

# User Response Classification Challenge

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## Abstract

*Abstract Text*

## I. INTRODUCTION

Chatbots are used in many applications today: customer support, flight booking, scheduling meeting, ordering food and many more. The application of a chatbot explored in this dataset is for a therapy chatbot. These types of chatbot, while very effective, may require human intervention. Determining when a human should intervene can be quite important, in this case when a person requires help in dealing with a complex situation, and requires tools to identify these situations.

The data set contains 80 examples of responses entered into a therapy chatbot. Each of these responses contains an id as well as an identification. The identification is either "flagged" if the response was flagged for human intervention or "not flagged" if not.

The task at hand was to create an AI agent to classify the user response.

## II. TOOLS

The following tools and modules were used to complete this task:

- python 3.
- pandas
- dy-net (for the RNN)
- scikit learn (for the Random Forest)
- numpy
- tqdm (for progress bars)

- csv (For reading the csv embeddings to pandas)
- re (regular expressions) (for cleaning the data)

## III. PREPARING DATA

The input data being sentences had to be cleaned up before passing into the models.

The first step was to load the csv file into a pandas dataframe and see what the data looked like. The data was, as mentioned above, a label as well as a sequence of words (not an array implementation yet). Due to the inherent nature of natural language processing both the label and sequence of words had to be converted to something which the machine could understand. That is, the label had to be converted from "flagged" or "not flagged" to 1 or 0 respectively and the sequence had to be converted to a series of word embeddings where each embedding represented a single word.

Natural language contains many words that are very common in sentences. These so-called stop words ("their", "he", "she", etc...) can make classifying a sentence very hard as, when combining word embeddings, they will take over the representation of the sentence simply by sheer number. That is why in the pre-processing of each sentence (before it is given to the model), the stop words were removed

from the sentence. By removing the stop words, we do not lose much important information and are able to classify more easily.

The models were created to do the conversion from label to 1 or 0 and from sentence of words to sequence of embeddings. The embeddings used were the GloVe 6B embeddings which come from wikipedia scapping<sup>1</sup>.

## IV. MODELS

### i. RNN

When looking at sentence classification, one of the first thought was to look at an RNN encoder that would encode the sentence word by word and the computing a probability of being "flagged" or "not flagged". The label with the highest probability would then be applied to the sentence input.

#### i.1 RNN Description

DESCRIPTION OF RNN AND IMAGE/SKETCH OF THE MODEL CREATED

#### i.2 Tuning Parameters

When the model was created, the different parameters were tuned:

- Embedding Dimension
- Hidden Dimension Size
- Number of Epochs Run

The results for all of these tuning experiments are shown in the results section.

### ii. Random Forest

After getting results for the RNN encoder and finding the best possible RNN, it was posited (based on research into text classification) that a random forest classifier could be more apt at this task.

<sup>1</sup><https://nlp.stanford.edu/projects/glove/>

### ii.1 Random Forest Description

#### RANDOM FOREST DESCRIPTION

Tuning Parameters When the model was created, the different parameters were tuned:

- Number of Estimators
- Sentence to Embedding Methodology

Whereas the number of estimators is a property of the random forest model itself, the sentence to embedding methodology describes how a sentence (or rather sequence of words) is transformed into a single vector which can be input to the Random forest model.

There were two methods for embedding the sentence. One was to compute the mean of all the word embeddings and the other to compute the sum. The mean would attempt to construct a mean representation of the sentence using all the words in the sentence. The summation would create a sentence which was a sum of its parts.

## V. RESULTS

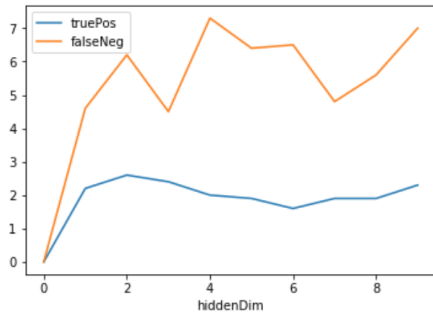
### i. RNN

#### i.1 Hidden dimension

The hidden dimension test was done by keeping all parameters of the RNN constant except for the hidden dimension of the RNN. The following figure shows the results for the hidden dimension test performed. The test was performed by changing the size of the embedding dimension from 0 to 9 dimensions in steps of 1. The training loss, dev set true positive, dev set true negative, dev set false positive and dev set false negative were computed for each of the models run and a graph was created showing the true positive rate and the false positive rate.

test	train	dev	train_loss	dev_loss	accuracy	train_pos	train_neg	train_pos	train_neg
0	RNN	hidden_dim	hidden_dim	hidden_dim	hidden_dim	hidden_dim	hidden_dim	hidden_dim	hidden_dim
0	RNN	hidden_dim	hidden_dim	hidden_dim	hidden_dim	hidden_dim	hidden_dim	hidden_dim	hidden_dim
1	RNN	hidden_dim	hidden_dim	hidden_dim	hidden_dim	hidden_dim	hidden_dim	hidden_dim	hidden_dim
2	RNN	hidden_dim	hidden_dim	hidden_dim	hidden_dim	hidden_dim	hidden_dim	hidden_dim	hidden_dim
3	RNN	hidden_dim	hidden_dim	hidden_dim	hidden_dim	hidden_dim	hidden_dim	hidden_dim	hidden_dim
4	RNN	hidden_dim	hidden_dim	hidden_dim	hidden_dim	hidden_dim	hidden_dim	hidden_dim	hidden_dim
5	RNN	hidden_dim	hidden_dim	hidden_dim	hidden_dim	hidden_dim	hidden_dim	hidden_dim	hidden_dim
6	RNN	hidden_dim	hidden_dim	hidden_dim	hidden_dim	hidden_dim	hidden_dim	hidden_dim	hidden_dim
7	RNN	hidden_dim	hidden_dim	hidden_dim	hidden_dim	hidden_dim	hidden_dim	hidden_dim	hidden_dim
8	RNN	hidden_dim	hidden_dim	hidden_dim	hidden_dim	hidden_dim	hidden_dim	hidden_dim	hidden_dim
9	RNN	hidden_dim	hidden_dim	hidden_dim	hidden_dim	hidden_dim	hidden_dim	hidden_dim	hidden_dim

Figure 1: Shows the table of hidden dimension tests for the RNN

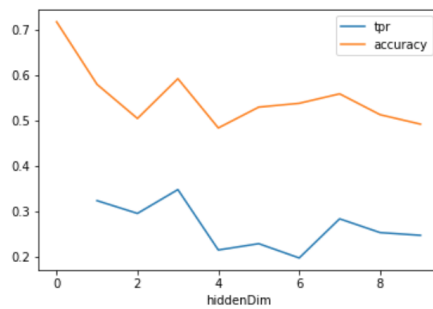


**Figure 2:** Shows the graph of true positive count vs hidden dimension of RNN

This graph shows that the true positive count is always lower than the false negative count. This means that there are more instances where the model will classify a sentence as "not flagged" when in fact it should be "flagged" than there are instances where the model correctly classifies a sentence as "flagged." While this points towards this particular model (with the hyperparameters described below) not being good, the true positive rate and accuracies are derived (and much more important) metrics to look at.

While this graph shows the true positive count as well as the false negative counts, a more interesting metric which can be derived from the true positive count and the false negative count is the true positive rate (tpr) which shows how much of the truth the model captures.

The following figure shows the tpr for the RNN model for different hidden dimensions.



**Figure 3:** Shows the graph of true positive rate vs hidden dimension of RNN

From this figure, we can clearly see that the tpr is greatest when the hidden dimension is 3, with the other parameters set to: number of epochs ran = 400, number of layers = 1 and embedding size = 50. This model received an accuracy of 0.591667 and a true positive rate of 0.347826.

While the graph of accuracies shows that when the hidden dimension is of size 0, the accuracy jumps to 0.7, this model would not be considered to be a good model as the true positive rate is non-existent because we are not classifying any results as being "flagged", which defeats the whole purpose of the model.

Thus, the hidden dimension will be set to 3 for the other models.

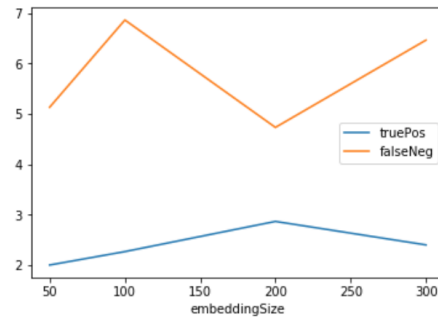
## i.2 GloVe embedding size

When the hidden dimension was found, the next hyper-parameter which could be tuned was the size of the GloVe embeddings used to convert the sentences into something the models could understand.

This next figure shows the true positive counts and false negative counts for each embedding dimension available (50, 100, 200 and 300).

type	test	filesize	readEpochs	num_layers	embeddingSize	hiddenDim	train_loss	accuracy	truePos	training	falsePos	falseNeg
RNN	embedding_dim: embedding_size:100000	400	1	50	3	0.00911541	0.590667	2	11.8	0.35867	0.10000	
RNN	embedding_dim: embedding_size:100000	400	1	100	3	0.00727300	0.590667	9.6	5.08667	0.98867		
RNN	embedding_dim: embedding_size:100000	400	1	300	3	0.00961308	0.591667	2.88667	11.3333	0.58667	4.70000	
RNN	embedding_dim: embedding_size:100000	400	1	300	3	0.00790819	0.600666	2.4	0.73333	0.4	6.48667	

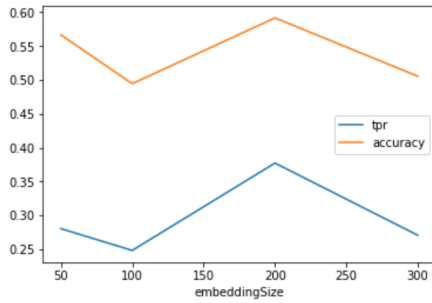
**Figure 4:** Shows the table of embedding dimension tests for the RNN



**Figure 5:** Shows the graph of true positive count and false negative count vs embedding dimensions of RNN

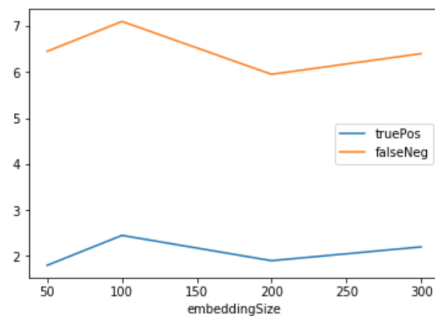
The table and graph show that the true positive count is always smaller than the false negative count. However a dip can be seen in the false negative count at an embedding size of 200. This dip in false negatives is coupled by a rise in the true positive. This indicates that the embedding size of 200 yields the best results.<sup>2</sup>

Confirmation of this is seen in the figures below as both the true positive rate and accuracy are highest at an embedding size of 200.

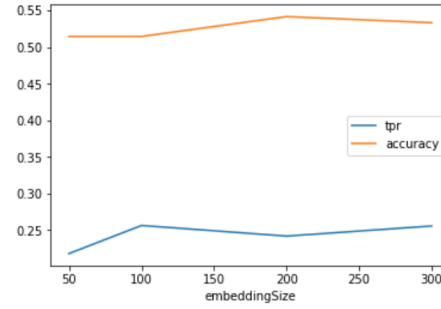


**Figure 6:** Shows the graph of true positive rate vs embedding dimensions of RNN

However upon further investigation, it seems that this may have been a random occurrence due to the randomization of the data. After running this test several times, the graph did not show any significant improvement. For example, the following two figures was another run which illustrates that, depending on the random set of data, the best embeddings change



<sup>2</sup>Note that the increase in the true positive count and decrease in false negative counts graphed are not the same magnitude as the samples were drawn randomly from the training set and thus may not always contain the same number of positive and negative examples.



Therefore, for computation purposes, the embedding size was set to 100. This was thought to be a good compromise between a larger embedding which may provide more information and the speed of loading the embeddings.

### i.3 Number Layers

The final hyperparameter to be tuned was the number of layers that the rnn contained. Before this test, the RNNs trained had a single layer. This test was performed twice in order to make sure there was consistency among even more random samples.

### i.4 RNN Final Model

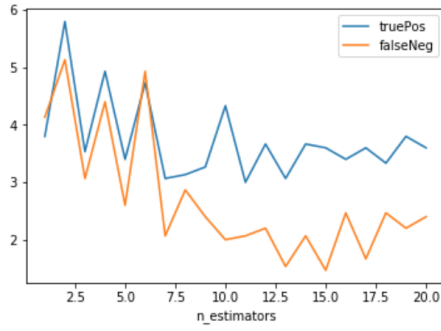
#### ii. Random Forest

As mentioned above, when the best rnn model was tuned it yielded an accuracy of

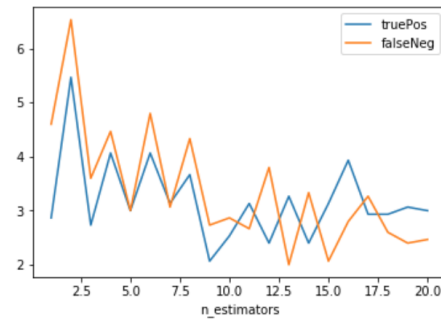
#### ii.1 Summation Methodology

	type	test	filename	n_estimators	accuracy	trucpos	trueneg	falsepos	falseneg	tpr	prc
0	RandomForest	sum	randomForest_1_estimators	1	0.69687	3.8	12.2	3.69687	4.13333	0.47892	0.48952
1	RandomForest	sum	randomForest_2_estimators	2	0.67222	5.8	10.3333	2.73333	5.13333	0.53048	0.67968
2	RandomForest	sum	randomForest_3_estimators	3	0.733333	3.53333	14.0667	3.3333	3.06667	0.53535	0.514563
3	RandomForest	sum	randomForest_4_estimators	4	0.705556	4.8333	12	2.66667	4.4	0.52871	0.64123
4	RandomForest	sum	randomForest_5_estimators	5	0.730556	3.4	14.1333	3.66667	2.6	0.56667	0.48789
5	RandomForest	sum	randomForest_6_estimators	6	0.680556	4.73333	11.6	2.73333	4.93333	0.48655	0.63389
6	RandomForest	sum	randomForest_7_estimators	7	0.780556	3.06667	15.6667	3.2	2.06667	0.59743	0.48362
7	RandomForest	sum	randomForest_8_estimators	8	0.718444	3.13333	14.1333	3.86667	2.86667	0.52222	0.447819
8	RandomForest	sum	randomForest_9_estimators	9	0.781111	3.26667	14.4	3.83333	2.4	0.57471	0.45374
9	RandomForest	sum	randomForest_10_estimators	10	0.811111	4.33333	15.1333	2.83333	2	0.64211	0.61058
10	RandomForest	sum	randomForest_11_estimators	11	0.722222	3	14.3333	4.6	2.06667	0.58219	0.384737
11	RandomForest	sum	randomForest_12_estimators	12	0.741667	3.66667	14.1333	4	2.2	0.625	0.478261
12	RandomForest	sum	randomForest_13_estimators	13	0.747222	3.06667	14.8667	4.53333	1.53333	0.69667	0.40209
13	RandomForest	sum	randomForest_14_estimators	14	0.738889	3.66667	14.0667	4.2	2.06667	0.63935	0.46102
14	RandomForest	sum	randomForest_15_estimators	15	0.781111	3.6	14.6667	4.26667	1.46667	0.71028	0.457827
15	RandomForest	sum	randomForest_16_estimators	16	0.725	3.4	14	4.13333	2.46667	0.57945	0.451327
16	RandomForest	sum	randomForest_17_estimators	17	0.772222	3.6	14.8333	3.8	1.86667	0.68344	0.486486
17	RandomForest	sum	randomForest_18_estimators	18	0.727778	3.33333	14.1333	4.06667	2.46667	0.57471	0.45045
18	RandomForest	sum	randomForest_19_estimators	19	0.722222	3.8	14.7333	3.86667	2.2	0.63333	0.537736
19	RandomForest	sum	randomForest_20_estimators	20	0.744444	3.6	14.2667	3.73333	2.4	0.6	0.48909

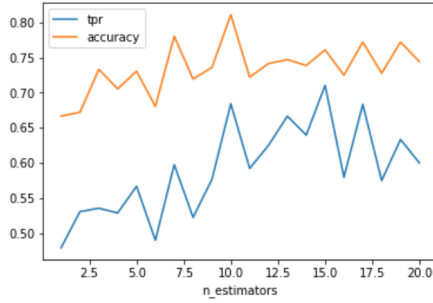
**Figure 7:** Shows the table for the experiments where the number of estimators used in the random forest classifier were used. This is for the summation methodology.



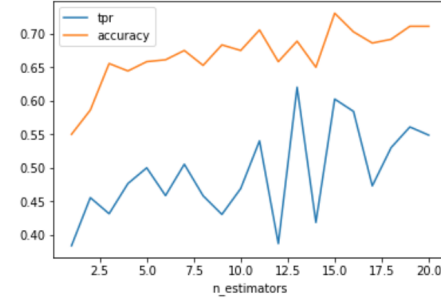
**Figure 8:** Shows the graph for the experiments where the number of estimators used in the random forest classifier were used. This is for the summation methodology.



**Figure 11:** Shows the graph for the experiments where the number of estimators used in the random forest classifier were used. This is for the summation methodology.



**Figure 9:** Shows the graph of true positive rate and accuracy vs number of estimators of random forest with summed embeddings as representation for the sentence



**Figure 12:** Shows the graph of true positive rate and accuracy vs number of estimators of random forest with summed embeddings as representation for the sentence

## ii.2 Mean Methodology

	type	test	feature	n_estimators	accuracy	truePos	trueNeg	falsePos	falseNeg	tpr	auc
20	RandomForest	mean	randomForest_meanMethodSum_1_estimators	1	0.50	2.86667	10.3333	8.2	4.6	0.30303	0.318175
21	RandomForest	mean	randomForest_meanMethodSum_2_estimators	2	0.586111	4.46667	6.6	3.4	6.33333	0.405000	0.416541
22	RandomForest	mean	randomForest_meanMethodSum_3_estimators	3	0.655556	2.73333	13	4.66667	3.8	0.421579	0.398089
23	RandomForest	mean	randomForest_meanMethodSum_4_estimators	4	0.644444	4.06667	11.4	4.06667	4.66667	0.476667	0.5
24	RandomForest	mean	randomForest_meanMethodSum_5_estimators	5	0.683333	3	12.8	5.2	3	0.5	0.390894
25	RandomForest	mean	randomForest_meanMethodSum_6_estimators	6	0.681111	4.26667	11.6	3.33333	4.8	0.486667	0.5493
26	RandomForest	mean	randomForest_meanMethodSum_7_estimators	7	0.675	3.13333	13.0667	4.73333	3.06667	0.503333	0.396905
27	RandomForest	mean	randomForest_meanMethodSum_8_estimators	8	0.627778	3.86667	12	4	4.33333	0.483333	0.476261
28	RandomForest	mean	randomForest_meanMethodSum_9_estimators	9	0.653333	2.06667	14.3333	4.86667	2.73333	0.435556	0.296777
29	RandomForest	mean	randomForest_meanMethodSum_10_estimators	10	0.675	2.33333	13.6667	4.93333	2.86667	0.46136	0.382828
30	RandomForest	mean	randomForest_meanMethodSum_11_estimators	11	0.705556	3.13333	12.8	4.4	2.66667	0.542000	0.418269
31	RandomForest	mean	randomForest_meanMethodSum_12_estimators	12	0.658333	2.4	13.4	4.4	3.8	0.367897	0.352941
32	RandomForest	mean	randomForest_meanMethodSum_13_estimators	13	0.688889	3.26667	13.2667	5.46667	2	0.522500	0.374046
33	RandomForest	mean	randomForest_meanMethodSum_14_estimators	14	0.65	2.4	13.2	5.06667	3.33333	0.418605	0.321429
34	RandomForest	mean	randomForest_meanMethodSum_15_estimators	15	0.730556	3.13333	14.4	4.4	2.66667	0.622500	0.418829
35	RandomForest	mean	randomForest_meanMethodSum_16_estimators	16	0.707778	3.33333	12.6667	4.53333	2.8	0.584158	0.475628
36	RandomForest	mean	randomForest_meanMethodSum_17_estimators	17	0.686111	2.93333	13.5333	4.26667	3.26667	0.473718	0.407402
37	RandomForest	mean	randomForest_meanMethodSum_18_estimators	18	0.691667	2.93333	13.6667	4.8	2.8	0.50212	0.37891
38	RandomForest	mean	randomForest_meanMethodSum_19_estimators	19	0.711111	3.06667	14	4.53333	2.4	0.582876	0.428269
39	RandomForest	mean	randomForest_meanMethodSum_20_estimators	20	0.711111	3	14.0667	4.46667	2.46667	0.54876	0.401786

**Figure 10:** Shows the table for the experiments where the number of estimators used in the random forest classifier were used. This is for the mean methodology.

## ii.3 Mean vs Summation Methodology

From the figures above, it can be seen that, for all numbers of estimators used in the random forest mode the summation accuracy and true positive rates are higher than the mean methodology. This makes sense as the summation method attempts to feed the model the summation of the words rather than the average representation.

## ii.4 Random Forest Final Model

The final model for the random forest had the following parameters:

iii. Final Model

iv. Using the Model Explanation of Code

#### REFERENCES

[Figueredo and Wolf, 2009] Figueredo, A. J. and Wolf, P. S. A. (2009). Assortative pairing and life history strategy - a cross-cultural study. *Human Nature*, 20:317–330.