressed. It is as harmful to the environment as it is to one's health. The toxic smoke from cigarettes pollutes the air as carbon dioxide rises in the air. A depressed person is more prone to various addictions than a normal person which is a threat not only to him but also to the whole environment. Moreover, a depressed person does not play a very helpful role in protecting the environment. So it can be said that depression harms not only mentally but also physically and even the environment. Our research will help bring a person back to a healthy life by detecting depression. We also hope that this will benefit the environment.

5.3 Ethical Aspects

Since we have dealt with people's comments, we have to keep in mind strictly so that no one's personal life is affected and no one's personal identity is revealed. We must keep in mind what kind of comments we are collecting and so that no one's personal life is harmed. In our work, we took the help of random and isolated comments, not the comments of any

individual person. We must remember what the main purpose of our work is not to have a humble effect on anyone's personal life by it. We strictly maintained the privacy of personal life in our work.

5.4 Sustainability Plan

Depression is a threat to the mental and physical health of any person. It disrupts normal life. The purpose of our research is to detect depression through Bangla comments on social media. So that this system can help other researchers in this related work in future and comes to the aid of a doctor to know about the condition of a depressed patient. If a depressed patient can be detected with depression and brought back to normal life through this system, it will be useful in personal and social life.

CHAPTER 6

Summary, Conclusion, Recommendation and Implication for Future Research

6.1 Summary of the Study

Depression is a major issue in today's world. Depression is a mental illness that causes a person to lose the motivation to lead a normal life. Even at one stage of depression, people choose the path of suicide. We create data sets by collecting Bangla comments on various social media (Facebook, Twitter) in our research papers. We detected depression through the application of various algorithms on the data set. We created a data set of 2000 Bangla comments. We applied CNN, LSTM and Combined CNN-LSTM on this data set. We got a good accuracy of these algorithms. We got 94.23% accuracy for LSTM, 94.69% accuracy for Combined CNN-LSTM and got the best accuracy from CNN at 95.50%. There are more detailed plans for this project in the future. Hope to get better accuracy by using bigger datasets.

6.2 Conclusion

In this paper a deep learning based architecture discussed to detect depression on Bangla comments from Social media(Facebook). We have tried to detect two types of conditions i.e. Depressed and not depressed from the collected data and set the architectures accordingly. To detect depression, we used state of art Deep learning architectures. We have used LSTM, CNN and Combined CNN-LSTM for our work. Among these architectures, we got the best accuracy by using CNN architecture. We used pre trained Word2Vec with 300 dimensions in our work. We hope that our work will encourage those who want to detect depression by using Deep learning architectures.

In the future, different types of dimensional as well as other pre-trained word2vec can be used. We will use deeper layers for better performance. We can work with images for detecting depression from Social media. We can also work on a dataset which will be collected physically.

6.3 Implication for further Study

There are more plans to work on a larger scale in the future with this research paper. It is not possible to use very large data sets in this work, but there are plans to work with larger data sets in the future. There are also plans to work with other more algorithms for better accuracy.

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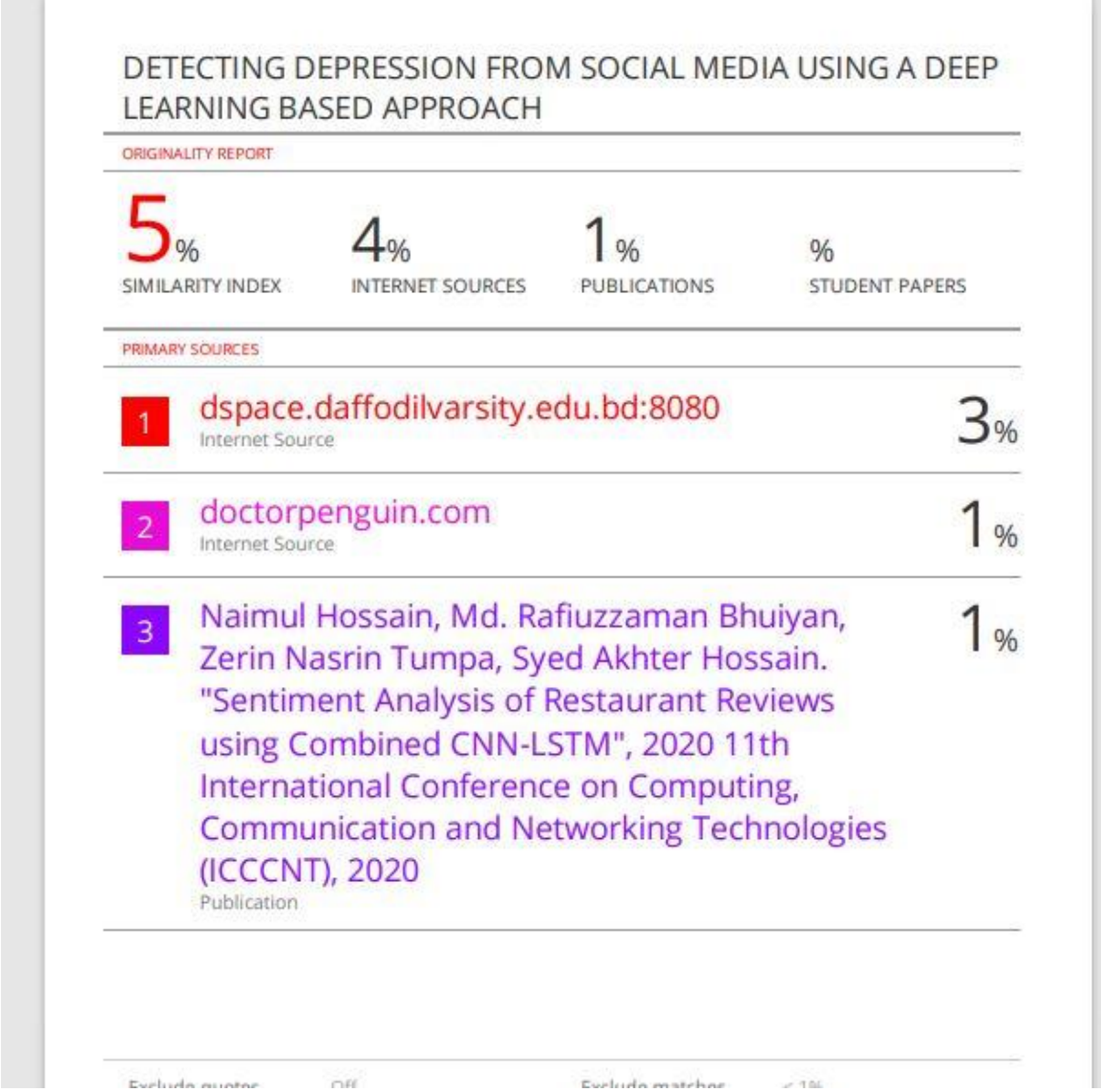

DETECTING DEPRESSION FROM SOCIAL MEDIA USING A DEEP LEARNING BASED APPROACH

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