Potential Movie Rating Prediction using Supervised Machine Learning Methods

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# Introduction (*Heading 1*)

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# Literature Review

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# Methods and Datasets

In this section, we shall look at the raw data available to us and select the attributes that are suitable to us. We will also examine how we selected the labels for the dataset. The dataset used for our project was taken from [Kaggle](https://www.kaggle.com/rounakbanik/the-movies-dataset) – the movies dataset.

The data was obtained by using the TMDB API to retrieve attributes of over 45000 movies. The main csv folder included the following attributes on 45000 movies that were used for our study:

* *Budget – in US dollars*
* *Genres – multiple genres per movie if applicable*
* *ID- identification number as index*
* *Popularity – quantified popularity measure*
* *Runtime – length of movie in minutes*
* *Vote\_average -the average of all the votes from users per movie – from 0 to 10 with 10 being the highest.*

The other attributes that could be potentially used were Revenue, number of Spoken Languages, and whether or not the movie belongs to a collection. To keep the experiment simple, we decided to only include the attributes as listed.

## Data Preprocessing

At this stage, we shall describe the content that we extracted from our data to feed into the machine learning models. To preprocess and clean the dataset, we used Pandas library in python. Firstly, we dropped all the columns that were not meaningful to us. Then, we converted the numerical columns to numerical data type, this included budget, runtime and popularity.

We then removed all then null values, from both numerical and non-numerical data columns. However, this was not sufficient since a lot of movies had a 0 value for the numerical data. We spotted this by plotting the distribution of all the quantitative columns. All the 0 values were removed from the dataset. Next, the all the duplicates were removed.

The genres column had multiple values per movie. In our experiment, we wanted to focus on the primary genre of each movie. Hence, the list of json objects were processed to only keep the first (primary) genre per movie.

Another important aspect of preprocessing that remains is categorizing the ratings into discrete labels. Currently, we had a rating between 0 to 10 for every movie. By logically considering the movie ratings, we decided to simplify the labels to Good (7.5+), Average (5 to 7.5) and Bad (0 to 5). This resulted in an imbalanced dataset, as expected, since majority of the movies would fall within the Average class. There were only 479 Good movies and 884 Bad movies, while 5204 Average movies.

In an attempt to solve the imbalanced class problem, we attempted the following:

* Oversample the minority class labels (Bad, Good) to 2000 data points each.
* Under sample the majority class label (Average) to 2000 data points.

Over sampling the data can often lead to overfitting, while under sampling can result in valuable data features being lost in the process. To prevent a significant impact of either of these changes, we decided to compromise between the over and under sampling.

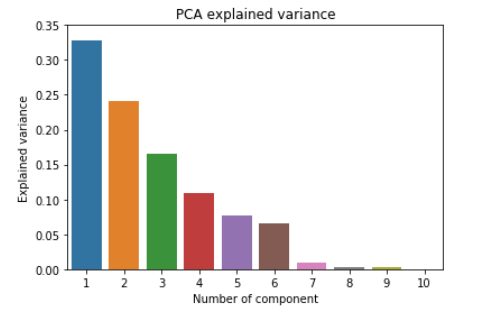
The remaining categorical column of genres were then one-hot encoded resulting in the following columns in our data frame: 'Action’, ‘Adventure', 'Comedy', 'Crime', 'Drama', 'Horror', 'Thriller'. The labels were saved for later analysis.

Finally, the numerical columns of 'budget', 'popularity', 'runtime', were normalized using the min-max normalization technique. It is imperative to normalize our data since some of the models are sensitive to the scaling issue. The data processing was complete and saved into arrays.

## Feature Selection and Dimensionality Reduction

In addition to saving the raw preprocessed data, as mentioned above, we also applied feature selection and dimensionality reduction.

* First, the selectKbest method in SKLearn was used- which selects the k highest scoring features, where k was used as 5. The scoring function used was the chi-squared test, which measures the dependence between the random variables so using this function means that it would weed out the features that are likely to be independent of the class.
* Second, the selectPercentile method of SKLearn was used – it selects features according to a percentile of the highest scores. In our project, we selected to keep 50 percent of the data. For the scoring function, we used f\_classif, which calculates the ANOVA F-value between feature for classification tasks. It measures if “the variance between the means of two populations significantly different?”. Variances measure the dispersal of the data points around the mean.
* Third, we use PCA to select an appropriate number of components. As seen on the figure below, the 6th component only explains 6.5% which is very small. The first 5 components explain a total of 92.3%. Hence, we decided to only take the first 5 components, since the remaining do not explain a lot of variance.



1. Number of PCA components and their explained variance.

Hence, we resulted in 4 different types of input data for each of the models, the raw data with all features, selectKbest data with 5 featues, the selectPercentile data with 50% of useful features, and the PCA data with 5 principal components.

## Machine Learning Models

For each of the supervised machine learning models discussed below, we used a Grid Search to find the best hyper-parameters for each of the 4 input data formats.

### Decision Tree classifier

The parameters tuned with their respective range:

* *Minimum samples required to split a node – range from 5 to 80 with increments of 5*
* *Maximum leaf nodes in the model – range from 5 to 80 with increments of 5*

### Naïve Bayes classifier

The parameters tuned with their respective range:

* *Var\_smoothing (portion of the largest variance added for calculation stability) – range from 1e-6 to 1e-15*

### KNN classifier

The parameters tuned with their respective range:

* *Weight function used in prediction – either ‘uniform’ or ‘distance’*
* *Number of neighbors to use for classification - range from 5 to 80 with increments of 5*

### SVM non-linear classifier

The parameters tuned with their respective range:

* *Kernel – either 'rbf' and 'sigmoid'*
* *C – a selection from the list: 0.1,1,10,100,1000*
* *Gamma – a selection from the list: 1e-4,1e-3,1e-2,0.1,1,5,10*
* *coef0 ( Independent term in kernel function) – range from -200 to 200, increments of 50.*

### SVM linear-kernel classifier

The parameters tuned with their respective range:

* *C – a selection from the list: 0.1,1,10,100,1000*

For each of the input data format to the models discussed, we used the train\_test\_split method from SKLearn with a fixed random state of 200 – to divide the data set into 80% training data and 20% testing. The random state ensures a consistent selection to increase fairness.

## Evaluation

For each of the models discussed, the evaluation was repeated for the 4 different input data types to the model (Default data, K best Data, K select Percentile Data, PCA data.). The evaluation steps included:

* The best model from the Grid Search was chosen based on the F1-Score (macro).
* The predicted labels were generated from the trained model and compared with the actual to get the testing score. The training score was also saved for the best model.
* A classification report indicating the precision, recall and f1-score for every class (Average, Good, Bad) were generated using the predicted and actual test labels.
* The confusion matrix was plotted.
* Using the best hyper-parameter selected model, we performed cross-validation with 5 splits. The resulting F1-Scores for every model was printed out to show the variation due to different selection of training/testing data.

# Experimental results

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