In the name of God

IUST
Iran University of
Science and Technology

Department of Computer Engineering

Natural Language Processing

Final Phase Report [*]

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[*] https://github.com/yegmor/NLPProject

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Abstract

In this project, we tried to use Natural Language Processing to better understand Depression and Anxiety posts. The dataset is gathered from Reddit communities r/depression and r/Anxiety.

For this project, at first, we wrote a project proposal (Google Docs), and afterwards, in the first phase (Google Docs), we gathered data and made some exploratory data analysis.

In the final phase, we went deeper, and tried various NLP tasks, such as, computing Word2Vec, Tokenization, Parsing, and creating a language model based on our the dataset.

Part I

Word2Vec

Filename: 3_word2vec.ipynb

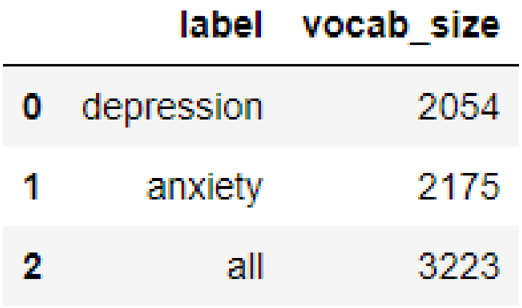
1 Overview

1.1 Code

We used Gensim implementation of word2vec.

For this part we have three Word2Vec models, named as dep_w2v_model, anx_w2v_model, and all_w2v_model. Moreover, with boolean parameters, load and save, the model will be saved and/or loaded in the my_word2vec function.

Table 1: Word2Vec vocabulary size



	label	vocab_size
0	depression	2054
1	anxiety	2175
2	all	3223

1.2 Results and Examples

In this part, we used t-SNE visualization. t-SNE is a non-linear dimensionality reduction algorithm that attempts to represent high-dimensional data and the underlying relationships between vectors in a lower-dimensional space.

To make the visualizations more relevant, we will look at the relationships between a query word (in **red**), its most similar words in the model (in **blue**), and other words from the vocabulary (in **green**).

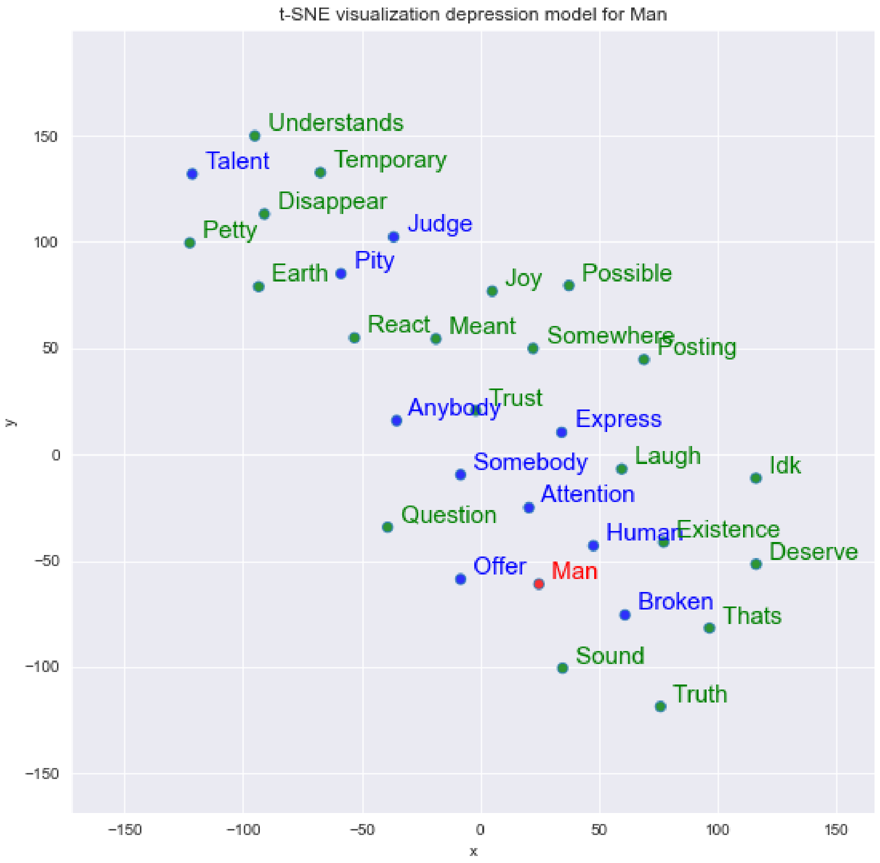


Figure 1: t-SNE visualization for man

Part II

Tokenization

Filename: 4_tokenization.ipynb

2 Overview

2.1 Code

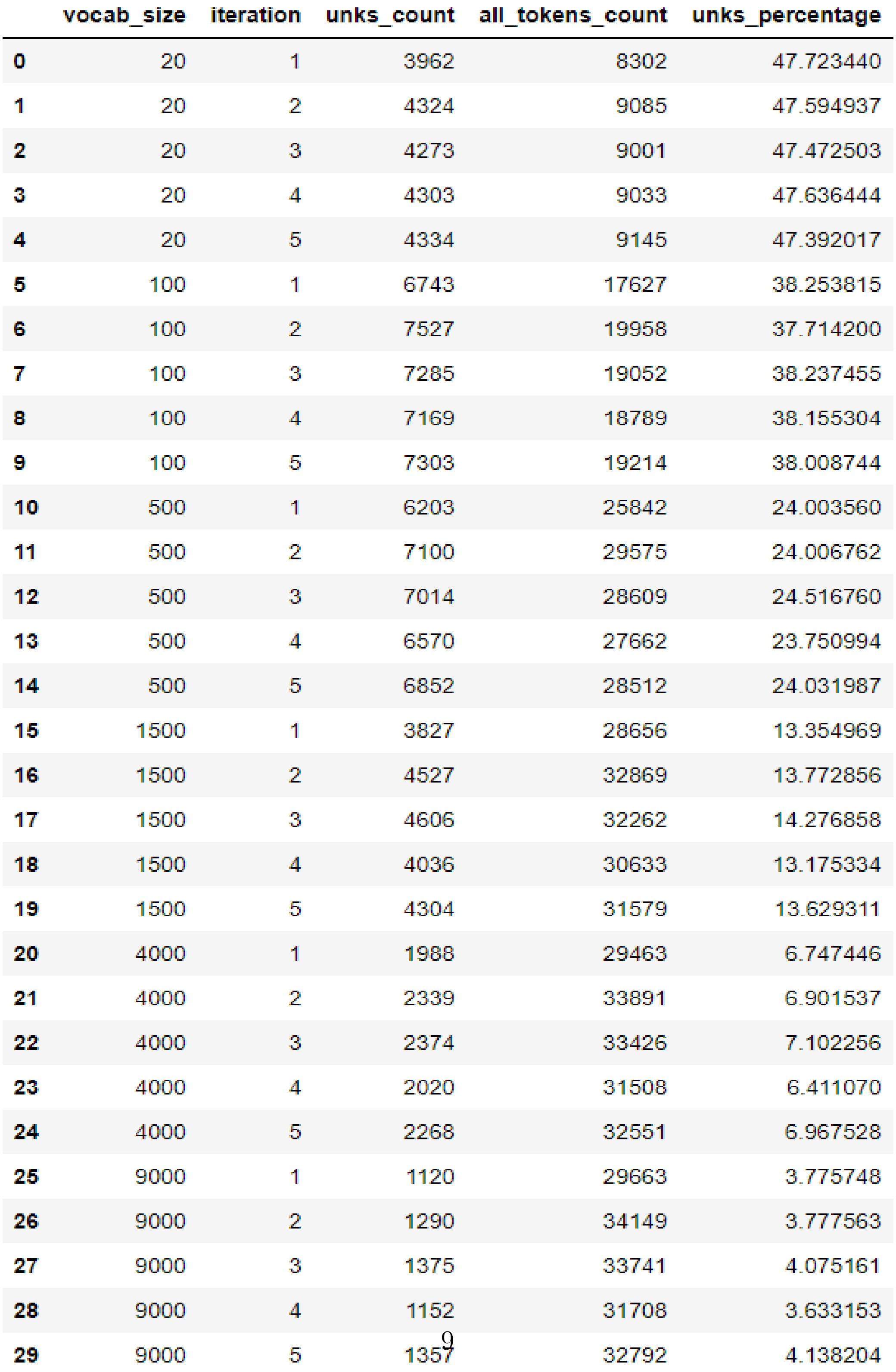
In this part, we have used KFold to split(=5) our data into train and test. Afterwards, we train SentencePiece model based on the data. Lastly, we evaluate the model by computing <UNK> on our test dataset, and finally choosing as well as hard coding the best model for the tokenizer.

2.2 Results and Examples

Based on Table 2, in which the percentage of unk tokens to all tokens is calculated for each vocabulary size, we can conclude that by setting higher vocabulary size for the tokenizer, the number of <UNK>s decreases.

Therefore, the best tokenizer is the one with the larger vocabulary size (=9000).

Table 2: Tokenizer outcome based on different vocabulary sizes



	vocab_size	iteration	unks_count	all_tokens_count	unks_percentage
0	20	1	3962	8302	47.723440
1	20	2	4324	9085	47.594937
2	20	3	4273	9001	47.472503
3	20	4	4303	9033	47.636444
4	20	5	4334	9145	47.392017
5	100	1	6743	17627	38.253815
6	100	2	7527	19958	37.714200
7	100	3	7285	19052	38.237455
8	100	4	7169	18789	38.155304
9	100	5	7303	19214	38.008744
10	500	1	6203	25842	24.003560
11	500	2	7100	29575	24.006762
12	500	3	7014	28609	24.516760
13	500	4	6570	27662	23.750994
14	500	5	6852	28512	24.031987
15	1500	1	3827	28656	13.354969
16	1500	2	4527	32869	13.772856
17	1500	3	4606	32262	14.276858
18	1500	4	4036	30633	13.175334
19	1500	5	4304	31579	13.629311
20	4000	1	1988	29463	6.747446
21	4000	2	2339	33891	6.901537
22	4000	3	2374	33426	7.102256
23	4000	4	2020	31508	6.411070
24	4000	5	2268	32551	6.967528
25	9000	1	1120	29663	3.775748
26	9000	2	1290	34149	3.777563
27	9000	3	1375	33741	4.075161
28	9000	4	1152	31708	3.633153
29	9000	5	1357	32792	4.138204

Part III

Parsing

Filename: 8_parsing

3 Overview

In this part, we used Stanza, which is a a Python NLP Package, and a collection of accurate and efficient tools for the linguistic analysis of many human languages. Starting from raw text to syntactic analysis and entity recognition, Stanza brings state-of-the-art NLP models to languages of your choosing.

More specifically, we used their Online Demo to create a manual CoNLL file based on our dataset (my_test.conll). Later, we can use Universal Dependencies CoNLL viewer to automatically generate parse tree from CoNLL file.

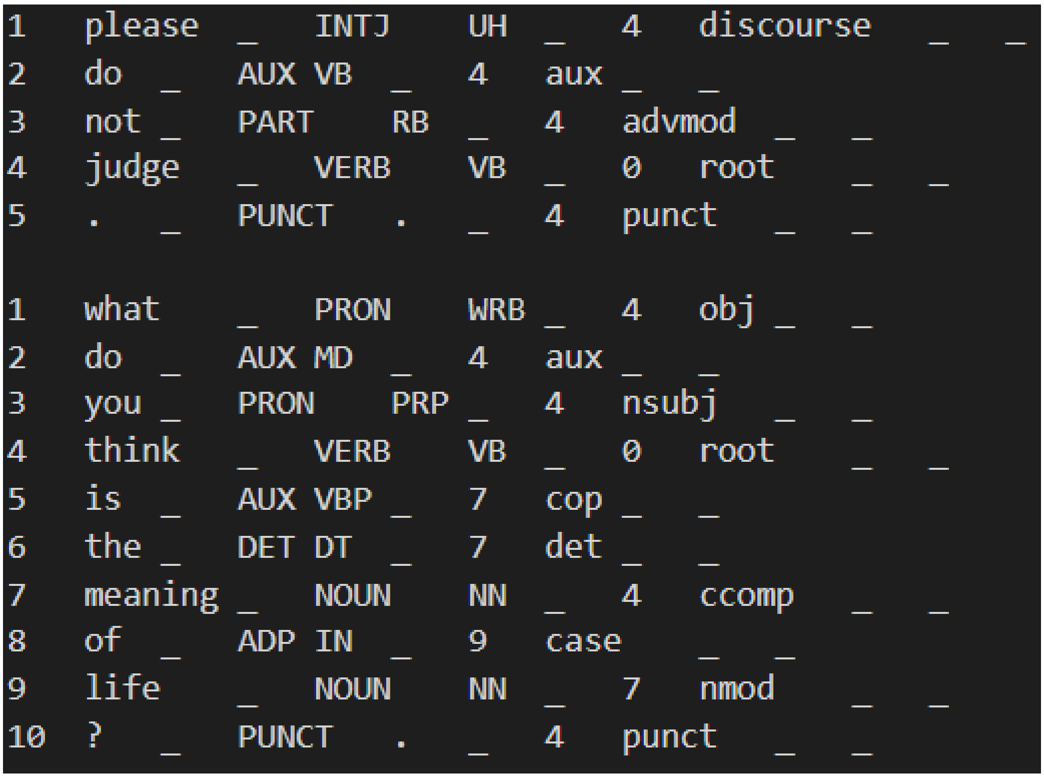
3.1 Results and Examples

We chose 10 sentences from our dataset as shown below.

1. I never really showed any sadness when I am with someone.
2. he is a good person, and I know that.
3. how am I feeling?
4. last year I went through a huge amount of stress.
5. how can you tell the difference between an actual issue or anxiety?
6. please do not judge.
7. what do you think is the meaning of life?

8. today was a very strange day.
9. all these emotions are too much sometimes.
10. everybody is going to die.

Afterwards, we created a CoNLL file as shown in Figure 2.

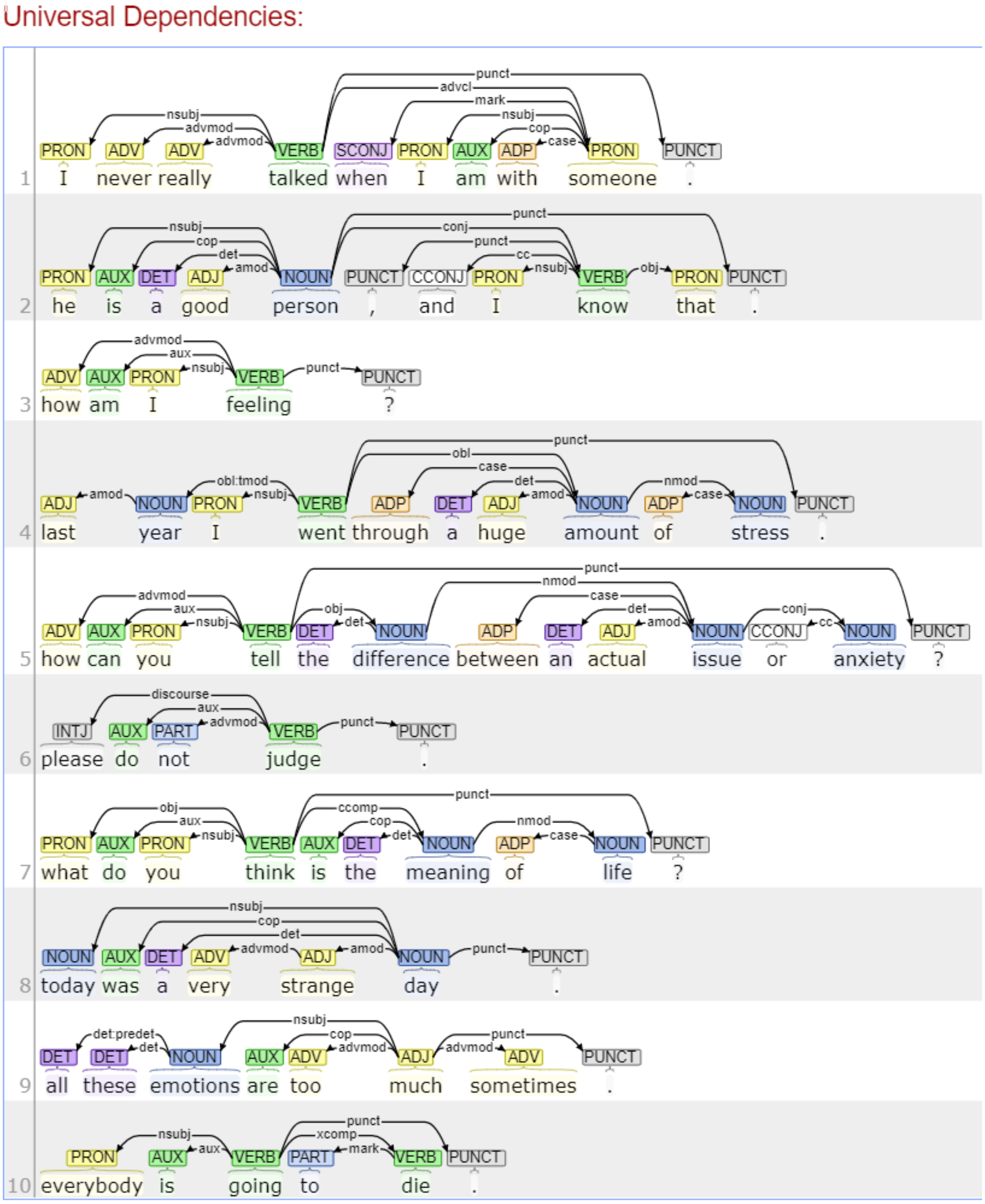


```
1   please  _   INTJ    UH  _   4   discourse   _   _
2   do  _   AUX VB  _   4   aux _   _
3   not _   PART    RB  _   4   advmod  _   _
4   judge   _   VERB    VB  _   0   root    _   _
5   .   _   PUNCT   .   _   4   punct   _   _

1   what    _   PRON    WRB _   4   obj _   _
2   do  _   AUX MD  _   4   aux _   _
3   you _   PRON    PRP _   4   nsubj   _   _
4   think   _   VERB    VB  _   0   root    _   _
5   is  _   AUX VBP _   7   cop _   _
6   the _   DET DT  _   7   det _   _
7   meaning _   NOUN    NN  _   4   ccomp   _   _
8   of  _   ADP IN  _   9   case    _   _
9   life    _   NOUN    NN  _   7   nmod    _   _
10  ?   _   PUNCT   .   _   4   punct   _   _
```

Figure 2: conll format of 6th and 7th sentences

For creating the .conll we used Stanza visualization to help us understand Universal Dependencies. (Figure 3)



1 I never really talked when I am with someone .

2 he is a good person , and I know that .

3 how am I feeling ?

4 last year I went through a huge amount of stress .

5 how can you tell the difference between an actual issue or anxiety ?

6 please do not judge .

7 what do you think is the meaning of life ?

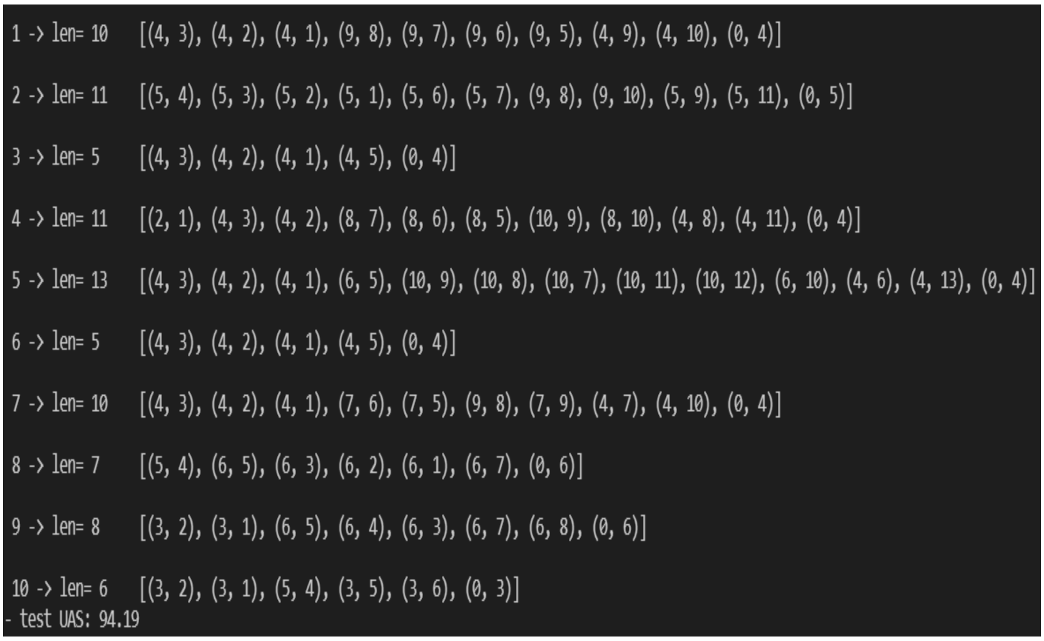
8 today was a very strange day .

9 all these emotions are too much sometimes .

10 everybody is going to die .

Figure 3: Universal Dependencies for 10 sentences

The reported Unlabeled Attachment Score (UAS) on our test file was 94.19, and the output of the code for dependencies are show in Figure 4.



```
1 -> len= 10    [(4, 3), (4, 2), (4, 1), (9, 8), (9, 7), (9, 6), (9, 5), (4, 9), (4, 10), (0, 4)]

2 -> len= 11    [(5, 4), (5, 3), (5, 2), (5, 1), (5, 6), (5, 7), (9, 8), (9, 10), (5, 9), (5, 11), (0, 5)]

3 -> len= 5     [(4, 3), (4, 2), (4, 1), (4, 5), (0, 4)]

4 -> len= 11    [(2, 1), (4, 3), (4, 2), (8, 7), (8, 6), (8, 5), (10, 9), (8, 10), (4, 8), (4, 11), (0, 4)]

5 -> len= 13    [(4, 3), (4, 2), (4, 1), (6, 5), (10, 9), (10, 8), (10, 7), (10, 11), (10, 12), (6, 10), (4, 6), (4, 13), (0, 4)]

6 -> len= 5     [(4, 3), (4, 2), (4, 1), (4, 5), (0, 4)]

7 -> len= 10    [(4, 3), (4, 2), (4, 1), (7, 6), (7, 5), (9, 8), (7, 9), (4, 7), (4, 10), (0, 4)]

8 -> len= 7     [(5, 4), (6, 5), (6, 3), (6, 2), (6, 1), (6, 7), (0, 6)]

9 -> len= 8     [(3, 2), (3, 1), (6, 5), (6, 4), (6, 3), (6, 7), (6, 8), (0, 6)]

10 -> len= 6    [(3, 2), (3, 1), (5, 4), (3, 5), (3, 6), (0, 3)]
- test UAS: 94.19
```

Figure 4: Outputs for the my_test.conll

When comparing Figure 3 and Figure 4, we can see couple of mistakes:

- **Sentence no.2**: *he is a good person, and I know that.*

  The parent of *and*, *person*, and *,* should be *know*, and that *know* is the root. However, our model thinks*person* is the root.

- **Sentence no.5**: *how can you tell the difference between an actual issue or anxiety?*

  The parent of *or* should be *anxiety*, whereas our model thinks it is *issue*.

Therefore, it looks like that the model in some cases fails to completely understand dependencies in complex sentences.

Part IV

Language Model

Filename: 5_language-model.ipynb

4 Overview

In this part, we have develop a model of the text that we can then use to generate new sequences of text. It is worth noting that we have used *selftext_clean* column of our dataframe to train this model.

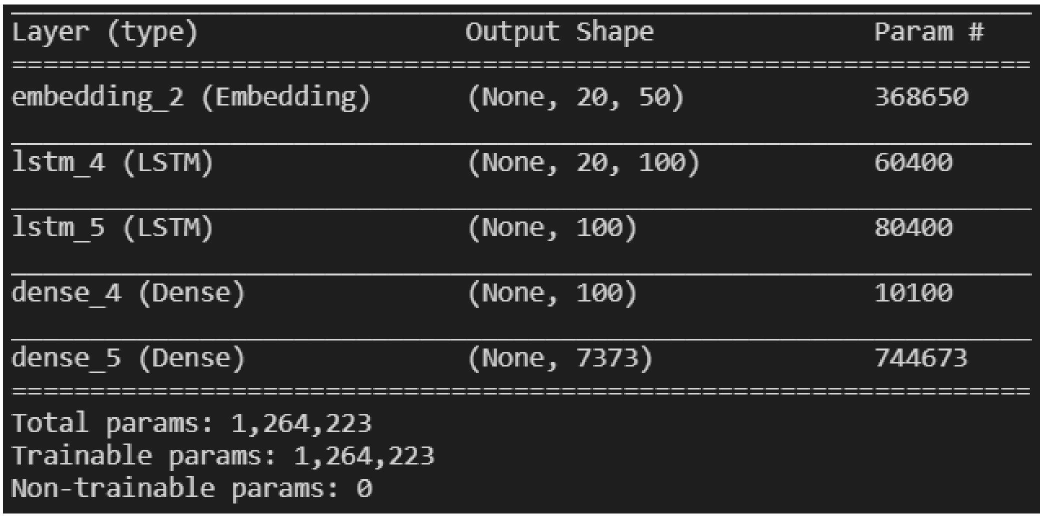
4.1 Code

We will start by preparing the data for modeling. We have picked a length of 50 words for the length of the input sequences, and we have attached 1 output word at the end of the sequences. Afterwards, we save the long list of sequences.

For our language model, after loading our dataset, we used an Embedding Layer to learn the representation of words, and a Long Short-Term Memory (LSTM) recurrent neural network to learn to predict words based on their context. More precisely, we have used a two LSTM hidden layers with 100 memory cells each. Following, we have a dense fully connected layer with 100 neurons connects to the LSTM hidden layers to interpret the features extracted from the sequence. The summary of the model is shown in Figure 5.

After the model is trained, we use generate_seq function that takes as input the model, the tokenizer, input sequence length, the seed text, and the number of words to generate.

Moreover, with boolean parameters, load_bool and save, the specific model will be saved and/or loaded.



```
_________________________________________________________________
Layer (type)                 Output Shape              Param #
=================================================================
embedding_2 (Embedding)      (None, 20, 50)            368650
_________________________________________________________________
lstm_4 (LSTM)                (None, 20, 100)           60400
_________________________________________________________________
lstm_5 (LSTM)                (None, 100)               80400
_________________________________________________________________
dense_4 (Dense)              (None, 100)               10100
_________________________________________________________________
dense_5 (Dense)              (None, 7373)              744673
=================================================================
Total params: 1,264,223
Trainable params: 1,264,223
Non-trainable params: 0
```

Figure 5: Model architecture for simple language model

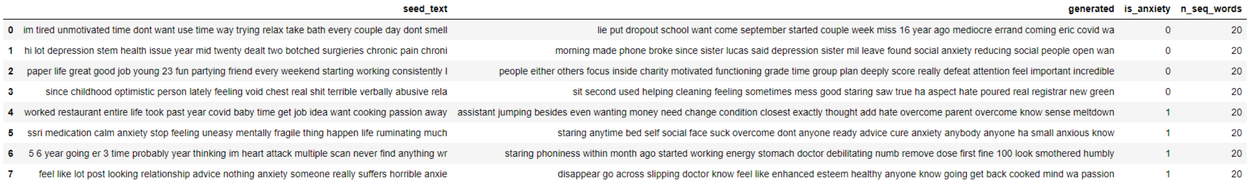
4.2 Results and Examples

Since we have used *selftext_clean* column of our data, and threfore the stopwords as well as punctuation symbols are removed, we see that our model can not follow grammatical rules and make complete sentences.
In addition, as we have not used pretrain models, the model requires more data to generate better sentences.

Overall, the model was somehow not bad at capturing the context of the dataset.

In Figure 3, by feeding the seed text, obtained randomly from either depression or anxiety dataset, the model generates a sequence.

Table 3: Examples for simple language model



	seed_text	generated	is_anxiety	n_seq_words
0	im tired unmotivated time dont want use time way trying relax take bath every couple day dont smell	lie put dropout school want come september started couple week miss 16 year ago mediocre errand coming eric covid wa	0	20
1	hi lot depression stem health issue year mid twenty dealt two botched surgieries chronic pain chroni	morning made phone broke since sister lucas said depression sister mil leave found social anxiety reducing social people open wan	0	20
2	paper life great good job young 23 fun partying friend every weekend starting working consistently l	people either others focus inside charity motivated functioning grade time group plan deeply score really defeat attention feel important incredible	0	20
3	since childhood optimistic person lately feeling void chest real shit terrible verbally abusive rela	sit second used helping cleaning feeling sometimes mess good staring saw true ha aspect hate poured real registrar new green	0	20
4	worked restaurant entire life took past year covid baby time get job idea want cooking passion away	assistant jumping besides even wanting money need change condition closest exactly thought add hate overcome parent overcome know sense meltdown	1	20
5	ssri medication calm anxiety stop feeling uneasy mentally fragile thing happen life ruminating much	staring anytime bed self social face suck overcome dont anyone ready advice cure anxiety anybody anyone ha small anxious know	1	20
6	5 6 year going er 3 time probably year thinking im heart attack multiple scan never find anything wr	staring phoniness within month ago started working energy stomach doctor debilitating numb remove dose first fine 100 look smothered humbly	1	20
7	feel like lot post looking relationship advice nothing anxiety someone really suffers horrible anxie	disappear go across slipping doctor know feel like enhanced esteem healthy anyone know going get back cooked mind wa passion	1	20

Part V

Fine-tuning

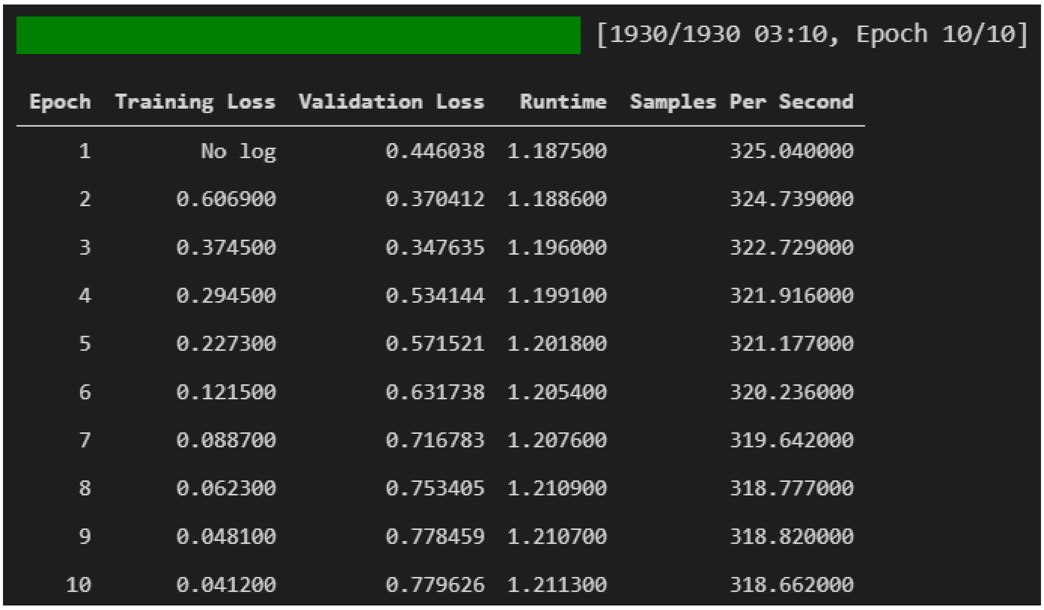
5 Classification

Filename: 6_finetune_classification.ipynb

Since some files exceeded GitHub's maximum file size (100Mb), we have uploaded them in Google drive.

- bert_classification_lm-pytorch_model.bin

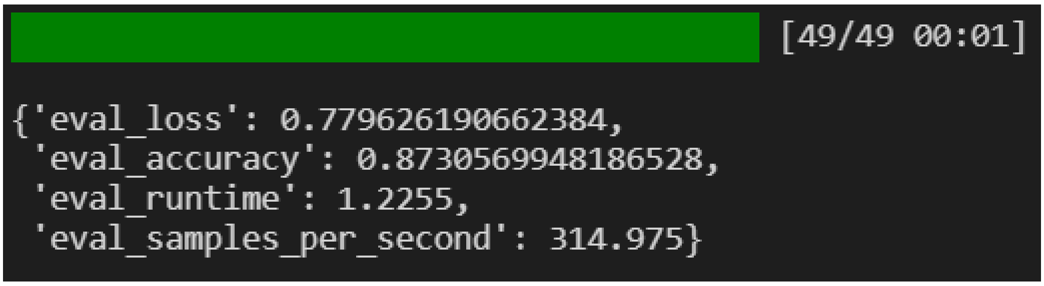
5.1 Code



```
                                    [1930/1930 03:10, Epoch 10/10]

Epoch  Training Loss  Validation Loss  Runtime   Samples Per Second
    1         No log         0.446038  1.187500          325.040000
    2       0.606900         0.370412  1.188600          324.739000
    3       0.374500         0.347635  1.196000          322.729000
    4       0.294500         0.534144  1.199100          321.916000
    5       0.227300         0.571521  1.201800          321.177000
    6       0.121500         0.631738  1.205400          320.236000
    7       0.088700         0.716783  1.207600          319.642000
    8       0.062300         0.753405  1.210900          318.777000
    9       0.048100         0.778459  1.210700          318.820000
   10       0.041200         0.779626  1.211300          318.662000
```

Figure 6: Training bert classification language model

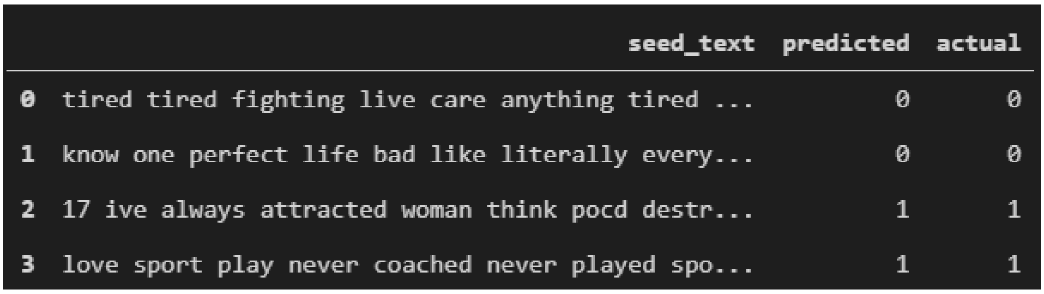


```
[49/49 00:01]

{'eval_loss': 0.779626190662384,
 'eval_accuracy': 0.8730569948186528,
 'eval_runtime': 1.2255,
 'eval_samples_per_second': 314.975}
```

Figure 7: Evaluating bert classification language model

5.2 Results and Examples



	seed_text	predicted	actual
0	tired tired fighting live care anything tired ...	0	0
1	know one perfect life bad like literally every...	0	0
2	17 ive always attracted woman think pocd destr...	1	1
3	love sport play never coached never played spo...	1	1

Figure 8: Examples for bert classification model

6 Language Model

Filename: 7_finetune_language-model.ipynb

Since some files exceeded GitHub's maximum file size (100Mb), we have uploaded them in Google drive.

- depression.bert_lm-pytorch_model.bin
- anxiety.bert_lm-pytorch_model.bin

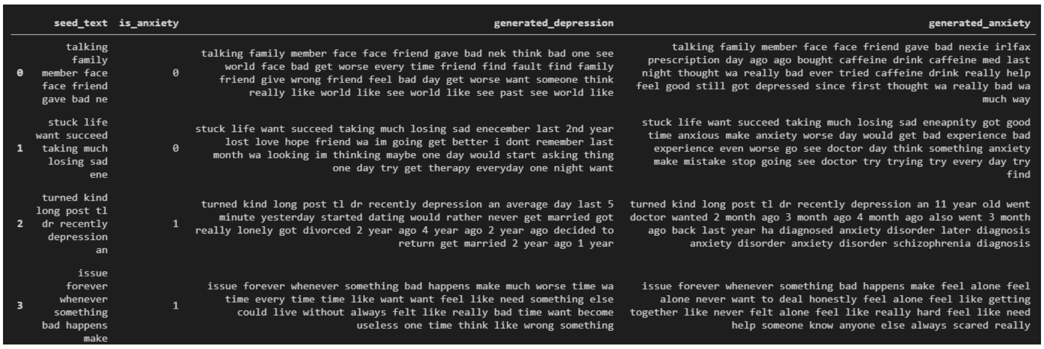
In this part, we have used our Reddit dataset to fine-tune our distilgpt-2.

For this purpose, we first prepare the dataset and build a TextDataset, load the pre-trained GPT-2 model and tokenizer, initialize Trainer with TrainingArguments, and finally, train and save the model.

6.1 Code

The TextDataset is a custom implementation of the Pytroch Dataset class implemented by the transformers(4.2.2) library.
Also, we have used the tokenzier from the distilgpt-2 model on huggingface.
Afterwards, we initialize Trainer class that provides an API for feature-complete training, and we set the Hyperparameters we are going to use in the TrainingArguments.

6.2 Results and Examples



	seed_text	is_anxiety	generated_depression	generated_anxiety
0	talking family member face face friend gave bad ne	0	talking family member face face friend gave bad nek think bad one see world face bad get worse every time friend find fault find family friend give wrong friend feel bad day get worse want someone think really like world like see world like see past see world like	talking family member face face friend gave bad nexie irlfax prescription day ago ago bought caffeine drink caffeine med last night thought wa really bad ever tried caffeine drink really help feel good still got depressed since first thought wa really bad wa much way
1	stuck life want succeed taking much losing sad ene	0	stuck life want succeed taking much losing sad enecember last 2nd year lost love hope friend wa im going get better i dont remember last month wa looking im thinking maybe one day would start asking thing one day try get therapy everyday one night want	stuck life want succeed taking much losing sad eneapnity got good time anxious make anxiety worse day would get bad experience bad experience even worse go see doctor day think something anxiety make mistake stop going see doctor try trying try every day try find
2	turned kind long post tl dr recently depression an	1	turned kind long post tl dr recently depression an average day last 5 minute yesterday started dating would rather never get married got really lonely got divorced 2 year ago 4 year ago 2 year ago decided to return get married 2 year ago 1 year	turned kind long post tl dr recently depression an 11 year old went doctor wanted 2 month ago 3 month ago 4 month ago also went 3 month ago back last year ha diagnosed anxiety disorder later diagnosis anxiety disorder anxiety disorder schizophrenia diagnosis
3	issue forever whenever something bad happens make	1	issue forever whenever something bad happens make much worse time wa time every time time like want want feel like need something else could live without always felt like really bad time want become useless one time think like wrong something	issue forever whenever something bad happens make feel alone feel alone never want to deal honestly feel alone feel like getting together like never felt alone feel like really hard feel like need help someone know anyone else always scared really

Figure 9: Examples for distilgpt2 language model

References

[1] https://towardsdatascience.com/goodbye-world-4cc844197d51

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[3] https://gmihaila.github.io/tutorial_notebooks/gpt2_finetune_classification/

[4] https://colab.research.google.com/github/philschmid/fine-tune-GPT-2/blob/master/Fine_tune_a_non_English_GPT_2_Model_with_Huggingface.ipynb

[5] https://github.com/huggingface/notebooks/blob/master/examples/language_modeling.ipynb

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[9] https://www.kaggle.com/achintyatripathi/gensim-word2vec-usage-with-t-sne-plot

[10] https://colab.research.google.com/github/borisdayma/huggingtweets/blob/master/huggingtweets-demo.ipynb

[11] https://huggingface.co/transformers/custom_datasets.html

[12] https://colab.research.google.com/github/google/sentencepiece/blob/master/python/sentencepiece_python_module_example.ipynb#scrollTo=-k5KbVgiYae-

[13] https://colab.research.google.com/drive/1ZZ9vJ_nIQkgjW776lnPvwVfRHuOKvbz8