IMDB Sentiment Analysis

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***Abstract*—The IMDb Movie Reviews dataset is a binary sentiment analysis dataset consisting of 50,000 reviews from the Internet Movie Database (IMDb) labeled as positive or negative. The dataset contains an even number of positive and negative reviews. Only highly polarizing reviews are considered. In this project,we predicted the number of positive and negative reviews based on sentiments using different classification models, including Logistic Regression, Naïve Bayes, Decision Tree (Random Forest, Adaboost), SVM, and Deep Learning using keras library.**

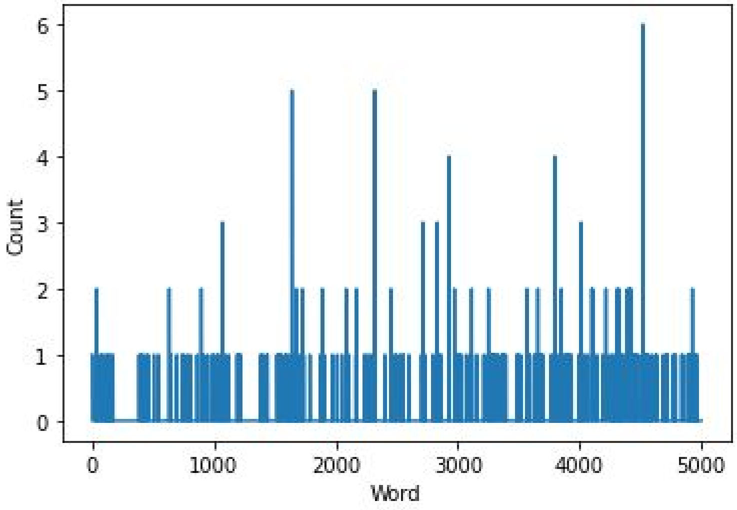
***Index Terms*—Classification, Sentiment Analysis, Machine Learning, Deep Learning**

I. Preprocess

The IMDb reviews contains html tags which do not serve any purpose for detecting sentiment, we also decided to remove punctuation whatsoever, even if this means that we get rid of emoticons (there are very few of them anyway), but it makes it easier for us to handle. Finally we lowercase everything. We also apply Porter stemming algorithm, which helps s replace every word with it's root, and so words like cats and cat, or running and run, become the same. This has been shown to improve classification accuracy in sentiment analysis tasks. Another step that helps improve classification performance is what we call negation handling, intuitively words that are preceded by a negation (i.e no, not, hardly, etc.) means the opposite, and thus we replace every patter of the form [negation] [word] by neg [word]. So for example, hardly good would be replaced by neg good.

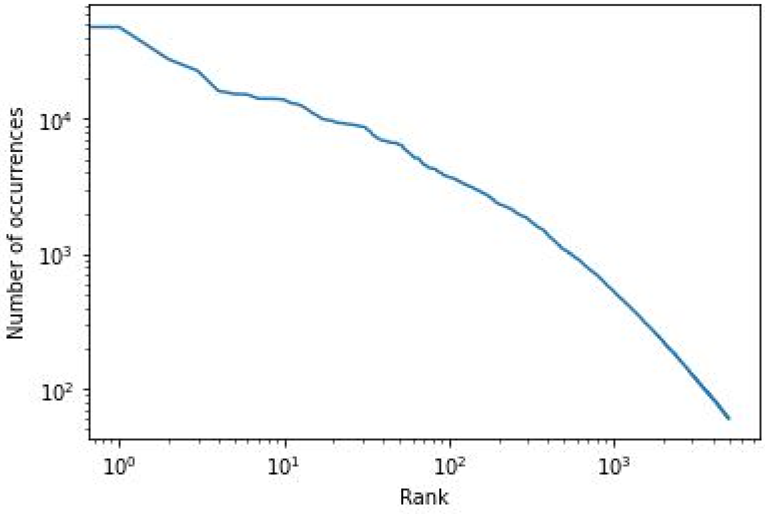
II. Vectorization

We used Bag of Words method to vectorize our data specifically we used CountVectorizer from sklearn to perform it. Vectorization is a technique that is used to transform a given text into a vector on the basis of the frequency (count) of each word that occurs in the entire text. The vocabulary we used has length of 5000.



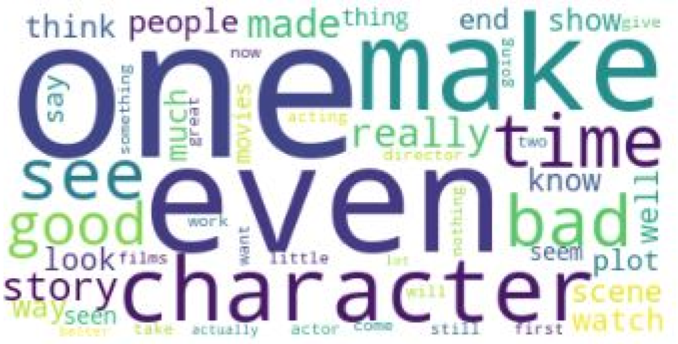
III. Zipf's Law

Also we find out that the words don' t follow Zipf's law **Theorem:** Zipf's law is an empirical law formulated using mathematical statistics that refers to the fact that for many types of data studied in the physical and social sciences, the rank-frequency distribution is an inverse relation.

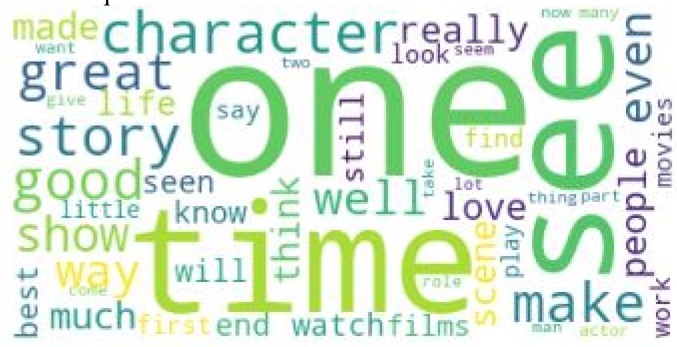


IV. WordCloud Visualisation

Most Frequent Negative Words in Reviews:



Most Frequent Positive Words in Reviews:



V. Final Observations and Normalizing

We found out that the number of occurrences of the most frequent word was 51696 and of the second word was 48191. Then we normalized(unit norm) the data because bag of words vectorize sentences by counting words so there are might be big differences between the dimensions of the vectors and that might affect our models.

VI. Non-Linear Machine Learning Models

We used these models to predict Sentiment ,Logistic Regression, Naïve Bayes, Decision Tree (Random Forest, Adaboost), SVM.

A. Logistic Regression

In statistics, the (binary) logistic model (or logit model) is a statistical model that models the probability of one event (out of two alternatives) taking place by having the log-odds (the logarithm of the odds) for the event be a linear combination of one or more independent variables (”predictors”) We used LogisticRegression from sklearn: Accuracy: train = 0.89696, test = 0.8744

B. Naive Bayes Classifier

In statistics, naive Bayes classifiers are a family of simple ”probabilistic classifiers” based on applying Bayes’ theorem with strong (naive) independence assumptions between the features.

- **Gaussian NB** When dealing with continuous data, a typical assumption is that the continuous values associated with each class are distributed according to a normal (or Gaussian) distribution. For example, suppose the training data contains a continuous attribute, x. The data is first segmented by the class, and then the mean and variance of x is computed in each class [GaussianNB] Accuracy: train = 0.81892, test = 0.72452
- **MultinomialNB** With a multinomial event model, samples (feature vectors) represent the frequencies with which certain events have been generated by a p1, . . . , pn is the probability that event i occurs (or K such multinomials in the multiclass case). A feature vector x =(x1,. . . ,xn) is then a histogram, with xi counting the number of times event i was observed in a particular instance. [MultinomialNB] Accuracy: train = 0.86768, test = 0.84344
- **BernoulliNB** In the multivariate Bernoulli event model, features are independent Booleans (binary variables) describing inputs. Like the multinomial model, this model is popular for document classification tasks. [BernoulliNB] Accuracy: train = 0.85488, test = 0.83136
- **ComplementNB** Complement Naive Bayes is somewhat an adaptation of the standard Multinomial Naive Bayes algorithm. Multinomial Naive Bayes does not perform very well on imbalanced datasets. Complement Naive Bayes is particularly suited to work with imbalanced datasets. [ComplementNB] Accuracy: train = 0.86768, test = 0.84344

C. Random Forest

Random forests or random decision forests is an ensemble learning method for classification, regression and other tasks that operates by constructing a multitude of decision trees at training time. For classification tasks, the output of the random forest is the class selected by most trees. We used GridSearch for hyperparameter tuning Number of Estimators: [5,50,100] Max Depth of the trees : [2,10,20,None] We checked the train and the test accuracy of these combinations: number estimators = 50, max depth = 20

[RandomForestClassifier]Accuracy: train = 0.93332, test = 0.83084

number estimators = 100, max depth = 20

[RandomForestClassifier]Accuracy: train = 0.94064, test = 0.84264

number estimators = 100, max depth = None

[RandomForestClassifier] Accuracy: train = 1.0, test = 0.84448

D. AdaBoost with Decision Trees

We used Adaboost to boost the performance of the decision tree classifier with max depth = 5

[AdaBoostClassifier] Accuracy: train = 0.9684, test = 0.80496

E. Support Vector Machine Classifier

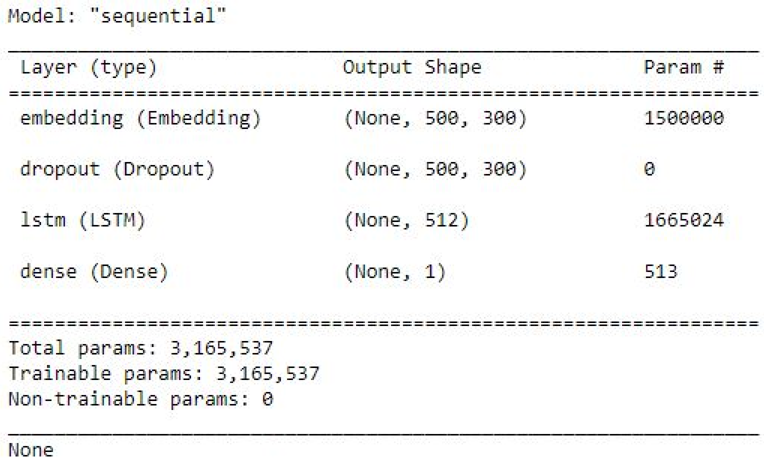
We standardized our data and fitted them in a svm model: [Support Vector Machine] Accuracy: train = 0.98324, test = 0.86904

VII. Neural Networks

A. Preprocess Data

Keras has a built-in IMDb movie reviews dataset that we can use, with the same vocabulary size The build in keras dataset has already tokenized the words. The next step is padding so all the vectors have the same length. We padded everything to have length of 500.

B. Model



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Model: "sequential"
_________________________________________________________________
 Layer (type)                Output Shape              Param #
=================================================================
 embedding (Embedding)       (None, 500, 300)          1500000

 dropout (Dropout)           (None, 500, 300)          0

 lstm (LSTM)                 (None, 512)               1665024

 dense (Dense)               (None, 1)                 513

=================================================================
Total params: 3,165,537
Trainable params: 3,165,537
Non-trainable params: 0
_________________________________________________________________
None
```

The model we used is the following: An embedding layer with vocabulary size = 5000 dimension of embeddings = 300, Dropout mechanism with probability of dropping out 0.2, a LSTM Layer with 512 units and 0.2 dropout and a dense layer with binary output, using sigmoid as an activation function.

C. Compilation and Evaluation

We compiled the model using as loss function binary crossentropy and optimizer adam v2.Adam with learning rate 0.001

We fitted our data using 32 as batch size. The training of the model stopped at 7 epochs

Train accuracy: 0.9825 val accuracy: 0.8828

Test accuracy: 0.8726400136947632

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