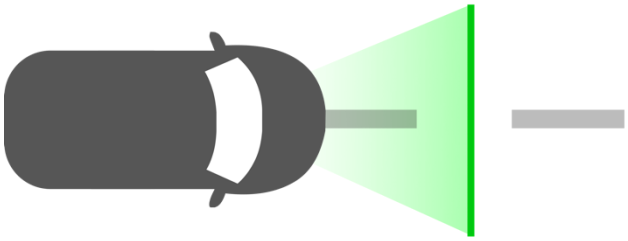
CpE-495: Capstone Design



Fixtreet

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2019 -2020

Signature Page

Guidelines

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- I did my share of the work, and I have a general understanding of the contents of the assignment

- I declare that this assignment is my own original work, except where the original source is cited.

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Credits

Member	Task
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Ahmed Mahdi Bin Nakhi	Use case model - Use case tables - List of abbreviations - Team qualifications & required skills – Standards - User Interface architecture - Prototype - Test plan
Sher Shah Arsalaie	Abstract – Acknowledgement - Needs - Objective -Requirements tradeoffs - Team qualifications & required skills - User profiles - System context – Alternative designs – Design limitations - Test plan
Omran Fadel Al Rasheed	Stakeholders - Structure of the report - Gantt chart - Role of team members - Costs - Team qualifications & required skills - Hardware components - Software components – State transition diagram - Test plan

Abstract

The increase of potholes in Kuwait has been accelerated considerably due to heavy rains. Potholes are one of the public's main local concerns as they are highly visible defects. Therefore, it is a need to carry out timely inspection and maintenance of potholes to avoid inconvenience, accidents and traffics for road users. Our design solves this problem by using a system known as "Fixtreet" that aims to automatically detect and classify potholes using a camera operated by the driver. The system sends the severity level, picture, location, date and time of the pothole automatically to the database that is then accessed by the admin using a website. The admin, in turn, can take immediate actions in order to repair the potholes. Fixtreet provides a relatively simple yet effective and efficient method to get rid of potholes across the streets of Kuwait.

Acknowledgement

Prima facie, we would like to express our gratitude to Allah (S.A.W) for the energy and commitment that allowed our work for Fixtreet design to be accomplished. Moreover, our team would like to thank our instructor Dr. Khaled Al-Zamel, as well as our teaching assistant Eng. Tareq Al-Melhem, who supervised our project and provided us with insightful perspectives that enabled us to work effectively and produce the best outcomes.

We would also like to thank Dr. Ameer, Dr. Asmaa Alsumait from CpE department and Eng. Dawood Bulbanat from MPW for their invaluable and insightful feedback and help to deal with our design issues and improve many aspects of this project.

Moreover, we would like to thank Kuwait Finder's team especially Eng. Khaled Al-Hindi and Mr. Maher Abdulkarim at PACI, for their collaboration in providing guidance and raw data needed to accomplish our goal and project.

Last but not least, we would like to send our affections to our friends and family members, who have motivated and helped us achieve our goals in this project.

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List of Abbreviations

CpE	Computer Engineering
MPW	Ministry of Public Works
PART	Public Authority for Roads and Transportation
PACI	Public Authority for Civil Information
GPS	Global Positioning System
WI-FI	Wireless Fidelity
GPU	Graphics Processing Unit
No.	Number
App	Application
Marker	A pin (specified location) in Google Maps
Info	Information
Deep Learning	Algorithms inspired by the structure and function of the brain
ARM	Advanced RISC Machines
LPDDR4	Low Power Double Data Rate random access memory version 4
DP	Display Port
HDMI	High-Definition Multimedia Interface
eMMC	Embedded Multimedia Card
LIDAR	Light Detection and Ranging
FPS	Frames Per Second
US	United States of America
LED	Light Emitting Diode
OS	Operating System
IDE	Integrated Development Environment
Photogrammetry	the use of photography in surveying and mapping.
API	Application Program Interface

Chapter 1: Requirement Document

1. Introduction

1.1 Need

Ever took a drive around the city and finally ended up in an accident or damaging your car due to a pothole? This problem is very torment for motorists and an expensive headache for the government. Potholes are mostly caused due to heavy rains and weak drainage system, that lead drivers to curse the authority and ministry's officials' shudder.

Similar problem has risen since last few months in Kuwait, where most of the streets and highways were filled with potholes that caused hundreds of accidents and car damages, and the ministry's priority is to fix potholes when citizens complain about a specific pothole, so they attach a photo with a written address to get to the pothole to fix it. Therefore, to solve this issue the government is turning to data and technology in order to monitor and keep track of potholes throughout the country, and hopefully start to fix every single one of them.

1.2 Objective

In this project, we are going to alleviate, and hopefully solve the problems people experience from potholes. Our project does not require a driver to inform the government entities, a camera attached to the car will automatically detect the locations of the potholes.

This project will be using a camera attached to a car that will be used to automatically recognize and capture the pothole with a bunch of related information about the location, time, date of recognition and class of severity level. The recognition of the pothole will be done by using deep learning neural networks where we will train thousands of pictures to make the recognition as accurate as possible. The coordinates can be traced using Google maps. PART and MPW are responsible for street projects in Kuwait. The specialized department for maintaining the streets are located in MPW and that's the main reason why MPW is a critical part of our solution. This project can be supported by MPW if they

want to make things more professional and official, but the application would still be independent from their database to keep things more organized.

By implementing this project, both the government and citizens will benefit from it. The government's job of searching for potholes and responding to people's complaints will be reduced. Also, the ministry would have complete information about the pothole with its classification of severity using US standards of pothole classification. The stress that many motorists experience while driving can be minimized and done in a timely manner to help reduce traffic delays and accidents.

1.3 Stakeholders and User Profiles

1.3.1 Stakeholder Summary

Table 1: Stakeholders

Name	Description	Responsibilities	User
Developer Team	Students of CpE department in Kuwait University who are responsible for developing and implementing the system.	• Programming the project and implementing the required specifications. • Connecting the hardware components. • Maintaining the system in case of any issue. • Applying updates for new features in the system	No
CpE Department	Computer Engineering Department in College of Engineering and Petroleum at Kuwait University.	• Supervising the project. • Providing the needed feedback.	No
Admin	Assigned by MPW to supervise the repairing of the streets, control the data in the application and to share the location of the pothole to the workers who fix the street.	• Approve the repaired pothole after it has been fixed. • Has the authority to remove the mark of a pothole to be set as fixed by the system. • Send the location of a certain pothole to the workers that intend to fix the street.	Yes
Driver	Assigned by MPW to drive through the streets to monitor potholes at daytime.	• Turn on/off the camera attached to the car. • Making sure camera is in working condition. • Drive around the streets with camera in running condition.	Yes
MPW	The intended customer for the system	Buying the system to use it to detect potholes of the streets.	No

1.3.2 Key Stakeholder or User Needs

Table 2: Concerns

Need	Priority	Concerns	Current Solution	Proposed Solutions
Detecting Potholes	High	Pothole needs to be reported immediately to the responsible authority in order to repair it as soon as possible.	By contacting MPW through social media platforms.	Fixtreet will automatically detect the pothole through a camera attached to the car either in motion or in parking state. It will take its picture and send it to the database.
Maintaining data about potholes	High	MPW needs to record date and location of the pothole to be repaired.	When MPW receive a complaint from social media, they type down the address and attach the photo (if sent with the complaint).	Fixtreet will automatically record the pothole coordinates via GPS along with the picture and sends it to the database.
Setting priorities	High	There should be a priority for fixing potholes according to their US standard severity levels.	Take manual measurements for every pothole in Kuwait and add the pothole to the list.	The application after detecting the potholes will automatically prioritize the pothole. The pothole will be classified to one of three severity levels: low, moderate, and high. Taking action on every pothole will be based on the severity level.

1.4Structure of the Report

In this report document, the requirements specification of the project will be discussed below, and it contains the marketing requirements, realistic constraints, requirements tradeoffs, use cases module and standards. Next, the related works are mentioned which include three similar projects implemented in the world. Finally, we have the project management which includes the work breakdown structure, team qualifications and required skills, costs, role of team members and the Gantt chart.

2. The Requirements Specification

2.1Marketing Requirements

1. The system shall detect potholes using the attached camera.
2. The system shall detect the coordinates using an external GPS unit.
3. The system shall be installed on the front of the car.
4. The system shall use the power generated by the car's battery to operate.
5. The system shall send a photograph of the frame of the detected pothole to the database.
6. The system shall send the time of pothole detection to the database.
7. The system shall send the date of pothole detection to the database.
8. The system shall send the GPS coordinates of the pothole to the database.
9. The system shall be able to find the severity level of a pothole using image classification techniques.
10. The system shall set pothole priorities automatically by severity level via depth.
11. The admin shall have the ability to view all pothole locations via Google Maps.
12. The admin shall have the ability to edit the status of the pothole.
13. The system shall add the date of repairing a pothole after deleting it by the admin from the map.
14. The system shall turn on/off by a push of a button in the car's cabin.

Table 3: Marketing and Engineering Requirements

Marketing Requirements	Engineering Requirements	Justification
1,2,5,6,7,8,9	The system shall detect the pothole, sends its coordinates, date, time, picture using a camera and a microcomputer that run deep learning neural network.	This package of information is mandatory for the authority to precisely identify the pothole with its specifications to fix it.
3	The camera should have a clear field of view to detect the potholes accurately.	The camera is attached in front in a way that it has least damage in case of accidents and can detect potholes accurately.
4	The camera should be operated by the driver a shut it down by pressing a power button.	The driver shall turn the camera off manually to overcome the limitation of operating the system at night and to limit the consumption of car battery.
10	The application shall prioritize the pothole using deep learning in three categories: 1. Pothole with high severity 2. Pothole with moderate severity 3. Pothole with low severity	Fixing highest severity potholes first will make the public more satisfied. Potholes in US are classified into 3 levels: low (< 25mm deep) moderate (25mm to 50mm deep) and high (> 50mm deep) [3]
12	The application should fetch the pothole coordinates from the database and show them as marks on google maps.	The admin should be able to see the potholes as marks to have a better view of the location of potholes.
13,14	The application should be able to remove the pothole marks after chosen repaired and should update the database.	The admin shall have the ability to remove the pothole from the map after he receives a confirmation that it has been fixed, and the system shall add the date of repair automatically to the database.

2.2Realistic Constraints

2.2.1 Capacity

- The system shall have enough space to save at least 10 000 potholes in the database.

2.2.2 Performance

- The system shall process 30 fps of live 1080p video through the camera.
- The system shall detect a pothole in less than 2 seconds.

2.2.3 Accuracy

- The system shall be trained to detect potholes with radius from 20 centimeters to 3 meters.

2.2.4 Usability

- The system shall be easy to use, and the user interface shall be as common as using the native Google Maps application.
- The Average learning time for the user shall be less than 10 minutes.

2.2.5 Reliability

- The system's probability of failure shall not exceed 1/1000.
- The system shall resist heat of Kuwait's weather.

2.2.6 Availability

- The detection system shall operate 10 hours a day and 365 days a year since it will operate during daylight only.
- The database shall be available 24/7 all year long.

2.3 Requirements Tradeoffs

Table 4: Requirements Tradeoffs

		No. of training set pictures	**Resolution of camera**	**GPU speed of microcomputer connected to the camera**	**Camera field of view**
Cost	-	↑	↑	↑	-
performance	+	-	↓	↑	-
Accuracy	+	↑	↑	↑	↑
Capacity	+	-	↓	-	-

2.4 Functional Requirements and Use-case module

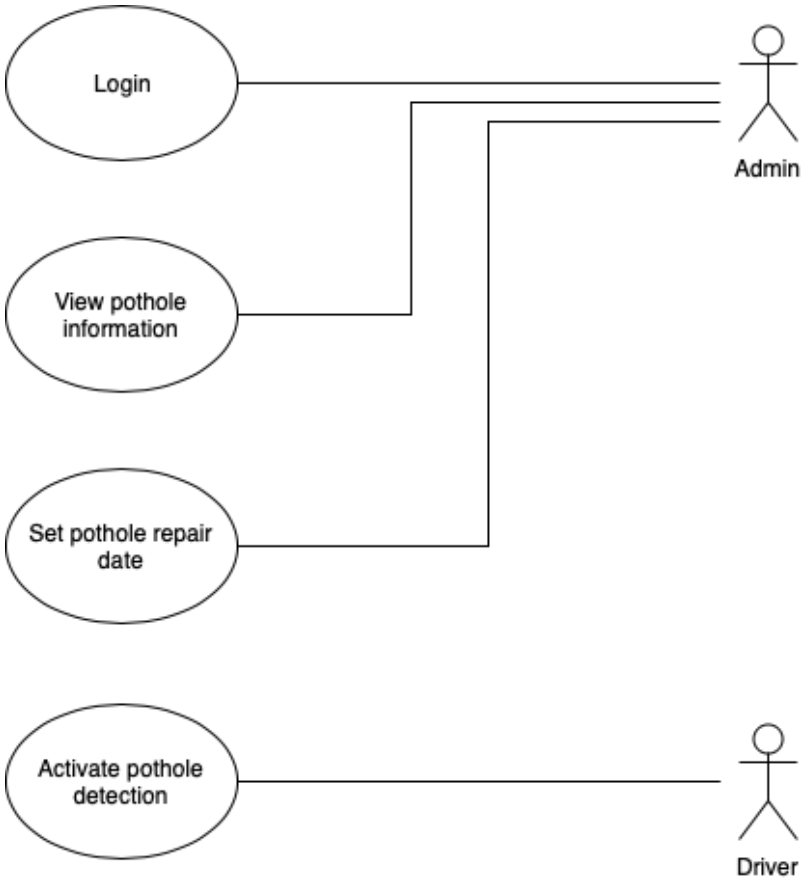

Fig. 1: Use case diagram

Table 5: Use Case 1

Use Case 1	***Login***	
Goal	*The admin accesses the website successfully.*	
Preconditions	*The admin acquires username and password from MPW.*	
Success End Condition	*The admin logins successfully.*	
Failed End Condition	*Incorrect username or password.*	
Primary Actors	*Admin.*	
Trigger	*Launching the website.*	
Description / Main Success Scenario	***Step***	***Action***
	1	*The website asks the user to enter his username and password.*
	2	*The admin types in his username and password.*
	3	*The website checks the database for the typed information.*
	4	*The website recognizes the username and password, and the website displays the main menu.*
Alternative Flows (Forget username or password)	***Step***	***Branching Action***
	4a	*If admin forgets the username or password, admin clicks on "Forgot username or password".*
	5	*A window pops out stating a message "Contact MPW to retrieve username and password" (for security purposes).*

Table 6: Use Case 2

Use Case 2	***View pothole information***	
Goal	*The admin can view the date, time, image, location and severity level through the website. Each pothole will be marked and just by clicking on the marker the info will appear.*	
Preconditions	*The admin must log in first.*	
Success End Condition	*The admin views the pothole info from the map.*	
Failed End Condition	*The admin is not able to view the potholes info from the map.*	
Primary Actors	*Admin.*	
Trigger	*starting the website.*	
Description / Main Success Scenario	***Step***	***Action***
	1	*The website will fetch the latest update from the database.*
	2	*The website will display Kuwait map with locations of the potholes as markers.*
	3	*The admin will press on the map tab.*
	4	*The admin will press on the marker.*
	5	*The website displays the following info about the selected pothole:* • *Date of detection.* • *Time of detection.* • *Pothole image.* • Pothole location as GPS coordinates. • Pothole severity level based of its depth.
Alternative Flows (Priority tab)	***Step***	***Branching Action***
	3a	*The admin presses the All potholes tab to access the list of potholes.*
	4	*The potholes are prearranged in order by their severity level in the application.*
	5	*The admin selects a specific pothole.*
	6	*The website displays a zoomed in view of the map for the selected pothole.*

Table 7: Use Case 3

Use Case 3	***Set Pothole Repair date***	
Goal	*To set date of repaired pothole.*	
Preconditions	*Admin is logged in.*	
Success End Condition	*Repairing date is added to the database.*	
Failed End Condition	*The admin forgets to remove the marker on the map.* *The Pothole is not repaired.*	
Primary Actors	*Admin.*	
Trigger	*The admin selects the marker of repaired pothole from the map.*	
Description / Main Success Scenario	***Step***	***Action***
	1	*The website displays the map page.*
	2	*The admin selects the marker.*
	3	*The admin selects "Fixed" option.*
	4	*The repairing date of that pothole is added to the database automatically.*
	5	*The marker is removed from the map.*

Table 8: Use Case 4

Use Case 4	***Activate pothole detection***	
Goal	*To collect data about the pothole for the database.*	
Preconditions	*The hardware will be Connected to the car battery & the driver starts the car.*	
Success End Condition	*The system uploaded all data recorded to the database.*	
Failed End Condition	*The driver forgets to activate the system, or didn't detect a pothole, or the system dud not upload the data.*	
Primary Actors	*Driver.*	
Trigger	*The driver presses the power button.*	
Description / Main Success Scenario	***Step***	***Action***
	1	*The driver pushes the button to activate the microcomputer.*
	2	*The camera turns on and the system is activated.*
	3	*The system detects a pothole.*
	4	*Capture the frame.*
	5	*The camera enters stage-2 image classification specifying the pothole severity level using deep learning neural networks while keeping the US standard of classification in mind.*
	6	*Calculate the estimation of distance between the pothole and the camera using mathematical notations.*
	7	*The system saves the pothole image, GPS coordinates, severity level, current date and time in the database.*
Alternative Flows (More than one pothole in camera's field of view)	***Step***	***Branching Action***
	5a	*The camera will enter stage-2 image classification specifying all potholes severity levels using deep learning while keeping the US standard of classification in mind.*
	6	*The system searches for the highest pothole severity level that exists in the captured frame and puts it as a primary label for this group of potholes.*
	7	*The system estimates the distance between the pothole and the camera using mathematical notations and calculates the coordinates of the group of potholes.*
	10	*The system saves the pothole image, GPS*

		coordinates, severity level, current date and time in the database.

2.5 Standards

2.5.1 Design Method

For the hardware part, our system will mainly be implemented by using Python 3.6 to program the NVIDIA Jetson TX2 and its attached hardware parts. Also, all the system diagrams shall be drawn in UML format.

For the software part, the website will be the interface between the user and Fixtreet system. The website will be programmed using Bootstrap, CSS and JavaScript. The main reason behind choosing a website is that it is a universal platform that can be accessed using any device with any system. The website also will be programmed to fit inside any screen size with its aspect ratio. So, if it detects that a user is accessing the website using a smartphone, it will be modified to fit its screen and same concept is implemented using an ordinary computer. The system database that captures, organizes and analyzes data will be implemented by using Firebase. Firebase will also be used for authentication and security.

2.5.2 Communication

The driver turns on/off the microcomputer using the power button. The camera is connected to the microcomputer that uses Wi-Fi in order to send the pothole information to the database. The website will request the pothole information from the database, then download this information to the Fixtreet website (Fixtreet.web.app) using Wi-Fi or cellular data.

2.5.3 Documentation

All the project reports shall follow a standard format specified by the computer engineering department.

3. Related work

In the standards of classification of potholes, there were no classifications related to width and height. All classifications are related to the depth of a pothole. As the street consist of more than one layer, the more layers damaged from a pothole the more severe it becomes and that is the core of pothole classification. So, this is the reason why all successful pothole detection systems include depth measuring mechanisms to classify the severity of a pothole.

3.1 Pothole Detection Using Accelerometers [1]

This study is done using the mobile sensing technology by using Euler angle formulas to normalize the three-axis accelerometer data. This project is limited to using mobile sensors and falling into a pothole in order to detect it, while our project uses a camera and deep learning neural network algorithm to detect potholes.

3.2 Pothole Detection Using Filter-Based Feature Extraction [2]

This project uses AI and Image processing methods including Gaussian filter, steerable filter, and integral projection are utilized for extracting features from digital images to detect potholes. It uses a type of machine learning. Our project uses real-time object detection and image classification using the deep learning neural network that definitely surpasses the accuracy of normal machine learning algorithms due its nature of finding features of a pothole.

3.3 MPW LIDAR Pothole Detector Vehicle

This vehicle uses Light frequencies to detect potholes while moving down the streets. One of the main strengths of this vehicle is its accuracy of getting the location, coordinates and the depth of the pothole to get the severity of this specific one. Some of the main disadvantages are concluded as the high price of the vehicle, limited number of quantities of the car and it can only detect potholes in one lane of the street while our solution provides detection for all the lanes in the street with a fraction of its cost that leads to higher deployment rate to monitor the streets of Kuwait.

4. Milestone and Project Management

4.1Work Breakdown Structure

Table 9: Work Breakdown Structure

	Task Name	Duration (Days)	Start	End	Dependency
1	Finding project idea	18	28/1/19	15/2/19	
2	Choosing team name	2	5/2/19	7/2/19	
3	Designing team logo	1	6/2/19	7/2/19	2
4	Writing team formation report	1	6/2/19	7/2/19	
5	Choosing project name	2	18/2/19	20/2/19	1
6	Writing project abstract report	3	18/2/19	21/2/19	1
7	Brainstorming for features of the system	6	21/2/19	27/2/19	6
8	Creating project abstract presentation	1	11/3/19	12/3/19	6
9	Writing final report ch1	6	18/3/19	24/3/19	7
10	System design	21	25/3/19	15/4/19	9
11	Creating system prototype	5	15/4/19	20/4/19	10
12	Writing Final report ch2	11	20/4/19	1/5/19	10
13	Purchasing hardware components	2	7/5/19	9/5/19	9
14	Learning required programming languages	46	9/6/19	25/7/19	9
15	Assembling hardware,	37	4/8/19	10/9/19	12

	software and database				
	Task Name	**Duration (Days)**	**Start**	**End**	**Dependency**
16	Training the system	84	7/9/19	31/11/19	12
17	System testing	6	1/12/19	7/12/19	16
18	System testing report	1	2/12/19	3/12/19	17
19	Writing User Manual	1	4/12/19	5/12/19	18
20	Exhibition	2	29/12/19	30/12/19	18

4.2 Team qualifications and Required Skills

- Omran Fadel Al Rasheed: Team managing and project organizing. Interested in hardware assembly, programming and documentation. Good background in Java and C++ programming.
- Ahmed Mahdi Bin Nakhi: Skilled in programming Android applications using Java. Also has a good background in C++ programming.
- Abdulhadi Ali Taqi: Worked on many programming projects and helped through the process of making good interface for the project. Interested in creating databases. Good background in Java and C++ programming.
- Sher Shah Arsalaie: Skilled in documentation, producing animations and partly software. Can help finding sponsors and funding the project by presentation skills. Good background in Java and C++ programming.

4.3 Costs

Table 10: Costs

Item	Cost
Nvidia Jetson TX2 developer kit	200 KD
Wires	5 KD
Camera unit	30 KD
GPS unit	15 KD
SD-Card	30 KD
Shipping cost	60 KD
Team efforts = No. of work hours * No. of team members * cost for 1 hour	(258days*3hours) *4 members*1 KD/hour = 3096 KD
Total cost	**3436 KD**

4.4Role of Team Members

Table 11: Role of Team Members

Name	Interest	Expertise
Abdulhadi Taqi	Database Programming	SQL Java
Ahmed Mahdi	Web development	Java C++
Omran Fadel	Hardware development Python programming language	Java C++
Sher Shah	System trainer Documentation	Java C++

4.5Gantt Chart

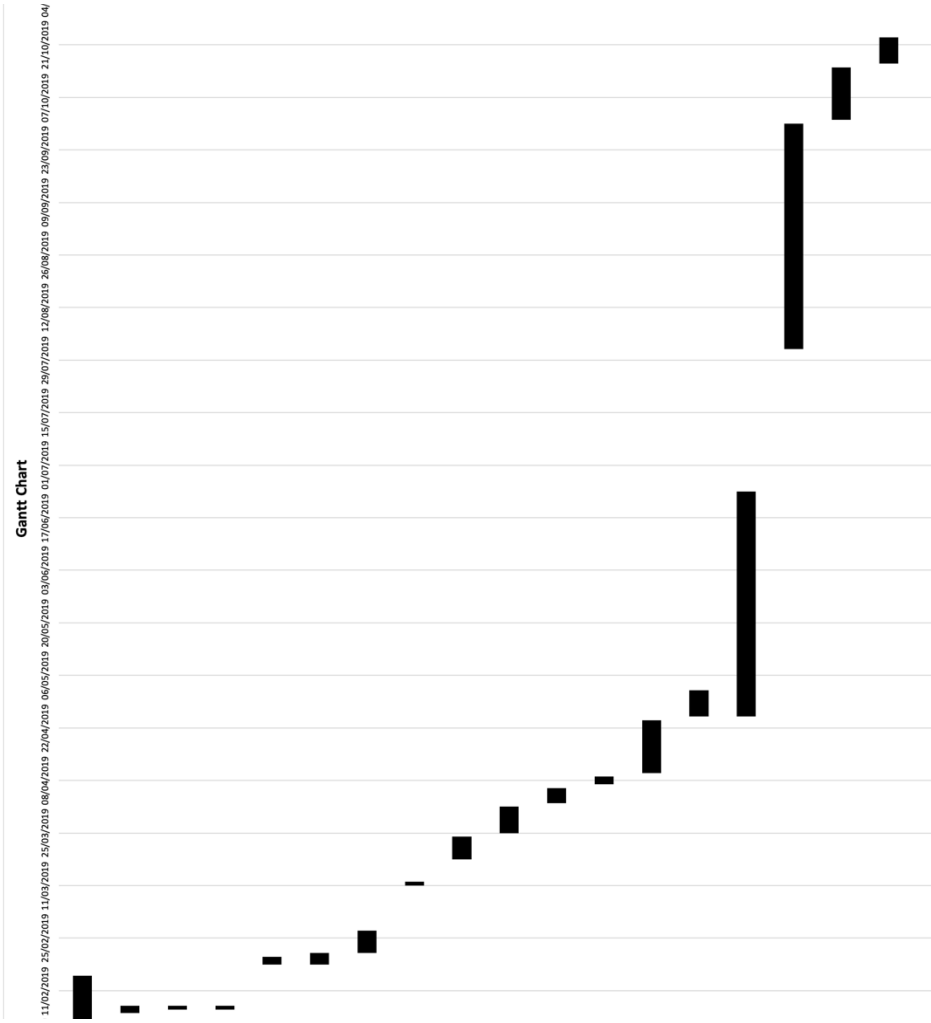

Fig. 2: Gantt Chart

Chapter 2: System Design and Evaluation

1. System Context:

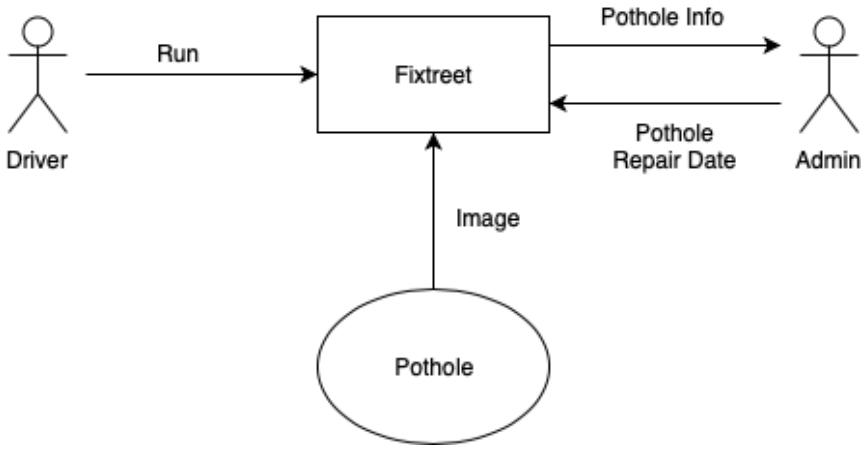

Fig. 3: System Context

The Fixtreet system consists of two user interfaces: The Driver's UI and the Admin's UI. The Driver's UI will have only one input that is switching the power button on/off with a push button, which will activate/deactivate the microcomputer taking into consideration that improper shutdown may lead to system failures. From the Admin's UI, the data saved from the pothole will be output for admin on application. The Admin will be able to view the pothole's information on map and the priority list and will be able to provide one input that is removing pothole's mark from the map.

2. System Architecture:

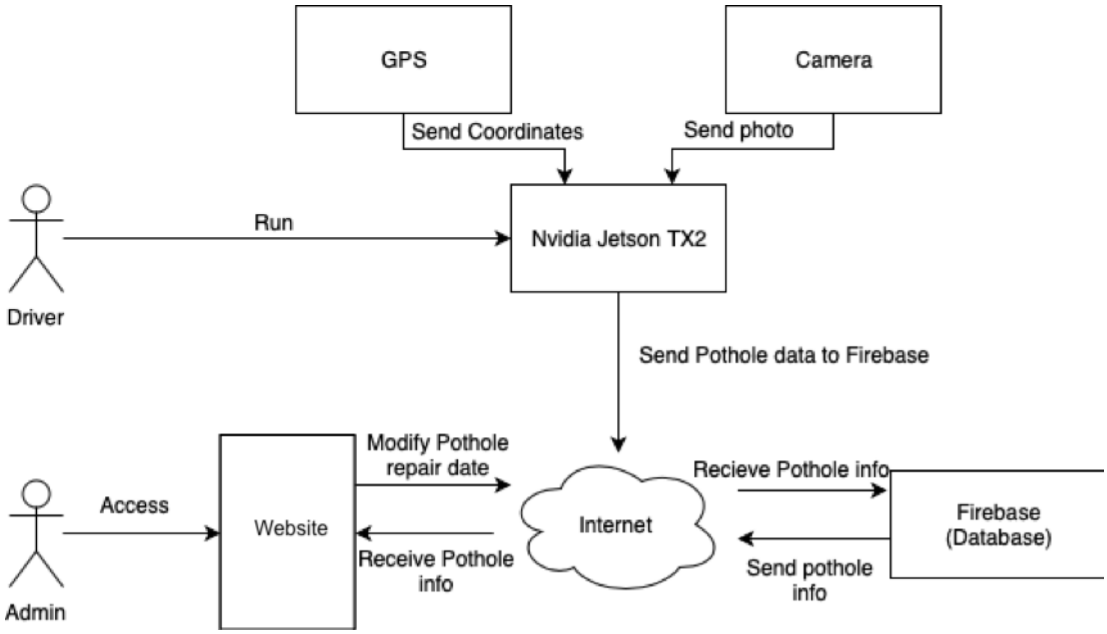

Fig. 4: System Architecture

2.1 Hardware Component Specs

2.1.1 Nvidia Jetson TX2

Table 12: Nvidia Jetson TX2 Hardware Specs

GPU	NVIDIA Pascal 256 CUDA GPU cores
CPU	Quad ARM® A57/2 MB L2
Video	4K x 2K 60 Hz Decode (12-Bit Support)
Memory	8 GB 128-bit LPDDR4 59.7 GB/s

Display Ports	HDMI 2.0
PCIE	Gen 2
Data Storage	32 GB eMMC SD-Card compatible
USB	USB 3.0 + USB 2.0
Connectivity	1 Gigabit Ethernet Wi-Fi 802.11ac Bluetooth

2.1.2 Admin's Computer

Table 13: Admin's Computer Hardware Specs

CPU	Intel core i3
Connectivity	Wi-Fi 802.11ac

2.1.3 Logi C922 Pro Stream Webcam

Table 14: Camera Specs

Resolution	1080p
Frame Rate	30 FPS

2.1.4 GPS Module U-BLOX NEO-7M

Table 15: GPS module Specs

GNSS Engine	GPS/QZSS, GLONASS
Connections	VCC (+5 V), GND (ground), TX, RX, PPS (time pulse)

Default baud Rate	9600 baud
Dimensions	4 x 2.5 x 1.5 cm

1.1.1 DC to AC Adapter

Table 16: DC to AC Adapter Specs

Input Voltage	12-24 Volts
Output Voltage	220-240 Volts
Peak Power Output	300 Watts

1.2 Software Component Specifications

1.2.1 Nvidia Jetson TX2

Table 17: Nvidia Jetson TX2 Software Specs

OS	JetPack 4.2.2
Architecture	ARMx64
Programming	Python

2. User Interface Architectural Design

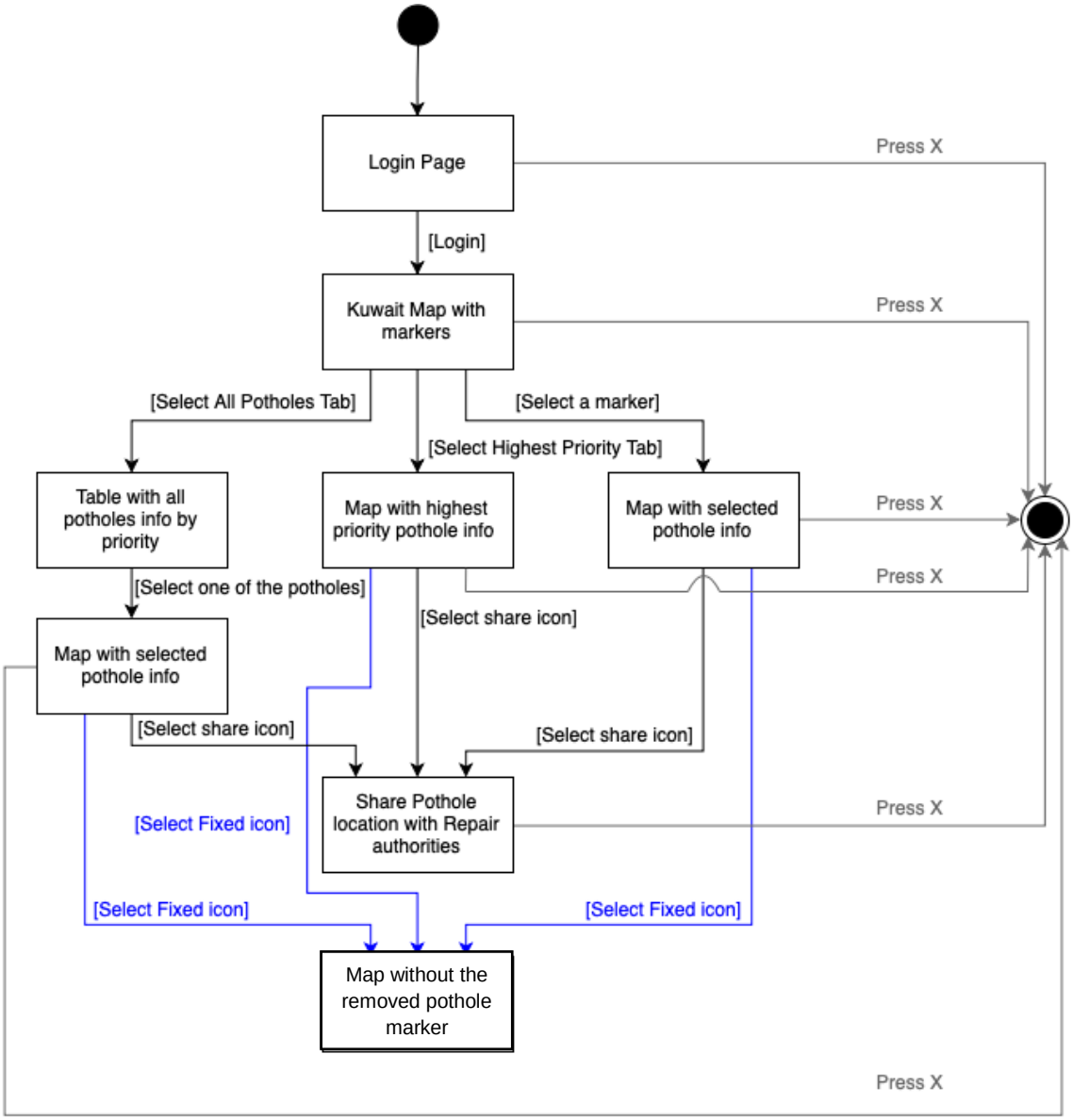

Fig. 5: Top-Level Diagram

3. Design Synthesis and Alternatives

4.1 Issue #1: Mechanism to Which the Camera is Attached

There was an uncertainty while choosing the machine on which the camera should be attached for detection of potholes. There were two options considered, the first option was a car and the second option was a drone.

Table 19: Issue #1: Mechanism to Which the Camera is Attached

	Weight	Car	Drone
Reliability	0.4	3	1
Availability	0.3	3	1
Coverage Area	0.3	3	0
Total Score	1.0	3	0.667

The scores in the table above are stated accordingly: Score 0 = bad; Score 1 = acceptable; Score 2 = good; Score 3 = excellent.

The final decision was to use a car to attach the camera instead of a drone for detection. Our decision was made because of several reasons. First, range of use is not limited as a car runs on fuel and does not require charging, so it can cover longer distances whereas a most drone's maximum flight time of 30 minutes. Weather conditions will also not affect the car, whereas in case of drone we have to consider many weather conditions, like hot weather, rainy weather or windy weather etc. Not to forget to mention that a drone cannot get away from its base for more than 7km whereas a car travel distance is determined from the fuel tank which is at least 300km depending on the car.

4.2 Issue #2: Detecting the Depth of the Pothole

Measuring the depth of the pothole can be done by several means including ultrasonic sensor, Image Classification using Deep Learning, and photogrammetry. Choosing the best option was a struggle because it required a lot of effort.

Table 20: Issue #2: Detecting the Depth of the Pothole

	Weight	LIDAR	Deep Learning Image Classification	Photogrammetry
Field of view	0.2	2	3	2
Accuracy of depth detection	0.4	2	2	2
Reliability in case of multiple potholes	0.2	1	3	3
Cost	0.2	1	3	1
Total Score	1.0	1.6	2.6	2

The scores in the table above are stated accordingly: Score 0 = bad; Score 1 = acceptable; Score 2 = good; Score 3 = excellent.

The chosen alternative was to use Deep Learning (Image Classification) instead of Photogrammetry and LIDAR for measuring the depth of the pothole. After the comparison between all alternatives, it was realized that Image Classification was more suitable for the functionality of the system for the meantime in Kuwait. It is a new concept of machine learning which uses thousands of pasts taken photos to decide if the object in front of the camera is a pothole or not. Image Classification was preferred upon the others because with its approach, we are going to have the widest field of view among the competitors which covers all the lanes in the street. As for the others they provide detection only for one lane and they require more hardware components (more cameras for photogrammetry and LIDAR sensor and emitter) while the chosen method only require the main camera to operate.

4. Detailed Design

4.1 Class Diagram

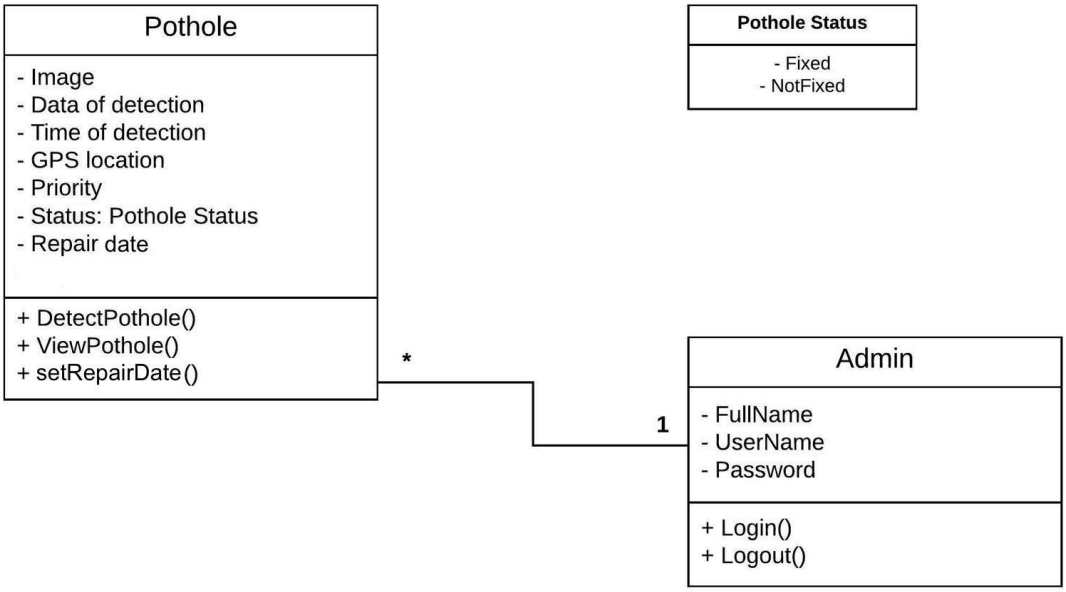

Fig. 6: Class Diagram

4.2 Sequence Diagram

4.2.1 View Pothole Information

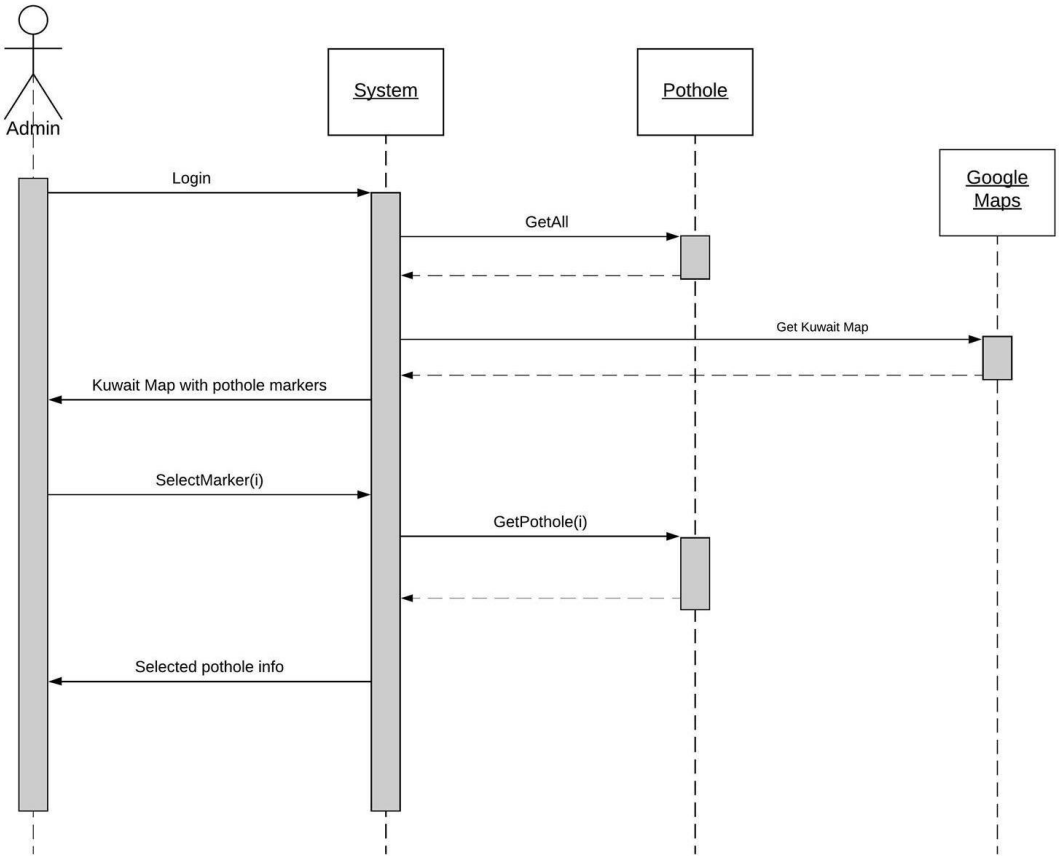

Fig. 7: View Pothole Information Sequence Diagram

4.2.2 Set Pothole Repair Date

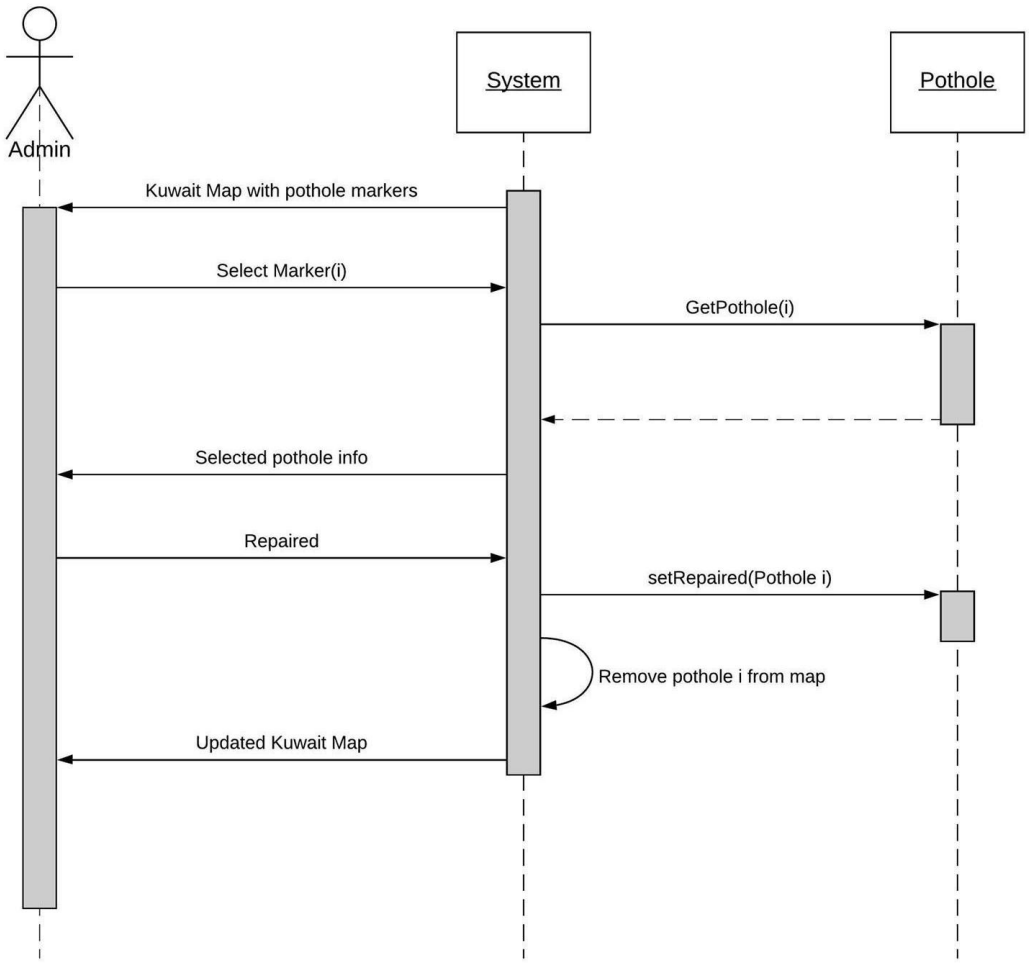

Fig. 8: Set Pothole Repair Date Sequence Diagram

4.2.3 Activate Pothole Detection

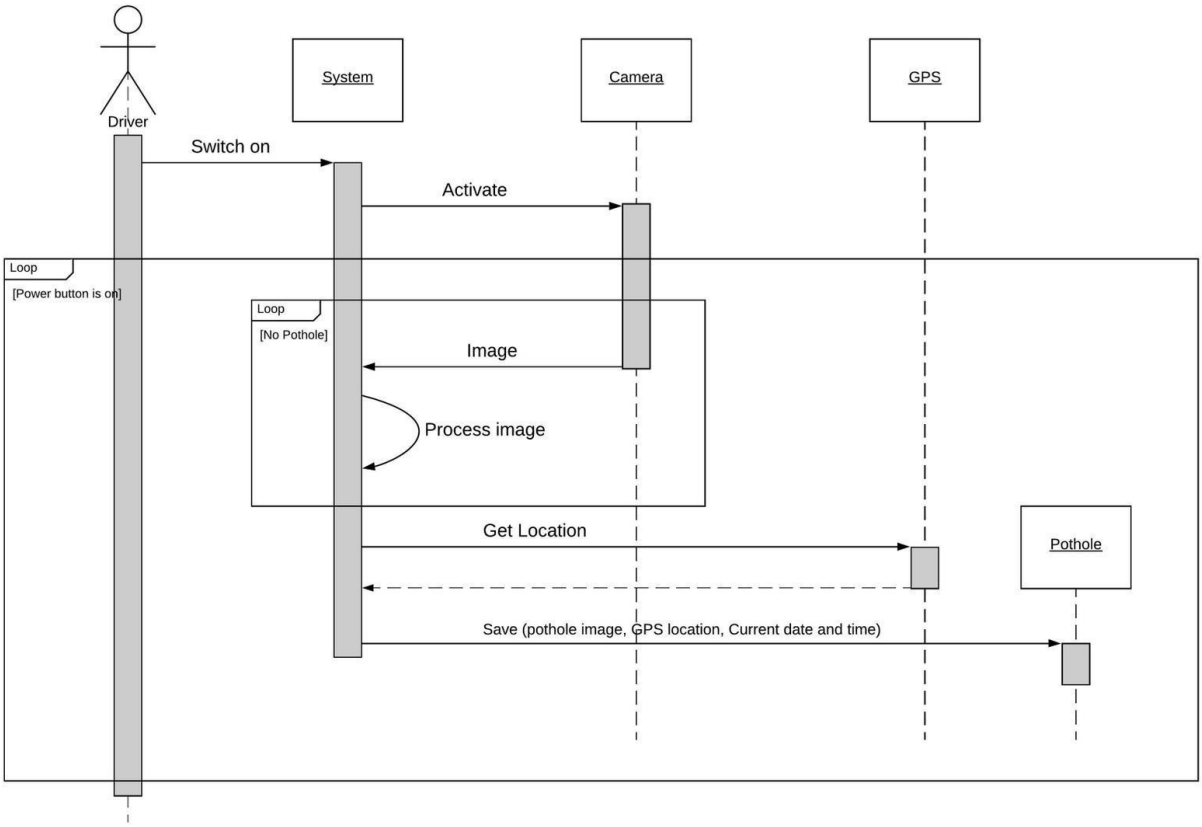

Fig. 9: Activate Pothole Detection Sequence Diagram

4.3 State Transition Diagram

4.3.1 User Interface

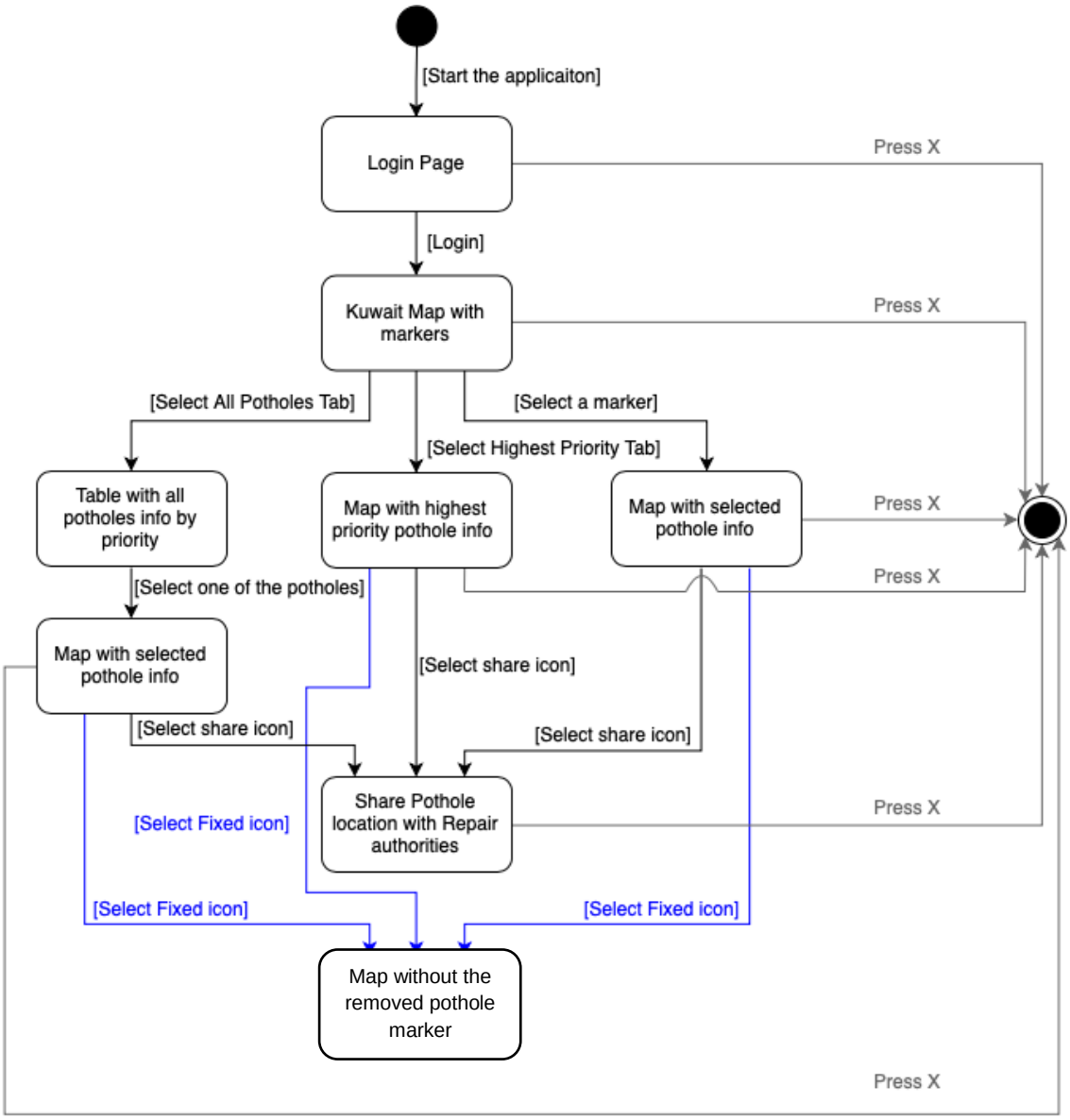

Fig. 10: User Interface State Transition Diagram

4.3.2 Camera System

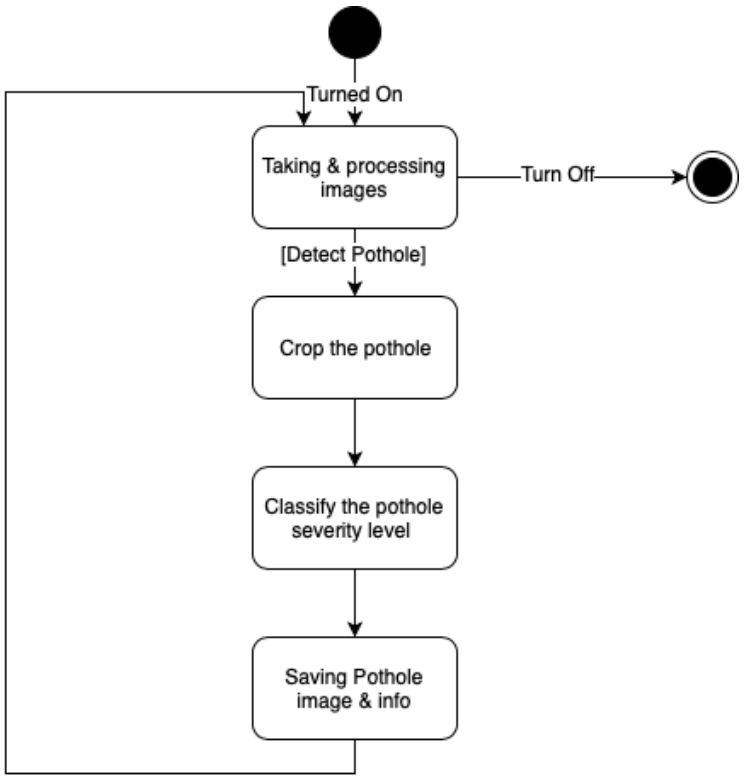

Fig. 11: Camera System State Transition Diagram

5. Design Limitations:

Our project is going to face the following challenges and limitations:

- The system can only detect potholes early in the morning or afternoon, as there must exist some shadow that distinguishes the pothole from the street.
- Accuracy will depend on the size of the dataset. If we train the system with more photos, the better it will get. A dataset contains features of thousands of pothole images to recognize potholes with similar features.
- The car speed should not exceed 30 km/h in order to get a clear picture of the detected pothole to be analyzed without movement distortion.
- Our hardware will always be the bottleneck of our design. The better the hardware, the faster the car can drive. Not to forget to mention that better hardware means larger budget for the project.

Chapter 3: Analysis and Simulation

A test plan is very critical to any engineering project. An engineer needs a test plan to observe whether his project is working and analyzes his observation to see if his system performed as expected. So, we are going to prepare a test plan to test all of the project's hardware and software features to ensure that our project is working without any errors and as expected.

1. Test Plan

1.1Features to be Tested

This section should identify all the features (use cases/scenarios/design constraints) and combinations of features that are to be tested. In addition, the section should identify all the features and significant combinations of features that are not to be tested, and why.

In Fixtreet, it is very critical to test all of our features based on hardware and software listed and to ensure the best possible quality, usability and functionality of our system. We are going test in detail the following:

1.1.1 Camera Module

- Check whether it shows a live feed for the microcomputer.
- Check whether it takes stable photos.

1.1.2 GPS Module

- Check whether it delivers the correct data for the microcomputer.

1.1.3 Microcomputer

- Check whether the microcomputer turns on in the car.
- Check whether it detects and classifies potholes successfully when only one pothole is in the field of view.
- Check whether it detects and classifies potholes successfully when more than one pothole is in the field of view.
- Check whether it calculates the location of a pothole correctly.
- Check whether it sends all data associated to the pothole to the database.

1.1.4 Database

- Check whether it maintains potholes information.

1.1.5 Application

- Check whether it fetches the contents of the database.
- Check whether it works as expected.

1.2 Environmental Needs

1.2.1 Physical Characteristics

- GPS module.
- Camera module.
- Microcomputer.
- Wiring.
- DC to AC voltage adapter.
- A Computer to access the website.

1.2.2 Communications Software

- Firebase.

1.2.3 System Software

- Ubuntu OS version 18.04 for the microcomputer (Linux based).

1.2.4 Mode of Use

- Microcomputer must be connected via WIFI only.

1.3 Risks and Contingencies

1.3.1 Flying rocks

When Driving on the highway, they is a possibility that a flying rock may damage the camera lens. We took our precautions to ensure that there is a low probability to hit the camera module since it is small sized yet powerful piece of hardware.

1.3.2 No WIFI on board the car

The microcomputer requires the existence of WIFI in order to send pothole data to the database or it will have a possibility of data loss due to unexpected shutdowns or car accidents. Fixtreet will continue to operate and saves the information internally until a WIFI connection is available.

1.3.3 Car accidents

The microcomputer is not shock-proof. Any car accident that may happen may lead to system malfunctioning or failure. The driver should be advised not to drive recklessly and stick to the rules of traffic in Kuwait.

1.3.4 No pothole classification is detected

The trained dataset for the pothole classification is much less that the dataset used for pothole detection. So, there exists a scenario in which no pothole classification is provided but the pothole still exists and uploaded to the database.

1.3.5 GPS location

GPS signals are not 100% accurate and every GPS application provides the current location with 5-15 meters radius approximation. GPS till today suffers from accuracy and that's why Fixtreet combines several detected potholes information into the worst severity available for the detected potholes. For example, Fixtreet found that 3 potholes exist in the frame: two medium and one low severity potholes. Fixtreet will combine them all as one label with Medium severity pothole to be fixed all at the same time.

1.4 Test Case Specification

1.4.1 Test Case 1

Table 21: Test Case#1: Camera Test

Test Writer:				
Test Case Name:		Camera Test	Test ID #:	1
Description:		A test for camera module for operating and taking photos	Type:	☐ white box ☑ black box
Tester Information				
Name of Tester:		Omran	Date:	1/10/2019
Hardware Version:		Nvidia Jetson TX2	Time:	10 p.m.
Setup:		Connect the camera to Nvidia Jetson TX2.		
Step	Input	Expected output	Comments	
1	Turn on camera.	Camera turned on.	Success	
2	Take a shot.	A photo is taken and saved.	Success	

1.4.2 Test Case 2

Table 23: Test Case#2: GPS Test

Test Writer:			
Test Case Name:	GPS Test	Test ID #:	3
Description:	A test for GPS module for giving correct coordinates.	Type:	☐ white box ☑ black box
Tester Information			
Name of Tester:	Omran	Date:	1/10/2019
Hardware Version:	Nvidia Jetson TX2	Time:	10:30 p.m.
Setup:	Connect the GPS module to Nvidia Jetson TX2.		

Step	Input	Expected output	Comments
1	Connect the GPS to output the coordinates of Khaldiya's Kuwait University campus.	Module starts to give Nvidia coordinates automatically. The coordinates are: 29.319250, 47.972723	Success

1.4.3 Test Case 3

Table 24: Test Case#3: Activate Pothole Detection for one pothole in frame

Test Writer:			
Test Case Name:	Activate Pothole detection (one pothole detected)	Test ID #:	4
Description:	To collect data about the pothole for the database.	Type:	☐ white box ☑ black box
Tester Information			
Name of Tester:	Abdulhadi	Date:	30/9/2019
Hardware Version:	Nvidia Jetson TX2	Time:	10 a.m.
Setup:	Executing Activate pothole detection Use Case.		

Step	Input	Expected output	Comments
1	The user takes a photo of a high severity pothole located in Khaldiya block 2, Street no. 20	The database contains a record of the pothole info that consist of: Date - Time - Coordinates - Severity level - photo	Success
2	The user takes a photo of a medium severity pothole located in Khaldiya block 3, Street no. 31	The database contains a record of the pothole info that consist of: Date - Time - Coordinates - Severity level - photo	Success
3	The user takes a photo of a low severity pothole located in Khaldiya block 1, Street no. 10	The database contains a record of the pothole info that consist of: Date - Time - Coordinates - Severity level - photo	Success

1.4.4 Test Case 4

Table 24: Test Case#4: Activate Pothole Detection for multiple potholes in frame

Test Writer:			
Test Case Name:	Activate Pothole detection (multiple potholes detected)	Test ID #:	5
Description:	To collect data about the pothole for the database.	Type:	☐ white box ☑ black box
Tester Information			
Name of Tester:	Abdulhadi	Date:	30/9/2019
Hardware Version:	Nvidia Jetson TX2	Time:	10 a.m.
Setup:	Executing Activate pothole detection Use Case.		

Step	Input	Expected output	Comments
1	The user takes a photo of multiple potholes in the same frame located in Khaldiya block 1, Street no. 16.	The database contains a record of all potholes info that consist of: Date - Time - Coordinates - Severity level of worst one in frame - photo	Success

1.4.5 Test Case 5

Table 25: Test Case#5: Login

Test Writer:			
Test Case Name:	Login	Test ID #:	6
Description:	The admin accesses the application successfully.	Type:	☐ white box ☑ black box
Tester Information			
Name of Tester:	Sher	Date:	30/9/2019
Hardware Version:	Smartphone	Time:	10 a.m.
Setup:	Running the application		

Step	Input	Expected output	Comments
1	The admin enters his username “Shershah2020”	In username text box “Shershah2020”	Success
2	The admin enters his password “1122334455”	In password text box “**********”	Success
3	The admin taps the login button.	The app displays a welcome screen.	Success

1.4.6 Test Case 6

Table 26: Test Case#6: View Pothole Information

Test Writer:			
Test Case Name:	View pothole information	Test ID #:	7
Description:	The admin views all information associated with a pothole.	Type:	☐ white box ☑ black box
Tester Information			
Name of Tester:	Sher	Date:	30/9/2019
Hardware Version:	smartphone	Time:	10 a.m.
Setup:	Executing login - Detect a pothole test cases		

Step	Input	Expected output	Comments
1	The admin taps a pothole marker	All information associated with that pothole appears.	Success
2	The admin taps the “Priority tab”	All information for all potholes appears in list view.	Success

1.4.7 Test Case 7

Table 27: Test Case#7: Set pothole Repair Date

Test Writer:			
Test Case Name:	Set pothole repair date	Test ID #:	8
Description:	The admin removes the pothole from the map	Type:	☐ white box ☑ black box
Tester Information			
Name of Tester:	Sher	Date:	30/9/2019
Hardware Version:	smartphone	Time:	10 a.m.
Setup:	Executing a pothole is detected - login test cases		

Step	Input	Expected output	Comments
1	The admin selects a pothole located in Khaldiya block 2, Street no. 20.	All information associated with that pothole appears.	Success
2	The admin chooses “Fixed” option	All information for all potholes appears in list view.	Success

1.5 Summary of Demonstration/Simulations

Everything in the project worked as expected and as efficient as possible with the budget constraint. The uploading and detection time are bad but with a better budget and the arrival of 5G networks all of our speed disadvantages could be resolved.

Table 28: Summary

Characteristic	Detection & Classification	Uploading to database
Delay	2s	5s

Conclusion and Future Work

Potholes are one of the public's main local concerns as they are highly visible defects. Fixtreet system solves this problem by automatically detecting and classifying potholes using a camera operated by the driver. Fixtreet might not be the first system that will detect potholes using deep learning, however, it is the first system that will detect the pothole and send full report including picture, location on map, date, time and priority of the pothole automatically to the authorities in order to take actions. The system will make the process much faster and more convenient for the government and for people.

There is always so much room to improve our design, and that is something that we gained from this course, along with time management and teamwork. Probable future enhancements will include expanding Fixtreet's features that we are considering as of training the system for more accurate results, expanding the system not just to detect potholes but also road cracks and reporting car accidents on the road. Also, we could gain the benefit of collecting enormous amount of raw data to create an analysis and taking actions based on it just as informing the authorities that there exists a specific road that has so many problems so we must question the company responsible for it.

References:

[1] Zviedris, Reinholds, Kanonirs, Georgijs, Selavo, Leo. “Real Time Pothole Detection Using Android Smartphones with Accelerometers”, 2011.

https://www.researchgate.net/publication/224253154_Real_Time_Pothole_Detection_Using_Android_Smartphones_with_Accelerometers

[2] N. Hoang, “An Artificial Intelligence Method for Asphalt Pavement Pothole Detection Using Least Squares Support Vector Machine and Neural Network with Steerable Filter-Based Feature Extraction”, 2018.

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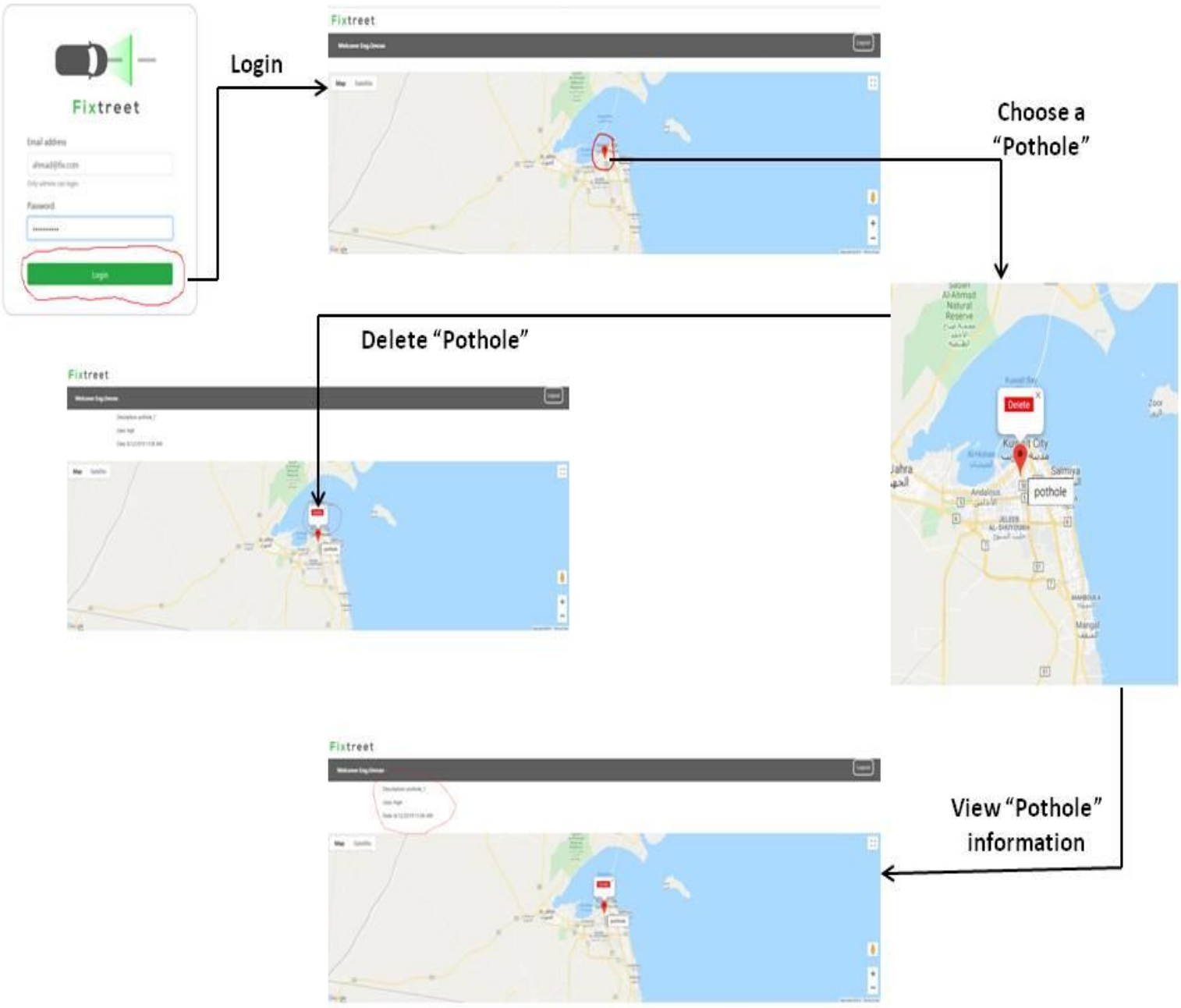
http://iet-journals.org/archive/2014/oct_vol_4_no_10/163829149386938.pdf

Appendices

Appendix A: Prototype



Appendix B: User Manual

1. Intended readership

Users are workers of MOPW who are appointed to report street problems. Users must have some knowledge in using computers.

2. Purpose:

The purpose of the user manual is to help the users to learn and understand the use of the system and to know how to edit or view information on the website. The goal of this is project is to provide an easy way for the government to detect and repair potholes on streets.

3. Operations

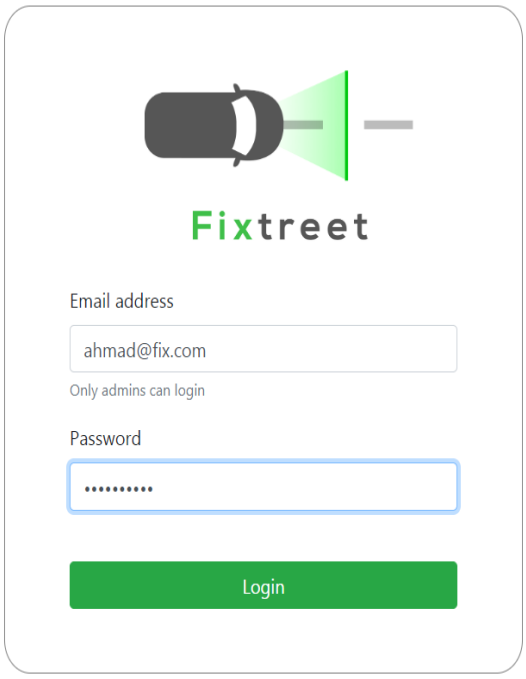
3.1 Task one: Login

a. Task description:

Allowing the user to login.

b. Procedure:

- The user opens the website
- Presses on the login tab
- The username and password is given to the administrator by default so only specific users can login.
- The user enters username and password and presses login.



c. Possible errors:

- The user may enter wrong username or password.

3.2 Task two: Main page

a. Task description:

The user after logging in will be directed to the main page that is a map containing marks on the location of potholes.

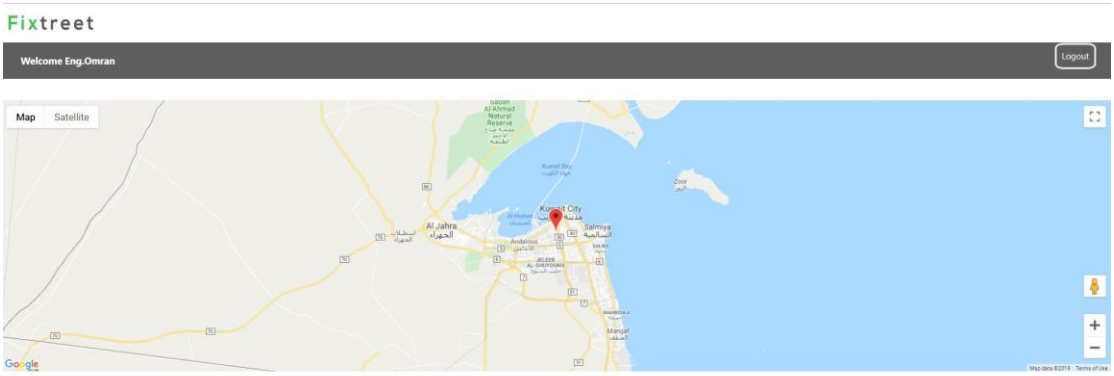
b. Procedure:

Setup:

- The user opens the “Fixtreet” website.
- The user logs in to the website.

The website will show the following information:

- Map on the main screen.
- View potholes information by clicking on the marks on map.
- Return to home by clicking on the “Fixtreet” logo.



3.3 Task three: Share Pothole information

a. Task description:

Sharing the pothole information with the repairing authority.

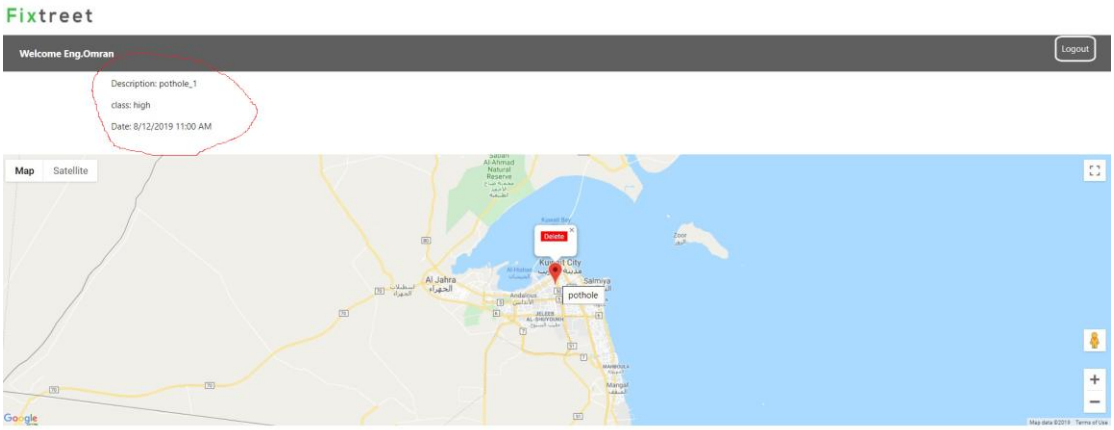
b. Procedure:

Setup:

- The user opens the "fixtreet" website.
- The user logs into the website.

The website will open the map and user will follow these steps:

- Select highest priority option, and view all the information of the pothole.
- Select any marker on the map that will show the information of the pothole.



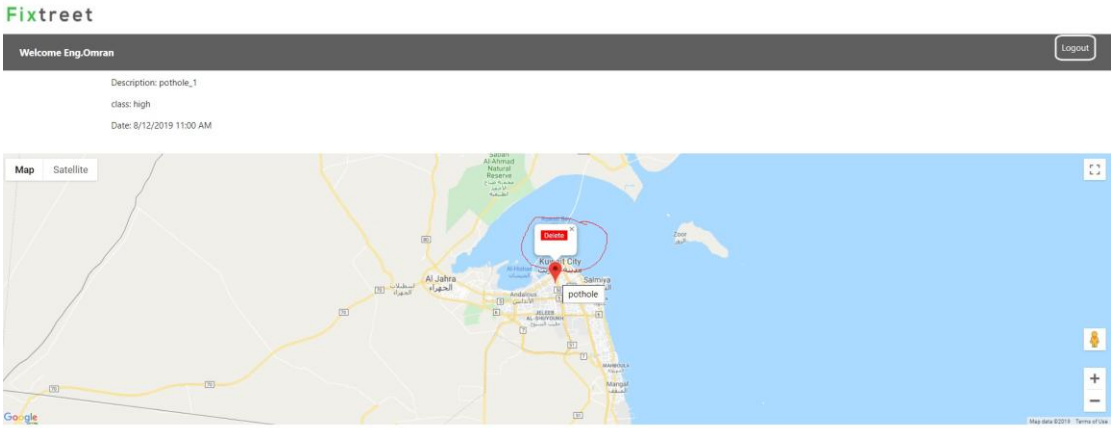
3.4 Task four: Deleting Pothole

a. Task description:

Allowing user to delete the pothole from the map after it has been repaired.

b. Procedure:

- The user logs in to the website.
- The user will see a map.
- The user will select the pothole by clicking on it.
- The user will click on delete.
- The pothole will be removed from the map.



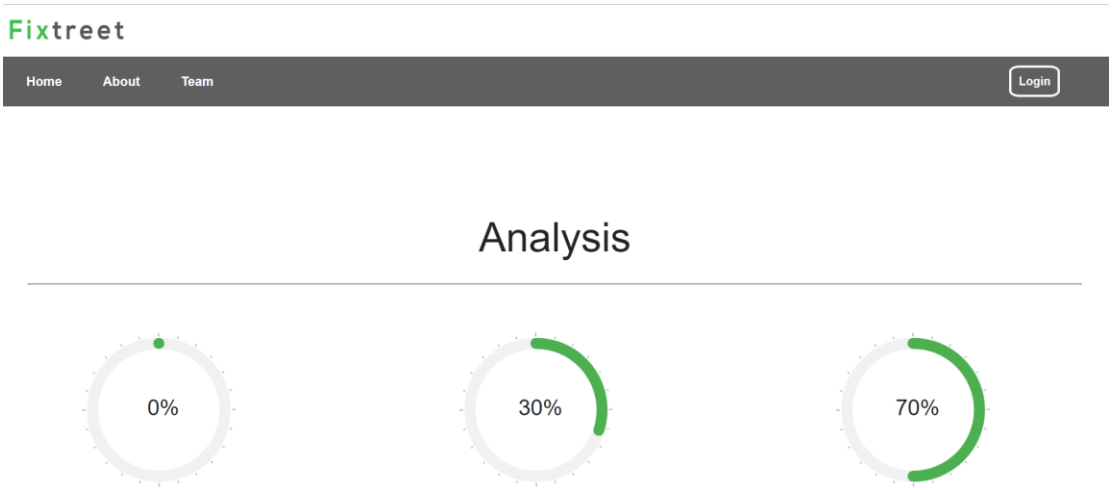
3.5 Task five: Analysis

c. Task description:

Allowing user and anyone accessing the website to see the analysis of potholes.

d. Procedure:

- The user clicks on “Fixtreet” logo to return back to home.
- The website displays three circles under the analysis heading.
- First circle shows the percentage of Low priority potholes.
- Middle circle shows the percentage of Medium priority potholes.
- Last circle shows the percentage of High priority potholes.
- The user will be able to see more information by taking the cursor on the “info” logo beside the name.



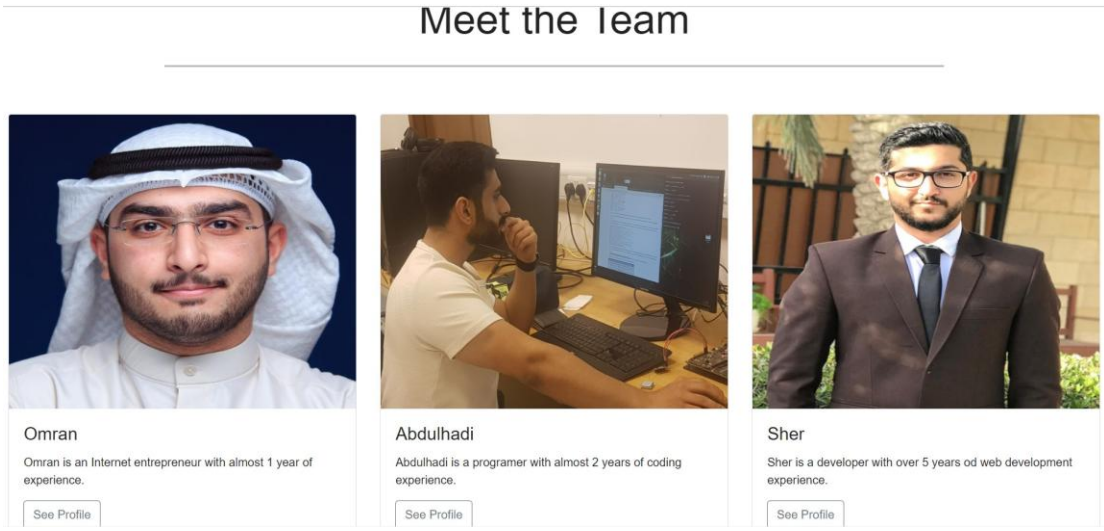
3.6 Task six: Team

a. Task description:

Gives information about the team members involved in making this project.

b. Procedure:

- The user or anyone accessing the website will be able to see the information on our website main screen.
- The user will press “team” tab on home page that will lead to the team information area.



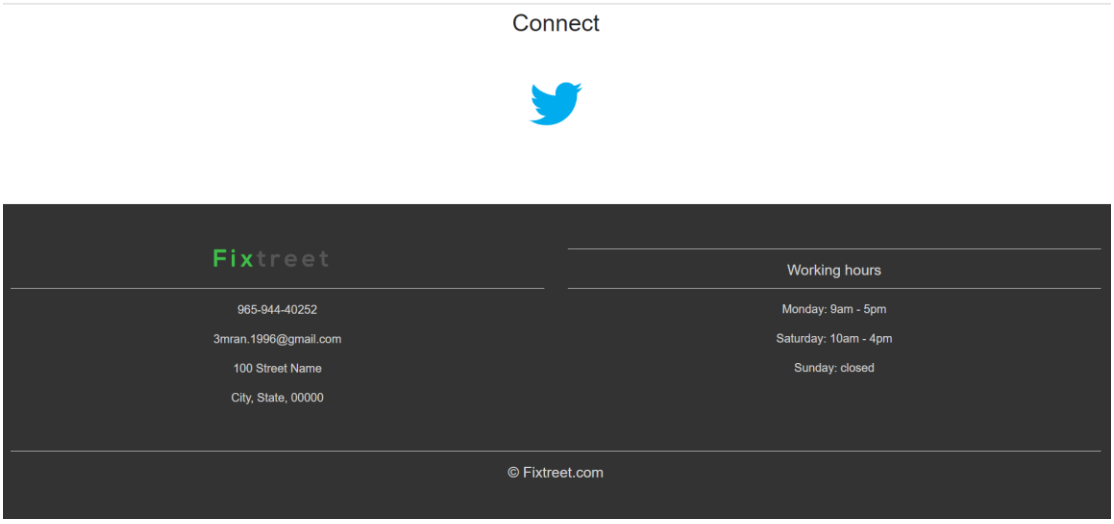
3.7 Task seven: Contact information and working hours

a. Task description:

Allowing the user accessing the website to view the contact information, address and working hours.

b. Procedure:

- The user needs to go to the end of the home page.
- The user will see the email address, phone number, twitter account and other information.
- The user will be able to see the working hours.



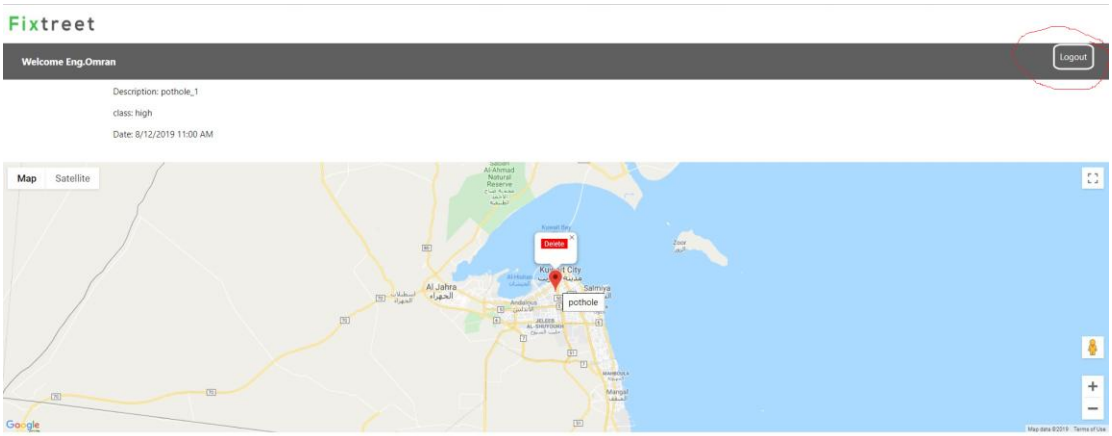
3.8 Task eight: Logout

a. Task description:

Allowing the user to logout from the website.

b. Procedure:

- The user clicks on the right button on the top.
- He then chooses either logout or cancel.


Fixtreet
Welcome Eng.Omran
Logout
Description: pothole_1
class: high
Date: 8/12/2019 11:00 AM
Map
Satellite
Delete
pothole
Google

Appendix C: Meeting Minutes

Kuwait University

College of Engineering & Petroleum
Computer Engineering Department

Team Meeting Minutes 1

Team Name: Team Infinity **Date of meeting** 29/9/2019
Start time: 11:00 AM **Finish time:** 1:00 PM

Members present: Abdulhadi, Shershah, Ahmed, Omran
Members excused: None
Members tardy: None
Members absent: None

Summary of meeting

1- Discussed the contents of the final 395 report.
2- Discussed the changes to the actual design.
3- Discussed what is going to change in the report.

Action items (Things to be done by members)

Task	Team Member	Due Date
Modify Use Cases Modify Design Alternatives Modify Related Works Modify exhibition date in Work Breakdown Structure	All	30/9/2019

Next meeting will be held on 1/10/2019

Kuwait University

College of Engineering & Petroleum

Computer Engineering Department

Team Meeting Minutes 2

Team Name: Team Infinity **Date of meeting:** 1/10/2019

Start time: 11:00 **Finish time:** 12:00

Members present: Abdulhadi, Shershah, Ahmed, Omran

Members excused: None

Members tardy: None

Members absent: None

Summary of meeting

1- Discussed how the cases will be tested.

Action items (Things to be done by members)

Task	Team Member	Due Date
Test cases - Future work & conclusion	Sher Shah	2/10/2019
Test cases - Risks & contingencies	Abdulhadi	2/10/2019
Features to be tested - Environmental needs	Ahmed	2/10/2019
Test cases	Omran	2/10/2019

Next meeting will be held on 8/10/2019

Kuwait University

College of Engineering & Petroleum

Computer Engineering Department

Team Meeting Minutes 3

Team Name: Team Infinity **Date of meeting:** 8/10/2019

Start time: 11:00 **Finish time:** 12:00

Members present: Abdulhadi, Shershah, Ahmed, Omran

Members excused: None

Members tardy: None

Members absent: None

Summary of meeting

1- Discussed the status of each member work to the project

Action items (Things to be done by members)

Task	Team Member	Due Date
Labeling pothole pictures	Sher Shah	-
Post-processing	Abdulhadi	-
Programming the website Creating the database	Ahmed	-
Choosing and Creating the CNN models	Omran	-

Next meeting will be held on 15/10/2019

Kuwait University

College of Engineering & Petroleum

Computer Engineering Department

Team Meeting Minutes 4

Team Name: Team Infinity **Date of meeting:** 15/10/2019

Start time: 11:00 **Finish time:** 12:00

Members present: Abdulhadi, Shershah, Ahmed, Omran

Members excused: None

Members tardy: None

Members absent: None

Summary of meeting

1- Discussed the status of each member work to the project

Action items (Things to be done by members)

Task	Team Member	Due Date
Labeling pothole pictures	Sher Shah	-
Post-processing	Abdulhadi	-
Programming the website Creating the database	Ahmed	-
Choosing and Creating the CNN models	Omran	-

Next meeting will be held on 22/10/2019

Kuwait University

College of Engineering & Petroleum

Computer Engineering Department

Team Meeting Minutes 5

Team Name: Team Infinity **Date of meeting:** 22/10/2019

Start time: 11:00 **Finish time:** 12:00

Members present: Abdulhadi, Shershah, Ahmed, Omran

Members excused: None

Members tardy: None

Members absent: None

Summary of meeting

1- Discussed the status of each member work to the project

Action items (Things to be done by members)

Task	Team Member	Due Date
Labeling pothole pictures	Sher Shah	-
Post-processing	Abdulhadi	-
Programming the website Creating the database	Ahmed	-
Choosing and Creating the CNN models	Omran	-

Next meeting will be held on 29/10/2019

Kuwait University

College of Engineering & Petroleum

Computer Engineering Department

Team Meeting Minutes 6

Team Name: Team Infinity **Date of meeting:** 29/10/2019

Start time: 11:00 **Finish time:** 12:00

Members present: Abdulhadi, Shershah, Ahmed, Omran

Members excused: None

Members tardy: None

Members absent: None

Summary of meeting

1- Discussed the status of each member work to the project

Action items (Things to be done by members)

Task	Team Member	Due Date
Labeling pothole pictures	Sher Shah	-
Post-processing	Abdulhadi	-
Programming the website Creating the database	Ahmed	-
Choosing and Creating the CNN models	Omran	-

Next meeting will be held on 5/11/2019

Kuwait University

College of Engineering & Petroleum

Computer Engineering Department

Team Meeting Minutes 7

Team Name: Team Infinity **Date of meeting:** 5/11/2019

Start time: 11:00 **Finish time:** 12:00

Members present: Abdulhadi, Shershah, Ahmed, Omran

Members excused: None

Members tardy: None

Members absent: None

Summary of meeting

1- Discussed the status of each member work to the project

Action items (Things to be done by members)

Task	Team Member	Due Date
Labeling pothole pictures	Sher Shah	-
Post-processing	Abdulhadi	-
Programming the website Creating the database	Ahmed	-
Choosing and Creating the CNN models	Omran	-

Next meeting will be held on 12/11/2019

Kuwait University

College of Engineering & Petroleum

Computer Engineering Department

Team Meeting Minutes 8

Team Name: Team Infinity **Date of meeting:** 12/11/2019

Start time: 11:00 **Finish time:** 12:00

Members present: Abdulhadi, Shershah, Ahmed, Omran

Members excused: None

Members tardy: None

Members absent: None

Summary of meeting

1- Discussed the status of each member work to the project

Action items (Things to be done by members)

Task	Team Member	Due Date
Labeling pothole pictures	Sher Shah	-
Post-processing	Abdulhadi	-
Programming the website Creating the database	Ahmed	-
Choosing and Creating the CNN models	Omran	-

Next meeting will be held on 19/11/2019

Kuwait University

College of Engineering & Petroleum

Computer Engineering Department

Team Meeting Minutes 9

Team Name: Team Infinity **Date of meeting:** 19/11/2019

Start time: 11:00 **Finish time:** 12:00

Members present: Abdulhadi, Shershah, Ahmed, Omran

Members excused: None

Members tardy: None

Members absent: None

Summary of meeting

1- Discussed the status of each member work to the project

Action items (Things to be done by members)

Task	Team Member	Due Date
Labeling pothole pictures	Sher Shah	-
Post-processing	Abdulhadi	-
Programming the website Creating the database	Ahmed	-
Choosing and Creating the CNN models	Omran	-

Next meeting will be held on 26/11/2019

Kuwait University

College of Engineering & Petroleum

Computer Engineering Department

Team Meeting Minutes 10

Team Name: Team Infinity **Date of meeting:** 26/11/2019

Start time: 11:00 **Finish time:** 12:00

Members present: Abdulhadi, Shershah, Ahmed, Omran

Members excused: None

Members tardy: None

Members absent: None

Summary of meeting

1- Discussed how to combine our work to create the User Manual.

Action items (Things to be done by members)

Task	Team Member	Due Date
Combining Our work to create the User Manual.	All	5/10/2019
		5/10/2019
		5/10/2019
		5/10/2019

Next meeting will be held on 7/12/2019