Karunya INSTITUTE OF TECHNOLOGY AND SCIENCES
(Declared as Deemed to be University under Sec.3 of the UGC Act, 1956)
MoE, UGC & AICTE Approved
NAAC A++ Accredited

*An internship report submitted by*

**AJAY KUMAR M – URK20CS2018**

*in partial fulfillment for the award of the degree of*

**BACHELOR OF TECHNOLOGY**
***in***
**COMPUTER SCIENCE AND ENGINEERING**

*under the supervision of*

**Mr. Srivatsa Sinha, Industry Mentor**


**DEPARTMENT OF COMPUTER SCIENCE AND ENGINEERING**
**KARUNYA INSTITUTE OF TECHNOLOGY AND SCIENCES**
(Declared as Deemed to be University under Sec-3 of the UGC Act, 1956)
**Karunya Nagar, Coimbatore - 641 114. INDIA**

# TITLE

SMART MOBILE PHONE PRICE PREDICTION USING MACHINE LEARNING

# TEAM NAME

X-01

# DATE OF SUBMISSION

15 JULY 2023

# LITERATURE SURVEY

## 1. Introduction

The mobile phones market has undergone colossal changes from 2010. Prior to 2010. Blackberry OS and Microsoft OS were the ones having the biggest share in the market till 2005, but then they were overtaken by the Symbian OS. Motorola, Samsung and Sony Ericsson held the most shares of the mobile phones market. But soon with the introduction of Android OS by Google changes the dynamic of mobile phones. Mobile phones started becoming smarter and powerful. Now it's the era of smartphones. Smartphones are not strange things anymore for people anymore. Smartphones are mobile phones with computer abilities and internet search. It has become a source of entertainment and a communication tool for the vast population. With technological innovations, the structure of smartphone market has undergone continuous evolution. Market structures according to Sutton's Model for tech products has evolved has a two-stage game. The first stage brand invests in sunk costs that is research and development (R&D) and advertisement. In the second stage the brand competes on price based on the decisions in stage one.

In this project we are going to study about the second stage that is how the smartphone brands decide the prices of each phone.

## 2. Evolution of Mobile Industry

Mobile phone was officially launched on April 3, 1973, named Motorola Dyna Tac, which was invented by Martin Cooper. Motorola Dyna Tac had the same shape as today's mobile phones, but it was quite bulky weighing more than 1 kilogram and didn't gain much popularity. Since then, mobile phones have developed constantly.

The era of smartphones began from 2007 when Apple showcased its first iPhone. At that time android was under development and was slowly growing and was on the way to become one of the most fascinating foundations. Android continues to grow and expand, lots of manufacturers supported Android. In today's era, smartphones is not only growing in popularity but also gives people a series of new possibilities in all fields like

entertainment anytime anywhere, information exchange, etc. Global smartphone audience count surpassed 1 billion in 2012.

## 3. Competition and Strategies

The process by which the mobile manufacturers choose to charge customers for their services is one of the most important duties that a company must do. It includes the choices on benchmarks that are to be made while calculating prices, higher and lower price limits, and the price policies implemented by competitors in the market. Keeping all these in mind, the compilation of data about costs has a lot of significance. Telecommunication firms used to rely on cost-based pricing strategies, demand-based pricing strategies, and competition-based pricing strategies while imposing their prices. However, the Indian mobile phone industry has implemented a very creative pricing techniques in light of the fact that cost, demand, and competition all need to be taken into consideration simultaneously while deciding the prices for mobile phones. So, predicting the price of mobile phones is a crucial step for each brand for maximizing their profit while keeping the price range in reach of customers so that the particular phones become successful. Prediction of price range for a particular mobile phone can be done by applying various machine learning algorithms like Linear Regression, Logistic Regression, Decision Trees, etc.

## 4. Literature Survey and Related Work

a) Research Sources:

Academic papers from reputable journals or conference proceedings focused on machine learning techniques for price prediction. Online resources such as industry reports, market analysis, and technology blogs that provide insights into mobile phone pricing trends and factors affecting prices.

b) Findings and Rationale:

Summarize the key findings from the research sources, highlighting the methodologies, algorithms, and features used in mobile phone price prediction models. Discuss the various factors considered in these models, such as hardware specifications, brand value, market demand, competition, and economic indicators.

c) Proposed Modifications or Alternative Techniques:

If you come across any modifications or alternative techniques during your research, propose them based on a logical thought process and evidence from the sources. For example, you may propose incorporating sentiment analysis of customer reviews as an additional feature for price prediction, considering its influence on consumer perception and buying decisions.

## 5. Dataset Selection and Exploratory Data Analysis

a) The selection of a suitable dataset and conducting exploratory data analysis are indeed crucial steps in building a successful machine learning model for Smart Mobile Phone Price Prediction.

b) For this project, it is important to choose a dataset that is publicly available and supported by sound reasoning. One possible option is to look for datasets that include information about mobile phone specifications (such as processor speed, RAM, storage capacity, camera quality, etc.), brand, release date, and actual price at the time of release.

c) The chosen dataset should include the following dimensions or features:

> Mobile Phone Specifications: Features like processor speed, RAM, storage capacity, display size, camera quality, battery capacity, etc. These specifications play a significant role in determining the price of a mobile phone.

> Actual Price: The actual price at the time of release is the target variable we aim to predict. It serves as the ground truth against which our machine learning model's predictions will be evaluated.

d) To support the selection of the dataset and features, relevant visualizations and statistical measurements can be employed

e) During the exploratory data analysis phase, it may be beneficial to create new features based on the insights gained.

## 6. Metric and Model Selection

a) Selecting the appropriate metrics for evaluating your models is of utmost importance in machine learning modeling. The chosen metrics should align with the specific goals and characteristics of your project.

b) We are expected to choose the right metric(s) that accurately assess the performance of your models for Smart Mobile Phone Price Prediction. Commonly used metrics for regression tasks include Mean Squared Error (MSE), Root Mean Squared Error (RMSE), Mean Absolute Error (MAE), and R-squared (R2). Prior research in the field can provide valuable insights into suitable metrics for price prediction tasks.

c) Establishing a baseline for comparison is crucial to filter out non-useful models. The baseline can be a simple model or a naive approach that sets a minimum level of performance.

d) When selecting models, consider the relevant features of your dataset and justify the choices with thorough reasoning. For Smart Mobile Phone Price Prediction, regression models such as Linear Regression, Decision Trees, Random Forests, Support Vector Regression, or Gradient Boosting Regression can be considered.

e) It is advisable to start with simpler models and gradually increase complexity. This approach allows for better understanding of the relationships between features and the target variable, and helps identify whether additional complexity is necessary.

# 7. Project Details

## 7.1 Introduction (Introduction, Problem Statement, Objectives & Chapterwise summary)

This report presents the findings of a project focused on predicting mobile phone prices using machine learning techniques. The project involved selecting a suitable dataset comprising mobile phone specifications, brand information, release dates, and actual prices. Exploratory data analysis was conducted to understand the dataset's characteristics and identify relevant features. Starting with simpler models, the complexity was progressively increased, considering dataset characteristics such as non-linearities and feature interactions. The report emphasizes the importance of metric selection and establishing a baseline for comparison.

Problem Statement: Smart Mobile Phone Price Prediction using Machine Learning

Objective: train the model by understanding the sample dataset and from the give test dataset predict the best data

## 7.2 Exploratory Data analysis (Dataset, 10 commands - functions and output)

- data.info(): This command provides a concise summary of the dataset, including the number of non-null values and the data types of each column. It also gives an overview of the memory usage.

- data.describe(): This command generates descriptive statistics for the numerical columns in the dataset. It provides statistical measures such as count, mean, standard deviation, minimum, maximum, and quartile values (25%, 50%, 75%).

- y.unique(): Assuming "y" is a variable in your dataset, this command returns the unique values present in the "y" variable. It is useful for categorical variables to see the distinct categories or classes in the dataset.

- data.columns: This command retrieves the column names of the dataset, providing you with a list of the variables or features present in the dataset.

- data.shape: This command gives you the shape or dimensions of the dataset, providing the number of rows and columns. It returns a tuple in the format (rows, columns).

- data.dtypes: This command displays the data types of each column in the dataset, indicating whether each variable is numeric, categorical, or of another data type.

## 7.3 Data Visualization (10 charts and discussion about the output)

Data visualization is the practice of representing data in graphical or visual formats to better understand patterns, relationships, and trends within the data. It is an essential component of exploratory data analysis and communication of insights

- Histogram: A histogram is used to visualize the distribution of a single numerical variable. It consists of a series of bins along the x-axis and the frequency or count of observations within each bin on the y-axis. Histograms provide insights into the shape, central tendency, and spread of the data.

- Box Plot: A box plot, also known as a box-and-whisker plot, is used to display the distribution of a numerical variable. It shows the minimum, first quartile (25th percentile), median (50th percentile), third quartile (75th percentile), and maximum values. It also provides information on outliers and the skewness of the data.

- Scatter Plot: A scatter plot displays the relationship between two numerical variables. Each data point is represented as a point on the graph, with one variable plotted on the x-axis and the other on the y-axis. Scatter plots help visualize patterns, trends, or correlations between the variables.

- Countplot: A countplot is a type of bar chart that displays the count or frequency of observations within different categories of a categorical variable. It is useful for visualizing the distribution or comparison of categorical data.

- Correlation Matrix: A correlation matrix is a visual representation of the correlation coefficients between multiple variables. It is commonly displayed as a table or heatmap, with each cell representing the correlation between two variables. Correlation matrices help identify relationships and dependencies between variables.

## 7.4 Model Training and Testing (Model explanation, Output & Performance analysis)

Model training and testing are essential steps in the machine learning workflow. In this phase, a model is trained on a portion of the available dataset, known as the training set, to learn patterns and relationships between the input features and the target variable. The trained model is then evaluated on a separate portion of the dataset, known as the testing set, to assess its performance and generalization ability.

- Linear Regression:

Linear regression is a supervised learning algorithm used for predicting a continuous numerical output variable based on one or more input features. It assumes a linear relationship between the input features and the target variable. The goal is to find the best-fit line that minimizes the sum of squared differences between the predicted and actual values. Linear regression is widely used for tasks such as price prediction, demand forecasting, and trend analysis.

- Multiple Regression:

Multiple regression extends linear regression to cases where there are multiple input features. It aims to model the relationship between the multiple independent variables and the target variable. It estimates the coefficients for each input feature, representing the influence of each feature on the target variable while accounting for the presence of other features.

- Logistic Regression:

Logistic regression is a classification algorithm used when the target variable is binary or categorical. It predicts the probability of an input belonging to a specific class using a logistic function. Logistic regression is commonly used in tasks such as predicting customer churn, fraud detection, or disease diagnosis.

- Decision Tree:

Decision tree algorithms create a tree-like model where each internal node represents a feature, each branch represents a decision or rule, and each leaf node represents an outcome or prediction. Decision trees are versatile and can handle both classification and regression tasks. They are interpretable and can capture non-linear relationships and interactions between features.

- Random Forest:

Random forest is an ensemble learning algorithm that combines multiple decision trees to make predictions. It works by constructing a multitude of decision trees on different subsets of the training data and aggregating their predictions. Random forest is known for its robustness, ability to handle high-dimensional data, and resistance to overfitting.

- K-Nearest Neighbors (KNN):

K-Nearest Neighbors is a simple yet effective algorithm used for regression tasks. Given a new data point, KNN determines its class or predicts its value based on the majority vote or average of the K nearest neighboring data points in the feature space. KNN is a non-parametric algorithm and does not make assumptions about the underlying data distribution.

## 7.5 Conclusion

### Exploratory Data Analysis

Importing necessary libraries

```
# The libraries & modules which we are going to use in our study:
import pandas as pd
import numpy as np
from sklearn import preprocessing
from sklearn.model_selection import train_test_split
from sklearn import metrics
from sklearn.linear_model import LogisticRegression
from sklearn.tree import DecisionTreeClassifier
from sklearn.ensemble import RandomForestClassifier
from sklearn.neighbors import KNeighborsClassifier
from sklearn.metrics import classification_report, confusion_matrix, accuracy_score
import matplotlib.pyplot as plt
%matplotlib inline
import seaborn as sns
```

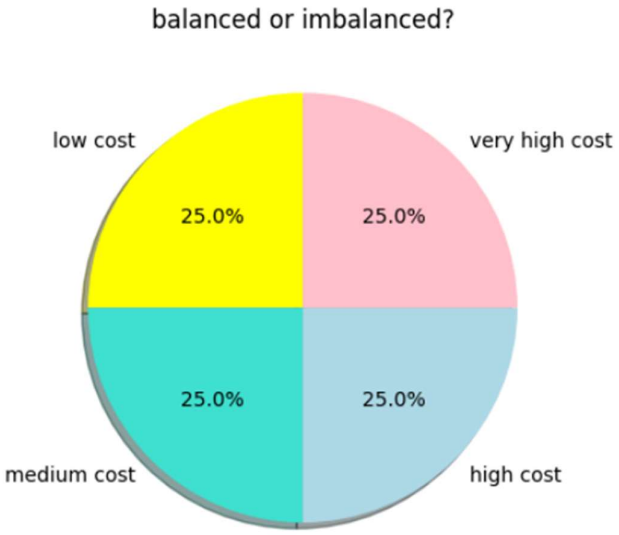
Information about the dataset(sample dataset)

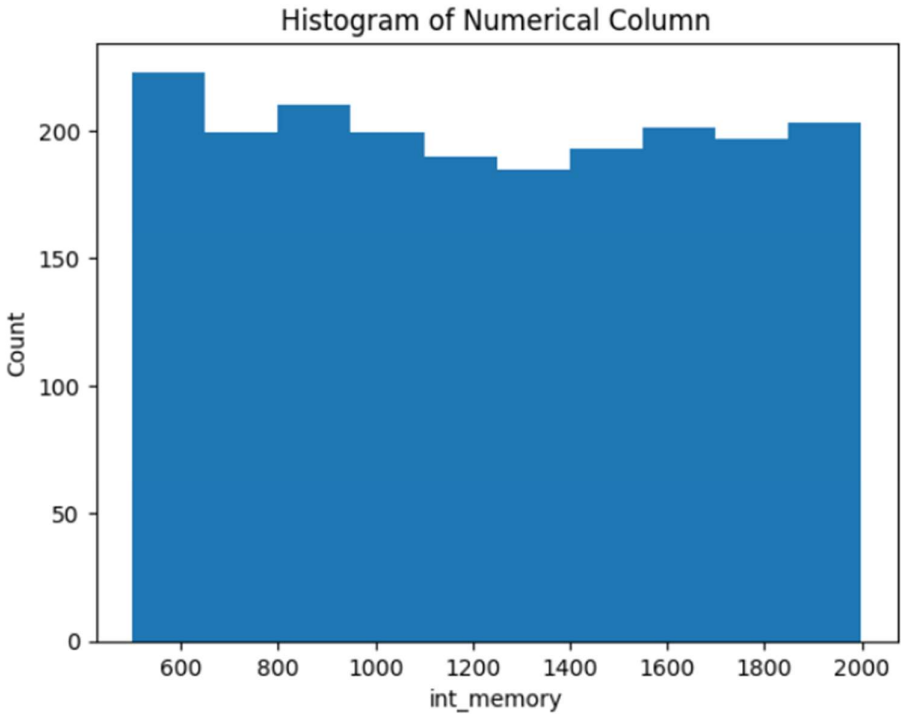
```
data.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 2000 entries, 0 to 1999
Data columns (total 21 columns):
 #   Column         Non-Null Count  Dtype
---  ------         --------------  -----
 0   battery_power  2000 non-null   int64
 1   blue           2000 non-null   int64
 2   clock_speed    2000 non-null   float64
 3   dual_sim       2000 non-null   int64
 4   fc             2000 non-null   int64
 5   four_g         2000 non-null   int64
 6   int_memory     2000 non-null   int64
 7   m_dep          2000 non-null   float64
 8   mobile_wt      2000 non-null   int64
 9   n_cores        2000 non-null   int64
 10  pc             2000 non-null   int64
 11  px_height      2000 non-null   int64
 12  px_width       2000 non-null   int64
 13  ram            2000 non-null   int64
 14  sc_h           2000 non-null   int64
 15  sc_w           2000 non-null   int64
 16  talk_time      2000 non-null   int64
 17  three_g        2000 non-null   int64
 18  touch_screen   2000 non-null   int64
 19  wifi           2000 non-null   int64
 20  price_range    2000 non-null   int64
dtypes: float64(2), int64(19)
memory usage: 328.2 KB
```

## Visualization Data

```
labels = ["low cost", "medium cost", "high cost", "very high cost"]
values = data['price_range'].value_counts().values
colors = ['yellow','turquoise','lightblue', 'pink']
fig1, ax1 = plt.subplots()
ax1.pie(values, labels=labels, colors=colors, autopct='%1.1f%%', shadow=True, startangle=90)
ax1.set_title('balanced or imbalanced?')
plt.show()
```

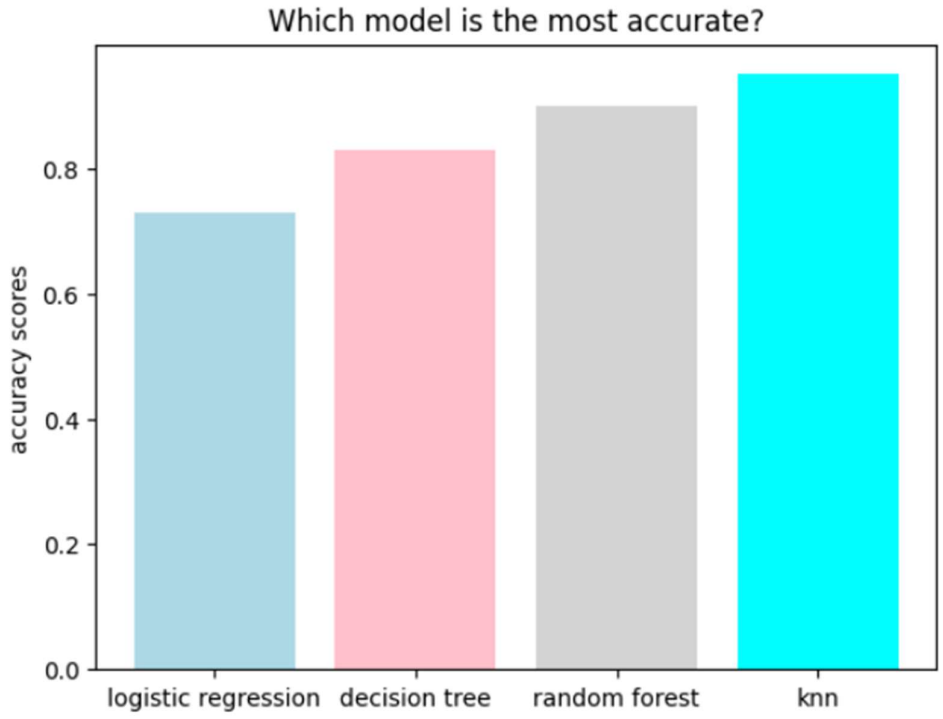


## Model Accuracy and Selection

```
[ ] #
    models = ['logistic regression', 'decision tree', 'random forest', 'knn']
    acc_scores = [0.73, 0.83, 0.90, 0.95]

    plt.bar(models, acc_scores, color=['lightblue', 'pink', 'lightgrey', 'cyan'])
    plt.ylabel("accuracy scores")
    plt.title("Which model is the most accurate?")
    plt.show()
```




## Predicting the best case using the model with high accuracy

```
test_data['price_range'] = predicted_price_range
test_data.head()
```

| | battery_power | blue | clock_speed | dual_sim | fc | four_g | int_memory | m_dep | mobile_wt | n_cores | ... |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **0** | 1043 | 1 | 1.8 | 1 | 14 | 0 | 5 | 0.1 | 193 | 3 | ... |
| **1** | 841 | 1 | 0.5 | 1 | 4 | 1 | 61 | 0.8 | 191 | 5 | ... |
| **2** | 1807 | 1 | 2.8 | 0 | 1 | 0 | 27 | 0.9 | 186 | 3 | ... |
| **3** | 1546 | 0 | 0.5 | 1 | 18 | 1 | 25 | 0.5 | 96 | 8 | ... |
| **4** | 1434 | 0 | 1.4 | 0 | 11 | 1 | 49 | 0.5 | 108 | 6 | ... |

5 rows × 21 columns

## 8. Conclusion

With the help of the machine learning models, we were able to find out the different accuracy values for the different models used to predict the dataset. From the above prediction, the logistic regression was able to give the highest accuracy value. So, the logistic regression is the best suited model to predict the different mobile prices for this dataset.

## 9. Reference

"Introduction to Statistical Learning" by Gareth James, Daniela Witten, Trevor Hastie, and Robert Tibshirani is a popular textbook that introduces the fundamental concepts of statistical learning and machine learning. It covers topics such as linear regression, classification, resampling methods, tree-based methods, support vector machines, and unsupervised learning.

**“**Machine Learning" by Andrew Ng is a comprehensive online course offered through platforms like Coursera. Andrew Ng is a prominent figure in the field of machine learning, and this course serves as a comprehensive introduction to the subject. The course covers various machine learning algorithms and concepts, including linear regression, logistic regression, neural networks, support vector machines, clustering, and dimensionality reduction. It also emphasizes practical implementation and provides programming assignments in Octave or Python.