Health Informatics Using Artificial Intelligence

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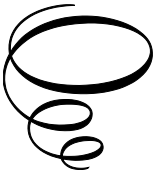
Edited by

Prabhpreet Kaur and Amandeep Kaur

Cambridge Scholars Publishing



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CHAPTER 1

MACHINE LEARNING MODELS FOR PREDICTING THE SUCCESS OF HEALTH CARE APPS ON GOOGLE PLAY STORE

ANUREET KAUR, PRABHPREET KAUR, AMANDEEP KAUR

Abstract

Background: At present, mobile apps play an imperative role in the lives of many people. Tens of thousands of apps are being put on the Play Store for users to install. The utilization of mobile technology in medicine and healthcare has become a decisive aspect. Mobile health (mHealth) is now referred to as the field related to health-related apps. However, the life of an app on the Play Store depends on its success parameters. By accurately predicting the success of mHealth applications based on their features, app designers can foresee which apps are most likely to be installed and stay on the Play Store for a longer period.

Methods: Initially, a literature survey is conducted to investigate the existing methods/models of predicting app success and what parameters are used to assess their performance. Then, machine learning models appropriate for the problem at hand are identified. The apps related to health care and medicine are filtered from the entire dataset with 10 features, and experimental analysis is performed. To accurately predict the success factor, five Machine Learning classifier models are used on a publicly available dataset on the Kaggle platform. The models employed in this report are Logistic Regression, Gaussian Naïve Bayes, Decision Tree, SVC, and Gradient Boosting. The correlation matrix is utilized to investigate the

association among the attributes. The confusion matrix and comparison between the models using accuracy measures (Recall, Precision, Accuracy, and F1-score) helped to choose the best model to forecast the app's future and make wise decisions.

Results: The results findings imply that the Gradient Boosting algorithm outperforms with 88% accuracy in making predictions among all five machine learning classification algorithms. The results are best supported by using four different evaluation metrics: Precision, Recall, F1-score, and Accuracy. Finally, K-fold cross-validation also supported the Gradient Boosting algorithm with nearly 88% accuracy.

Conclusions: According to the result analysis, it can be inferred that all 5 machine learning classifiers used in the study were competent enough to predict success, but the Gradient Boosting algorithm surpassed in terms of accuracy.

Keywords: Mobile Applications, Prediction, Android, Success, Machine Learning, Health Care

1. Introduction

1.1 Background

Apps for mobile health, or mHealth apps, are growing in popularity as people's emphasis shifts towards their health. Based on projections made by Precedence Research, the global mHealth (mobile health) market will attain $340.5 billion by 2030 at a CAGR of 26.79% (Haldiya 2024). mHealth apps have transformed the manner in which health information is attained and upgraded the value of services in the healthcare field (Sadegh et al. 2018; Zhang et al. 2018). According to Zion Market Research (Research 2024), the market for mHealth apps is expected to reach a value of about USD 111 billion by 2025.

As the sooq for mobile devices has considerably improved in the last two decades, the mobile app development and deployment on respective app stores of the mobile device has also amplified. Unlike many other mobile OS, Android apps play a major role in the mobile software industry. The

Google Play Store on Android mobile devices provides access to millions of apps to work on. Daily, this platform is flooded with an enormous number of fresh apps. Developers of these apps are anticipating that their efforts won't be wasted and try to build an app that will be successful in this competitive market. It would be beneficial for the developers to know in advance if their app will be successful or not before uploading it to the Google Play Store. It would prove to be highly advantageous for developers to have a method that can help predict the success possibility of an application.

The success of an app can be ascertained by features like ratings, number of installs, and reviews, as opposed to the revenue it generates. Generally, many apps in the Play Store are not charged; the revenue generated by subscriptions, in-app purchases, and in-app advertisements is practically unknown. Although many apps are added to the Play Store daily, only a few apps achieve their monetary benefits and endure in their respective competitive marketplaces. It would be really helpful if the possibility of app success could be ascertained in advance.

This research paper aims to investigate a Machine Learning algorithm to predict the success of a healthcare app before it is uploaded to the Google Play Store. To achieve this objective, relevant features are explored that enable an app to succeed or fail. Many studies have been conducted to improve the prediction using various methods. Some of the identified literature is provided, which forms the background for this study.

In the paper by (Tuckerman 2014), the author used the mobile app data from the Google Play Store. From the data available, the author extracted the features of apps and then used a modeling approach to conclude that predictions can be made using features like no. of installs and user ratings. The author concluded that PCA with Linear regression presented the best pattern for prediction.

In the paper by (Guerrouj and Baysal 2016)The authors focused on API quality along with other features of the app for the success of the mobile app. They determine this quality based on bugs removed in APIs and what modifications were made in API methods.

Another approach by the authors in (Yao et al. 2017) considered versions released for the apps to recommend the app for its success. They addressed that the rating for an app, which is a major factor for the success of an app, highly changes when a new version of the same application is released.

Mueez et al. Khushba et al. (2018), considered a dataset obtained from the Google Play Store. The dataset obtained is used in predicting the success of an app. They based their prediction first on features like ratings, length of the app name, and the no. of installs for an app. Then they took the reviews under consideration to make predictions.

Suleman et al.(Suleman, M., Malik, A., & Hussan 2019), also used a Google Play Store dataset and then worked on seven features having 10839 apps in the dataset. They used machine learning techniques in predicting app success. The emphasis of their study concluded which model performed best in predicting app ratings.

In the paper by (Businge et al. 2019), the authors distinguished the apps based on their popularity of the apps. They collected data sets from two marketplaces, GitHub and the Google Play Store. Then they introduced social and technical factors to understand how they affect the popularity of an app and hence its success.

In the paper by Muradul Bashir et al. (2019), the focus of the authors for predicting the success of mobile apps on Google Play was based on user rating and the no. of installs of apps. The authors analyzed a repository of the Google Play Store and applied various machine learning algorithms. The authors later concluded that the SVM model generated the most accurate predictions.

In the study by Singh (2020), the authors operated on a dataset having Android apps and implemented data evaluation using machine learning methods. They then aimed to understand features/factors in apps that most impact their success.

In the research by Dehkordi et al. (2020), the authors presented a repository consisting of 100 successful and 100 unsuccessful apps from the Google Play Store. This repository consisted of 34 features that are used as input to

a neural network in predicting app success on the Play Store.

In the paper presented by Zhong et al. (2020), the authors collected data from the Google Play store, having 10,841 mobile apps with features such as app size, free or paid. Then the authors presented a model by using mobile app features and user reviews in the model to predict the possible rate.

The authors in Rathod et al. (2020) suggested a framework that predicts the success of mobile apps not only based on no. of installs, ratings, and reviews but also on the sentiments of customers. They have applied various machine learning algorithms to a dataset collected from the Google Play Store Data. Lastly, they incorporated the Voting Ensemble technique to improve the accuracy of algorithms.

In the study by Shashank and Naidu (2020), the authors intended to predict the success of an app based on the ratings of the app on the Google Play Store. The authors used machine learning Algorithms for predicting success. The dataset for analysis and prediction is collected from the Kaggle platform.

In a study by Prakash Reddy and Nallabolu (2020), the authors only presented explanatory analysis for a dataset from the Google Play store, having 2,67,000 apps. Their analysis can help app developers make better judgments on app reachability to their intended customers.

The authors of a study, Magar, Mali, and Abdelfattah (2021), presented the success prediction as a classification problem. They started by classifying the mobile apps based on numerous degrees of success. Based on this theory, the authors used various classification models to comprehend the app's success. The models are then assessed based on their performance rates.

In the study by (Tafesse 2021), the authors used a dataset obtained from the Apple App Store. The dataset consist apps from the gaming and productivity categories. The author examined how app ratings and user reviews influence the number of downloads of mobile applications. The findings revealed that both ratings and reviews have a direct impact on the number of downloads, indicating that higher ratings and more positive

reviews significantly increase the likelihood of an app being downloaded.

In the paper by Davazdahemami et al. (2023), predictive network analytics, deep learning, and artificial intelligence are used that focus on the developer-oriented aspect of an app. They worked on two aspects of the problem. One was focused on recommending developers to distinguish the suitable customers. The second work focused on providing perceptions in terms of design principles and factors for the app developers to explore the possibilities for app success.

In the study by Pattanaik, Priyadarshini (2023), the authors used a dataset from the Google Play Store to forecast the success of the app. Again, the authors extracted features of apps available in the dataset and employed machine learning techniques to analyze data from varied metrics and ascertain relationships.

Table 1.1 depicts a summarized comparison of various existing success predictions. It can be inferred that machine learning techniques are the most followed approach for prediction in the majority of the research papers. The factors that affect each method are also listed for prediction. Each method is evaluated on some parameter. Table 1.2 lists the prominent evaluation metrics followed in existing studies.

Table 1.1 Comparison of existing success prediction approaches

References	Approach	Factors	Machine Learning	Method
(Guerrouj and Baysal 2016)	Model-Based	App size, category, reviews, rating	No	Multiple Linear Regression
(Yao et al. 2017)	Algorithmic	Ratings, reviews, versions	No	Version-Aware rating prediction
(Khushba et al. 2018)	Model-Based	App name, category, content rating, installs, rating, last updated, type, rating text, review text, size	Yes	Random Forest, XBoost Classifier, K-NN, SVM
(Suleman, M., Malik, A., & Hussan 2019)	Model-Based	Review, size, install, type, content rating, version, rating	Yes	Linear Regression, Decision Tree, Logistic Regression, Naïve Bayesian, K-Means Clustering, KNN, ANN
(Businge et al. 2019)	Model-Based	User app downloads, avg rating, activities forked on GitHub	No	Multiple Linear Regression
(Muradul Bashir et al. 2019)	Model-Based	Installation, no, user rating, category, size, price	Yes	KNN, SVM, Random Forest
(Ruhel, S. 2019)	Algorithmic	Review, rating, category, size, install, type, content, genre, last updated	Yes	Backpropagation (ANN), Deep Learning (HIVE)
(Singh 2020)	Model-Based	Content rating, installs	Yes	SVM, random forest, Linear regression

(Dehkordi et al. 2020)	Algorithmic	Name, No. of packages, No. Of classes, No. Of Methods, LOC, size	Yes	MLP, SVM, Random Forest, Decision trees, ANN, LVQ, NPR, PCA
(Zhong et al. 2020)	Model-Based	Category, reviews, size, installs, type, price, content rating, android version	Yes	Random forest, MLP, gradient boosting, Logistic regression
(Rathod et al. 2020)	Model-Based	Installs, rating, review, type, size, price, genre, user group, last updated, android version	Yes	KVM, SVM, Decision trees, Random Forest
(Shashank and Naidu 2020)	Model-Based	App category, rating, review, installs, size, type, price, content rating, genre	Yes	KNN, SVM, Linear regression, Random Forest, K- K-means clustering
(Prakash Reddy and Nallabolu 2020)	NA	App category, rating, review, installs, size, price, paid/free	No	N.A., only analysis
(Magar, Mali, and Abdelfattah 2021)	Model-Based	rating, installs, size, price, type	Yes	KNN, SVM, logistic regression, Random Forest, Decision trees, SGD
(Tafesse 2021)	Model-Based	App rating, size, App version (major), App version. (minor), Revenue, app name, app value, Download, reviews, update Regency	Yes	regression, Random Forest
(Pattanaik, Priyadarshini 2023)	Model-Based	Rating, reviews, size, installs, type, price, content rating, genre, last update	Yes	Random Forest, Decision trees, SVM, SGB, GRU

Table 1.2. Evaluation Metrics used by different studies

Evaluation metrics	Various Studies
R, R^2	(Guerrouj and Baysal 2016), (Suleman, M., Malik, A., & Hussan 2019), (Businge et al. 2019), (Singh 2020), (Shashank and Naidu 2020), (Tafesse 2021)
RMSE, MAE	(Yao et al. 2017), (Suleman, M., Malik, A., & Hussan 2019)
MSE	(Khushba et al. 2018),(Suleman, M., Malik, A., & Hussan 2019), (Muradul Bashir et al. 2019),(Singh 2020), (Dehkordi et al. 2020),(Zhong et al. 2020), (Rathod et al. 2020),(Shashank and Naidu 2020), (Tafesse 2021)
Cost function	(Ruhel, S. 2019)
Precision, recall, F-score, Accuracy	(Magar, Mali, and Abdelfattah 2021), (Pattanaik, Priyadarshini 2023)

2. Methods

Fig. 1.1 depicts the flow of the method adopted for conducting experimental work using Python Jupyter Notebook 7.0.8. Below is a breakdown of each stage.

1. Data Collection

In this research work, the mobile app dataset was collected from Kaggle.com (Jithin 2021), which is a hub for data scientists to publish and share their work. Mobile apps related to the health care and medicine category of the Google Play app store dataset are considered in this study. The variables such as App Name, Category, LOC, APK Size, Avg Rating, Installs, Version, Free/Paid, Age group, Genres, Last Updated, Current Version, Min required Android version form the columnar part of the dataset.

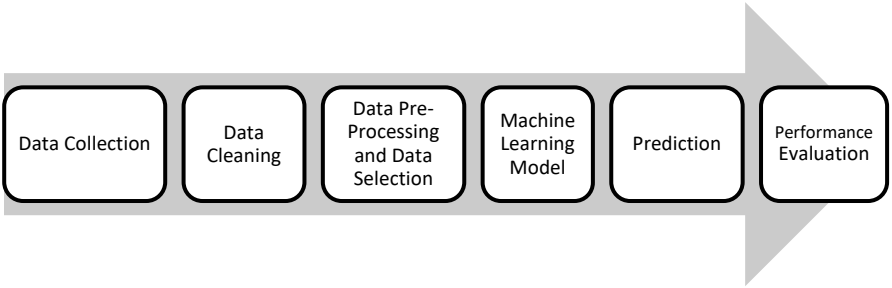

Fig 1.1 Methodology Adopted

2. Data Cleaning

The dataset initially had 10841 rows (mobile apps) and 13 columns (features of the app). After selecting health and medicine-related apps, only 804 mobile apps were left. The duplicate, missing, and inappropriate rows were removed and left with 564 rows. Relevant features or attributes required for success prediction are chosen. Fig. 1.2 gives some insights into the final dataset. There are 564 apps of the 2 categories (Health and medical), with ratings from 1 to 5, and the Calorie Counter-MyFitnessPal App is at the top of the medical category. Fig. 1.3 shows the total apps in each category, with nearly 300 apps under the medical category.

	App	Category	Rating	Reviews	Size	Installs	Type	Price	Content Rating	Genres	Last Updated	Current Ver	Android Ver
count	564	564	564.000000	5.640000e+02	564	5.640000e+02	564	564	564	564	564	564	564
unique	534	2	NaN	NaN	160	NaN	2	30	4	2	257	315	21
top	Calorie Counter - MyFitnessPal	MEDICAL	NaN	NaN	Varies with device	NaN	Free	0	Everyone	Medical	27-Jul-18	Varies with device	4.1 and up
freq	3	302	NaN	NaN	88	NaN	489	489	523	302	20	81	118
mean	NaN	NaN	4.219149	5.716577e+04	NaN	2.487888e+06	NaN	NaN	NaN	NaN	NaN	NaN	NaN
std	NaN	NaN	0.668491	2.590531e+05	NaN	2.185135e+07	NaN	NaN	NaN	NaN	NaN	NaN	NaN
min	NaN	NaN	1.000000	1.000000e+00	NaN	1.000000e+00	NaN	NaN	NaN	NaN	NaN	NaN	NaN
25%	NaN	NaN	4.000000	3.375000e+01	NaN	1.000000e+03	NaN	NaN	NaN	NaN	NaN	NaN	NaN
50%	NaN	NaN	4.400000	5.745000e+02	NaN	5.000000e+04	NaN	NaN	NaN	NaN	NaN	NaN	NaN
75%	NaN	NaN	4.600000	1.557725e+04	NaN	1.000000e+06	NaN	NaN	NaN	NaN	NaN	NaN	NaN
max	NaN	NaN	5.000000	4.559407e+06	NaN	5.000000e+08	NaN	NaN	NaN	NaN	NaN	NaN	NaN

Fig. 1.2 Description of the dataset after selecting Health care and Medical Apps

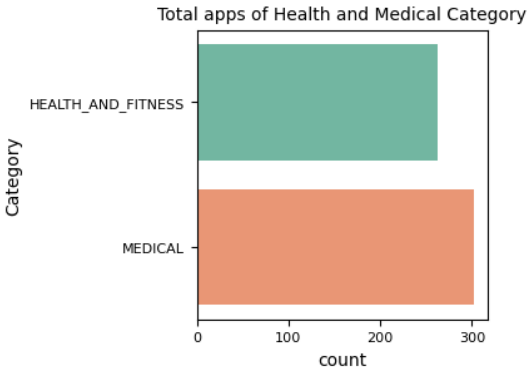

Fig. 1.3 Total Apps of Health Care and Medical category

3. Data Pre-processing and Data Selection

Data is prepared for classification to enhance classifier accuracy, and *the Installs* column is chosen as the target variable for success prediction. The following are the preprocessing tasks performed on the data to prepare for classification models: -

1. Casting of *Installs* to int, *Avg. Rating* and P*rice* to float (and remove $ from Price column).
2. Encode features (*Type, Category*) by the label encoding method.
3. Replaced *the Size* column with unified size values by converting Megabytes and Kilobytes into Bytes, then normalizing App size values.
4. Remove unimportant features like (*App Name, Versions, Last updated*).

The Installs column is considered as targets/labels for classifier Models. As App success is based on the *Installs*, there is a need to categorize the target as follows

1. If the number of *Installs* is less than 5000, then it's a failed app and is coded as 0.
2. If the number of *Installs* is greater than 5000 and less than 1,000,000, then the limited success *app,* is coded as 1.

3. If the number of *Installs* is greater than 1,000,000 then a successful app, is coded as 2.

Fig. 1.4 shows the final data set after pre-processing, encoding, and categorizing *the Installs* column. The dataset is also checked to see if it is equally distributed under all three categories of *the Installs* column. The result shows that 30% fall in the 0 (failed app) category, 41% for 1(limited success app) category, and 29% for 2 (successful app).

	Category	Rating	Reviews	Size	Installs	Type	Price	Content Rating	Genres_Health & Fitness	Genres_Medical
669	0	5.0	4	0.139998	0	0	0.00	0	1	0
638	0	3.9	26	0.119998	0	0	0.00	0	1	0
247	1	3.0	4	0.033998	0	1	0.99	0	0	1
608	0	4.4	622	0.024998	1	0	0.00	0	1	0
611	0	5.0	3	0.092998	0	0	0.00	0	1	0

Fig. 1.4 Dataset after coding of the Installs variable in 3 categories (0,1,2) (success predictor)

4. Machine Learning Models

Five Machine Learning models are carefully chosen as a classification problem (success or fail). The selected ones are as follows: -

1. *Logistic Regression Classifier* (Hancock et al. 2023)*:* LRC is applied in binary classification where the sigmoid function is used, taking independent variables as input and producing a probability value between 0 and 1.
2. *Naive Bayes Classifier* (Shaban et al. 2021)*:* NBC is based on Bayes' Theorem, which defines the probability of a certain event, built on the aforementioned knowledge of conditions that could be associated with this event.
3. *Decision Tree Classifier* (Singh 2020), DTC's purpose is to generate a model that predicts an objective built on input attributes using Tree models. The leaves in models signify class labels, and feature conjunctions are represented by branches.

4. *Support Vector Machine classifier* (Hancock et al. 2023) SVM is considered a robust classifier that aims to find an optimal hyperplane that divides feature space by finding how far the margin is from the hyperplane, and the traits that are closest across all classes.
5. *Gradient Boosting Classifier* (Hancock and Khoshgoftaar 2021), GBC is a strong boosting algorithm that unites numerous weak learners to robust learners, in which each new model is trained to minimize the loss function.

5. Prediction

The Machine Learning models are used to generate/fit the model and predict the values after splitting the dataset into training (75%) and testing (25%). The time (in seconds) is also recorded for each classifier to compare the performance metric.

6. Performance Evaluation

For performance evaluation, four different measures: Precision, Recall, F1-score, and Accuracy (Sohil, Sohali, and Shabbir 2022; Bognár and Fauszt 2022) are used. The ratio of True Positives to all Positives is known as precision. The recall formula is calculated by dividing the total number of positive results and false negative results. The F-score is a measure of predictive performance ranging from 0 to 1.

The ratio of all correctly identified observations to total observations, which ranges from 0 to 1, is known as Accuracy (Sohil, Sohali, and Shabbir 2022). The k-fold Cross-validation method is used to test the classifier's reliability. Cross-validation divides the training data into k parts (k=10 in this implementation), then uses 9 parts as a training dataset and tests with the remaining part (validation dataset). This operation is repeated 10 times, and then the final result is the average score of 10 trials.

3. Results

In this study, five classification models of the dataset are subjected to machine learning. The 10 features selected for fitting the models are examined for further processing using a heatmap. The correlation between

all features is assessed to check if they are independent of each other. Fig. 1.5 shows that there is very little correlation between all the features.

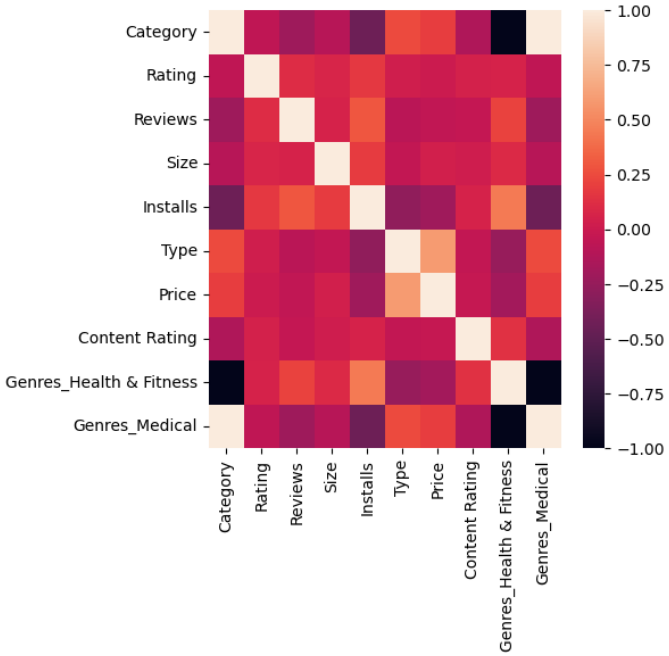

Fig. 1.5 Correlation between features using Heatmap

Following model fitting on the final dataset, each model is assessed using the classification report and confusion matrix produced on four distinct metrics: accuracy, precision, recall, and F1-score. The confusion matrix shows true positives, false positives, true negatives, and false negatives in a visual manner in Fig. 1.6. When combined, these metrics provide useful data regarding the model's overall effectiveness, aiding in the assessment and improvement of its classification capabilities.

The results in Table 1.3 and Fig.1.7 for F1-scores show that prediction accuracy above 80% is for Gradient Boosting, Gaussian Naïve Bayes, and Decision Tree. The best prediction accuracy is given by Gradient Boosting with 88%. Performance-wise, Decision Tree succeeded with 0.0094 secs,