IOT DOMAIN ANALYST

ECE3502

PROJECT REPORT

TITLE: SMART VENDING MACHINE

SUBMITTED TO:

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ABSTRACT

As a regular vending machine we have to operate manually and insert money to get our required product. We plan to apply the iot to use the vending machine with ease and data analytics to increase the sales of the vending machine. We plan to create a system so that the usage of vending machine is simple and it benefits both the customer and the vending machine industry as we can analyze the sales of a vending machine and try to increase the sales using the data

INTRODUCTION

Smart vending machines are the next evolution of retail because they allow businesses to reach customers in new locations and in new ways. These machines work around the clock. They also serve customers with ease and efficiency by only displaying what selections are in stock. Businesses no longer need to invest in expensive packaging. Smart vending machines use high-definition touchscreen displays showing high quality product photos and animations. You can also add a custom user interface (UI) to attract customers with interactive videos, commercials, and more. All these features create a unique user experience that can help drive sales and grow more customers.

Customers are looking for something unique and in a digital age where technology is attractive and innovation is respected, adding a smart vending machine to any business plan is an easy decision. And it has great potential to boost the return on investment (ROI). They can also accept cash payments as well as, cashless and mobile payments in this days. At the same time, Smart Vending Machines allow you to manage and publish digital signage and paid advertisements to provide a better user experience with touch-screen and multimedia interactivity. We can also help you to assess and target the age and gender demographics of your customers, leading to stronger sales.

SYSTEM DEVELOPMENT

1. NODE MCU (ESP8266 Wi-Fi)

It is an open-source Lua based firmware and development board specially targeted for IoT based Applications.

2. SERVO MOTORS

A servomotor is a closed-loop servomechanism that uses position feedback to control its motion and final position.

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3. PYTHON

This is the programming language used to analyze the data gathered and to develop and use a machine learning model to predict suggestions.

4. MIT APP INVENTOR

We are going to use this software to develop an app which is used to locate a vending machine and make purchases.

5. FIRE BASE

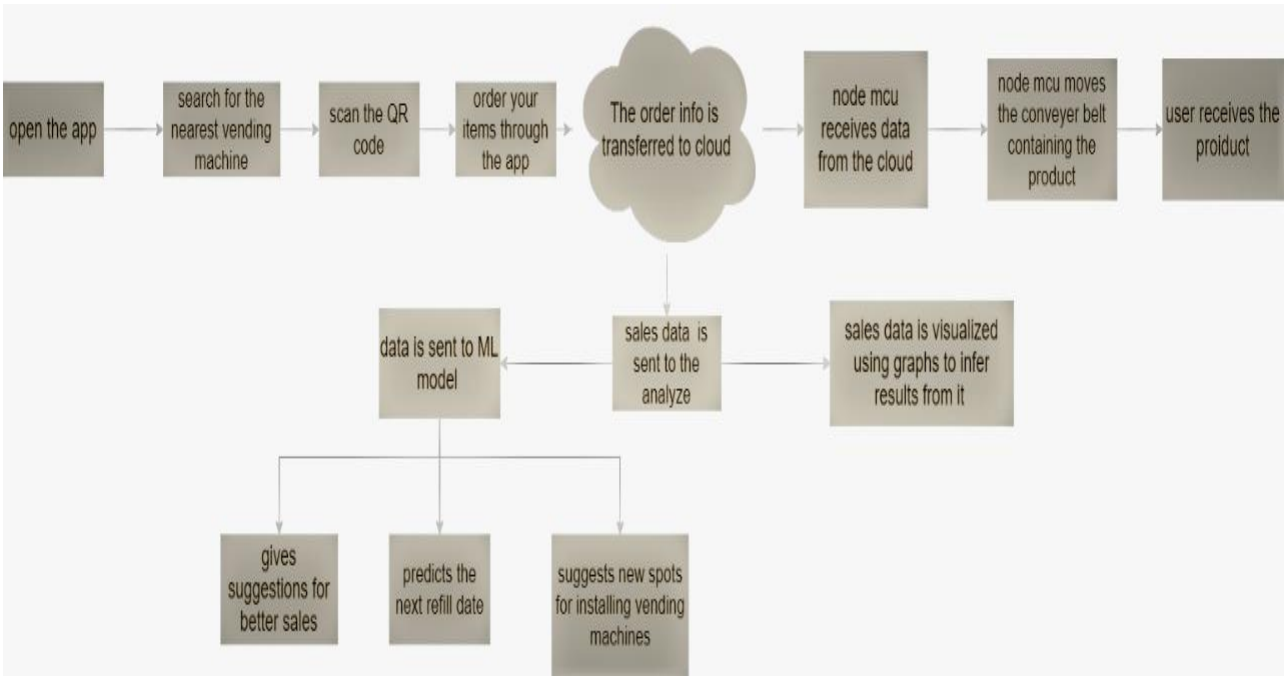
Firebase is a platform developed by Google for creating mobile and web applications and to store the data gathered by an application we plan on using this to store our data gather through app.

6. ARDUINO IDE

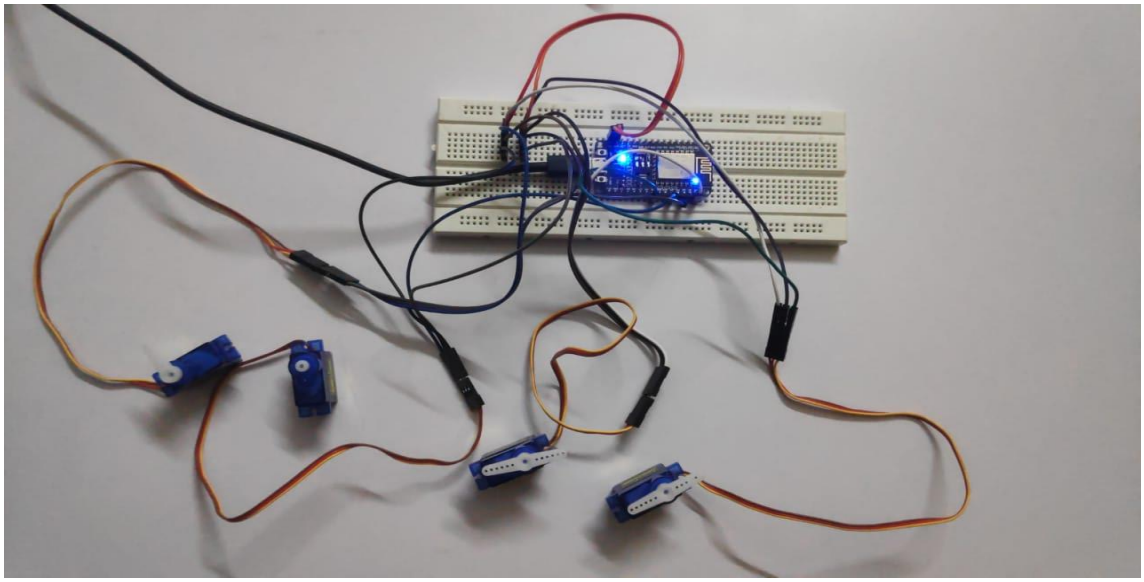
The open-source Arduino Software (IDE) makes it easy to write code and upload it to the board.

PROPOSED METHODOLOGY

- When the person opens our app they will be able to see the nearby vending machines with help of GPS and they move near to it.
- As the person reach the respective vending machine they will be able to see the items which are present in that vending machine and prices are also visible along with that.
- So the person makes the selection of their desired item and give their number of quantities requirement and makes purchase.
- After purchase they will be able to see a payment success and if they want to make purchase of items again they can make it from here.
- In this as we are building a prototype so when the payment is done the respective vending machine servo motor rotates the number of times the items quantity purchase is done.
- So we gather this all information in the firebase and there we will be able to see the number of items, what type of items and how fast they are getting sold and when do we need to refill the items in our vending machine so it's like getting overview of the vending machine as analysis.



HARDWARE MODEL



NODE MCU CODE

Including the libraries and setting up the libraries and connecting to firebase, Wi-Fi client for NODE MCU

vendingmachine §

```
#include <ESP8266WiFi.h>
#include <SoftwareSerial.h>
#include <FirebaseESP8266.h>
#include <ArduinoJson.h>
#include <ESP8266HTTPClient.h>
#include <Servo.h>
#define FIREBASE_HOST "smart-vending-machine-9807f-default-rtdb.firebaseio.com" //Your Firebase Project URL goes here without "http:" , "\" and "/"
#define FIREBASE_AUTH "YX7UPkCBLXroiZIiR2Hc6ETuaJJvRcddJzxB0Jyr" // Your Firebase Database Secret goes here
#define WIFI_SSID "vinith" //your WiFi SSID for which your NodeMCU connects
#define WIFI_PASSWORD "11221967"//Password of your wifi network
FirebaseData fbdo;
String tag1 ;
String tag2 ;
Servo servo_1;
Servo servo_2;
Servo servo_3;
Servo servo_4;
void setup() {
// put your setup code here, to run once:
Serial.begin(9600); //baud rate ,if you want to see the process in the serial monitor ,same baud rate should be set.
WiFi.begin(WIFI_SSID,WIFI_PASSWORD);
Serial.print("connecting");
while (WiFi.status()!=WL_CONNECTED){
Serial.print(".");
delay(500);
servo_1.attach(4);
servo_2.attach(16);
servo_3.attach(2);
servo_4.attach(14);
}
Serial.println();
Serial.print("connected:");
Serial.println(WiFi.localIP());
Firebase.begin(FIREBASE_HOST,FIREBASE_AUTH);
}
```

CODE FOR VENDING MACHINE 1

In this section we will update the get the data from the firebase and rotate the servo motors accordingly

```
void loop()
{
  if( Firebase.getString(fbdo,"/vending_machine_1/tag1")){
  tag1 = fbdo.stringData();
    if (tag1.toInt() > 0) {
      for(int i=0;i<tag1.toInt();i++){
        Serial.println(i);
        servo_1.write(0);
        delay(1000);
        servo_1.write(90);
        delay(1000);
      }

    Firebase.setInt(fbdo,"/vending_machine_1/tag1",0);
    }}
    if( Firebase.getString(fbdo,"/vending_machine_1/tag2")){
  tag2 = fbdo.stringData();
    if (tag2.toInt() > 0) {
      for(int i=0;i<tag2.toInt();i++){
        Serial.println(i);
        servo_2.write(0);
        delay(1000);
        servo_2.write(90);
        delay(1000);
      }

    Firebase.setInt(fbdo,"/vending_machine_1/tag2",0);
    }
  }
```

CODE FOR VENDING MACHINE 2

Similar to what we did in vending machine 1 , the same is done in vending machine 2

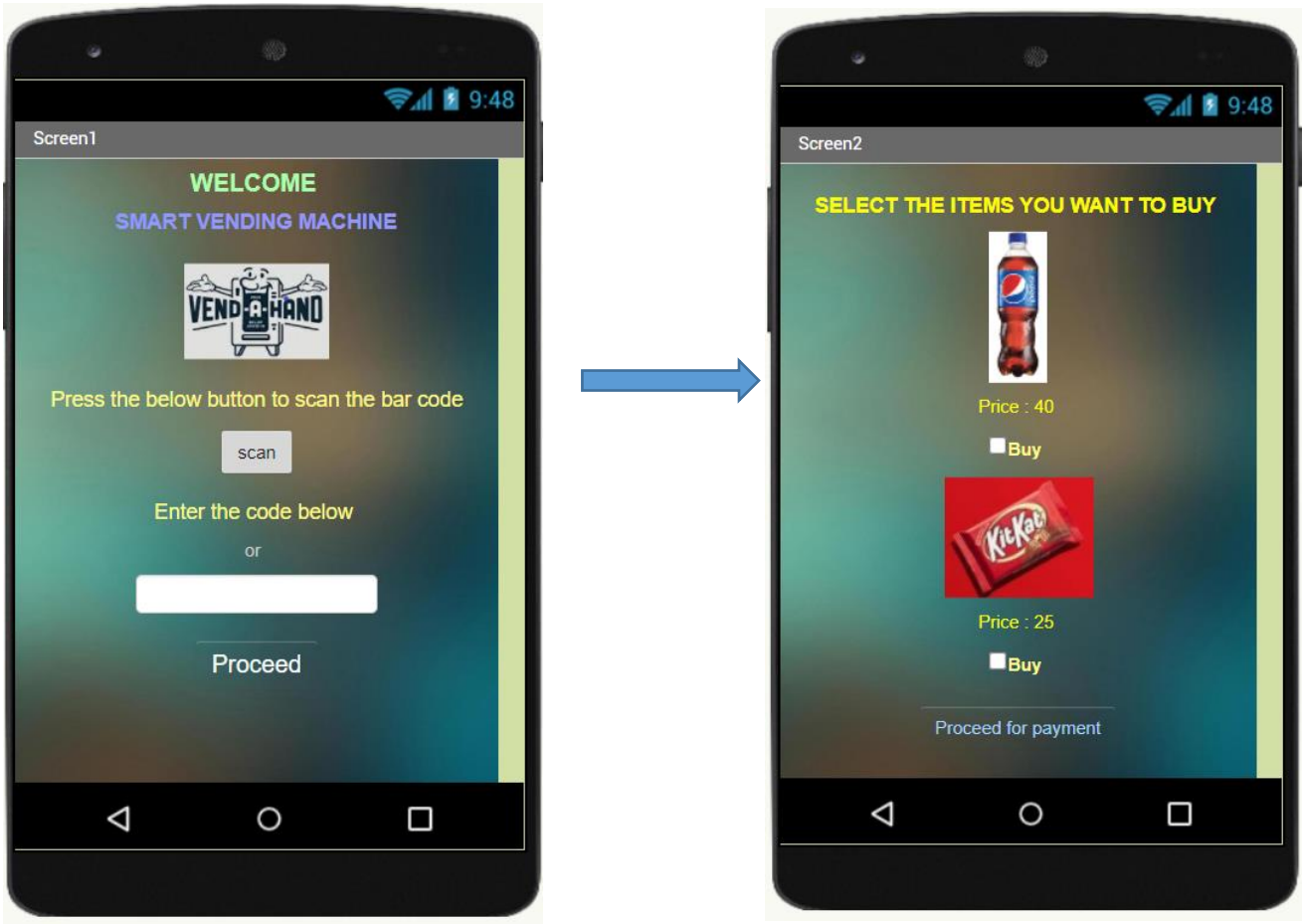
```
  if( Firebase.getString(fbdo,"/vending_machine_2/tag1")){
  tag1 = fbdo.stringData();
    if (tag1.toInt() > 0) {
      for(int i=0;i<tag1.toInt();i++){
        Serial.println(i);
        servo_3.write(0);
        delay(1000);
        servo_3.write(90);
        delay(1000);
      }

    Firebase.setInt(fbdo,"/vending_machine_2/tag1",0);
    }}
    if( Firebase.getString(fbdo,"/vending_machine_2/tag2")){
  tag2 = fbdo.stringData();
    if (tag2.toInt() > 0) {
      for(int i=0;i<tag2.toInt();i++){
        Serial.println(i);
        servo_4.write(0);
        delay(1000);
        servo_4.write(90);
        delay(1000);
      }

    Firebase.setInt(fbdo,"/vending_machine_2/tag2",0);
    }}

}
```

MIT APP INVENTOR

By using the MIT APP INVENTOR, we created a app to make purchase of the items from vending machine using mobile.

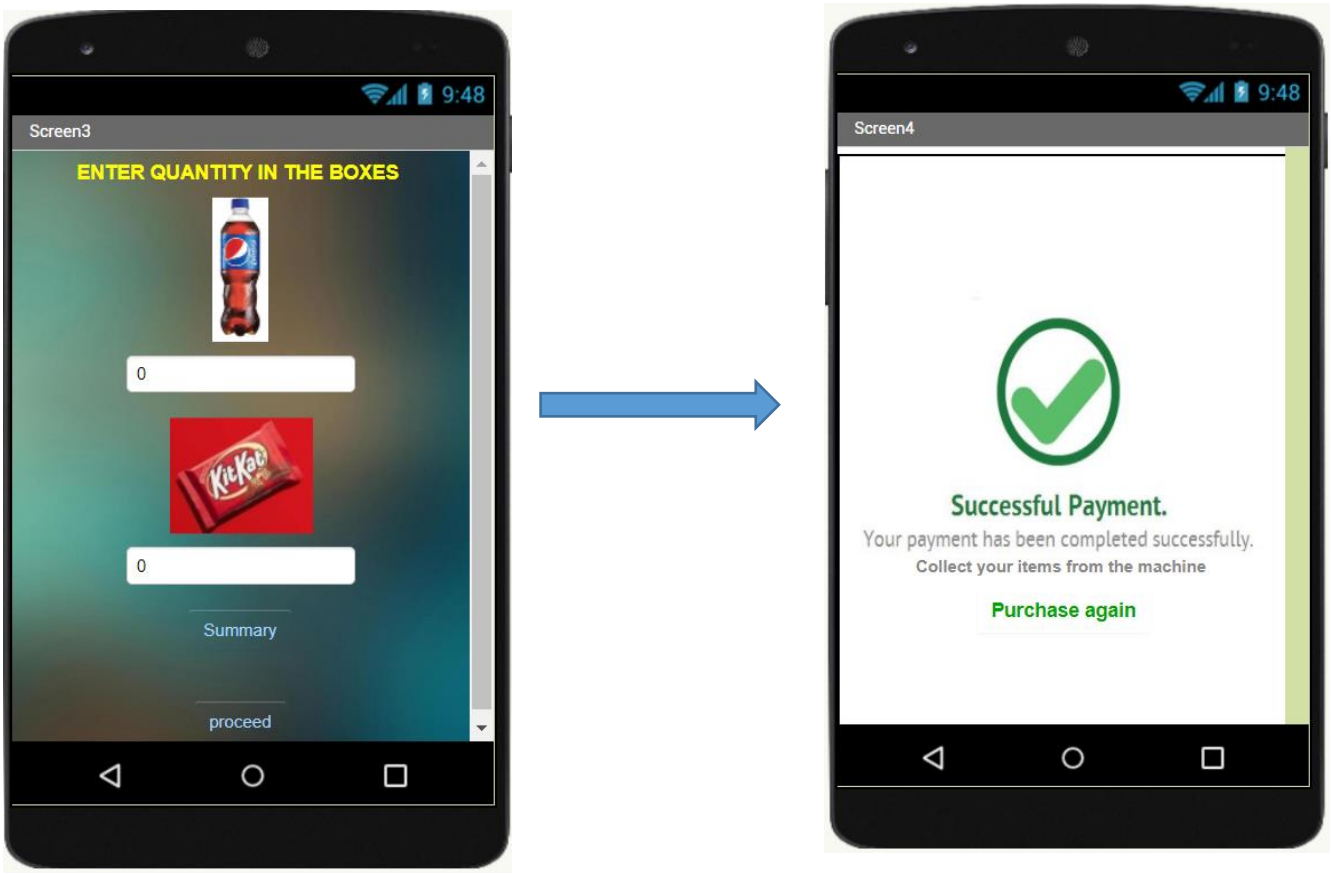
The process of app goes as follows

In screen one the user needs to scan the barcode present on the vending machine or needs to enter the code text from the vending machine



In screen 2 user will be taken to the items in the vending machine and there it displays the number of items present in the vending machine and user needs to select the items in the vending machine user needs to buy and proceed for payment

In screen 3 the user need to enter the amount of the items they need and in summary they will be able to see the amount they need to pay which will be deducted from their virtual wallet

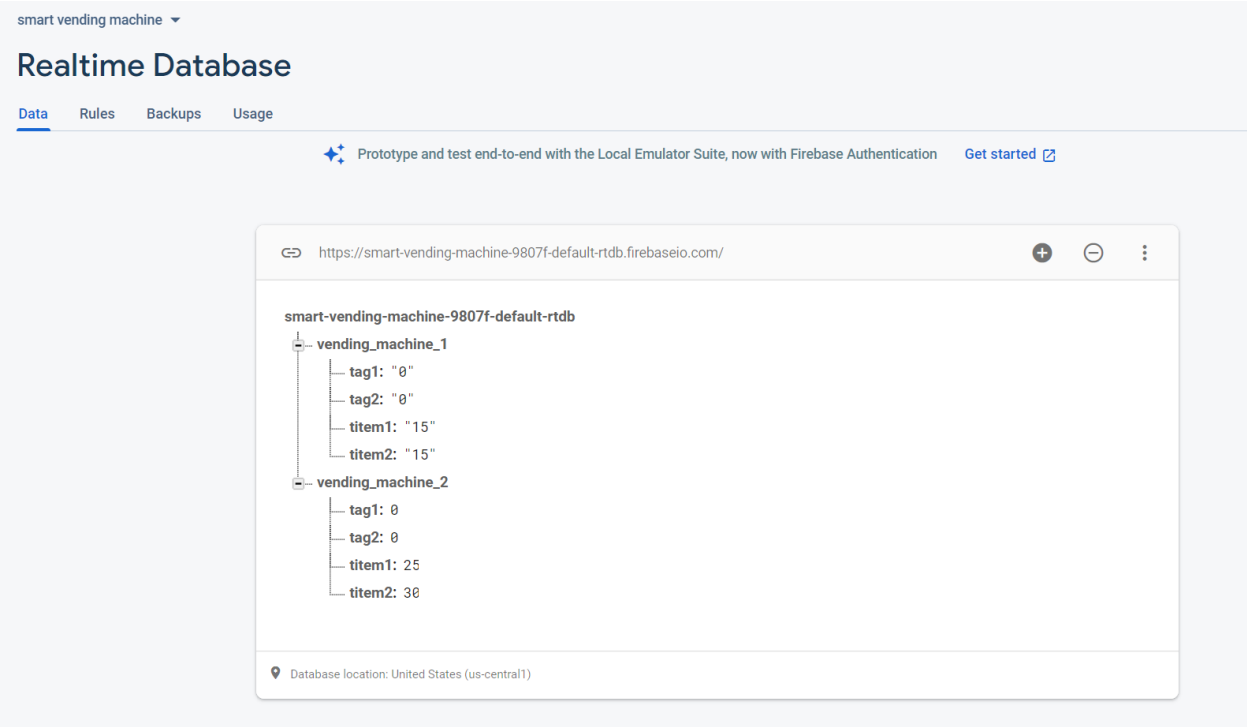


After the payment user will be taken to successful payment page and the item will be dispensed from vending machine and they will be given an option to purchase again

Here, we created the same above screens for vending machine 2 and it follows the same pattern to make purchase of the items (Which are different items from vending machine 1).

FIREBASE

For storing the data and the number of items present in vending machine we used a cloud storage called Firebase. Firebase is a Backend-as-a-Service (Baas). It provides developers with a variety of tools and services to help them develop quality apps, grow their user base, and earn profit. It is built on Google's infrastructure. Firebase is categorized as a NoSQL database program, which stores data in JSON-like documents.



As we can see the data present relates to 2 vending machines we created and the number of items present in each vending machine and the amount of each item present in them

There is also a tag for each item which will be read from NODE MCU and it takes the data form the tag and dispense the products accordingly and later updates the tags to 0

PREDICTION AND ANALYSING

As there isn't enough time to collect a large data set using our hardware we opted to use a dataset from Kaggle to perform analysis and models to predict the future sales of the vending machine so that we can change the items as required

DATASET USED - **https://www.kaggle.com/c/demand-forecasting-kernels-only/data?select=train.csv**

Google collab -
https://colab.research.google.com/drive/1kYFEmgPwaWY8g3G_AbaxnGr-qFir9X2m?usp=sharing

Data fields

- Date - Date of the sale data. There are no holiday effects or store closures.
- Store - Store ID
- Item - Item ID
- Sales - Number of items sold at a particular store on a particular date.

We performed sales prediction using 3 different models

1. Linear regression
2. Random forest
3. LSTM

MODEL	R2
Linear regression	0.9907
Random forest	0.9868
XGBoost	0.9935

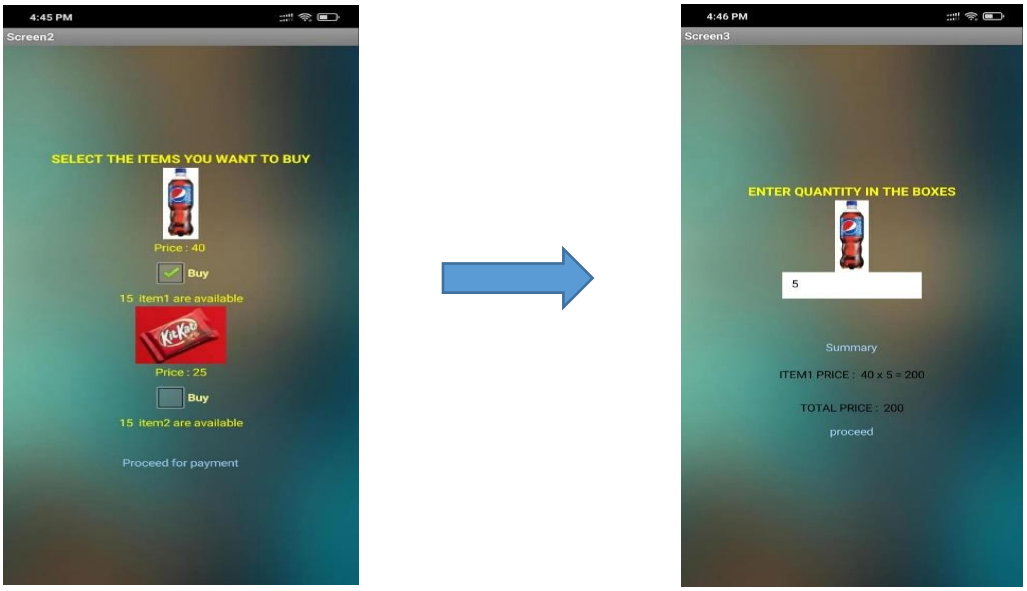
As we can observe form the R2 scores XGBoost model has highest score and we can use this method for our predictions

RESULTS

Initially when we find a vending machine we go near it and we open the app in our mobile and select the item and enter the quantity

We selected Pepsi to buy. Here we can see that the app displays the remaining items left in vending machine i.e. 15 Pepsi's are left and we selected 5 of them

On the other screen we can see the summary total which will be deducted from our virtual wallet

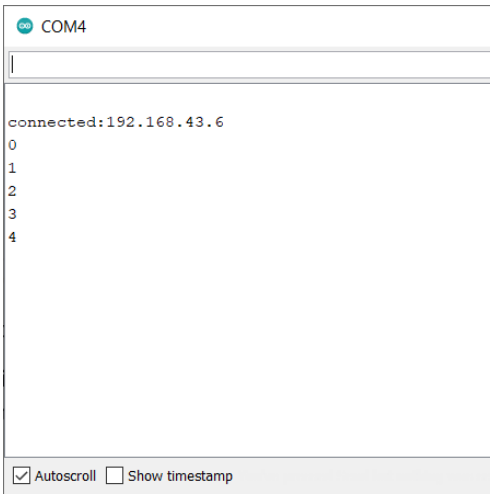


In firebase we can see the total data base of vending machines

After purchasing 5 Pepsi's from vending machine 1

We can see that item1 has been reduced by 5 and tag 1 is increased by 5

Now NODEMCU will read the tag data from firebase and rotate the respective servomotor as to mimic the motion of dispensing the item.

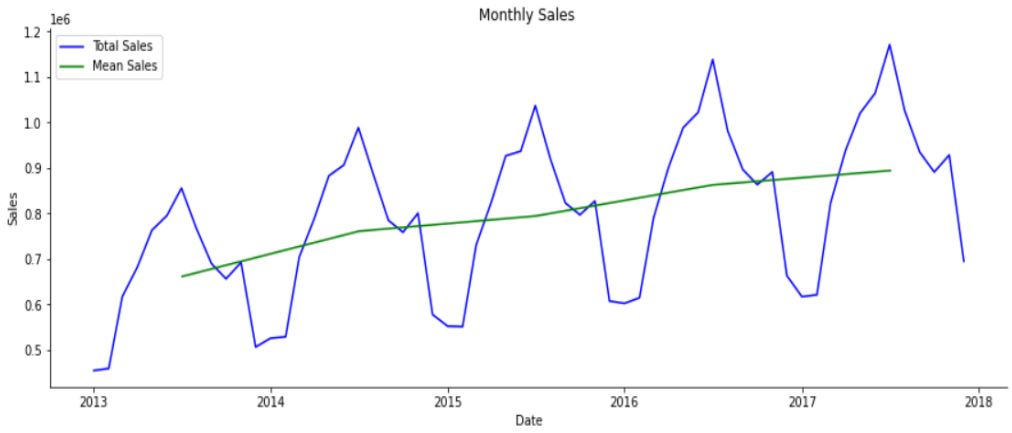


Here we can see the number of times the servo motor has been rotated in serial monitor, after completing the process NODEMCU will change the value of the tag 1 back to 0

With this the working of smart vending machine is done

Now by collecting the data of sales from firebase we will analyze them and predict future sales, we are using a data set from Kaggle to analyze the sales

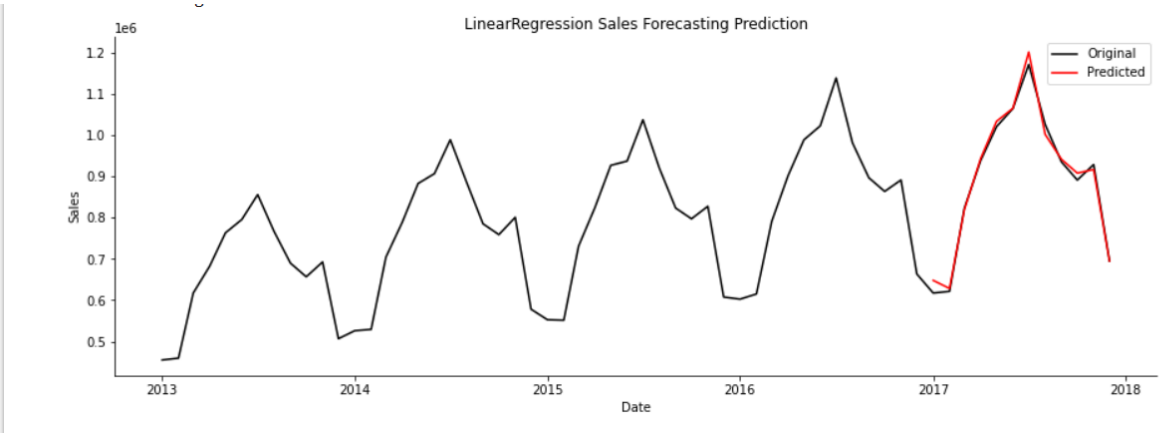
Time series plot of the sales of all stores



LINEAR REGRESSION

RMSE: 16221.040790693221
MAE: 12433.0
R2 Score: 0.9907155879704752

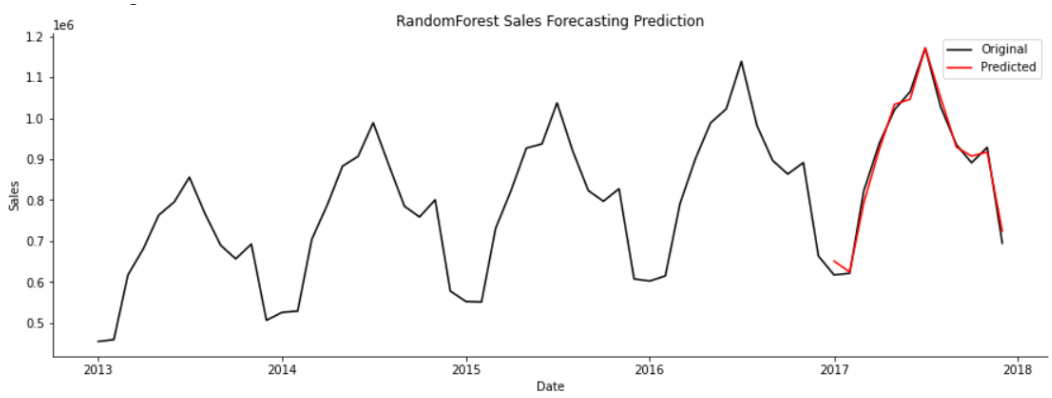
Predicted V/s Actual Sales Plot



RANDOM FOREST

RMSE: 19342.33446570846
MAE: 16405.583333333332
R2 Score: 0.9867987592785946

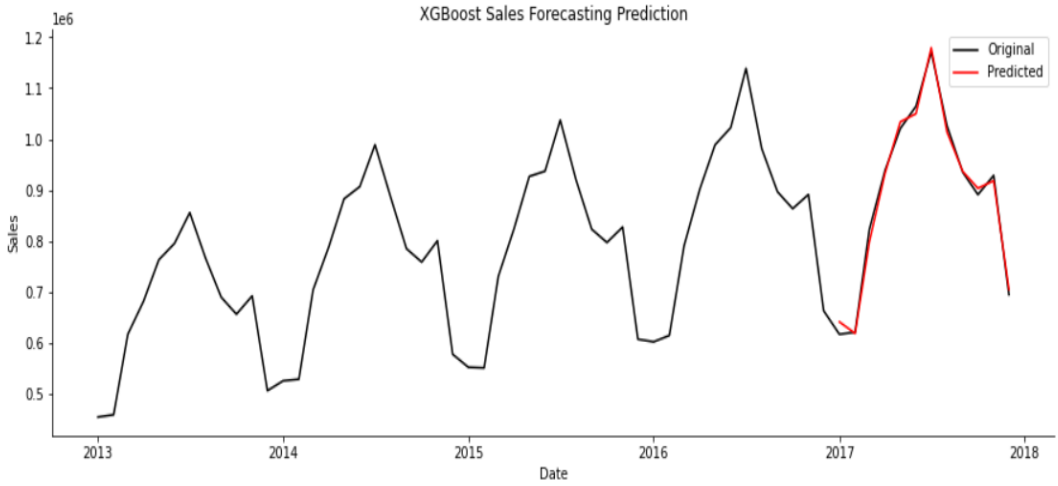
Predicted V/s Actual Sales Plot



XGBOOST

RMSE: 13574.792631933646
MAE: 11649.666666666666
R2 Score: 0.9934977542289017

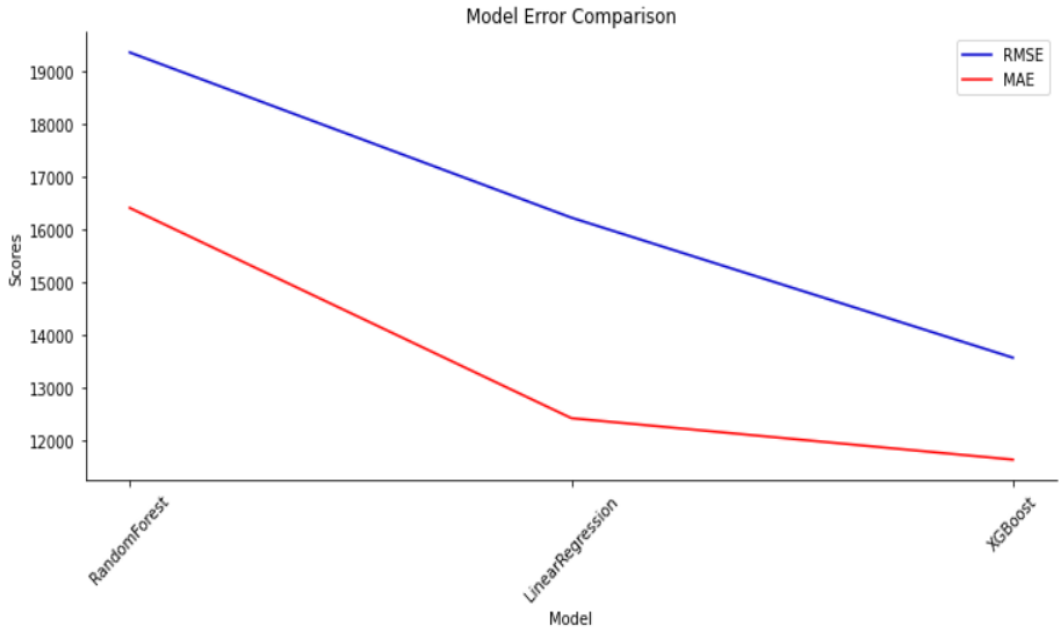
Predicted V/s Actual Sales Plot



We can see that although our model outputs looked similar in the plots above, they do vary in their degree of accuracy. Below is a visual to help us see the difference

	index	RMSE	MAE	R2
0	RandomForest	19342.334466	16405.583333	0.986799
1	LinearRegression	16221.040791	12433.000000	0.990716
2	XGBoost	13574.792632	11649.666667	0.993498

MODEL ERROR COMPARSION GRAPH



We have found that with XGBoost prediction is within 1.3% of the actual and is the best suit for predicting sales in comparison to other models we tried

REFERENCES

1. W. Alam, F. Sultana, J. B. Saba and A. C. Kofi, "IOT Based Smart Vending Machine for Bangladesh," 2019 IEEE International Conference on Robotics, Automation, Artificial-intelligence and Internet-of-Things (RAAICON), 2019, pp. 73-76, doi: 10.1109/RAAICON48939.2019.36.
2. M. S. Arifin et al., "Smart vending machine based on SMS gateway for general transactions," 2017 15th International Conference on Quality in Research (QiR): International Symposium on Electrical and Computer Engineering, 2017, pp. 34-39, doi: 10.1109/QIR.2017.8168447.