Sentiment Analysis using BERT

BERT: Sentiment Analysis in the NLP Suite

Huggingface.co is a platform where any machine learning models can be deployed to help others with any ML tasks that they may have. Huggingface.co has a transformers library for Natural Language Processing problems, and thus, naturally, it provides us with many models that utilize BERT (a transformer-based technique) for a variety of NLP tasks. Some of these models use BERT to create a tool for sentiment analysis. In the NLP Suite, the model used is 'cardiffnlp/twitter-xlm-roberta-base-sentiment'. This model is a multilingual XLM-roBERTa-base model trained on ~198M tweets and finetuned for sentiment analysis. The model was trained using 30+ languages. These languages can be seen in the graph below.
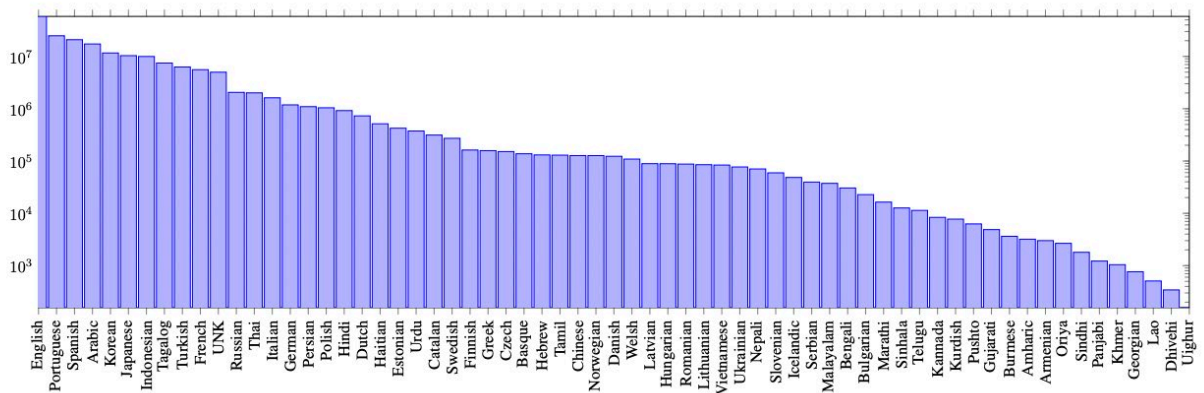

The sentiment fine-tuning was done on 8 languages: Arabic, English, French, German, Hindi, Italian, Spanish, and Portugese (but it can be used for 30+ languages as seen above). This roBERTa model, as the name suggests, uses BERT as its base.
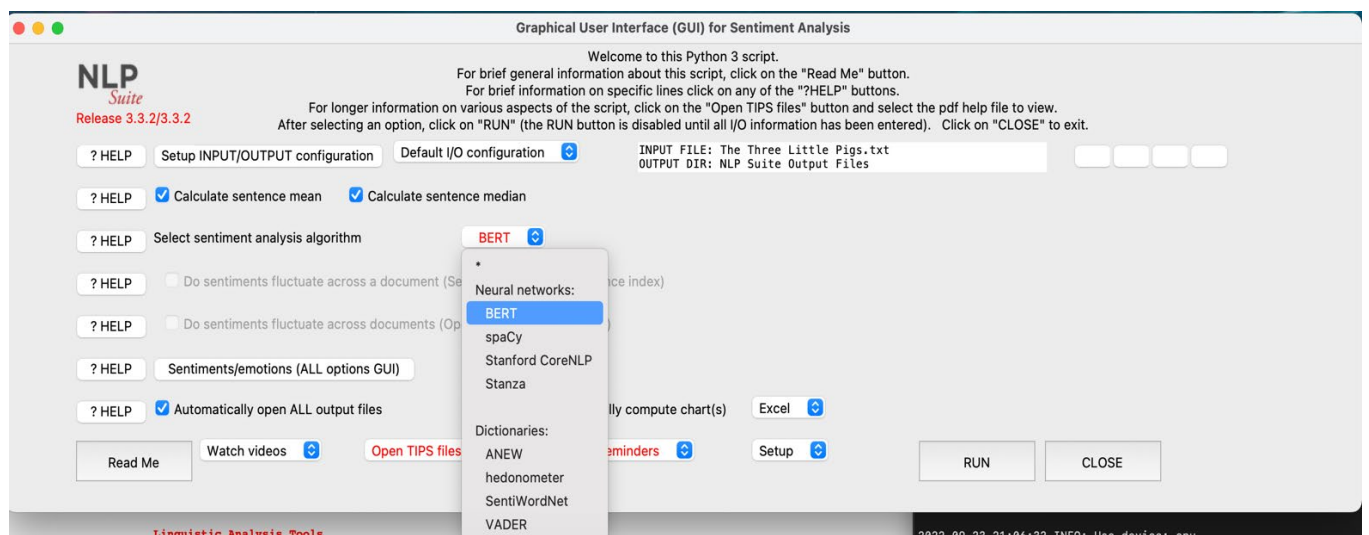
BERT: Using the Multilingual xlm-roberta Model

Follow these steps to run sentiment analysis using BERT in the NLP Suite:

1. Pick an input text file or directory of text files, and a valid output directory
2. Select 'Sentiment Analysis' from the 'CORPUS/DOCUMENT Analysis Tools'
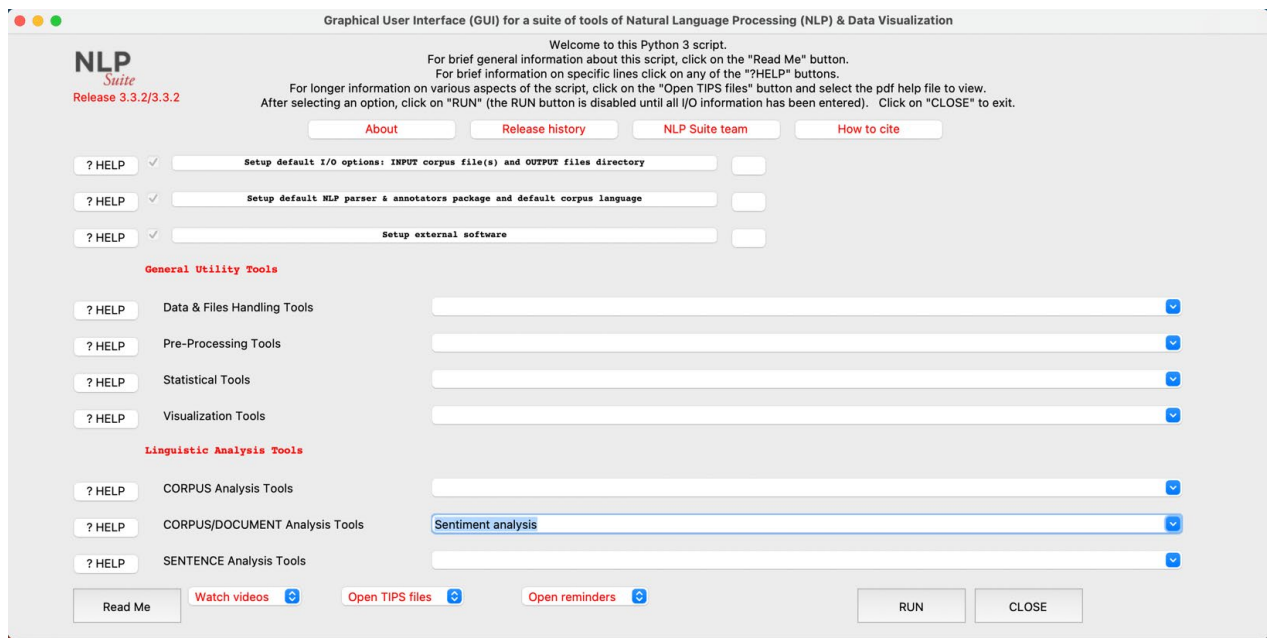
3. Click 'RUN', and the sentiment analysis GUI will open up

4. Select BERT in the 'Select sentiment analysis algorithm' dropdown menu and run it

Output

You will get three output files: -

A .csv file with the sentiment scores and label per sentence:

Sentiment score	Sentiment label	Sentence ID	Sentence	Document ID	Document
0.5084734559059140	Negative	1	There was an old sow with three little pigs, and as she had not enough to keep them, she sent them out to seek their fortune.	1	
0.48161831498146100	Neutral	2	The first that went off met a man with a bundle of straw, and said to him: "Please, man, give me that straw to build me a house."	1	
0.4660746455192570	Neutral	3	Which the man did, and the little pig built a house with it.	1	
0.4645686447620390	Neutral	4	Presently came along a wolf, and knocked at the door, and said: "Little pig, little pig, let me come in."	1	
0.49842941761016800	Neutral	5	To which the pig answered: "No, no, by the hair of my chiny chin chin."	1	
0.4729090332949200	Neutral	6	The wolf then answered to that: "Then I'll huff, and I'll puff, and I'll blow your house in."	1	
0.8648075461387630	Negative	7	So he huffed, and he puffed, and he blew his house in, and ate up the little pig.	1	
0.42985185980796800	Neutral	8	The second little, pig met a man with a bundle of furze, and said: "Please, man, give me that furze to build a house."	1	
0.5435979962348940	Neutral	9	Which the man did, and the pig built his house.	1	
0.4528388977050780	Neutral	10	Then along came the wolf, and said: "Little pig, little pig, let me come in."	1	
0.4892185628414150	Neutral	11	"No, no, by the hair of my chiny chin chin."	1	
0.4822690486907960	Neutral	12	"Then I'll puff, and I'll huff, and I'll blow your house in."	1	
0.7287344336509710	Negative	13	So he huffed, and he puffed, and he puffed, and he huffed, and at last he blew the house down, and he ate up the little pig.	1	
0.4394102990627290	Neutral	14	The third little pig met a man with a load of bricks, and said: "Please, man, give me those bricks to build a house with."	1	
0.5683606266975400	Neutral	15	So the man gave him the bricks, and he built his house with them.	1	
0.4882607161998750	Neutral	16	So the wolf came, as he did to the other little pigs, and said: "Little pig, little pig, let me come in."	1	
0.4892185628414150	Neutral	17	"No, no, by the hair of my chiny chin chin."	1	
0.45398393273353600	Neutral	18	"Then I'll huff, and I'll puff, and I'll blow your house in."	1	
0.7966296076774600	Negative	19	Well, he huffed, and he puffed, and he huffed and he puffed, and he puffed and huffed; but he could not get the house down.	1	
0.6220259666442870	Negative	20	When he found that he could not, with all his huffing and puffing, blow the house down, he said: "Little pig, I know where there is a nice field of turnips."	1	
0.523867130279541	Negative	21	"Where?" said the little pig.	1	
0.5341402292251590	Positive	22	"Oh, in Mr. Smith's Home-field, and if you will be ready to-morrow morning I will call for you, and we will go together, and get some for dinner."	1	
0.7746590971946720	Positive	23	"Very well," said the little pig, "I will be ready.	1	
0.8448449373245240	Neutral	24	What time do you mean to go?"	1	
0.7739757299423220	Neutral	25	"Oh, at six o'clock."	1	
0.6678135991096500	Neutral	26	Well, the little pig got up at five, and got the turnips before the wolf came (which he did about six) and who said: "Little Pig, are you ready?"	1	
0.618236064108890	Positive	27	The little pig said: "Ready!	1	
0.757459282875061	Positive	28	I have been and come back again, and got a nice potful for dinner."	1	
0.5259473919868470	Negative	29	The wolf felt very angry at this, but thought that he would be up to the little pig somehow or other, so he said: "Little pig, I know where there is a nice apple-tree."	1	
0.5465331077575680	Negative	30	"Where?" said the pig.	1	
0.4353504776954650	Neutral	31	"Down at Merry-garden," replied the wolf, "and if you will not deceive me I will come for you, at five o'clock tomorrow and get some apples."	1	
0.3909467160701750	Negative	32	Well, the little pig bustled up the next morning at four o'clock, and went off for the apples, hoping to get back before the wolf came; but he had further to go, and had to climb the tree, so that just as he was coming down fro[m]	1	
0.5049856901168820	Negative	33	When the wolf came up he said: "Little pig, what are you here before me?	1	
0.4520940826164200	Neutral	34	Are they nice apples?"	1	
0.3867337703704830	Neutral	35	"Yes, very," said the little pig.	1	
0.5611397624015810	Negative	36	"I will throw you down one."	1	
0.41941556334495500	Neutral	37	And he threw it so far, that, while the wolf was gone to pick it up, the little pig jumped down and ran home.	1	
0.6272719502449040	Neutral	38	The next day the wolf came again, and said to the little pig: "Little pig, there is a fair at Shanklin this afternoon, will you go?"	1	

An Excel chart of the frequency of sentiment scores:
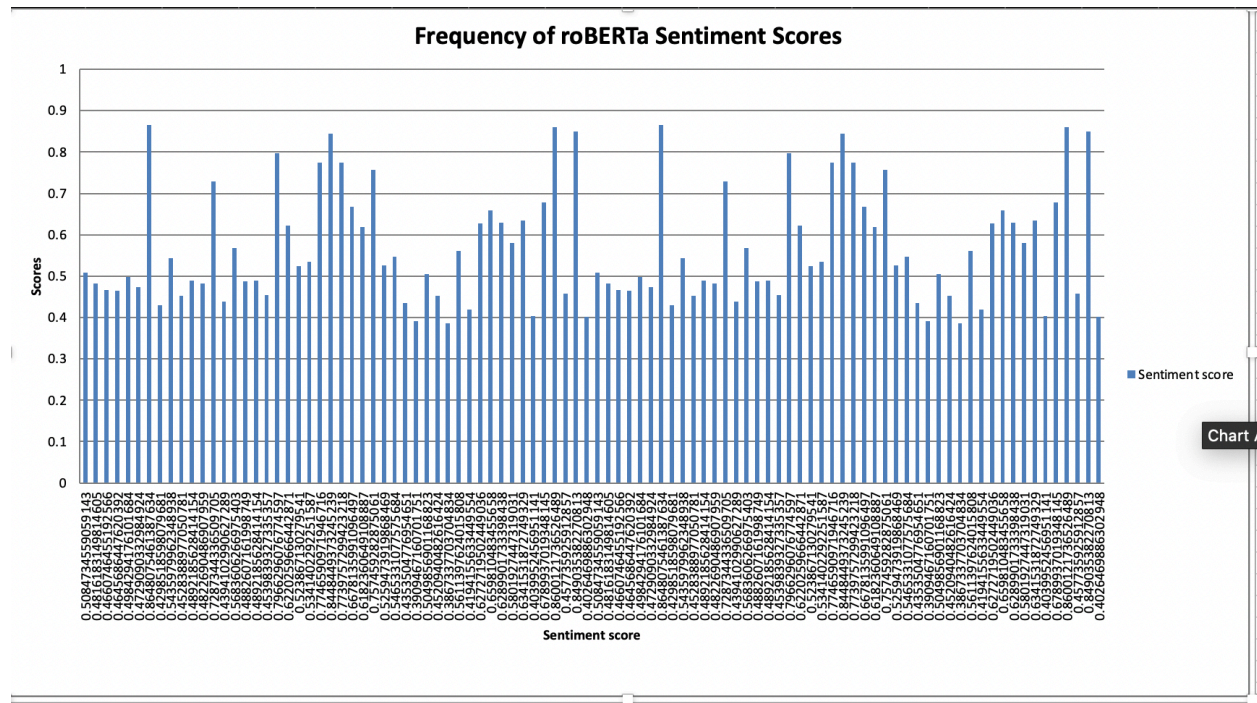
And finally, an Excel chart of the frequency of the sentiment labels:

**Frequency of roBERTa Sentiment Labels**
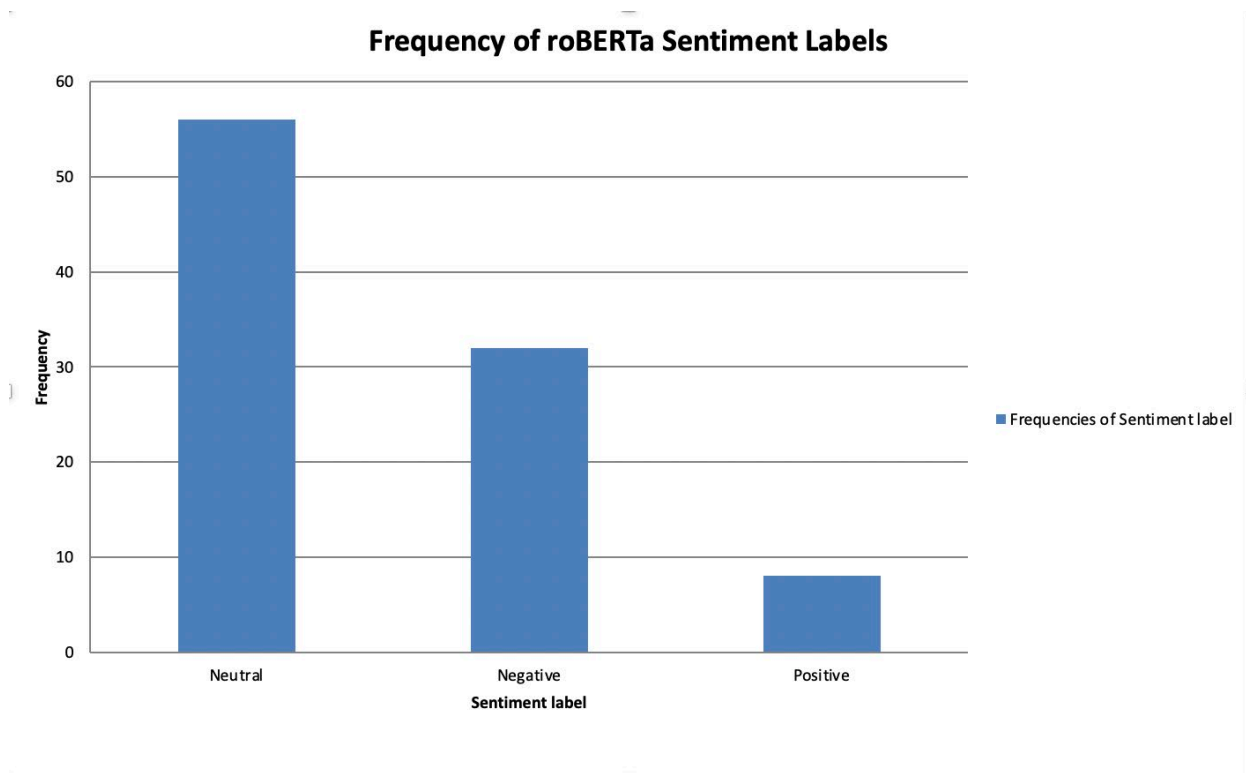
The Multilingual Nature of the Model

The BERT model used in the NLP Suite can provide sentiment analysis for 30+ languages. The user is not required to specify the language of the corpus analyzed; the model does it automatically. To demonstrate this, shown are the results from the Three Little Pigs text file, translated into German using Google Translate.

Sentiment score	Sentiment label	Sentence ID	Sentence	Document ID	Document
0.7691465020179750	Neutral	1	Da war eine alte	1	
0.5105459094047550	Neutral	2	Sau mit drei kleinen Schweinchen, und da sie nicht genug hatte, um sie zu halten, schickte sie sie aus, um ihr Glück zu suchen.	1	
0.6474734544754030	Neutral	3	Der erste, der losging, traf einen Mann mit einem Bündel Stroh und sagte zu ihm: "Bitte, Mann, gib mir das Stroh, damit ich mir ein Haus baue."	1	
0.7639961242675780	Neutral	4	Was der Mann tat, und das kleine Schweinchen baute ein Haus damit.	1	
0.3878004848957060	Neutral	5	Alsbald kam ein	1	
0.4502364695072170	Neutral	6	Wolf daher und klopfte an die Tür und sagte: "Kleines Schweinchen, kleines Schweinchen, lass mich rein."	1	
0.6604164838790890	Neutral	7	Worauf das Schwein antwortete: "Nein, nein, bei den Haaren meines Kinnkinns."	1	
0.4770972430706020	Neutral	8	Der Wolf antwortete darauf: "Dann werde ich schnaufen, und ich werde pusten, und ich werde dein Haus einblasen."	1	
0.5577002167701720	Neutral	9	Also schnaufte er, und er schnaufte, und er sprengte sein Haus ein und aß das kleine Schweinchen auf.	1	
0.6081258058547970	Neutral	10	Das zweite Schweinchen begegnete einem Mann mit einem Ginsterbündel und sagte: "Bitte, Mann, gib mir das Ginster, um ein Haus zu bauen."	1	
0.8158283233642580	Neutral	11	Was der Mann tat, und das Schwein baute sein Haus.	1	
0.4599322676586300	Neutral	12	Da kam der Wolf und sagte: "Kleines Schweinchen, kleines Schweinchen, lass mich rein."	1	
0.5670098066329960	Neutral	13	"Nein, nein, bei den Haaren meines Kinnkinns."	1	
0.5304553508758550	Neutral	14	"Dann werde ich paffen, und ich werde schnaufen, und ich werde dein Haus einblasen."	1	
0.621855616569519	Negative	15	Also schnaufte er und schnaufte und schnaufte und schnaufte und schließlich sprengte er das Haus in die Luft und aß das kleine Schweinchen auf.	1	
0.5642240047454830	Neutral	16	Das dritte kleine Schwein traf einen Mann mit einer Ladung Ziegel und sagte: "Bitte, Mann, gib mir diese Ziegel, um damit ein Haus zu bauen."	1	
0.6846144795417790	Neutral	17	Da gab ihm der Mann die Ziegel, und er baute sein Haus damit.	1	
0.6000988483428960	Neutral	18	Da kam der Wolf, wie er es zu den anderen kleinen Schweinchen tat, und sagte: "Kleines Schweinchen, kleines Schweinchen, lass mich rein."	1	
0.5670098066329960	Neutral	19	"Nein, nein, bei den Haaren meines Kinnkinns."	1	
0.5390222668647770	Neutral	20	"Dann werde ich schnaufen, und ich werde paffen, und ich werde dein Haus einblasen."	1	
0.7054275870323180	Negative	21	Nun, er schnaufte und schnaufte und schnaufte und schnaufte und schnaufte und schnaufte; aber er konnte das Haus nicht herunterbekommen.	1	
0.693844735622406	Negative	22	Als er feststellte, dass er mit all seinem Schnaufen und Schnaufen das Haus nicht in die Luft jagen konnte, sagte er: "Kleine Sau, ich weiß, wo ein schönes Rübenfeld ist."	1	
0.5011488795280460	Neutral	23	"Wo?" sagte das kleine Schwein.	1	
0.5169705748558040	Positive	24	"Oh, in Mr. Smiths Heimfeld, und wenn Sie morgen früh bereit sein werden, werde ich nach Ihnen rufen, und wir werden zusammen gehen und etwas zum Abendessen holen."	1	
0.686680257320404	Positive	25	„Nun gut", sagte das Schweinchen, „ich werde bereit sein.	1	
0.886969195438385	Neutral	26	Um wie viel Uhr willst du gehen?"	1	
0.8155454397201540	Neutral	27	"Oh, um sechs Uhr." Nun, das kleine Schwein stand um fünf auf und holte die Rüben, bevor der Wolf kam (was er ungefähr um sechs tat) und der sagte: "Kleines Schwein, bist du bereit?"	1	
0.3806865215301510	Negative	28	Das kleine Schwein sagte: "Fertig!	1	
0.8840489387512210	Positive	29	Ich war und komme wieder und habe einen schönen Topf zum Abendessen bekommen."	1	
0.4003669321537020	Neutral	30	Der Wolf wurde darüber sehr wütend, dachte aber, dass er dem kleinen Schwein irgendwie gewachsen sein würde, also sagte er: "Schweinchen, ich weiß, wo ein schöner Apfelbaum steht."	1	
0.4940955042839050	Neutral	31	"Wo?" sagte das Schwein.	1	
0.6297488212585450	Neutral	32	„Unten in Merrygarden," antwortete der Wolf, „und wenn du mich nicht täuschen willst, werde ich morgen um fünf Uhr zu dir kommen und Äpfel holen."	1	
0.7607742547988890	Neutral	33	Nun, das kleine Schwein eilte am nächsten Morgen um vier	1	
0.5129078030586240	Neutral	34	Uhr herbei und ging Äpfel holen, in der Hoffnung, zurückzukommen, bevor der Wolf käme; aber er musste weiter gehen und auf den Baum klettern, so dass er, als er von ihm herunterkam, den Wolf kommen sah, was ihn, wie	1	
0.6820218563079830	Neutral	35	Als der Wolf kam, sagte er: „Schweinchen, was bist du hier vor mir?	1	
0.6251206398010250	Positive	36	Sind das schöne Äpfel?" "Ja, sehr", sagte das kleine Schwein.	1	

Frequency of roBERTa Sentiment Scores

Frequency of roBERTa Sentiment Labels
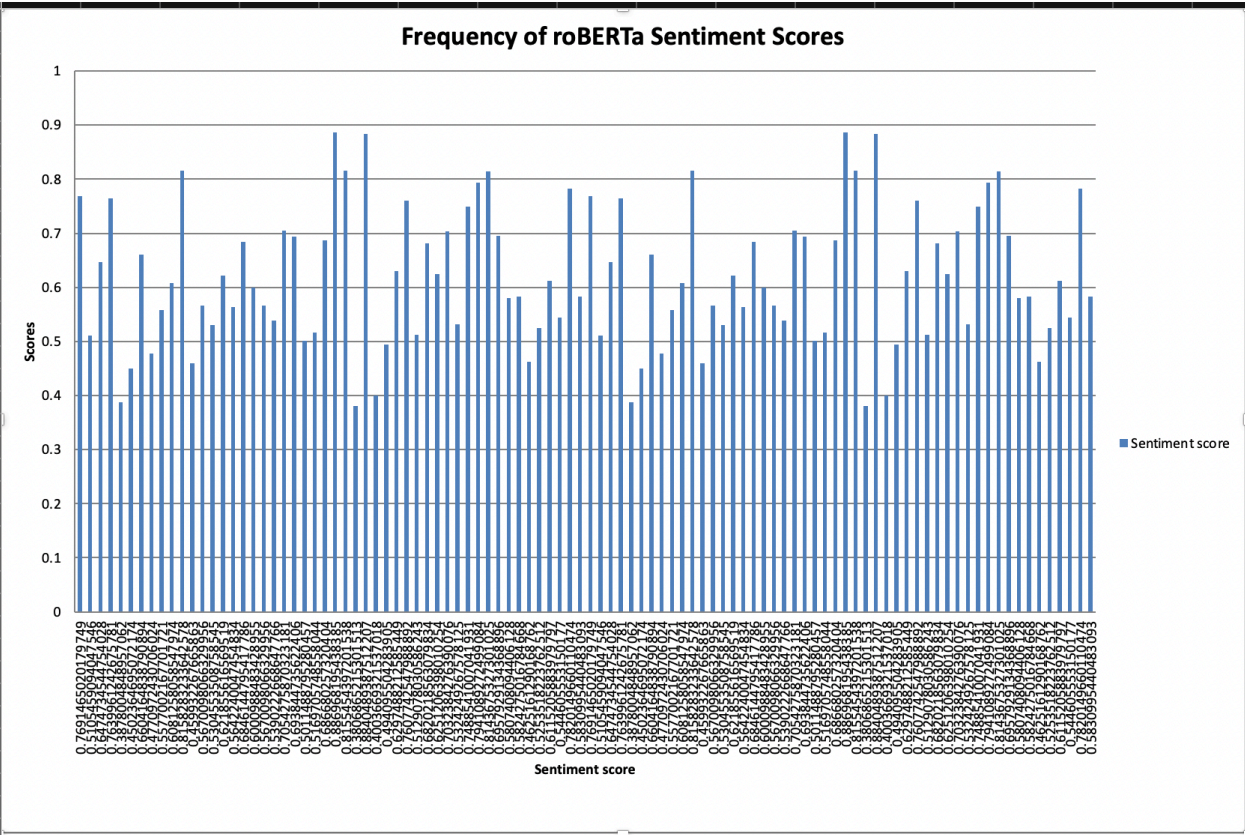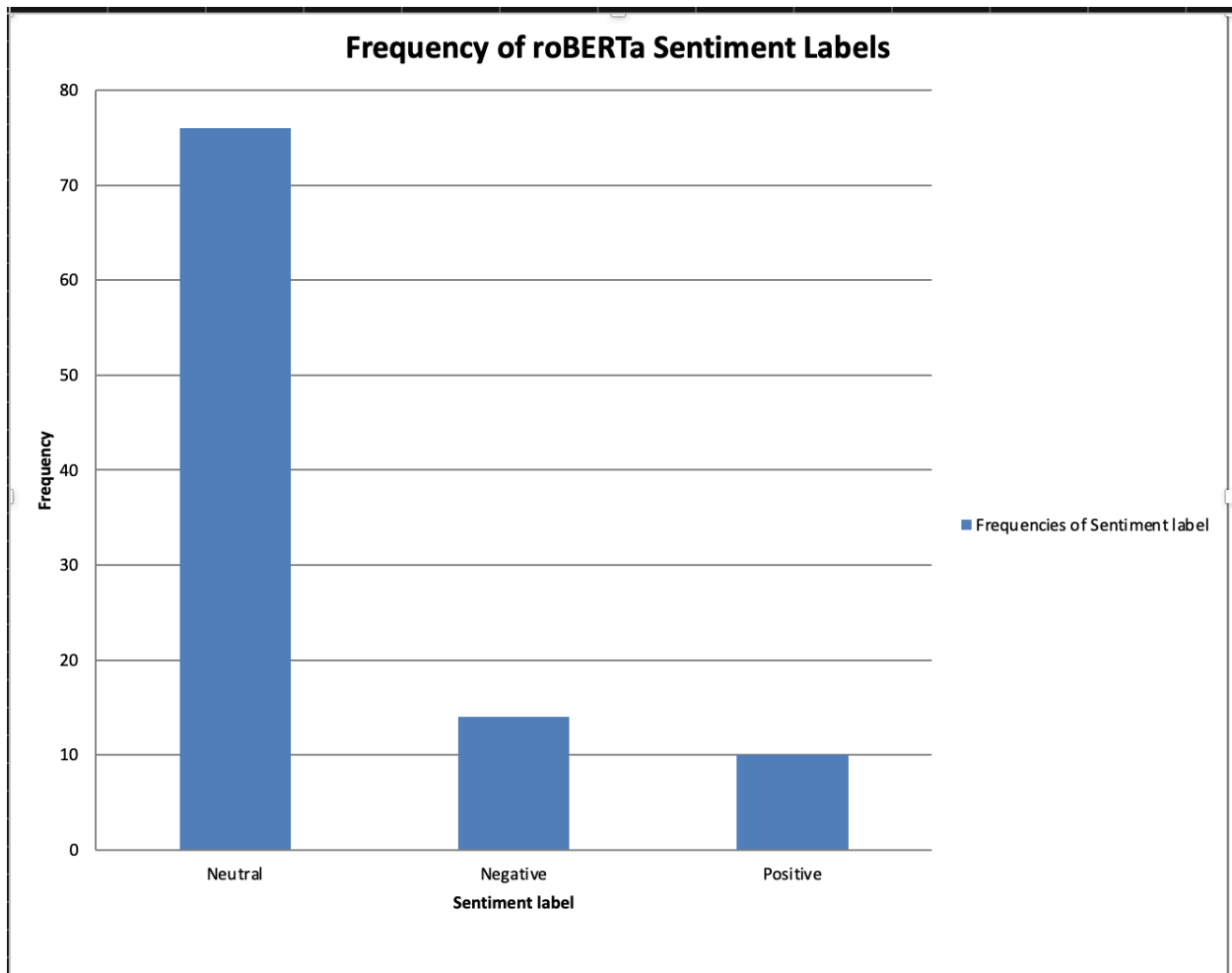
The results based on the German text differ slightly from the English text, but that is likely to be the result of translation from English to German through Google Translate.

Other BERT Models

There are numerous more BERT models of sentiment analysis available on Huggingface.co. However, not all of them are as close to optimal as the ones used in the NLP Suite. For instance, there is a sentiment analysis model ('nlptown/bert-base-multilingual-uncased-sentiment') which has been trained on product reviews and provides sentiment scores in terms of stars ranging from 1 star to 5 stars (Ex. A sentence could be 0.787 5 stars and 0.002 1 star). In context of the types of corpora the NLP Suite is generally used for, a model with such reviews as its training set does not seem like it would provide the most accurate results. Thus, the NLP Suite instead makes use of a model trained on around 200 million tweets.

Just as a point of comparison and for extra information, here is an example of another BERT model for sentiment analysis ('cardiffnlp/twitter-roberta-base-sentiment-latest'). This model was trained on ~124M tweets from January 2018 to December 2021 and finetuned for sentiment analysis with the TweetEval benchmark. It is important to note this model is not multilingual, so

it is simply a point of comparison for the English sentiment analysis of the multilingual model. Here are its results on the Three Little Pigs text.

NLP_roBERTa_The Three Little Pigs

Sentiment score	Sentiment label	Sentence ID	Sentence	Document ID	Document
0.7635764479637150	Neutral	1	There was an old sow with three little pigs, and as she had not enough to keep them, she sent them out to seek their fortune.	1	
0.7404029965400700	Neutral	2	The first that went off met a man with a bundle of straw, and said to him: "Please, man, give me that straw to build me a house."	1	
0.7363114356994630	Neutral	3	Which the man did, and the little pig built a house with it.	1	
0.7777256369590760	Neutral	4	Presently came along a wolf, and knocked at the door, and said: "Little pig, little pig, let me come in."	1	
0.8267984132766720	Neutral	5	To which the pig answered: "No, no, by the hair of my chiny chin chin."	1	
0.6457981467247010	Neutral	6	The wolf then answered to that: "Then I'll huff, and I'll puff, and I'll blow your house in."	1	
0.4209007322782400	Neutral	7	So he huffed, and he puffed, and he blew his house in, and ate up the little pig.	1	
0.6075448989868160	Neutral	8	The second little, pig met a man with a bundle of furze, and said: "Please, man, give me that furze to build a house."	1	
0.738959550857544	Neutral	9	Which the man did, and the pig built his house.	1	
0.7371624708175660	Neutral	10	Then along came the wolf, and said: "Little pig, little pig, let me come in."	1	
0.7729271650314330	Neutral	11	"No, no, by the hair of my chiny chin chin."	1	
0.4459572434425350	Negative	12	"Then I'll puff, and I'll huff, and I'll blow your house in."	1	
0.5286512970924380	Negative	13	So he huffed, and he puffed, and he puffed, and he huffed, and at last he blew the house down, and he ate up the little pig.	1	
0.6679732203483580	Neutral	14	The third little pig met a man with a load of bricks, and said: "Please, man, give me those bricks to build a house with."	1	
0.7884110808372500	Neutral	15	So the man gave him the bricks, and he built his house with them.	1	
0.7553850412368770	Neutral	16	So the wolf came, as he did to the other little pigs, and said: "Little pig, little pig, let me come in."	1	
0.7729271650314330	Neutral	17	"No, no, by the hair of my chiny chin chin."	1	
0.490134626269680	Negative	18	"Then I'll huff, and I'll puff, and I'll blow your house in."	1	
0.4691441953182200	Negative	19	Well, he huffed, and he puffed, and he huffed and he puffed, and he puffed and huffed; but he could not get the house down.	1	
0.4928456842899200	Neutral	20	When he found that he could not, with all his huffing and puffing, blow the house down, he said: "Little pig, I know where there is a nice field of turnips."	1	
0.6870347261428830	Neutral	21	"Where?" said the little pig.	1	
0.6904053092002870	Neutral	22	"Oh, in Mr. Smith's Home-field, and if you will be ready to-morrow morning I will call for you, and we will go together, and get some for dinner."	1	
0.7794914841651920	Positive	23	"Very well," said the little pig, "I will be ready.	1	
0.92995685338974	Neutral	24	What time do you mean to go?"	1	
0.8905565142631530	Neutral	25	"Oh, at six o'clock."	1	
0.8187683820724490	Neutral	26	Well, the little pig got up at five, and got the turnips before the wolf came (which he did about six) and who said: "Little Pig, are you ready?"	1	
0.540087640285492	Neutral	27	The little pig said: "Ready!	1	
0.8367289643287660	Positive	28	I have been and come back again, and got a nice potful for dinner."	1	
0.4583230912685390	Negative	29	The wolf felt very angry at this, but thought that he would be up to the little pig somehow or other, so he said: "Little pig, I know where there is a nice apple-tree."	1	
0.5378699898719790	Negative	30	"Where?" said the pig.	1	
0.700234949587760	Neutral	31	"Down at Merry-garden," replied the wolf, "and if you will not deceive me I will come for you, at five o'clock tomorrow and get some apples."	1	
0.7771129012107850	Neutral	32	Well, the little pig bustled up the next morning at four o'clock, and went off for the apples, hoping to get back before the wolf came; but he had further to go, and had to climb the tree, so that just as he was coming down fro	1	
0.8028768301010130	Neutral	33	When the wolf came up he said: "Little pig, what are you here before me?	1	
0.6482000350952150	Positive	34	Are they nice apples?"	1	
0.5375304222106930	Neutral	35	"Yes, very," said the little pig.	1	
0.6511635184288030	Negative	36	"I will throw you down one."	1	
0.7203326225280760	Neutral	37	And he threw it so far, that, while the wolf was gone to pick it up, the little pig jumped down and ran home.	1	
0.845874011516571	Neutral	38	The next day the wolf came again, and said to the little pig: "Little pig, there is a fair at Shanklin this afternoon, will you go?"	1	

Frequency of roBERTa Sentiment Scores

Frequency of roBERTa Sentiment Labels
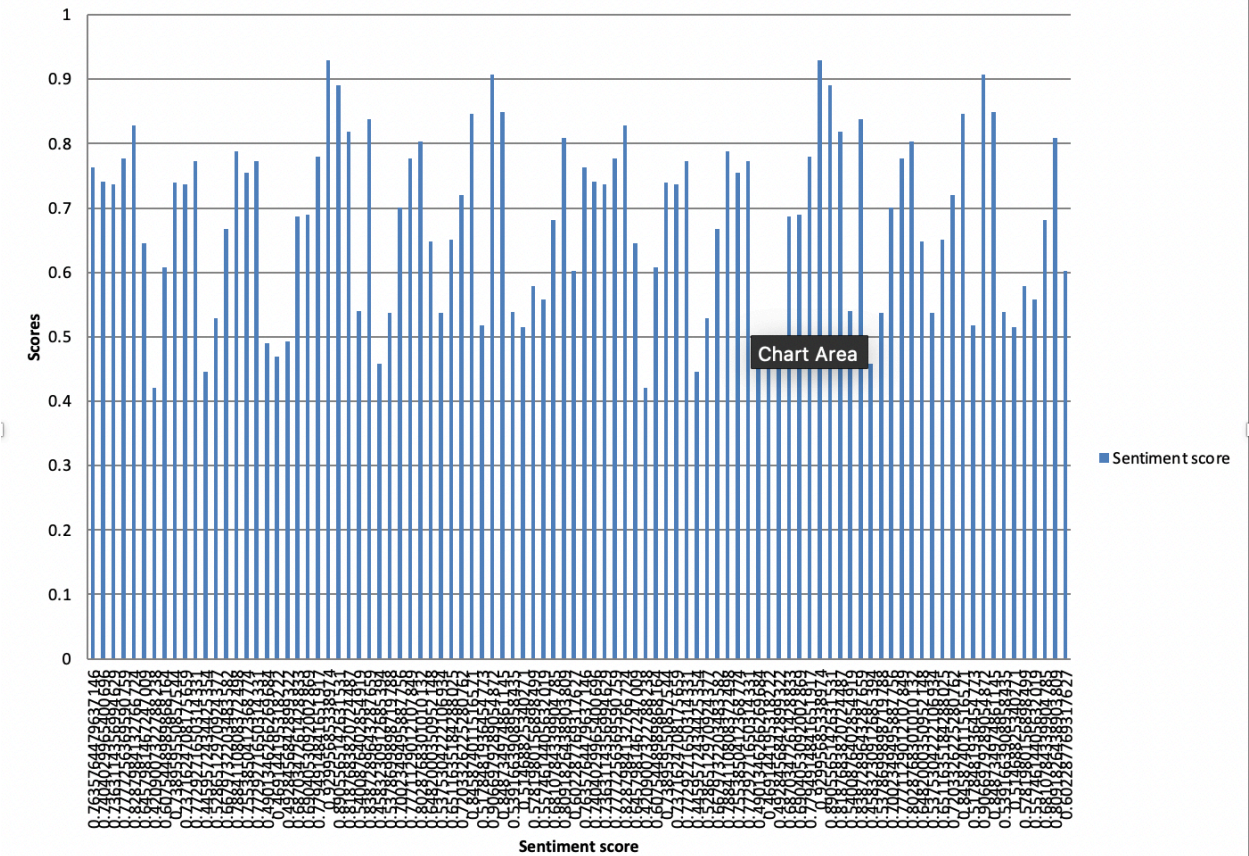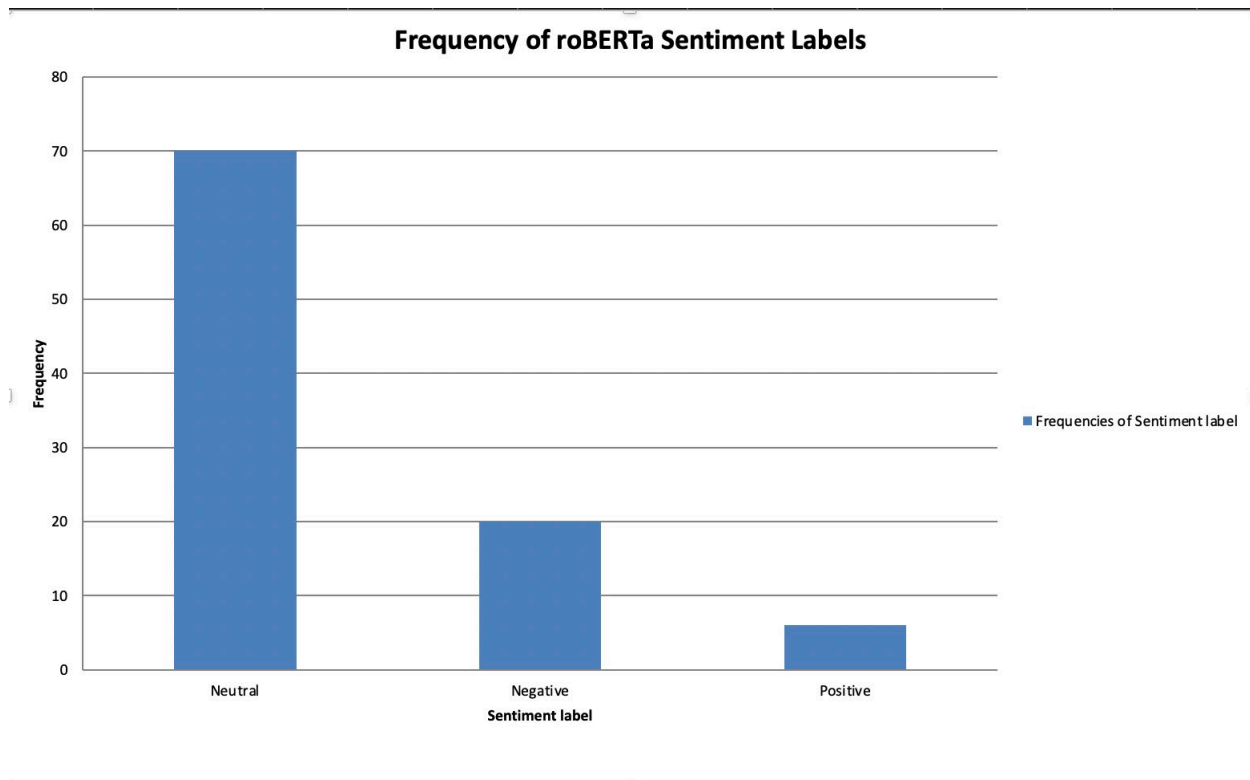
Again, these results are slightly different to the multilingual model's results but close reading of the sentences in the .csv files suggest that the multilingual model is more accurate. In addition, it provides sentiment analysis in many languages other than English, so of course, it appears to be the better choice.

References

These are the papers for the two models talked about in this file.

Francesco Barbieri, Luis Espinosa Anke, Jose Camacho-Collados, 2022, "XLM-T: Multilingual Language Models in Twitter for Sentiment Analysis and Beyond." arXiv:2104.12250v2 [cs.CL] 11 May 2022 (available at https://arxiv.org/pdf/2104.12250.pdf)

Daniel Loureiro, Francesco Barbieri, Leonardo Neves, Luis Espinosa Anke, Jose Camacho-Collados, 2022, "TimeLMs: Diachronic Language Models from Twitter." arXiv:2202.03829v2 [cs.CL] 1 April 2022 (available at https://arxiv.org/pdf/2202.03829.pdf)

https://en.wikipedia.org/wiki/BERT_(language_model)