

A Project Report
On
Movie Recommendation System

Submitted

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Abstract

In recent years, movie industry is getting more and more profitable and prosperous. Thousands of movies are released every year across the World. Now days, it became more popular as a research topic. In this project, we propose a Movie Recommendation System by Combining the Naïve Bayes Algorithm with K- means culturing. Recommendation systems are ubiquitous in versatile online platforms these days. Our aim is to build a movie recommendation system based on dataset. We wish to Segment our Movies Data in clusters which is relatable to Specific Customers data.

Keywords: Dataset, One- Hot encoding, EDA (Outlier detection), data cleaning (Outlier removal)

Problem definition

In this report, we want to implement Movies recommendation System using Naïve Bayes Classifier and K- means culturing. Here we have dataset of the people from different cultures having different interest in movies web series. We are predicting people lying in the same group according to movies in particular language.

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Introduction

A recommender system is a simple algorithm whose aim is to provide the most relevant information to a user by discovering patterns in a dataset. The algorithm rates the items and shows the user the items that they would rate highly. An example of recommendation in action is when you visit Amazon and you notice that some items are being recommended to you or when Netflix recommends certain movies to you. They are also used by Music streaming applications such as Spotify and Deezer to recommend music that you might like.

The most common types of recommendation systems are content-based and collaborative filtering recommender systems. The recommendation is based on the preference of other users. A simple example would be recommending a movie to a user based on the fact that their friend liked the movie.

Collaborative Filtering: In collaborative filtering, the behaviour of a group of users is used to make recommendations to other users. They are divided into two parts:

- **User-based collaborative filtering:** In this model, products are recommended to a user based on the fact that the products have been liked by users similar to the user. For example, if Derrick and Dennis like the same movies and a new movie come out that Derrick like, then we can recommend that movie to Dennis because Derrick and Dennis seem to like the same movies.
- **Item-based collaborative filtering:** These systems identify similar items based on users' previous ratings. For example, if users A, B, and C gave a 5-star rating to books X and Y then when a user D buys book Y they also get a recommendation to purchase book X because the system identifies book X and Y as similar based on the ratings of users A, B, and C.

Content-based system: It uses metadata such as genre, producer, actor, musician to recommend items say movies or music. Such a recommendation would be for instance recommending Infinity War that featured Vin Diesel because someone watched and liked The Fate of the Furious. Similarly, you can get music recommendations from certain artists because you liked their music. Content-based systems are based on the idea that if you liked a certain item, you are most likely to like something that is similar to it.

1. Dataset

Classifying objects in the field of computer science, in general, is a difficult task. However, if large data sets consisting of similar objects to classify are available, a predictive model can be obtained using various techniques. As the problem of object classification became increasingly relevant in computer applications, developments in the field of Machine Learning (ML), a sub-field of Artificial Intelligence (AI), allowed for the construction of Machine Learning Algorithms that efficiently predict, categorize, and classify distinct objects based on different features and their association to classification labels. Recommendation System is generally a subclass of information filtering system that helps to predict the preference that users would give to an item. We use "Naïve Bayes Algorithm" in this project to getting our results. Object classification problems occur frequently and are complex problems that often involve many features. Machine learning algorithms are used to effectively handle classification problems and are highly effective.

Related Work: With new applications of computer algorithms in fields that often require the solution to object classification problems such as medicine, defence contracting, transportation, and retail, machine learning techniques drastically increase safety, consumer products, and health due to the use of machine learning to solve critical problems. Furthermore, as the field of machine learning expands, new learning techniques are implemented to further increase model accuracy and

reliability. The Naïve Bayes (NB) classifier method is one simple but effective example of how supervised machine learning algorithms proficiently solve complex problems.

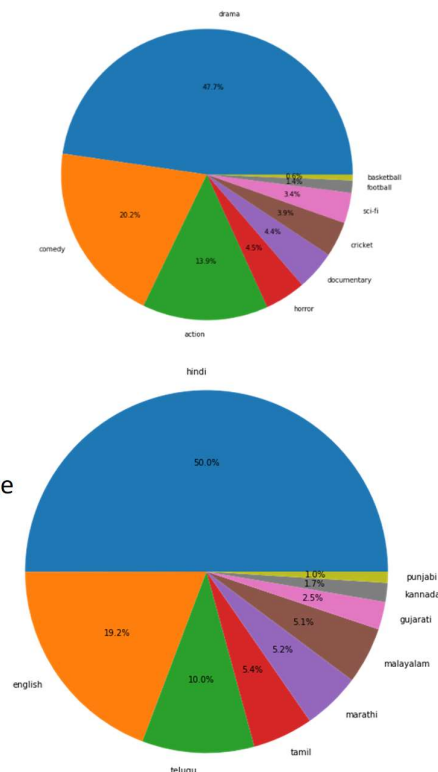
Often data that are analysed and learned using ML techniques are sensitive. In other words, the data set, such as medical records, security footage, and financial information, that predictive models are trained on cannot be accessible to the end user. This problem concerns supervised ML models such as the NB classifier.

- **About Data:** The dataset we used for this project is the “content.csv”. The dataset has 48,646 rows and 9 columns. Some features of this dataset include content_id, content_type, language, genre, rating etc. The size of the “content.csv” is 2.84 MB.
- **Data Pre-processing:** It is the technique which used to covert raw data into useful and efficient format so that we can perform other processes. This involves many steps:
 1. Data cleaning like handle missing data, Noisy data that cannot be interpreted by our machine, handling data entry errors etc. Here we detect the Outlier by Clustering the data and we will manipulate this.
 2. Data transformation to transform data in appropriate form. Here we construct new attributes which helps in further process.
 3. Data Reduction used when we have huge amount of data. Since we know handling data is big task and if that data is very large with very huge volume. Then analysing data became the harder part of Data pre-processing. It aims to decrease data storage and cost of data analysis and moreover to increase the storage efficiency. In this method we use “One Hot encoding for removing some columns”.

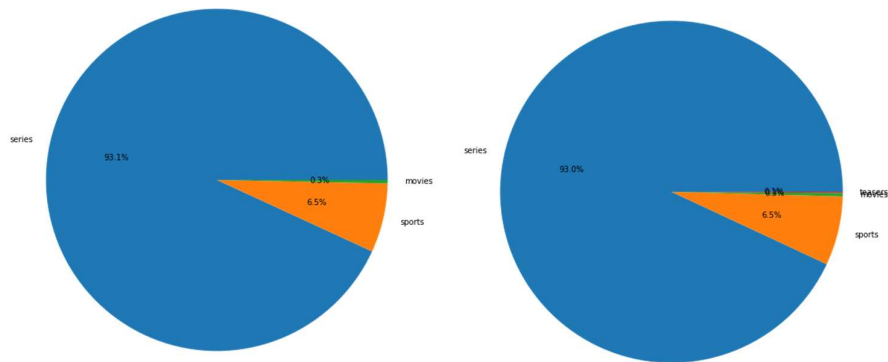
We split the dataset into test and train based on content_id, such that 80% of the content by every single user is used for training the model and the remaining 20% of the content to validate the correctness of our model which are known as training set and test set respectively. We achieve this by using the train_test_split method in scikit-learn library.

- **Data Analysis:**

1. **Genre Distribution of data:**
Most of the contents are drama of distribution 47.7% followed by comedy 20.2%, action 13.9%, horror 4.5% and so on.
2. **Language Distribution of the data:**
Most of the contents are in hindi language of distribution 50% followed by english 19.2%, telugu 10%, tamil 5.4%, marathi 5.2% and so on.



3. Content type distribution of data:



(Top 3 content type in our data)

(Distribution of all content type in our data)

We can see, 93% of the contents is series only followed by sports 6.5%, movies 0.3% and remaining are have very small contribution.

2. Prerequisites

Probability

Experiment: An experiment or trial is any procedure that can be infinitely repeated and has a well-ordered set of possible outcomes. The result of an activity or experiment is called an outcome.

Ex: - "Throw a die" is an experiment and {1,2,3,4,5,6} are the possible outcomes of the given experiment.

Sample Space: The set of all possible outcomes of an experiment is called Sample Space and is denoted by S.

Event: It is generally a subset of sample space and denoted by A, B, E, etc.

For any experiment, if $|S|=n$ then number of events = 2^n

Independent events: Let A and B be two events that are said to be independent if

$$P(A/B) = P(A)$$

$$\text{i.e., } P(A \cap B) = P(A) P(B)$$

Partitions of Sample Space: Let S be any non-empty sample space for an experiment. The collection $\{A_i\}_{i=1}^n$ of non-empty subsets of S such that

$$(i) \quad \bigcup_{i=1}^n A_i = S$$

$$(ii) \quad A_i \cap A_j = \phi$$

Conditional probability: Let A and B be random variables then

$$P(A/B) = P(A \cap B) / P(B)$$

Mutually Exclusive events: Let A and B be two events that are said to be Mutually exclusive if

$$P(A/B) = P(B/A) = 0 \text{ i.e., } P(A \cap B) = 0$$

Bayes theorem: Let $\{A_i\}_{i=1}^n$ be non-empty events, constitute a partition on a sample space S or are mutually exclusive and exhaustive events. Let E be the event occurs with any A_k then

$$P(A_k/E) = \frac{P(A_k) P(E/A_k)}{\sum_{i=1}^n P(A_i) P(E/A_i)}$$

- The formula for Bayes' theorem is given as:

$$P(A/B) = \frac{P(A) P(B/A)}{P(B)}$$

Where, P(A/B) is Posterior probability: Probability of hypothesis A on the observed event B.

P(B/A) is Likelihood probability: Probability of the evidence given that the probability of a hypothesis is true.

P(A) is Prior Probability: Probability of hypothesis before observing the evidence.

P(B) is Marginal Probability: Probability of Evidence.

Bayes Theorem used in Machine learning to predict the classes accurately. It describes the probability of occurrence of an event related to any given condition i.e., for the case of conditional probability.

Normal Distribution: Suppose $Z \sim B(n, p)$ then

$$P(Z = z) = \binom{n}{z} p^z q^{n-z}, \quad p + q = 1$$

If n is large and neither p nor q is very small (i.e., they are close to ½) then distribution of B (n, p) approaches to Normal Distribution.

We know for Binomial Distribution,

$$\text{Mean}(\mu) = np, \text{ Variance } (\sigma^2) = npq \text{ and Standard deviation}(\sigma) = \sqrt{npq}$$

$$\text{Then consider } X = \frac{Z - \mu}{\sigma} = \frac{Z - np}{\sqrt{npq}}$$

$$\text{When } Z = 0 : X = -\sqrt{\frac{np}{q}} \rightarrow -\infty \text{ and } Z = n : X = \sqrt{\frac{nq}{p}} \rightarrow \infty \text{ as } n \rightarrow \infty$$

So, X is Continuous random Variable, known as Normal Distribution denoted by $N(\mu, \sigma^2)$.

Suppose $X \sim N(\mu, \sigma^2)$ then Probability distribution function (p.d.f) is given by

$$f_X(x) = \frac{1}{\sigma\sqrt{2\pi}} e^{-\frac{1}{2}\left(\frac{x-\mu}{\sigma}\right)^2}$$

The expression $f_X(x)$ is symmetric about $x = \mu$ and $f_X(x) > 0$ for every finite value of x.

$$\text{Now, } f'_X(x) = -\frac{1}{\sigma\sqrt{2\pi}} e^{-\frac{1}{2}\left(\frac{x-\mu}{\sigma}\right)^2} \frac{x-\mu}{\sigma}, \quad \text{Where } \mu = \text{mean}, \sigma^2 = \text{Variance}$$

Also, for $x < \mu : f'_X(x) > 0$ i.e., $f_X(x)$ is increasing function.

for $x > \mu : f_X'(x) < 0$ i.e., $f_X(x)$ is decreasing function.

So, curve of p.d.f of X is bell-shaped with x-axis as asymptote.

Note that, $P(\mu - \sigma \leq X \leq \mu + \sigma) = 0.68$

$P(\mu - 2\sigma \leq X \leq \mu + 2\sigma) = 0.95$

$P(\mu - 3\sigma \leq X \leq \mu + 3\sigma) = 0.99$

Standard Normal Distribution: for $\mu=0$ and $\sigma=1$, Normal distribution is known as Standard Normal Distribution. i.e., $Z \sim N(0, 1)$

For $X \sim N(\mu, \sigma^2)$, the Standard Normal Distribution is given by

$$Z = \frac{X - \mu}{\sigma}$$

Z- score: Let x be the test value then z-score is calculated as

$$z = \frac{x - \mu}{\sigma}$$

Where μ is the mean and σ is the standard value.

If the number of elements in the set is large, about 68% of the elements have a z-score between -1 and 1; about 95% have a z-score between -2 and 2 and about 99% have a z-score between -3 and 3.

Machine Learning

Feature transformation: It is a technique used to boost our model performance. In this method, we apply a mathematical expression or formula to a particular feature and transform the values of that feature or column's value to useful value for further analysis. There are of various types of transformations: Log transformation, Reciprocal transformation (not defined for Zero), Square transformation, square root transformation etc.

In this Project, we used Log transformation because after this transformation, our data is almost Normally distributed.

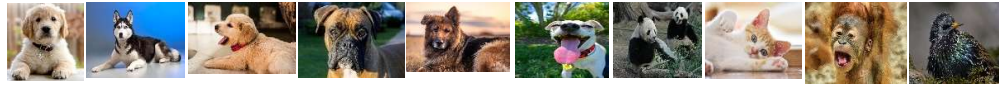
Outlier detection: An Outlier is a data that generally far from mainstream of data or piece of data that deviates drastically from average dataset. There are different Outlier Detection techniques such DBSCAN (density-based clustering), using Z-score etc.

In this Project, we use Z-score outlier detection technique. There is an assumption for using this technique that the data should be Normal distributed or almost Normally Distributed.

Cross validation: It is a method to make model better before the final implementation of the model. The data we use in Cross validation is known as Cross Validation data. We could not fit the model on training data and cannot say that the model will work fine and accurately for the real data in Machine Learning. So, we must assure that our model got the correct pattern from the data, we use Cross validation Technique.

True Positive, True Negative, False Positive and False Negative:

Images:



Predict(Dog):	X	✓	X	✓	✓	✓	✓	✓	X	✓
Actual:	✓	✓	✓	✓	✓	✓	X	X	X	X

True Positive = 4, False Positive = 3, True Negative = 1, False Negative = 2

So, Accuracy = number of accurate predictions / total number of predictions
= 5/10 = 0.5

Precision: Precision is the ratio between the True Positives and all the Positives.

$$Precision = \frac{True\ Positive}{True\ Positive + False\ Positive}$$

In above case: Precision = 0.57

Recall: The recall is the measure of our model correctly identifying True Positives. Recall also gives a measure of how accurately our model can identify the relevant data. It is also known as Sensitivity.

$$Recall = \frac{True\ Positive}{True\ Positive + False\ Negative}$$

In above case: Recall = 0.67

3. Naïve Bayes Algorithm

Classifier: A classifier is a machine learning model used to differentiate different objects on certain properties.

Naïve Bayes Classifier Algorithm: It is technique used for text classification where you have a large data. This algorithm is based on Bayes' theorem with naïve assumption that features are independence among themselves. Let $X = (x_1, x_2, x_3, \dots, x_n)$

$$P(C_k/x_1, x_2, x_3, \dots, x_n) = P(C_k/X) = \frac{1}{z} P(C_k) \prod_{i=1}^n P(x_i/C_k)$$

$$\text{Where } z = P(x_1)P(x_2) \dots P(x_n)$$

Among $P(C_1/X)$, $P(C_2/X)$, ..., $P(C_k/X)$, the greatest one will tag as Class Label.

Suppose we have a dataset of **weather conditions** and corresponding target variable "**Play**". So, using this dataset we need to decide that whether we should play or not on a particular day according to the weather conditions. So, to solve this problem, we need to follow the below steps:

1. Convert the given dataset into frequency tables
2. Generate Likelihood table by finding the probabilities of given features
3. Now, use Bayes theorem to calculate the posterior probability

Problem: If the weather is sunny, then the Player should play or not?

Solution: To solve this question, consider the following dataset:

	Outlook	Play
0	Rainy	Yes
1	Sunny	Yes
2	Overcast	Yes
3	Overcast	Yes
4	Sunny	No
5	Rainy	Yes
6	Sunny	Yes
7	Overcast	Yes
8	Rainy	No
9	Sunny	No
10	Sunny	Yes
11	Rainy	No
12	Overcast	Yes
13	Overcast	Yes

Frequency table for the Weather Conditions:

Weather	Yes	No	Probability
Overcast	5	0	$5/14 = 0.35$
Rainy	2	2	$4/14 = 0.29$
Sunny	3	2	$5/14 = 0.35$
Total	10	5	
Likelihood Probability	10/14	4/14	

Applying Bayes' theorem:

Since, $P(\text{Sunny}) = 0.35$, $P(\text{Yes}) = 0.71$, $P(\text{No}) = 0.29$

$$P(\text{Sunny} / \text{Yes}) = 3/10 = 0.3, P(\text{Sunny} / \text{No}) = 2/4 = 0.5$$

$$\text{So, } P(\text{Yes} / \text{Sunny}) = P(\text{Sunny} / \text{Yes}) * P(\text{Yes}) / P(\text{Sunny}) = 0.3 * 0.71 / 0.35 = 0.60$$

$$P(\text{No} / \text{Sunny}) = P(\text{Sunny} / \text{No}) * P(\text{No}) / P(\text{Sunny}) = 0.5 * 0.29 / 0.35 = 0.41$$

So, as we can see from the above calculation that $P(\text{Yes} / \text{Sunny}) > P(\text{No} / \text{Sunny})$

Hence on a Sunny day, Player can play the game.

Another Example:

Suppose a table given below:

Outlook	Yes	No	$P(\text{Yes})$	$P(\text{No})$
Sunny	2	3	$2/9$	$3/5$
Overcast	4	0	$4/9$	0
Rainy	3	2	$3/9$	$2/5$
Total	9	5		

Temp	Yes	No	$P(\text{Yes})$	$P(\text{No})$
Hot	2	2	$2/9$	$2/5$
Mild	4	2	$4/9$	$2/5$
Cool	3	1	$3/9$	$1/5$
Total	9	5		

Humidity	Yes	No	P(Yes)	P(No)
High	3	4	3/9	4/5
Normal	6	1	6/9	1/5
Total	9	5		

Wind	Yes	No	P(Yes)	P(No)
False	6	2	6/9	2/5
True	3	3	3/9	3/5
Total	9	5		

Play	Probability
Yes	9
No	5
Total	14

Probability of playing given that the temperature is cool is

$$P(\text{Temp} = \text{cool} / \text{play} = \text{Yes}) = 3/9$$

Let us consider the set of new features as

today = (Sunny, Hot, Normal, False)

Then, Probability of Playing and Not Playing are respectively given by

$$P(\text{Yes} / \text{today}) = P(\text{Sunny}/\text{Yes}) P(\text{Hot}/\text{Yes}) P(\text{Normal}/\text{Yes}) P(\text{False}/\text{yes}) P(\text{Yes}) / P(\text{today})$$

$$P(\text{No} / \text{today}) = P(\text{Sunny}/\text{No}) P(\text{Hot}/\text{No}) P(\text{Normal}/\text{No}) P(\text{False}/\text{No}) P(\text{No}) / P(\text{today})$$

Since $P(\text{today})$ is common in both probabilities, so we can ignore it then

$$P(\text{Yes} / \text{today}) \propto (2/9) * (2/9) * (6/9) * (6/9) * (9/14) = 0.0141$$

$$P(\text{No} / \text{today}) \propto (3/5) * (2/5) * (1/5) * (2/5) * (5/14) = 0.0068$$

And we know, $P(\text{Yes} / \text{today}) + P(\text{No} / \text{today}) = 1$

$$\text{Then, } P(\text{Yes} / \text{today}) = (0.0141) / (0.0141 + 0.0068) = 0.67$$

$$P(\text{No} / \text{today}) = (0.0068) / (0.0141 + 0.0068) = 0.33$$

Since $P(\text{Yes} / \text{today}) > P(\text{No} / \text{today})$ So, Prediction that they can play is "Yes".

Advantages:

1. Does not require large training data
2. Easy to implement and fast to predict the class of test data
3. High scalability and unsensitive to irrelevant data

Disadvantage: It assumes that all features are independent, so it cannot learn the relationship between features.

Application:

1. It is used in Text classification such as Spam filtering
2. It can be used in real time predictions

4. K-means Clustering

Clustering: Clustering is unsupervised machine learning technique and used to find meaningful structure for further analysis. It is a task in which we divide data points into several groups such that points in the same group are more like other data points in same group and dissimilar to the data points in other groups i.e., a collection of objects based on similarity and dissimilarity between them.

Clustering is very important to determine the Outlier and for analysis of data points. There are no criteria for good clustering but it depends on the user that what is the criteria they may use to satisfy their need.

There are many Clustering algorithms such as Partitional Clustering eg, K-means (we used this in this project); Hierarchical clustering etc. A distance or similarity function need to define such as Minkowski metric, Euclidean metric, Cosine distance etc. for measuring the distance between two data points that will help to check in which cluster the data point needs to be there. The quality of Clustering result depends on the algorithm, distance function and the application for which we are using it.

K -means Clustering: It is Partitioning Clustering method in which we have K and we need to produce K clusters. Also, objects within the cluster are similar to each other and objects belonging to different clusters are different to each other according to features. In this project we use Sum of Square for measuring distance.

The algorithm works as follows:

- a. We initialize K points, called cluster centroids randomly
- b. Categorize each item to its closest centroid and update centroid location which is averages of items categorized in that cluster
- c. Repeat the process for given number of times to get clusters

Elbow Method: Choosing the value of K is literally a big task. There are many ways to calculate this and Elbow Method is one of the most popular methods used to find optimal number of clusters. This method used the concept of WCSS (Within Cluster Sum of Squares) value. The formula for calculating WCSS value (for 3 clusters i.e., K=3) is given by:

$$WCSS = \sum_{P_i \text{ in Cluster1}} \text{dist}(P_i C_1)^2 + \sum_{P_i \text{ in Cluster2}} \text{dist}(P_i C_2)^2 + \sum_{P_i \text{ in Cluster3}} \text{dist}(P_i C_3)^2$$

Where, $\sum_{P_i \text{ in Cluster1}} \text{dist}(P_i C_1)^2$: sum of the square of the distances between each data point and its centroid within a cluster1

To find optimal value of clusters, this method uses steps as follows:

- a. Execute K-means clustering on given dataset for different k values (ranges from 1- 10)
- b. For each value of k, calculate WCSS value
- c. Plot a curve between WCSS value and k
- d. the sharp point of bend is considered as the best value for K

5. Procedure

Aim: To segment our Movies data in clusters which is relatable to specific Customers data

Algorithm:

Naive Bayes is a popular algorithm for classifying text. It is Supervised learning algorithm. Although it is simple, it often performs as well as much more complicated solutions. A Naive Bayes' classifier works by figuring out the probability of different attributes of the data being associated with a certain class. This is based on Bayes' theorem.

The Theorem is $P(A|B) = \frac{P(B|A) \cdot P(A) \cdot P(B)}{P(B)}$.

This states "the probability of A given that B is true equals the probability of B given that A is true times the probability of A being true, divided by the probability of B being true."

It is called Naïve because it assumes occurrence of certain feature is independent of that of other features. For example, if the fruit is identified on bases of shape, colour and taste then red, spherical, and sweet fruit recognized as an apple. Also, it called Bayes because it is based on Bayes' theorem.

Technical stack:

We use Python in this project. The Python libraries used here are:

1. NumPy: It is one of the most useful libraries used to handle Numerical values. NumPy is short for "Numerical Python".
2. Pandas: Pandas is python library used for working with data sets. It has functions for analysing, cleaning, and manipulating data.
3. Scikit- Learn: It is one of the most powerful and useful libraries used for Machine Learning in Python. It provides lots of efficient tools for modelling the data.
4. Matplotlib: It is one of the most popular Python Package used for Data visualization.
5. Pylab: It is a module in Matplotlib and installed alongside Matplotlib.
6. Scipy: It provides algorithms for Optimization, interpolation, differential equations and many more classes of problems. The data structure provides by Scipy is very helpful for solving such problems.
7. Seaborn: This library used for Statistical plotting in Python and provides beautiful default styles.

Actual Procedure:

1. Importing Raw data from source
2. EDA (Exploratory Data Analysis): Exploratory Data Analysis (EDA) is an approach to analyse the data using visual techniques. It is used to discover trends, patterns, or to check assumptions with the help of statistical summary and graphical representations. We use Pie chart, Histogram and Scatter plots to analyse our data.
3. Feature transformation: Data pre-processing is one of the many crucial steps of any Machine Learning project. As we know, our real-life data is often very unorganized and messy and without data pre-processing, there is no meaning in making a machine learning model. We must first pre-process our data and then feed that processed data to our machine learning models for good performance. One part of pre-processing is Feature Transformation.

4. Data cleaning: Our first step to remove Outliers for Predicting our data with better Accuracy
5. Making pipeline for unsupervised algorithm to make Clusters (K- means clustering)
6. Predict each data point using Supervised Learning (Categorical Naïve Bayes) whether the output is belonged to same clusters or not
7. We Transform our data into Z- score and remove the Data Correspondences which having Z -score>3 and Z- score<-3

6. GitHub Link for Python code

https://github.com/sikandarburnwal1408/Movie_Recommendation_system

Results and Conclusion

The Naïve Bayes Partitioning model is very popular model where we cluster the data for generating recommendations and understanding the notion of similarity. Also, we come up the model whose accuracy on test data is 97.994% and error 2.03% on training data.

Future Work

We have already used Naïve Bayes Algorithm with K-means Clustering to build a model which have accuracy 97.994 %.

In part 2, We implement this model using different methods like by using Popularity model, Hybrid model, combined model etc. with different pre-processing method. Then analyse the difference created by these models and then compare the output created by these models. At last, we come up with the detailed analysis of these models.

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