POTHOLE LOCATION SURVEY AND COST ESTIMATION

FINAL YEAR PROJECT UG 2017

By

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Final Year Project Titled

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DEDICATION

We dedicate this thesis to our family and teachers who have supported us in this challenging journey.

ACKNOWLEDGEMENTS

In the name of Allah, who is the most Beneficent, the most Merciful and peace and blessings upon Prophet Muhammad ﷺ. We are obliged to Allah Almighty to give us enough power and a positive attitude to complete our project without whose willingness we could not have accomplished such an enormous task.

First and foremost, we would like to say wholehearted thanks to our parents for their sacrifices and generous support during our entire lives and especially in pursuing this bachelor’s degree.

We would humbly like to express our gratitude to our mentor and supervisor Dr. Muhammad Usman Hassan for his persistence, guidance, motivation, immense knowledge, and continuous support throughout our project. We could not have imagined a better advisor and mentor for our FYP.

Lastly, we would extend our appreciation towards our friends and colleagues who kept motivating and encouraging us and provided assistance when required throughout our project.

ABSTRACT

Human life is regarded as the most precious thing on earth. Roads are a mean of transport for the humans but these very roads can also be dangerous for them usually when accidents occur. On roads, most of the accidents occur due to the presence of potholes. These accidents can be fatal and can cause loss of life and damage to vehicles. To ensure the safety of the people from this dangerous road problem the currently used process needs to be upgraded. Currently, the process of potholes checking is usually done manually that leads to inconsistencies in the maintenance program. There is a huge possibility of human errors from these processes. Therefore, there is a need for a new detection system keeping in view the advancement in technology. This study presents a system of pothole detection which is much more efficient and less time consuming from the previous one. The system updates the pothole location to a server as soon as it is detected. The data is then used to estimate the average cost for the maintenance of the pothole. For the visual representation of the location data, an application is created which can be accessed by anyone in the road maintenance department and can also be used by the public to avoid the road with a greater number of potholes. The application shows a map with the pinpoint location of the potholes. The authorities can use this data or application to plan the timely maintenance of the roads which are affected by potholes. The study aims to benefit both the authorities and the public

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Chapter 1

INTRODUCTION

1.1. Background:

Everyone performs their daily activities by travelling from one place to another using road networks. In the previous years, the transport system which is traditionally being used has been affected very much as a result of rapid economic growth and advancement in technology. Due to safety reasons, people usually do not prefer to drive on rough roads. The main reason for the roughness is potholes.

A pothole is usually given a name to a bowl-shaped depression which is usually in the flexible pavement surface, and its dimension is approximately close to 150 mm. Potholes extend from the asphalt layer to the bottom surface and they form because of moisture infiltration and leaving alligator cracking untreated. Small chunks of pavements are created as a result of high severity of alligator cracking, which usually dislodges as vehicles drive on them. After the pavement chunk is dislodged, the remaining hole is called a pothole. These days there is an immense increase of these potholes. This increase in the number and frequency of potholes has dramatically increased the number of accidents and as a result of these, the number of lawsuits and claims in courts due to these accidents have also skyrocketed. It has brought the entire construction quality and management under some serious problems.

The conditions of roads in Pakistan are also not very good. According to a study by R. Ahmed, in Karachi many roads have far too many potholes. These potholes cause many traffic accidents and time delays. Vehicles' suspensions are damaged due to these potholes, which carry a high repair cost. Moreover, when the monsoon season comes, the road surface and quality become more degraded.

The Ministry of Communications issued the National Road Safety Strategy for the year 2018-2030. According to it, every five minutes a human life is lost due to traffic accidents in Pakistan. Moreover, if no new road safety action is taken, there will be an increase of about 77 percent in 2020 and about 200 percent in 2030. It also states that 27,500 people die and 500,000 are injured on our roads annually. There are many reasons for these accidents but the majority of it occurs due to the lack of road maintenance and paying no attention to these potholes at all.

It is a big challenge to maintain a good quality of transport infrastructure but maintaining roads in particular is a difficult task due to many factors including but not limited to bad weather, load borne by the road, and the inconsistency of road deterioration. So, the effectiveness of the program to upkeep of the infrastructure is highly dependent on the monitoring program.

The monitoring program for the detection of these potholes has two methods. First one is the public reporting which is an economical way of addressing the problem but is not efficient as there are many cases of misreporting. The second method is becoming more common, which includes the usage of a special pothole detection vehicle which is driven on the roads to detect potholes and its location, so it takes time to detect the potholes depending upon the available vehicles. Moreover, after the detection then it takes further time to do the cost analysis and refilling of the potholes. But the potholes deteriorate with time and the one detected earlier may be much bigger now at the time of refilling. According to some figures, the money spent on road pothole repair annually is up to $1.3 billion in the USA. The loss incurred by potholes is up to $4.8 billion.

1.2. Problem Statement:

Even though the concept of pothole detection is not relatively new, developing countries like Pakistan still lag in adopting this technology. Pakistan, a developing nation with a good economy, has a complex system of almost 259,197 kilometers of roads. These include 172,827 KM of high type roads and 86,370 KM of low type roads. This number alone emphasizes the importance and severity of the matter.

The traditional method being used in the country is the detection through naked eye and then reporting it to the main administration. This method looks a little on the economical side but is not an efficient one and certainly not economical. It requires much time and requires updating.

In the transport industry of Pakistan, the uses of equipment and systems that are modern and sophisticated are not encouraged on many levels. Many of the people involved with the maintenance department are hesitant towards adopting the new generation systems because most of them think that they are comfortable using the traditional methods and some of them are rather incapable of using it.

The cost of the traditional method increases with time because a lot of time is spent in detection alone which further deteriorates the potholes condition. The need is for a system which offers continuous updating of the data so that the necessary action can be taken without any delay and thus loss of precious lives can be prevented.

The process of detection is already automated in most of the countries around the world, so if it is not done now, Pakistan will lag behind in this race of advancement in maintenance practices.

1.3. Objectives:

The objectives of this research are:

- To develop a system for the survey and identification of potholes location in the form of GPS data.
- To develop a method for the cost estimation of potholes which are identified.
- To develop a relationship between pothole detection systems, Google sheets and Apps sheet for the real time storage of the data.
- To develop an application for the visual representation of location data and cost estimation data in the form of a map.

1.4. Thesis Organization:

The thesis consists of the following five chapters:

Chapter 1 (Introduction) which covers general introduction to the research, problem statement, objectives and the pros of the system. It provides a general and broad outline of the research. Chapter 2 (Literature Review) gives information about the studies and research which were done prior and the system they used for the detection of potholes. Chapter 3 (Research Methodology) explains how the system, code and application were developed to achieve the objectives of the research. Chapter 4 (Results and Discussion) covers the analysis of the data and the results of the research. It shows how the analyzed and processed data helped us in the achievement of our desired research objectives. Chapter 5 (Conclusions and Recommendations) provides the conclusion of the whole research and what are the recommendations for the future research.

Chapter 2

LITERATURE REVIEW

2.1. Background

Every construction project is susceptible to some problems. They may be in the form of time overrun, cost overrun, poor workmanship, use of old techniques, risk identification and management and so on. The most important aspect which should be catered for, during the construction and the maintenance of a facility is its safety and quality of use. Therefore, to ensure safety and quality of a project, utmost care of the building codes and standards should be taken throughout the construction and operational period of the project.

Since our project is associated with the maintenance of roadways, hence using the traditional manual techniques would be difficult, time consuming, more costly and irregular. To automate the process and make it regular, considerable research has been done in the past. Our project is yet another addition in this regard.

2.2. What Is a Pothole and It's Causes?

A pothole is usually a round shaped depression/hole formed in the asphaltic pavement of roadways. It varies in both shape and size. The pieces from the road surface which are broken are taken away by the heavy vehicles [1].

The water present beneath the road surface undergoes repeated compressions and expansions. This water gets beneath the pavement from either the surface or it may percolate through the subgrade of the road [2].

When water freezes, it gets expanded and occupies more space than available. Thus, exerting pressure on the asphalt pavement and trying to displace it. This expansion causes cracks in the surface of the road and weakens the material of pavement[3]. Now when the ice melts, it contracts and occupies less spaces causing empty spaces under the pavement. These empty spaces act as a home for water to entrap and thus give rise to repeated freeze-and-thaw effects. Consequently, the pavement gets weakened and cracks appear in it[4].

When heavy traffic passes through such weak spots, the material of the pavement gets loosen and is displaced from its original position, causing the pothole to be generated[5][6].

2.3. Formation of Pothole

Two factors to be there for pothole formation at a time, water, and heavy traffic[7]. The underneath water weakens the pavement material and then the traffic displaces it, causing the formation of potholes[6]. An average pothole is usually one and a half feet wider and about an inch deep. If it is not filed timely, it can expand to several feet in width. If it is wide enough, it can cause damage to vehicles and can also cause serious accidents[8].

Potholes may form due to the following reasons:

- Insufficient pavement thickness
- Poor drainage system

- Failures at main-holes and drainage casing
- Defects and cracks on pavement which are left unmaintained and unsealed[9].

2.4. Time and Cost Loses Due to Traditional Manual Filling

The traditional manual filling is of course both time consuming and relatively more costly[10]. The nonsystematic identification of potholes and then filling them should not be an approach in this world of technology. Previously potholes filling was based on the trail methods mostly[11]. The concerned authority would take a truck full of Asphalt Concrete with some equipment and manpower, and start filling the potholes. This takes a lot more time because the authority does not have the location of each pothole. Also, the material can exceed the amount required for all the potholes and in the same fashion it can be less than the amount required[12][13].

Considering the technological evolution with time, sufficient techniques have been used for smart detection of potholes. The use of modern techniques and apparatus has made us able to identify and redeem these defects in roadways smartly[14]. Consequently, both cost and time can be saved using such modern tools and techniques.

2.5. Pothole Detection

Pothole detection system is the systematic process in which some apparatus is set up in the vehicle[15][16]. When the vehicle passes through the potholes, the instrument notes the data which is connected to the GPS sensors, which process data onto the

Google sheet[17]. The data collected is then used to monitor the road surface. Figure 1 provides us with the sample of potholes detected citywide.

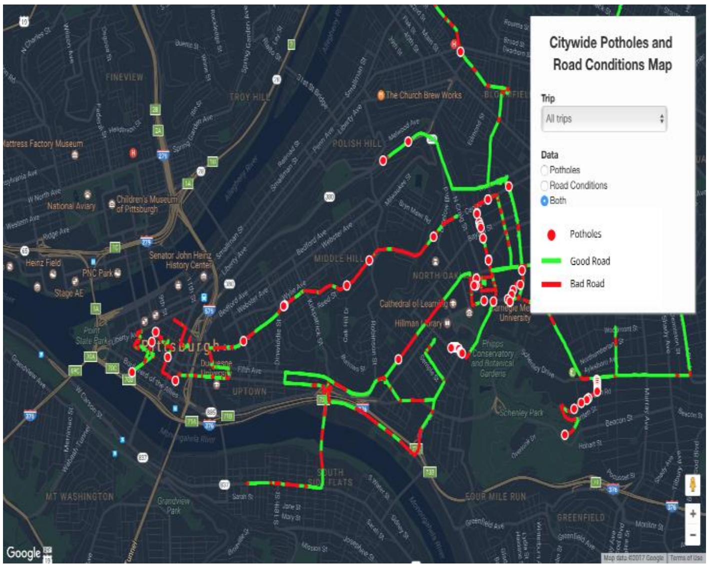

Figure 1 Citywide Potholes Road Condition

2.6. Related Work

Following pothole detection methods have been proposed which can be classified into two categories:

- Image recognition method
- Mobile sensing method.

2.7. Image Recognition Method

Based on laser imaging techniques, Yu and Solari presented a pothole detection technique in which information related to the roads was to be collected. Yu and Solari then used the Artificial Neural Network (ANN) algorithm for the analysis of the information already collected, to detect the potholes[18].

For the same reason (potholes detection), Lin and Liu used the Support Vector Machine (SVM) algorithm for the analysis of the road images collected to detect the potholes[19].

2.7.1. Advantages

- Provides high quality images.
- High accuracy

2.7.2. Disadvantage

- High power required to recognize the laser images.
- For mobile devices, it is inappropriate[20].

2.8. Mobile Sensing Method

For the BusNet project, to collect accelerometer data and the information about location the On-Board Unit is equipped with GPS and G-sensor[21].

The data collected can then be sent into the central data processing by using wireless networks and it can analyze the data entered to confirm whether the vectors of accelerometer data exceed the thresholds set for pothole detection[22]. Since this approach needs to send the batch accelerometer data when the bus enters the station, thus it does not provide information about real-time pothole detection[23].

A project syndicate from Massachusetts Institute of Technology (MIT) proposed a pothole detection system in which they combined the G-sensor and GPS. The system analyzed the accelerometer data from both x-axis and z-axis, and it was equipped with five data filters including high-pass, speed, and speed vs. ratio, z-peak and xz-ratio.[14], [24].

All the five data filters set up can detect the potholes but only the data from z-peak is the precise one. However, with the upward or downward streaming of the road the z-peak of data filters can be misjudged[25].

Nericell proposed a project in which he used a smartphone based on Windows Mobile operating system in which G-sensor and GPS are combined to collect and analyze the accelerometer data for the identification of potholes[26][27]. However, in this project the smartphone should be set at a specified angle.

Mednis et al. proposed four different approaches for the detection of potholes. It includes the Z-DIFF approach, STDEV-Z approach, Z-TRESH approach and G-ZERO approach to analyze the data of the accelerometer[28]. The data in this project is acquired from Texas instruments controllers, Analogue G-sensors and Tmote sensors. The values of Z-DIFF and STDEV-Z approaches depend on the timing and frequency[28][29]. Therefore, proper investigation is required to design and compare these four approaches for the mobile device.

2.9. Machine Learning

Machine learning is a computer algorithm data analysis, in which analytical model building is automated. It is considered as a part of Artificial Intelligence (AI) in which performance is improved and automated through experience and use of data[30].

It is usually based on the principle that ‘Given a system can learn from the information provided, identify it, process it and make decisions on its own without any human intervention.’ Greater the data, more is the accuracy[24].

Machine Learning has made it possible to automatically generate models and then analyses the complex and large-scale data fast, efficiently and with more accuracy.

2.9.1 Applications

Many organizations which must deal with large amounts of data have now realized the importance of machine learning technology in their work. By getting enough insights from this data which is often in real time, organizations are now able to work more efficiently and are able to gain some advantage over other organizations[30].

Following are some of the organizations/fields which use machine learning techniques to excel in their respective fields:

a) Financial Services

To identify data insights and online fraud prevention, all business organizations use the Machine Learning technology[31].

b) Government

Government also needs the services of Machine Learning to see business insights. They need to identify ways to increase efficiency, save money and provide opportunities to the citizens.

c) Transportation

To make the routes more efficient and to make the traffic smooth, Machine Learning can help us in this regard as well. It can help us in identifying any potential hazards on the roads. An example of using ML in transportation and commuting can be that of an Uber cab[32].

d) Oil and Gas

To streamline the oil distribution system to increase efficiency and find new non-renewable energy sources.

e) Self-Driving cars

f) Health Care

It includes the devices or the sensors that use data to assess a patient's health. It can also help the health experts to identify new and advanced ways to diagnose and treat diseases.

g) Online Fraud detection

With the increase of online transactions, criminals are also growing in number. To safeguard it from sabotage Machine Learning is used[33].

2.9.2 Types of Machine Learning Algorithms

There are two methods of machine learning most widely used:

a) Supervised Learning

b) Unsupervised Learning

a) Supervised Learning

In supervised learning as the name suggests, the machine is supervised while it is learning. Supervising the machine means that when we provide a system with data and its outcome. The whole data set is used as input and the outcome is called as labelled data[34].

For example, we show the machine 100 cases when customer paid the bill and 100 other cases where customer did not. Here the labelled data is paid/unpaid.

After training the system for these 200 cases, when any other case is provided to it, the system will compare the actual output with the correct output and show the result[35].

b) Unsupervised Learning

In unsupervised learning, the system does not require human intervention to learn. It is commonly used for anomaly detection, like online fraud transactions or payments. In unsupervised learning there is no labelled data[36]. The machine identifies the error in the pattern itself as it is not told the correct answer. There is also another method of machine learning known as Reinforcement Learning.

It is usually used for navigation, gaming and robotics. In this type of machine learning, the algorithm learns through trial and error on the basis of highest reward[37].

It has three components:

- The agent
- The environment and
- The action

2.10. Equipment Used

Following were the equipment used in making the model for our project:

- NodeMCU ESP8266
- UBLOX NEO 6M GPS

2.10.1 NodeMCU ESP826

Some features of Node MCU ESP8266 are:

- Microcontroller: Tensilica 32-bit RISC CPU Xtensa LX106
- Input Voltage: 7-12V
- Operating Voltage: 3.3V
- Analog Input Pins (ADC): 1

- Digital I/O Pins (DIO): 16
- Flash Memory: 4 MB
- UARTs: 1
- SPIs: 1
- I2Cs: 1
- USB-TTL is included onboard
- PCB Antenna
- SRAM: 64 KB
- Clock Speed: 80 MHz
- Small Sized module to fit inside your IoT projects[38].

The NodeMCU ESP8266 is a device which comes with the ESP-12E module and containing ESP8266 chip. It has a Tensilica Xtensa 32-bit LX106 RISC microprocessor. It has 4MB of memory and 128 KB RAM. This microprocessor used in it supports RTOS and operates between 80MHz to 160 MHz adjustable clock frequency. A Micro USB jack can be used to power the NodeMCU [39].

Its high processing power with other features like the in-built Wi-Fi, Bluetooth and Deep Sleep Operating features are what make it ideal for IoT projects[40].

Figure 3 depicts the what a Node MCU ESP8266 looks like.

Figure 2 Node MCU ESP8266

2.10.2 How to Program Node MCU ESP8266 with Arduino IDE

To link NodeMCU ESP8266 with Arduino IDE, all we need is a USB cable along with the NodeMCU and the Arduino IDE software (installed in PC). The NodeMCU can very easily be programmed with the Arduino IDE. This programming can be done in less than 10 minutes[41]. Figure 4 depicts the appearance of Arduino IDE.

Figure 3 Arduino IDE

2.10.3 Ublox Neo 6M GPS

The UBLOX NEO-6M is a type of a GPS receiver which have a built-in antenna made up of ceramic. Inside the module is a NEO-6M GPS chip which is made by u-blox. The chip packs a significant number of features into its little size frame. It provides a strong satellite search capability using its features[42].

It can perform up to 5 location updates per second with 2.5m Horizontal position accuracy. Some of the best features the chip provides includes its Power Save Mode (PSM) which allows a reduction in power consumption. It does this by selectively switching parts of the receiver ON and OFF. The u-blox 6 engine also includes a Time-To-First-Fix (TTFF) of under 1 second[42].

It can detect up to 22 satellites on 50 channels and achieve the sensitivity up-to 161 dB tracking, while consuming only 45mA supply current. Figure 5 depiccts the appearance of UBLOX NEO-6M[43].

Figure 4: UBLOX NEO-6M

The NEO-6M supports baud rate from 4800bps to 230400bps. Its default baud is 9600. The necessary data pins of chip are broken out to 0.1″ pitch headers[44].

There is also an LED on the module which tells us about the status of Position Fix[45]. It usually blinks at various rates depending on what state it's currently in:

- If there is no blinking then it means it's searching for satellites.
- But if it blinks every 1s it means the Position Fix is found.

Chapter 3

METHODOLOGY

3.1. General Overview:

The following figure 6 is the general methodology adopted for our project. .

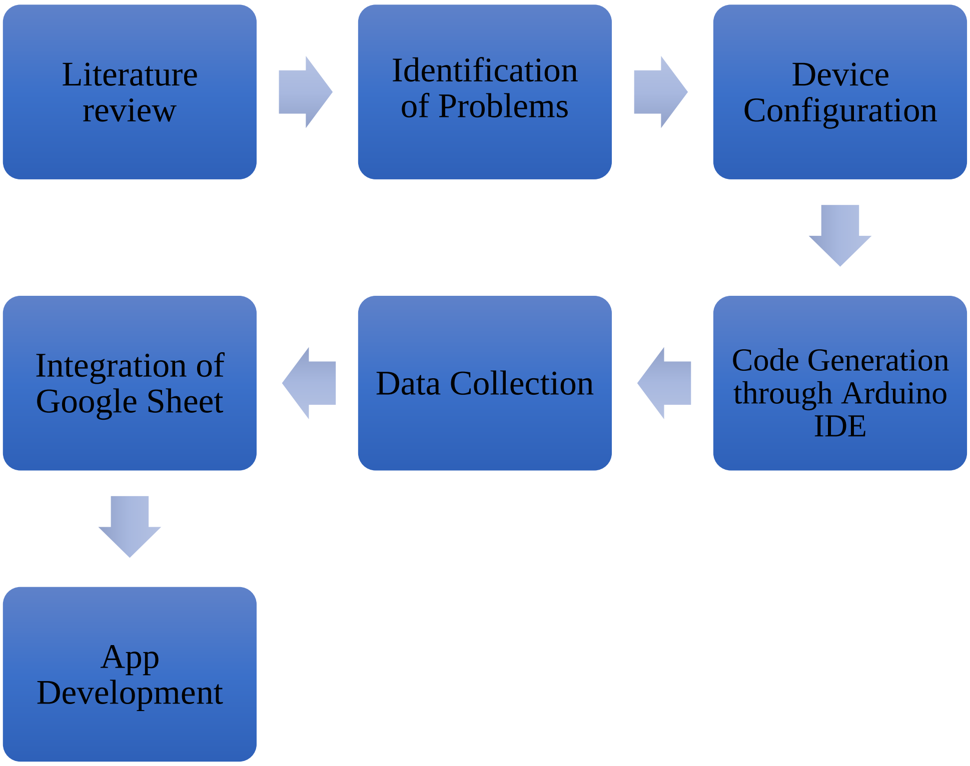

Figure 5: General Methodology

3.2. Configuration of Device:

The necessary components for the configuration of the device were acquired. The main components were:

- ESP8226 MCU
- UBLOX NEO 6M
- Jumper Cables
- Power Supply (Power-Bank)
- WIFI Device
- Buttons, LEDs

ESP8226 is a micro controller with a built-in Wi-Fi module that can work if programmed by a code. The UBLOX NEO-6M was used as a GPS receiver with a built-in ceramic antenna. It provided a strong satellite search capability. Jumper cables are used to establish the connection between the ports and terminals of the two equipment's. USB cable is used to supply the power to our equipment and the WIFI connection is made available using a portable WIFI device.

The purpose of connections is to send and receive signals by device. We made use of 4 ports of ESP8266 that are D1, D2, TX and Ground. The 4 ports of UBLOX 6M that are connected with ESP8266 were VCC, RX, TX and Ground. The VCC port of GPS was connected with the 3.3 V source on ESP while the RX and TX were connected with the D1 and D2 port for receiving and transferring the data. Following figures will brief the connection of the circuit we constructed. Figure 7 depicts the terminals of modules and Figure 8 explains the connection ESP8266 with GPS.

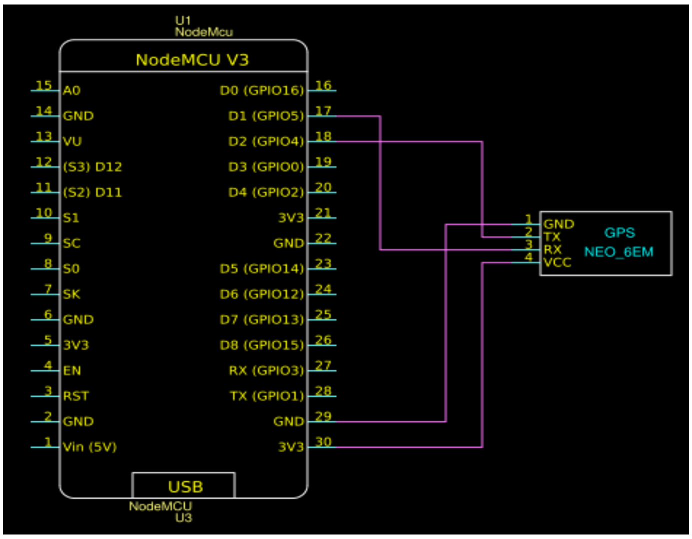

Figure 6: Terminals of Modules

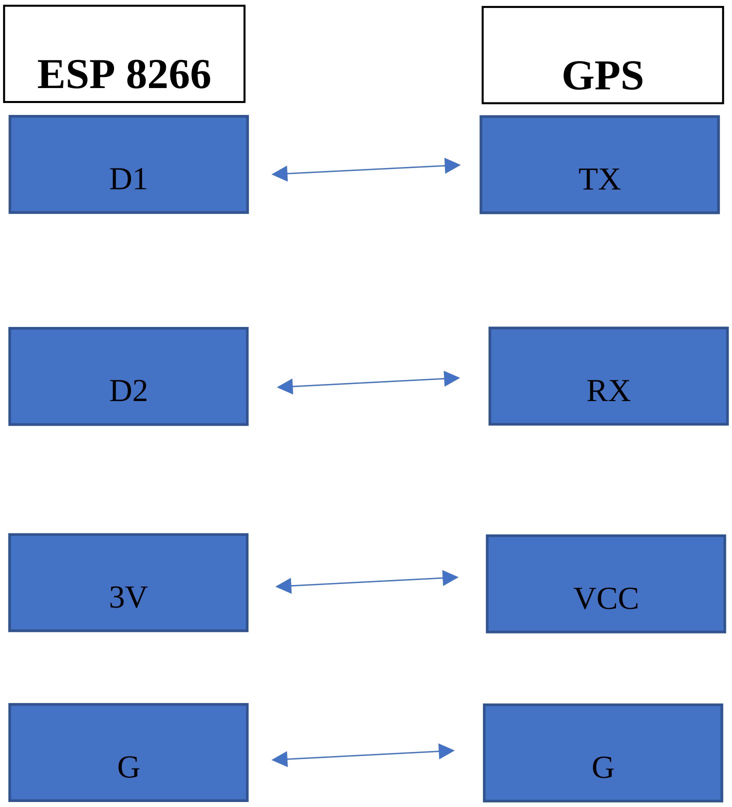

Figure 7: Connections of ESP8266 to GPS

3.3. Code Generation:

The process of code generation is lengthy and tiresome as it involved learning the programming languages and its different libraries which were essential in making the components work. The code is developed on the Arduino IDE in many parts. The code for the running of the ESP8266 and UBLOX 6M is developed to obtain the GPS data and then the code for the cost estimation is developed and integrated with the previous one.

3.4. Libraries:

Different libraries are included for each component of the detection system and their respective functions are defined. The library "EasyButton.h" is used for the operation of buttons which will be pressed as soon as a pothole is detected. "TinyGPS++.h" library is for the GPS data collection. While the library "ESP8266WiFi.h" is used to incorporate the EPS module. Figure 9 displays the Libraries used in programming.

```
#include <EasyButton.h>
#include <TinyGPS++.h>
#include <SoftwareSerial.h>
#include <ESP8266WiFi.h>
#include <WiFiClientSecure.h>

#define BUTTON_PIN 0
#define BAUDRATE 9600
#define ON_Board_LED 2
static const int RXPin = D1, TXPin = D2;
static const uint32_t GPSBaud = 9600;

// Instance of the button.
EasyButton button(BUTTON_PIN);
TinyGPSPlus gps;
SoftwareSerial ss(RXPin, TXPin);
```

Figure 8: Libraries

3.5. Code for GPS data collection:

Different functions for the operation of the WIFI device and the LEDs are inserted in the void setup function of the Arduino IDE. These functions are meant to run for one time to initialize the whole code. These functions obtain the information about the WIFI device, its password and about when the LED goes ON or OFF. Figure 10 displays the void setup code.

```
void setup()
{
  // Initialize Serial for debuging purposes.
  Serial.begin(BAUDRATE);
  ss.begin(GPSBaud);
//====================================================//
  WiFi.begin(ssid, password); //--> Connect to your WiFi router
  Serial.println("");

  pinMode(ON_Board_LED,OUTPUT); //--> On Board LED port Direction output
  digitalWrite(ON_Board_LED, HIGH); //--> Turn off Led On Board

  //----------------------------------------Wait for connection
  Serial.print("Connecting");
  while (WiFi.status() != WL_CONNECTED) {
    Serial.print(".");
    //----------Make the On Board Flashing LED on the process of connecting to the wifi router.
    digitalWrite(ON_Board_LED, LOW);
    delay(250);
    digitalWrite(ON_Board_LED, HIGH);
    delay(250);
    //----------------------------------------
  }
```

Figure 9: Void Setup Code

The “void loop” contains a function about whether the button is pushed or not. It will continue to run until some GPS data is detected. If the button is pressed and GPS data is received the void loop calls the “Void display info” function. As a result of calling the void display info function the longitude and latitude data are then stored as an X and Y variable respectively. The data is stored up to 6 digits. Figure 11 displays the void display information code.

```
void loop()
{
     while (ss.available() > 0)
     if (gps.encode(ss.read()))
       button.read();

   if (millis() > 5000 && gps.charsProcessed() < 10)
   { button.read();
     Serial.println(F("No GPS detected: check wiring."));
     while(true);
   } }
void displayInfo()
{
   Serial.println(gps.location.lat());
   Serial.println(gps.location.lng());
   float x = gps.location.lat();
   float y = gps.location.lng();

   String FLAT = "Latitude : " + String(x,6) ;
   String FLON = "Longitude : " + String(y,6) ;
   Serial.println(FLAT);
   Serial.println(FLON);

   sendData(x, y);

   Serial.println();
}
```

Figure 10: Void Display Info Code

3.6. Code for Integration with Google sheets:

The next step is to import or send the data to the Google sheets which is our primary storage place. The Google sheets store the data in the form of an editable file. The data is sent to the Google sheets as soon as the button is pressed. So, there is real-time updating of data. The code for sending the data is represented in the form of “Void sendData”. Figure 12 displays the Google Sheet integration code.

```
//==========================================================//
void sendData(float la, float lo) {
  Serial.println("==========");
  Serial.print("connecting to ");
  Serial.println(host);

  //----------------------------------------Connect to Google host
  if (!client.connect(host, httpsPort)) {
    Serial.println("connection failed");
    return;
  }
  //----------------------------------------

  //----------------------------------------Processing data and sending data
  String Latitude =  String(la,6);
  String Longitude =  String(lo,6);
  String url = "/macros/s/" + GAS_ID + "/exec?Latitude=" + Latitude + "&Longitude=" + Longitude;
  Serial.print("requesting URL: ");
  Serial.println(url);

  client.print(String("GET ") + url + " HTTP/1.1\r\n" +
         "Host: " + host + "\r\n" +
         "User-Agent: BuildFailureDetectorESP8266\r\n" +
         "Connection: close\r\n\r\n");

  Serial.println("request sent");
  //
```

Figure 11: Google Sheets Integration Code

The app script is developed for the Google sheets so that real-time integration of data between the device and Google sheets can take place through Wi-Fi. This enables us to view the data from any place in the world. The script also incorporates the cost estimation of the potholes. As soon as the button is pressed and some GPS data is stored the very next column of the respective GPS data (Longitude, Latitude) column stores a value of “1” in the same row. The value is “1” for each pothole detected and “0” when no pothole is detected. Figure 13 displays the the App script code.

```
function doGet(e) {
  Logger.log( JSON.stringify(e) );
  var result = 'Ok';
  if (e.parameter == 'undefined') {
    result = 'No Parameters';
  }
  else {
    var sheet_id = '1gET21nSbYyrdjd7U8J9R0S9zX1gb3q0s81wTqqffq4o';  // Spreadsheet ID
    var sheet = SpreadsheetApp.openById(sheet_id).getActiveSheet();
    var newRow = sheet.getLastRow() + 1;
    var rowData = [];
    var Curr_Date = new Date();
    rowData[0] = Curr_Date; // Date in column A
    var Curr_Time = Utilities.formatDate(Curr_Date, "Asia/Islamabad", 'HH:mm:ss');
    rowData[1] = "1"; // Time in column B
    var lat = '';
    var lon = '';
    for (var param in e.parameter) {
      Logger.log('In for loop, param=' + param);
      var value = stripQuotes(e.parameter[param]);
      Logger.log(param + ':' + e.parameter[param]);
      switch (param) {
        case 'Latitude':
          lat = value;

          result += ' ,Latitude Written on column C';
          break;
        case 'Longitude':
          lon = value;
```

Figure 12: Apps Script Code

3.7. App development using AppSheet:

Appsheet is used to develop an application for the data collected. The data from the Google sheets is directly linked with the Appsheet server. Whenever there is an addition or removal of data from the Google sheets the same data alterations happen on the Appsheet data. The data is then used to create a map of the location in which the survey was performed. The map shows the position of the potholes according to the linked data.

Chapter 4

RESULTS AND DISCUSSIONS

4.1. Background:

To identify the problems, present in the existing pothole detection procedure, literature review was studied and a simple and efficient method was devised. For this purpose, code was generated for the new device which is used in the pothole detection. The Arduino IDE was used for code generation with Google sheets as a storage place for data. Appsheet was used for the development of an application.

4.2. Generating the complete code for the detection device:

The complete code for the detection device was successfully created using the Arduino IDE. The code for the cost estimation of the potholes was also generated. The code was tested and was found to be according to our requirements. The code was used for acquiring the GPS data of potholes.

4.3. Data Collection on Google sheets:

Data of the potholes which consisted of their latitude and longitude was stored continuously on the Google sheets as soon as a new pothole was detected. The data was stored in the form of an excel file on the sheets. The file also contained the cost estimation of the potholes along with the time and date of when the pothole was detected. Following Table 1 and 2 displays the coordinates collected in NUST H12 and City Islamabad

Table 1: Data collection in NUST H12

Date	Times a button is pushed	Latitudes and Longitudes
4/29/2021	1	33.6456570,072.992989
4/29/2021	1	33.6448330,072.992493
4/29/2021	1	33.6456300,072.990715
4/29/2021	1	33.6463850,072.989662
4/29/2021	1	33.6472510,072.989990
4/29/2021	1	33.6473120,072.989120
4/29/2021	1	33.6460950,072.986023
4/29/2021	1	33.6450730,072.985382
4/29/2021	1	33.6440810,072.985123

4/29/2021	1	33.6422350,072.985649
4/29/2021	1	33.6420210,072.985809
4/29/2021	1	33.6407010,072.986794

Table 2: Data collection in City Islamabad

Date	Times button is pressed	Latitudes and Longitudes
6/2/2021	1	33.6671180,072.998718
6/2/2021	1	33.6663320,072.996277
6/2/2021	1	33.6674610,072.995140
6/2/2021	1	33.6707270,072.999947
6/2/2021	1	33.6697350,072.998070
6/2/2021	1	33.6690440,072.997261
6/2/2021	1	33.6687240,072.996880
6/2/2021	1	33.6685410,072.995827
6/2/2021	1	33.6674840,072.993759
6/2/2021	1	33.6656530,072.989532
6/2/2021	1	33.6649210,072.990074
6/2/2021	1	33.6644630,072.990425
6/2/2021	1	33.6625940,072.991821
6/2/2021	1	33.6619870,072.992294
6/2/2021	1	33.6599160,072.993843
6/2/2021	1	33.6583980,072.994987
6/2/2021	1	33.6575470,072.994987
6/2/2021	1	33.6621440,073.004463
6/2/2021	1	33.6642570,073.008423
6/2/2021	2	33.6665950,073.012680

6/2/2021	1	33.6714360,073.009392
6/2/2021	1	33.6731190,073.008041
6/2/2021	1	33.6779210,073.004524
6/2/2021	2	33.6809160,073.002258
6/2/2021	1	33.6829380,073.005081
6/2/2021	1	33.6849440,073.008934
6/2/2021	1	33.6872440,073.013336
6/2/2021	3	33.6894910,073.017502
6/2/2021	1	33.6928060,073.016037
6/2/2021	1	33.6944920,073.012962
6/2/2021	1	33.6941910,073.012390
6/2/2021	1	33.6932330,073.010559
6/2/2021	1	33.6944010,073.012558
6/2/2021	1	33.6951220,073.013138
6/2/2021	1	33.6954570,073.012619
6/2/2021	1	33.6958080,073.012512
6/2/2021	2	33.6955760,073.012070
6/2/2021	1	33.6953430,073.011627
6/2/2021	1	33.6958240,073.011192
6/2/2021	2	33.6962200,073.010918
6/2/2021	1	33.6965410,073.010674
6/2/2021	1	33.6967390,073.010529
6/2/2021	2	33.6969600,073.010368
6/2/2021	1	33.6978030,073.009735
6/2/2021	1	33.6987040,073.009117
6/2/2021	1	33.6999020,073.008217
6/2/2021	1	33.7003820,073.008125
6/2/2021	1	33.7009010,073.007782
6/2/2021	1	33.7004430,073.006653
6/2/2021	1	33.6995770,073.004982
6/2/2021	3	33.6950870,072.996483
6/2/2021	1	33.6943630,072.995117
6/2/2021	1	33.6938020,072.994064

6/2/2021	1	33.6943020,072.991501
6/2/2021	1	33.6952710,072.990425
6/2/2021	2	33.6989400,072.987198
6/2/2021	1	33.6993480,072.986664
6/2/2021	1	33.7004700,072.985802
6/2/2021	1	33.7019840,072.984383
6/2/2021	1	33.7017440,072.983925
6/2/2021	1	33.7011760,072.982819
6/2/2021	2	33.7009470,072.982368
6/2/2021	1	33.6991620,072.978012
6/2/2021	1	33.6991620,072.977119
6/2/2021	3	33.6991540,072.976273
6/2/2021	1	33.6991580,072.976013
6/2/2021	1	33.6991650,072.975693
6/2/2021	1	33.6991880,072.975540
6/2/2021	1	33.6992450,072.975311
6/2/2021	1	33.6992450,072.975166
6/2/2021	1	33.6992490,072.974960
6/2/2021	2	33.6992570,072.974739
6/2/2021	1	33.6991770,072.974258
6/2/2021	1	33.6977960,072.971504
6/2/2021	1	33.6963080,072.968575
6/2/2021	1	33.6999660,072.980064
6/2/2021	1	33.7005460,072.981224
6/2/2021	1	33.7009320,072.982002
6/2/2021	1	33.7011380,072.982422
6/2/2021	3	33.7019350,072.983948
6/2/2021	3	33.7021750,072.984451
6/2/2021	1	33.6989360,072.987534
6/2/2021	3	33.6956900,072.993271
6/2/2021	1	33.7029340,073.007172
6/2/2021	1	33.7090720,073.029312
6/2/2021	1	33.7072910,073.030632

6/2/2021	1	33.7056660,073.031845
6/2/2021	2	33.7049290,073.032402
6/2/2021	2	33.7030640,073.033806
6/2/2021	2	33.6931380,073.027313
6/2/2021	2	33.6944120,073.029892
6/2/2021	1	33.6895370,073.034157
6/2/2021	1	33.6884990,073.034935
6/2/2021	1	33.6887400,073.034599
6/2/2021	1	33.6903040,073.033401
6/2/2021	1	33.6899600,073.032745
6/2/2021	2	33.6899490,073.032852

4.4. Creating an application:

The application for the visual representation of the pothole data was also successfully developed using the Appsheet server. The data was directly imported and linked with Google sheets. The map displayed the locations where potholes were detected. The application can be conveniently used on any laptop and mobile. Using the application, the personnel of the maintenance department can login at any time using very easily. The app can also be used by the public to view the map and see which roads have more potholes and which have less. It will help them to make their drive more comfortable.

The link to download application is given below:

https://www.appsheet.com/newshortcut/a407fb7d-9629-4429-b1c3-44bc8ac14eee

Figure 14 displays the data of potholes we spotted in the premises of NUST H12 Pakistan.

Figure 13: NUST Pothole Map 1

Figure 16 displays the Satellite view of data collected

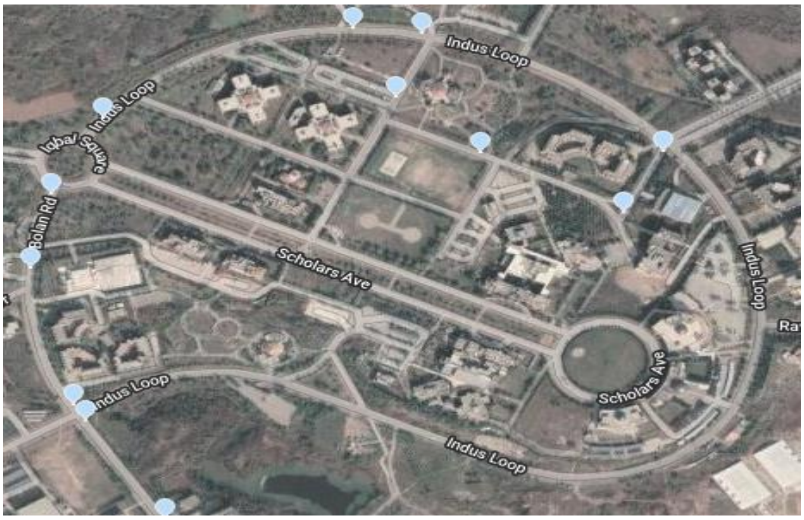

Figure 14: NUST Pothole Map 2

The following Figure 16 and 17 display the data we collected in City Islamabad Pakistan

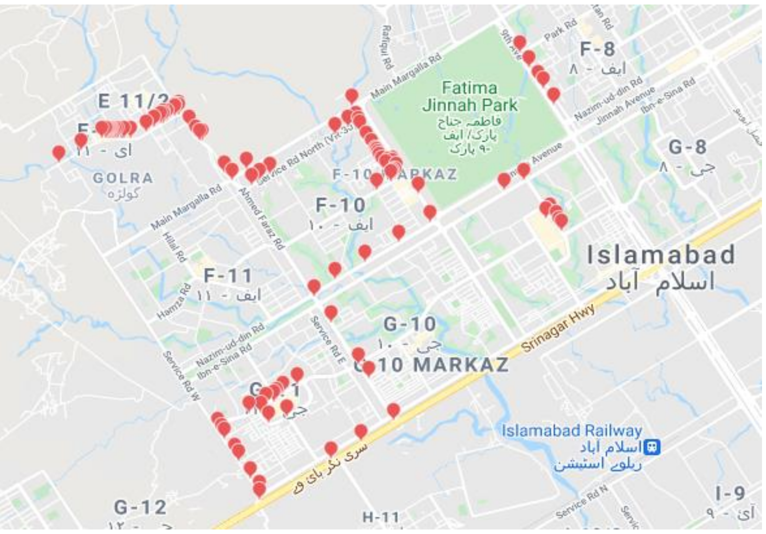

Figure 15: data collection in Islamabad, Pakistan

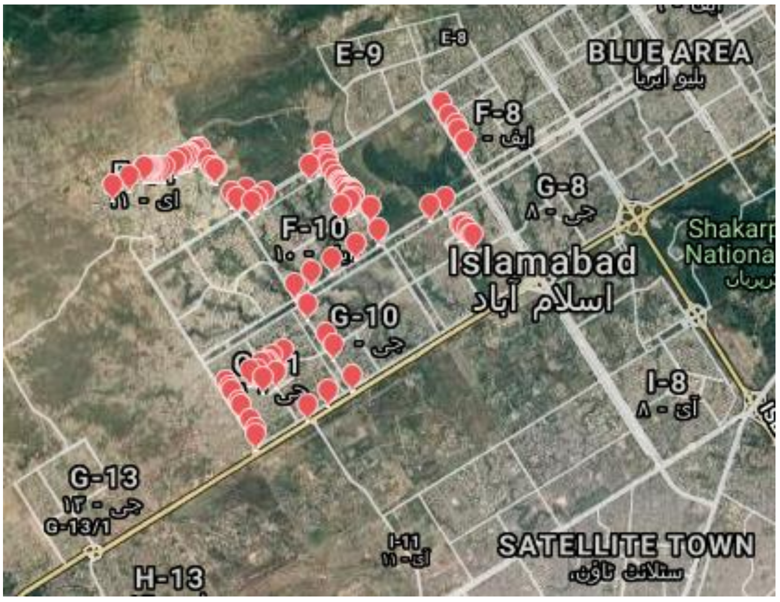

Figure 16: Satellite view of data collection in Islamabad

Chapter 5

CONCLUSION AND RECOMMENDATIONS

5.1. Conclusion:

Traditional pothole detection is a laborious and time taking process, automating it saves a lot of time and effort. The work of days can be done in minutes or hours.Since delays and errors are greatly reduced and time is saved in the process, this device should be used in the road maintenance office.No such expertise is required by either the user/customer or the maintenance office to operate the device and the application.By providing an efficient pothole detection system, a lot of precious human lives could be saved by taking timely responses.The pinpoint location of potholes can be seen on the application's map which reduces the need to remember the coordinates.No need to spend money and hire workers for cost estimation as it is done by the code.Less costly as the user does not need to hire many agents to detect and mark the locations of potholes on a paper along with forming a document file. All this can be done with a push of a button.

5.2. Recommendations:

Due to the prevailing pandemic Novel Coronavirus (COVID-19) and limited availability of time and resources, the scope of this project was limited. However, there are many research opportunities that can be explored.

5.2.1 Machine Learning:

The detection method can further be automated using machine learning algorithms which were not used by us due to scope and time limitations. The data required for training of machine learning algorithms is huge, costly and time consuming.

5.2.2 Camera/Image processing:

Different sensors and cameras can be used for future research. With these it can be further upgraded to a level that not only would locate a pothole but with it, it would also inform us about the depth of it and accurate size of the potholes.

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