MACHINE LEARNING APPROACH ON INDIAN HEALTHCARE CONSUMER DATA

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ABSTRACT: Revisiting of an outpatient to hospital is an important parameter to evaluate the per-formance of a hospital. It depends on the outpatient perceptions of healthcare services by a hospital. In this study 416 outpatient's perception is captured through an online questionnaire. Machine learning approach is used to predict the revisiting outpatient to hospital. Ten machine learning algorithm (MLA) were applied on the healthcare consumer data. Top 5 and bottom 5 features on the basis of feature importance is de-rived from the MLA. This can be used as indicator by hospital administrator to take remedial actions when the revisiting outpatient's number is below the desired level. The best MLA in terms of accuracy is SVC.

KEYWORDS: Outpatient, machine learning, revisiting, hospital

1. INTRODUCTION

Out-patient performs following activities: searches for healthcare provider collects data on the healthcare provider, searches on the medical specialist, books an appointment or walk in at the healthcare provider, physically reaches the healthcare provider, meets the reception, waits for the medical specialist, medical specialist gives prescription to the healthcare consumer, buys medicines, takes diagnostic tests and probably visits canteen. Every touch point of the outpatient with the healthcare provider leaves a perception with the outpatient. Outpatient's perception is the sum of all the individual perception gained from all the touch points. This affects outpatient's decision in selecting a hospital.

Hospital would like all their outpatients to revisit when need arises. A predicting model for 'revisiting of an outpatient' will indicate the performance of the hospital. The hospital administrator can take appropriate action accordingly.

1.1 Literature survey

Machine learning is used in many fields. Healthcare also uses machine learning (Chen, Pierson, et al., 2021). Diagnosis is one of the fields in healthcare where machine learning can be used to make healthcare better by adopting the machine learning algorithms (Gerard et al., 2008). The other field of healthcare where machine learning can be used is in treatment of diseases, remote patient monitoring (Saleem&Chishti, 2019) and in patient documents (Toh& P. Brody, 2021). Machine leaning can give the complete picture of the healthcare data (Chen, Joshi, et al., 2021).

This paper tries to find the best machine learning algorithms to arrive the healthcare consumer to revisit the healthcare facility in need. Some of the earlier work done are :

KyunJick Lee in his research paper 'A Practical Method of Predicting Client Revisit Intention in a Hospital Setting' states the five important predictors of revisit intention as overall satisfaction, intention to recommend to others, awareness of hospital promotion, satisfaction with physician's kindness, and satisfaction with treatment level. This is based on a study in South Korea (Lee, 2005).

Singh &Goyal in their research paper to find the best machine learning algorithm for cervical cancer concluded logistic regression is best suited for the cervical data set (Singh &Goyal, 2020). Dhwaani Parikh and VineetMenon in their research paper 'Machine Learning Applied to Cervical Cancer Data' have chosen the best performing machine learning algorithm K-nearest neighbor amongst decision tree and random forest algorithm (Dhwaani&Vineet, 2019).

Sandhya in research paper presented a machine learning model for hospital recommendation which they were implementing in a application (B, 2020). Mani research paper presents a software based on machine learning the suggests the names of nearby hospital basing on patients disease condition (V, 2020).

2. METHODOLOGY

2.1 Data acquisition

An online questionnaire developed in Google form is used to collected data from outpatients .The questionnaire captured the outpatient's perception during his visit to the hospital. The following Table 1 gives the description of the data acquired.

Table 1: Data description

S.No	Column	Description
1	Gender	Gender of respondent
2	Age	Age of respondent
3	Income	Income of respondent
4	Advertisement	Advertisement done by healthcare provider
5	Choose	Choose healthcare provide for
6	Rdoctor	Read on the medical specialist
7	Appointment	Appointment made using
8	Clean	Premises were clean and hygienic
9	Softused	Software used in making appointment
10	Insuranceco	Medical insurance is from
11	Equipment	Medical equipment
12	Waitingarea	Waiting area for out-patient
13	Canteen	Hospital canteen
14	Opreseception	Out-patient reception
15	Feedback	Feedback collection system
16	Confidence	Doctor while treating exhibited confidence
17	Testexplain	Doctor explains the diagnostic tests
18	Rateservices	Rate serviced of hospital
19	Staffcoop	Hospital staff cooperation
20	Registrationtime	Time taken for out-patient registration
21	Waitingtime	Waiting time for doctors
22	Purchasingtime	Time to purchase medicines
23	Timereports	Time taken to collect reports
24	Hospprescription	Doctors prescription
25	Informdiseases	Information on disease
26	Feedbackcustomer	Feedback by earlier consumers
27	Suggestpatient	Consumer suggestions
28	Pricingopinion	Opinion on hospital pricing
29	Hospcompetitor	Hospital competitor
30	Revisit	Revisit by healthcare consumer

2.2 Data Exploration

The data has 416 rows and 30 columns. The output is in 'revisit' column. Remaining columns provides perception of the outpatient. All the columns contained integer data type (int64).

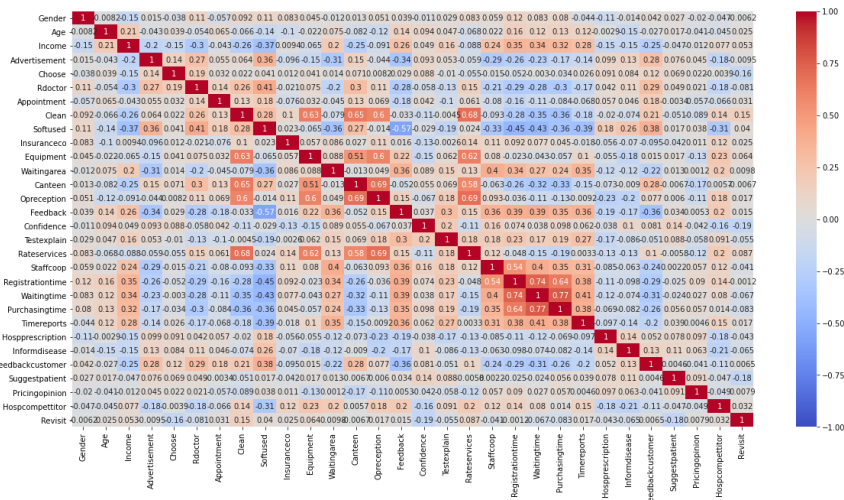The correlation matrix between features is shown in Fig 1.

Figure 1: Correlation matrix between features

Two columns 'waitingtime' and 'rateservices' have high correlation values.
The frequency count of the 'Revisit' column shows number of rows containing 1 are 205 and 2 are 211.

2.3 Machine learning algorithm comparison

Ten machine language algorithms (MLA) are used to create the model for MLA comparison. The ten algorithms are

a. Logistic Regression
b. Linear Discriminant Analysis
c. SVC
d. Decision TreeClassifier
e. Random Forest Classifier
f. Gradient Boosting Classifier
g. Ada Boost Classifier
h. XGB Classifier
i. KNeighbors Classifier
j. LGBM Classifier

Steps involved in the machine learning algorithm comparison are

Step 1: Initial model building
The ten machine learning algorithms (MLA) are run with the data (rows=416, columns=30). They are sorted in descending order on the basis of accuracy as shown in Table.2.

Table 2:Initial model accuracy

S.No	MLA name	Training accuracy mean	Test accuracy mean
1	LGBMClassifier	0.996787	0.6112
2	DecisionTreeClassifier	1	0.6096
3	SVC	0.804819	0.6
4	XGBClassifier	0.959839	0.5968
5	GradientBoostingClassifier	0.990361	0.5888
6	RandomForestClassifier	0.987149	0.5872
7	AdaBoostClassifier	0.803213	0.5872
8	KNeighborsClassifier	0.726104	0.5856
9	LinearDiscriminantAnalysis	0.663454	0.5616
10	LogisticRegression	0.665863	0.5568

Step 2: Feature importance
Feature importance (see **Error! Reference source not found.**) from each algorithm is extracted and sorted in descending order. SVM and K – Neighbors do not give feature importance. Thus they are not included in the feature importance.
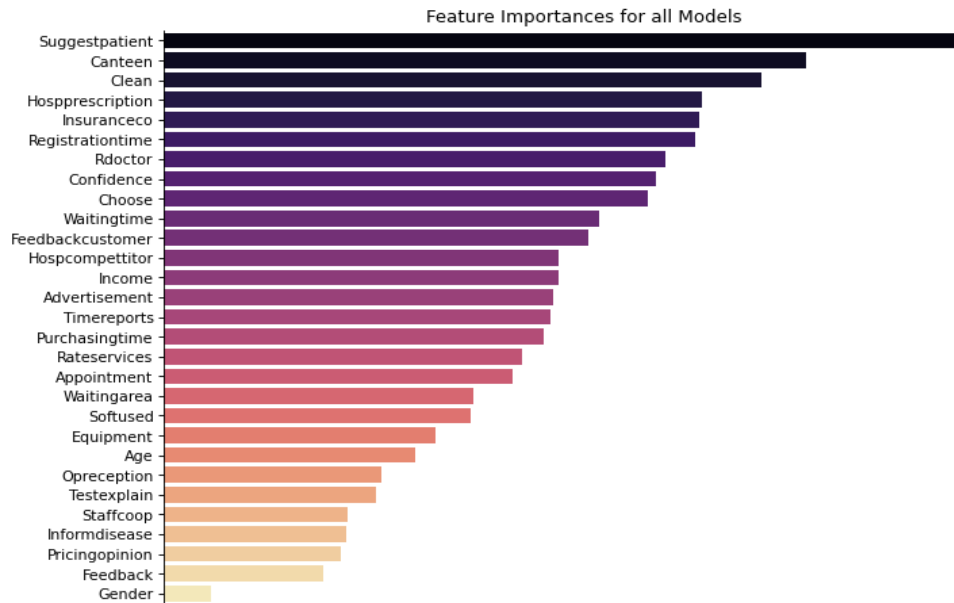
Figure 2: Feature Importance for all the models

Step 3: Standardize the data

Data is split as input features and output feature. The inputs features are standardized using StandardScalar(). Standardizing of the sample is represented by the equation 1 where x = sample, u = mean of the sample, s=standard deviation and z=standard score

$$z = (x - u) / s \qquad (1)$$

Step 4: Principal component analysis (PCA) on data

PCA is used on the data for dimension reduction and reduce correlations of features.

a. Dimension reduction

Fig 3 gives the graph of cumulative explained variance and number of PCA components. From the graph it is evident that 20 PCA components account for 92 % variance. These 20 PCA components are used in subsequent model building.
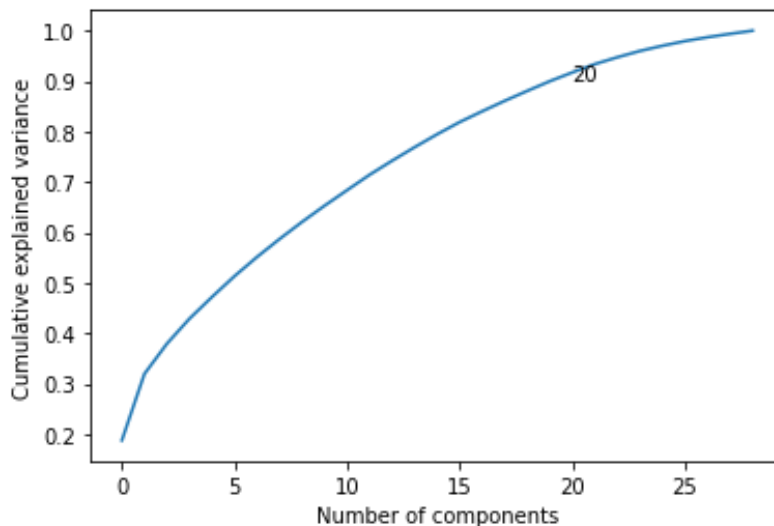

Figure 3: Graph between cumulative explained variance and number of PCA components

b. Reducing the correlation between input features

The correlation matrix between PCA features is given in Fig 4. From correlation matrix it is evident that there is reduction in correlation.
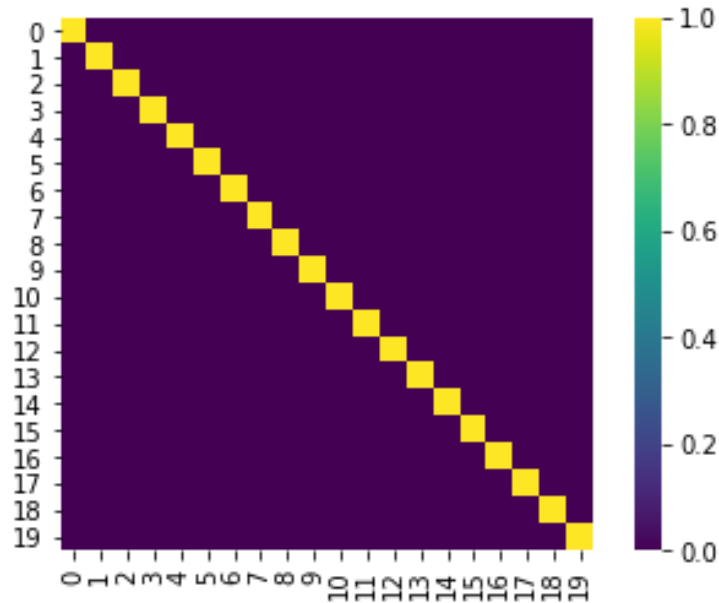
Figure 4: Correlation matrix between PCA components

Step 5: Model comparison for MLA after PCA

The ten machine learning algorithms (MLA) are run with the data (rows=416, columns=20). They are sorted in descending order on the basis of accuracy as shown in Table.3.

Table 3: Initial model for comparison of MLA after PCA accuracy

S.No	MLA name	Training accuracy mean	Test accuracy mean
1	SVC	0.82249	0.6176
2	KNeighborsClassifier	0.714859	0.6096
3	XGBClassifier	0.998394	0.5888
4	LGBMClassifier	1	0.5824
5	RandomForestClassifier	0.980723	0.5776
6	AdaBoostClassifier	0.93012	0.5712
7	GradientBoostingClassifier	1	0.5664
8	LinearDiscriminantAnalysis	0.635341	0.5536
9	LogisticRegression	0.629719	0.552
10	DecisionTreeClassifier	1	0.5184

3. RESULT AND DISCUSSION

'Revisit' column shows number of rows containing 1 are 205 and 2 are 211. The difference between both the classes is 6.The data is assumed as balanced.

Many features have shown correlation more the 0.50 in correlation matrix. PCA is used to reduce the correlation.

The table 4 below shows top 5 and bottom 5 in feature importance. These can be indicator for the hospital administrator to take remedial actions if the revisiting outpatients are not to the desired number. The hospital administrator has to focus on the top 5 feature in case the number of revisiting outpatients is below the desired number.

Table 4: Top 5 and bottom 5 features

S.No	Top 5 features	Bottom 5 featires
1	Suggestpatient	Gender
2	Canteen	Feedback
3	Clean	Pricingopinion
4	Hospprescription	Informdiseases

5	Insuranceco	Staffcoop

PCA gave 20 PCA components which account for 92 % variance. These are used for developing the model further.

The table 5 indicates the top 2 MLA initially and after PCA in terms of accuracy.

Table 5: MLA initial model and model after PCA

S.No	Initial Model	Model after PCA
1	LGBMClassifier	SVC
2	DecisionTreeClassifier	KNeighborsClassifier

4. CONCLUSION

Shape of initial data consists of 30 columns and 416 rows. In the initial model, MLA with highest accuracy is LGBM Classifier. In feature importance the top feature is 'Suggestpatient'. The data is standardized. There are 20 PCA components which are taken for further model building. The MLA with highest accuracy after PCA is SVC.

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