AUTOMATION OF SURVEILLANCE SYSTEMS

Capstone Project Report

End-Semester Evaluation

Submitted by

(101703037) ADITYA THAKUR

(101703039) ADITYA VASHISTA

(101703048) AKRITI SEHGAL

BE Fourth Year, COE

CPG No: 136

Under the Mentorship of

Dr Shalini Batra

Associate Professor, CSED

THAPAR INSTITUTE
OF ENGINEERING & TECHNOLOGY
(Deemed to be University)

COMPUTER SCIENCE AND ENGINEERING DEPARTMENT

Thapar Institute of Engineering and Technology, Patiala, India

December 2020

ABSTRACT

With the growing technology and wealth in the world, there is a high demand for security systems in the market. Everyone is racing against time to complete their task efficiently. The security systems prevailing in the market for monitoring a particular area needs to be automated in order to trace someone in case of any mishappening. Visual tracking and human path tracing features are picking up pace in the market in order to make human lives easier. The goal is to build an application that will aim to automate security systems that will help to reduce time in the identification of individuals and track their movements from a large number of surveillance cameras installed in such places. This will also help in solving theft crimes quicker. This visual tracking that we aim at achieving will help understand the behaviour of moving objects after moving objects' detection and recognition. All the people present under the surveillance of CCTV cameras will be detected, and co-ordinates of their respective movements will be calculated, resulting in a graph containing multiple paths of all the people present. This application can be further expanded to smart homes in future.

DECLARATION

We hereby declare that the design principles and working prototype model of the project entitled Automation of Surveillance Systems is an authentic record of our own work carried out in the Computer Science and Engineering Department, TIET, Patiala, under the guidance of Dr Shalini Batra during 6th semester (2020).

Date: 30-07-2020

Roll No.	Name	Signature
101703037	Aditya Thakur	----
101703039	Aditya Vashista	----
101703048	Akriti Sehgal	----

Counter Signed By:

Faculty Mentor:

Dr Shalini Batra
Associate Professor,
CSED
TIET, Patiala

ACKNOWLEDGEMENT

We would like to express our thanks to our mentor Dr Shalini Batra. She has been of great help in our venture, and an indispensable resource of technical knowledge. She is truly an amazing mentor to have.

We are also thankful to Dr Maninder Singh, Head, Computer Science and Engineering Department, entire faculty and staff of Computer Science and Engineering Department, and also our friends who devoted their valuable time and helped us in all possible ways towards successful completion of this project. We thank all those who have contributed either directly or indirectly towards this project.

Lastly, we would also like to thank our families for their unyielding love and encouragement. They always wanted the best for us and we admire their determination and sacrifice.

Date: 30/07/2020

Roll No.	**Name**	**Signature**
101703037	Aditya Thakur	
101703039	Aditya Vashista	
101703048	Akriti Sehgal	

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF ABBREVIATIONS

3D	3-Dimensions
IoT	Internet of Things
IP	Image Processing
KLT	Kanade–Lucas–Tomasi
CCTV	Closed-circuit television
USB	Universal Serial Bus
CNN	Convolutional Neural Networks

CHAPTER 1: INTRODUCTION

1.1 Project Overview

- With the growing number of video surveillance systems and the need of real-time data, video data has become a new kind of data source. Such type of information is increasingly integrated into GIS commercial platforms, such as GoogleTM StreetView (2007), Microsoft® Live Maps (2005), and Intergraph's® GeoMedia. This video data can be applied in a varied range of applications, and the most common one of them is visual tracking. Visual tracking aims at understanding the behaviour of moving objects after moving objects' detection, recognition and tracking.

- Our aim with this project is to automate security systems that will optimize the surveillance system and increase the security for the places where there is a high need for security, where even a small information leakage/ item theft can result in a significant loss.

- This project will involve real-time data collection from sensors and cameras and will perform real-time data streaming, video processing and streaming (using Raspberry Pi). All these techniques will help us in plotting a graph/path showing a person's movement within the given blueprint of the place.

- It will help to reduce time in the identification of individuals and track their movements from a large number of surveillance cameras installed in such places. This will also help in solving theft crimes quicker and would make surveillance systems automated.

- We process the surveillance videos to detect single human moving traces; then we match the depth information of 3D scenes to the constructed 3D indoor network model and define the human traces in the 3D indoor space. Finally, the single human traces extracted from multiple cameras are connected with the help of the connectivity provided by the 3D network model. Using this approach, we can reconstruct the entire walking path.

- The approach consists of three major steps as follows:

  (1) single moving traces extraction based on video tracking

  (2) derivation a 3D network based on the 3D indoor model

  (3) matching single moving traces in video with 3D indoor path model based on 3D scene depth information.

1.2 Need Analysis

As we make way into the new decade of the world where technology is a very important part of our day to day life. Due to the rise in demand and popularity of techniques like IoT, Machine learning and Image Processing, many industries and tasks are now being automated to increase optimization to solve the tasks, get better results and decrease the problem-solving time prominently, along with giving accurate and reasonable outputs.

One such area, where we can use these techniques to aid humans and save a lot of time is *Surveillance Systems.* The conventional surveillance systems in high-security places that are banks, jewellery stores, museums etc, involve installing multiple cameras and a surveillance room to monitor the activities that are happening in real-time. Since these places are safe houses for many expensive and important things, even a small theft will result in big losses.

These issues have to be resolved quickly and in a more efficient way. Using the traditional surveillance system techniques for such cases results in a lot of time consumption and delay in problem-solving. We can make this process and system faster and accurate in real-time, by using a technological stack of Machine Learning, IoT, video processing and real-time data streaming to track movements of people using the surveillance cameras and increase the security of the anti-theft system with adding the features of IoT sensors and real-time video capturing with the earlier, to track immediate movements of individuals and trace their movements and show it in a graphical form for better visualization.

This technique will enhance security as well as reduce a lot of surveillance time. As video surveillance systems are widely available in many buildings, we believe this approach has great potential in indoor security surveillance and indoor navigation.

1.3 Research Gaps

Nowadays, there is a growing demand of video surveillance systems in some applications such as public security, transportation control, defence, military, urban planning, and business information statistics has attracted increasing attention, and a large number of networked video surveillance systems are getting installed in public places, for instance, airports, subways, railway stations, highways, parking lots, banks, schools, shopping malls, and military areas. These video surveillance systems not only effectively protect the security of public facilities and citizens, but also seamlessly help to transform to a smart city, which has attracted more and more scientific researchers to invest huge funds in research related to intelligent video surveillance. It is observed that the main focus of the current research on intelligent video surveillance mainly relies on video object detection/tracking, and video object activity analysis/recognition. The video object tracking is not only one of the most important techniques in intelligent video surveillance, but also the base of high-level video processing and applications such as the subsequent video object activity analysis and recognition. But there are still many limitations to it and research is going on. Some of them are listed below:

1. Slow Performance: To deliver with robust performance, the system integrates several computer vision algorithms to perform its function: a human detection algorithm, an object tracking algorithm, and a motion analysis algorithm. To utilize the available computing resources to the maximum possible extent, each of the system components is designed to work in a separate thread that communicates with the other threads through shared data structures which is tricky. We argue that this indicates that other, slower methods could not be

used for tracking in real-time, but that more research is required specifically on this.

2. Limited to limited number of human tracing in 3D framework: In the 3D blueprint model, process the surveillance videos to detect single human moving traces; then match the depth information of 3D scenes to the constructed 3D indoor network model and define the human traces in the 3D indoor space. Finally, the human traces extracted from multiple cameras are connected with the help of the connectivity provided by the 3D network model. Using this approach, we can reconstruct the entire walking path of a single person but cannot be used in an overly crowded place.
3. Limitations in case of moving environments: Multiple object detection and tracking in an outdoor environment is a challenging task because of the problems raised by poor lighting conditions, variation in poses of human objects, shape, size, clothing, etc. An experiment to eliminate the problem is done which can detect and track multiple humans in a video adequately fast in the presence of poor lighting conditions, variation in poses of human objects, shape, size, clothing etc. But the technique cannot handle and process fast varying numbers of human objects in a video at various points of time.
4. Problem of errors in KLT technique: Experimental results are provided to demonstrate the system's capability of accurately tracking objects in real-time applications where scenes are subject to noise particularly resulting from occlusions and sudden illumination variations but errors are still there in a crowded place.
5. Total occlusion and similar persons: Some developed frameworks are able to address challenges like cluttered scenes, change in illumination, shadows and reflection change in appearances and partial occlusions. However, total occlusion and similar persons in the same frame remain a challenge to be addressed. The framework is able to generate the detection and the tracking results at the rate of four frames per second.

1.4 Problem Definition and Scope

There are two major problems:

i. Absence of a proper integrated system/software for direct implementation at high-security places. Going through a load of video data after a theft/crime has taken place leads to loss of both time and resources. Thus a real-time system is necessary for immediate alarms of an imminent crime scene; tracking individuals from a large crowd and multiple video cameras wherein the data being all served to concerned authorities via a user-friendly dashboard.

ii. Most of the implementations in this area involve only one human,i.e all the implementation is done at the basic level only.

1.5 Assumptions and Constraints

TABLE 1.1: Assumptions

S. No.	Assumptions
1	It is assumed that the area for implementation of the project is to be held in confined areas and a limited number of test cases, for time being.
2	It is assumed that the cameras have high resolution for video capturing.
3	The cameras installed are not under any movement/rotation.
4	Our product is assumed to be used at places where high surveillance exists, i.e full coverage of the place (no blind spots) is provided.

TABLE 1.2: Constraints

S. No.	Constraints
1	Our project can track the movement path of only a limited designated human face at a point of time from the given human crowd in a video feed.
2	Our target person i.e. face to be tracked has to be fed into the system. Thus the system itself can not recognise the person (the thief) to be tracked.
3	Also the surveillance is confined to limited areas.

1.6 Standards

- **Safety Standards**

  ISO 26262: Securing both software and hardware components.

- **Hardware**
  1. The total system must be fully IP based and IP enabled. Each camera shall be IP based, UTP ready.
  2. All indoor fixed Cameras shall be Power Over Ethernet (POE) compliant.
  3. The system should provide interoperability of hardware, Operating System, software, networking, printing, database connectivity, reporting, and communication protocols. System expansion should be possible through off-the-shelf available hardware.
- **Software**
  1. Application Development Standard: Standards for SDLC. Application development refers to a software development process used by an application developer to make application systems. This process is commonly known as the Software Development Lifecycle (SDLC) methodology and encompasses all activities to develop an application system and put it into production, including requirements gathering, analysis, design, construction, implementation, and maintenance stages. Examples of the SDLC methodology include waterfall, iterative, rapid, spiral, RAD, Xtreme.

  2. Interface: Python Tkinter; Compatibility: Mac/Windows

  3. Accessibility: Restricted to security in charge.

1.7 Approved Objectives

1. Python subprogram for face detection, recognition and entry access denial, including areas of restricted/authorised visits.
2. Python subprogram for person detection and movement tracking, training ML models.
3. GUI design for integrating hardware data with software subprograms, online repository and server configuration; hence completing the project.

1.8 Methodology

1. The blueprint of the area of implementation of the project is obtained and is adjusted to make a 3D indoor network in order to get referential positions of the path, that is to be tracked.
2. Now, real-time data collection is employed using CCTV cameras and motion sensors and is then transmitted live through Arduino Uno to our server.
3. We process the surveillance videos to detect human movement traces using CNN, darknet YOLOv3 with manual assignment of weights.
4. We integrate the depth information of 3D scenes to the constructed 3D indoor network model and define the human traces in the 3D indoor space. Thus, constructing a path.
5. The screen displays total no. of persons in the space along with their movement traces.

1.9 Project Outcomes and Deliverables

- Both cost and time effective solution to surveillance systems.
- A real-time human path tracker.
- Reduction of effort hours, that is manually obtaining the path by connecting dots is replaced with software.
- A user-friendly Graphic User Interface, that acts as a black box and provides directly the results required.

1.10 Novelty of work

As far as the authors are aware, the study of the combined working of machine learning and path detection has been carried out rarely. There are some applications that exist in the current era that detect humans and objects but don't accurately trace paths. The project will be providing maximum possible accuracy for tracing the human path within a short span of time and alert by combining the hardware with a machine learning algorithm. The machine learning algorithm will be chosen by comparing various algorithms and choosing the one with maximum accuracy

CHAPTER 2: REQUIREMENT ANALYSIS

2.1 Literature Survey

2.1.1 Theory Associated With Problem Area

With a sudden steep increase in video surveillance systems for indoor applications, tracing has become a requirement for an easy and timely visualization. Presently, places requiring high security need to track the items of concern as well as the person involved through various surveillance cameras and their footages. Most existing systems do not provide a realtime and efficient solution to this problem. Research, on the other hand, shows how video surveillance systems can analyse human behaviour, discover and avoid crowded areas, monitor human traffic and so forth. Thus here we concentrate on the use of surveillance cameras to track and reconstruct the path a person has followed/is following. For the complete development of this software, we employ machine learning and image processing with the integration of CCTV camera, motion sensor and PIR sensor.

2.1.2 Existing Systems and Solutions

1. **Real-Time Multiple Object Tracking - A Study on the Importance of Speed**

   This project by Samuel Murray is a multiple object tracker project by Samuel Murray.It models the object movement by solving the filtering problem and associating detections with predicted new locations in new frames. This submission has so far the highest score in the non-anonymous submission category, and uses three different similarity measures for object detection. In this model when trained on the Okuma-Action Dataset at various frame-rates , a degradation of performance was seen. In some cases the score got reduced by 90%.[1]
2. **Real-Time Human Detection, Tracking, and Verification in Uncontrolled Camera Motion Environments**

   This paper focuses on the real-time environment, e.g freely moving camera platforms, thus even detection becomes more difficult, further tracking and verification in another challenge. To overcome these challenges and produce an efficient output, the authors came up with three different algorithms which use computer vision at its backend. The algorithms are as: a human detection algorithm, an object tracking algorithm, and a motion analysis algorithm. To optimize the resource use, each component works in its own thread but shares/ communicates with the other using common data structures. This paper emphasis is more on the implementation than the algorithmic issues.[2]

3. **Real-time tracking of humans and visualization of their future footsteps in public indoor environments**

   This work is an interactive entertainment system, here along with multiple-human tracking a prediction of future steps is also shown. This system tracks people in indoor environments and displays the footstep predictions in real-time. System Hardware: camera, computer, projector. It uses background subtraction for feature extraction and object detection.[3] The exhibition of this was done at an airport during some art event.

4. **Moving Human Path Tracking Based on Video Surveillance in 3D Indoor Scenarios**

   Increased video surveillance has resulted in increased variety for the 3D indoor surveillance applications, the authors tried to implement the path tracer for various applications: (1) analyse human behaviour, (2)avoiding congestions, (3)traffic monitoring and so forth. This system focuses on reconstruction of paths followed by a human through an entire building in real time. In this project, integration of 3D surveillance systems with indoor models of building resulted in construction of path traces of a single object. The connected the results from multiple cameras to construct the entire walking path.[4]

5. **Automatic Multiple Human Detection and Tracking for Visual Surveillance System**

   Tracking human paths depend on many conditions, variation of personal belongings, composition, size, clothing, etc. This paper proposes a novel process for the discovery and tracing of many human objects in a video. The model is trained to detect an object using Haar features from a training image set. Personal items are detected with the help of a professional detector and tracked using file filters. Test results show that the proposed process can detect and track multiple people in the video as quickly as possible in adverse light conditions, human-induced variations, textures, sizes, clothing etc. and the process can treat a different number of people in video content in different time zones.[5]

6. **An Automated Real-Time People Tracking System Based on KLT Features Detection**

   Advances in technology allow video acquisition devices to work better, thus increasing the number of applications that can effectively use digital video. Compared to still images, video sequences provide more details of how things and things change over time. People tracking is popular for a variety of applications including surveillance, job monitoring and gate analysis. Many of the algorithms that follow the sequence are suggested in the literature, however, part of those semi-automatic algorithms require human interference. As for fully functional algorithms, most of them do not work in real-time applications. This paper shows a low-cost algorithm that carries virtual reality applications to programs that run real-time video. The proposed system novel uses a simplified version of the Canadian-Lucas-Tomasi (KLT) method to detect both continuous and unauthorized features. Since selective feature selection is associated with noise and may lead to some unsupported tracking feature, authors suggest the use of the Kalman filter with the aim of seeking good limitations in tracking. An integrated tracking system is able to manage shadows and is based on a dynamic background removal process that minimizes errors and quickly adapts to changing circumstances. Test results are provided to demonstrate the system's ability to directly track objects in real-time applications where scenes are exposed to noise mainly caused by signals and automatic light variations. [6]

7. **Security System and Surveillance using Real-Time Object Tracking and multiple Cameras**

   In this paper, we recommend multiple cameras that use real-time tracking and security systems. It is widely used in the research field of computer vision applications, such as video surveillance, authentication systems, robots, pre-phase MPEG4 image reduction and user interaction with body language. The key traces of tracking systems have taken over feature, removal from the background and identification of extruded objects. Video surveillance, object detection and tracking have attracted successful interest in recent years. Object tracking can be seen as a finding problem (e.g. trajectory) and can be defined as the process of finding different object spaces in each video frame. Based on the previous task of finding a single object using a single suspension camera, we expand the concept to enable multi-object detection tracking under multiple cameras and also maintain a security-based system with multiple cameras to track a person internally, point to my suggestion system with multiple surveillance cameras. Current research aims to provide security and discovery on the go with real-time video streaming and live video streaming. Based on a solid algorithm for human body detection and tracking on videos made with the support of multiple cameras. [7]

8. **Real-Time Multi-person Tracking in Video Surveillance**

   In this paper, we briefly summarize our video viewing research framework. We then look at the current study of man-made recognition and present our current work in mass tracking in real time. By using dynamic domain removal, premature regions are identified and subdivided. The merging algorithm is then used to combine the front pixels in an unconventional way to measure the location of an individual image. The Kalman filter is used to track each individual and is given a separate label for each person downloaded. Based on this method, people can log in and leave the event from time to time. Trauma, such as a combination of silhouette, is well managed and individuals can be well tracked after a group of people have split up. Tests show real-time performance and robustness of our system that works on complex scenes. [8]

9. **Real-time detection and tracking of pedestrians in CCTV images using a deep convolutional neural network**

   In this work, deep neural networks are used to activate the process of feature extraction in CCTV images. The extracted features serve as a solid basis for a variety of object recognition functions and are used to address the tracking problem. This approach compares the released features of the individual acquisition independently, which is why it has created the acquisition agreement across all frames. The improved frame is able to deal with challenges such as changed scenes, changes in light, shadows and displays, changes in appearance and specific signs. However, increasing occlusion with the same people in the same frame remains a challenge to consider. The framework is able to generate detection and tracking results at a rate of four frames per second. [9]

2.1.3 Research Findings for Existing Literature

TABLE 2.1: Research Findings for Existing Literature

S.No.	**Roll No.**	**Name**	**Paper Title**	**Tools/ Technology**	**Findings**	**Citation**
1	101703037	Aditya Thakur	Real-Time Multiple Object Tracking A Study on the Importance of Speed	Coding Environment- C++ Deep Learning Models- Caffe	Using Kalman filters, tracking% decreases with decreasing FPS (frame per second)	[1]

2			Real-Time Human Detection, Tracking, and Verification in Uncontrolled Camera Motion Environments	Camera mounted on freely moving platform	Verification could be used to remove false alarms.	[2]
3			Real-time tracking of humans and visualization of their future footsteps in public indoor environments.	A video camera (640 × 480 pixels resolution), a projector and a computer.	Easy Camera Calibrations using OpenCV	[3]
4	101703039	Aditya Vashista	Simple Online and Realtime Tracking with a Deep Association Metric.	Cameras	Using nearest neighbor queries reduces the number of identity switches by 45%, achieving overall competitive performance at high frame rates	[4]
5			Automatic Multiple Human Detection and Tracking for Visual Surveillance System	Video Camera of frame resolution 640x480	Haar-like feature extraction, Particle Filtering results in easy and high accuracy implementation.	[5]
6			An Automated real-time People Tracking System Based on KLT Features Detection	Real-Time Video Surveillance Cameras	Instead of detecting and tracking a large number of feature points of an object in a continuous manner, this paper proposes a simplified algorithm that detects and tracks a limited amount of both, continuous and discontinuous features.	[6]
7	101703048	Akriti	Security System and	Multiple Video	Use of a modified frame	[7]

		Sehgal	Surveillance using Real-Time Object Tracking and multiple Cameras.	Cameras of resolution 640x480	differencing approach which deals with the less misdetection rate.	
8			Real-Time Multi-person Tracking in Video Surveillance	Single-view Video surveillance camera	Kalman filter predictions can be used to handle merging, emerging and splitting of objects.	[8]
9			Real-time detection and tracking of pedestrians in CCTV images using a deep convolutional neural network	Inexpensive CCTV video cameras	Use of avg representation of individual pedestrians, to address the problem of Occlusion and similar persons.	[9]

2.1.4 Problem Identified

The main problem identified is obtaining accuracy in the actual environment, the problems faced in the actual environment are considering multiple camera inputs, cameras mounted on freely moving platforms, multiple obscuring points. The software should be able to maintain real-time performance. Feature extraction should be able to identify different persons differently.

2.1.5 Survey of Tools and Technologies Used

Most of Projects/Researches are divided into the following modules:

- Hardware (sensors)
  1. Cameras of resolution 640x480
- Path Tracking Software
  1. Either Haar-like features or Kalman feature extraction is used for feature detection and extraction.
  2. Average representations of Individual persons is used to avoid false results in occlusion and people with similar features.

2.2 Standards

1. **Application Software Standards**
    - Platform Used: PyQt5
    - Compatibility: Platform Independent
    - Accessibility: Free

2.3 Software Requirement Specifications

2.3.1 Introduction

2.3.1.1 Purpose

The purpose of this SRS document is to provide a detailed overview of our software product, its parameters, and goals. This document describes the project's target audience and its user interface, hardware and software requirements. It defines how our client, team, and the audience see the product and its functionality.

2.3.1.2 Intended Audience and Reading Suggestions

This document is intended for individuals finding a solution for all time supervision of the old age people. Readers interested in a brief overview of the product should focus on the rest of Part 1 (Introduction), as well as Part 2 of the document (Overall Description), which provides a brief overview of each aspect of the project as a whole. Readers who wish to explore our Automation of Surveillance Systems in more detail, Part 3 (External Interface Requirements) offers further technical details, including information on the user interface as well as the hardware and software platforms on which the application will run. Readers interested in the non-technical aspects of the project, which covers performance, safety, security and various other attributes can also refer to Part 4 (Other Non-Functional Requirements) for clarity. Readers who have not found the information they are looking for should check other requirements, which includes any additional information which does not fit logically into the other sections.

2.3.1.3 Project Scope

The goal is to design hardware and software systems for real-time surveillance of all objects and people present in that area. In this system, video footages from the CCTV will be sent to the server for the tracking as long as the hardware is kept on. All this will then be accessed by a tracking algorithm which will compute the recorded data into positions of object/person every few seconds. The identification of the person/object(to be traced in the surveillance area) will be done using a feature extraction algorithm. A path tracking system will be made which will generate a path embedded within the blueprint of the surveillance area.

The system (hardware + software) should be able to perform the following tasks:

1. Record proper readings from the sensors(mainly CCTV) attached.
2. Properly extract object/person features.
3. Compute the coordinates every few seconds of the tracing object using the sensor data.
4. Generate a real-time path.

Note: A key point to be noted here is that the hardware will be active for the whole time and data will be recorded as long as it is on.

2.3.2 Overall Description

2.3.2.1 Product Perspective

The product will consist of the following physical components:

- Surveillance (CCTV) cameras
- Embedded Systems (such as Arduino Uno/Raspberry Pi or alike)
- Sensors

The functionality and processing of the entire project shall be done on a computer system attached to the data storage server/ local database.

The cameras and sensors will be sending data to the system continuously for processing and storage.

The aim of this product is to do real-time human tracking with the help of real-time data and video streaming.

Our product will aim to automate security systems that will help to reduce time in the identification of individuals and track their movements from a large number of surveillance cameras installed in such places. This will also help in solving theft crimes quicker.

This visual tracking that we aim at achieving will help understand the behaviour of moving objects after moving objects' detection and recognition. Thus, this idea can be expanded in future and smart homes.

After the tracking is done, the output will be shown on the screen as a graph plot on the blueprint of the area under surveillance.

2.3.2.2 Product Features

The following list offers a brief outline and description of the main features and functionalities of the system. The features are split into two major categories: core features and additional features. Core features are essential to the application's operation, whereas additional features simply add new functionalities. The latter features will only be implemented as time permits.

CORE FEATURES

1. Data Collection

    Data is recorded using a camera, located at various parts in a building. Live data is then transmitted to the server by the hardware using the Arduino Uno.

2. Data Processing

    Data is processed through various CNN layers present in the model and object detection results in a bounding box around the objects that can be traced.

3. Path Tracking Algorithm

    A path of selected objects is displayed on the screen, with a unique tag to each person present in the video.

ADDITIONAL FEATURES

Info Storage and Analysis: The data and pattern of the path in the building of regular visitors or employees are stored and analysed.

2.3.3 External Interface Requirements

2.3.3.1 User Interfaces

1. The GUI should be user friendly.
2. The GUI should be highly responsive.

3. Data of people present in the building should be secured.

2.3.3.2 Hardware Interfaces

1. Accurate data should be recorded by the hardware device.
2. The data recorded should be sent to the server in real-time.
3. The Arduino Uno should be connected to the server and cameras 24*7.

2.3.3.3 Software Interfaces

a. The path should be tracked in real-time.
b. The info of people being tracked should be kept secure, and be used for security reasons only.
c. Feature Extraction and path tracking should be accurate.

2.3.4 Other Non-Functional Requirements

2.3.4.1 Performance Requirements

1. The person/object will be monitored as long as he/she is under CCTV surveillance.
2. The data will be transferred to the server for real-time calculations and path tracking.
3. The camera resolution should be high enough to capture minute details of objects for feature extraction.

2.3.4.2 Safety Requirements

The data being collected and the path being tracked is available only to the authorized users. Moreover, the user interface requires a login id and a password along with different levels of access to each user according to his/her role in surveillance duty. Hence, the safety of the data is being taken care of.

2.3.4.3 Security Requirements

The personal information of people under surveillance that is being recorded by the application is secure with our interface. The data won't be shared with anyone at all.

2.4 Cost Analysis

TABLE 2.2: Cost Analysis

S.NO.	Item	Price(per unit in INR)	Quantity	Price(INR)
1	USB Webcams	2000	3	6,000
2	High-speed multi-port USB connector	200	1	200
3	Arduino UNO R3	500	1	500
4	HC-05 Bluetooth Module	320	1	320
5	Sensors(various)	150	-	150
6	500 GB External Hard Disk	2500	1	2500
7	Miscellaneous (Jumper Wires +Breadboard)	100	-	100
TOTAL				**9770/-**

2.5 Risk Analysis

1. Incorrect path traced.
2. Path tracing in non-real-time.
3. Inaccurate and ambiguous feature extraction.
4. Data lost or corrupted during transmission or blackout.

CHAPTER 3: METHODOLOGY ADOPTED

3.1 Investigative Techniques

Investigative techniques involved: COMPARATIVE

Justification:

Comparative Technique of investigation involves the collection of data under various circumstances and looking for patterns by comparing similarities and differences, similarly in this project we collect raw data using cameras as sensors and refine this data into coordinates, further analysing these coordinates paths are formed.

Our project is based on comparative technique as the idea of tracing human paths is not new as there are many research papers based on human path tracing and tracking multiple objects. We first put our emphasis on Real-Time Multiple Object Tracking through a research paper but we saw processing speed is the main issue prevailing when tracking the path. Then we saw Real-Time Human Detection, Tracking, and Verification in Uncontrolled Camera Motion Environments but tracking people and objects in a crowded place is the main issue out here. We also saw Real-time tracking of humans and visualization of their future footsteps in public indoor environments but our main purpose is to automate the surveillance systems rather than focusing on the prediction of footprints but this gave us an idea how human steps are visualized using different techniques. The thing which drew our attention was Moving Human Path Tracking Based on Video Surveillance in 3D Indoor Scenarios by making a graph of the area but this research was still not complete as it can only track a single person effectively in a given span of time. Automatic Multiple Human Detection and Tracking for Visual Surveillance System and An Automated Real-Time People Tracking System Based on KLT Features Detection were the techniques which also solved our purpose by tracking multiple persons but there are sudden illuminations and sudden noise which causes errors. So we put our emphasis on Real-time detection and tracking of pedestrians in CCTV images using a deep convolutional neural network which can use the main idea to plot certain things together and make an application out of these prevailing techniques.

Methodology:

Here we are going to implement the Convolutional Neural Networks in a different and efficient way. We will have snapshots of the video and using CNN we will find the person's occurrence and details at different areas through which we will mark the person’s traces. For Detection, we apply a single neural network to the complete image, this results in division of images into various regions and the box for detection is predicted using Logistic probability scores, K-means clustering for the box dimensions.

3.2 Proposed Solution

- **Software**
    1. In our project, google tensor flow 2.0 will be used when we will be making a path tracking algorithm
    2. We will use OpenCV to open previously downloaded videos and to see the live feed
    3. CNN will be used in order to detect objects.
    4. In order to make our model for path tracking inside a confined area, we will use ML Regression and Classification techniques.
    5. For the UI application of our model, we will use the pyqt5 library which is a cross-platform GUI toolkit.
- **Hardware**
    1. We will be currently using webcams for video surveillance.

Procedure:

Video recording from the CCTV cameras will be stored in a local server.

Then the snapshots of the videos will be taken. Using these snapshots we will detect no. of people in the compound and extract each person's facial details using CNN(Convolutional Neural Networks). Then we will calculate the coordinates on which the person is seen according to the blueprint and make a path of that person. The graph obtained containing numerous paths will be embedded on the blueprint of the place and the path of that person in that particular compound will be visible to us.

3.3 Work Breakdown Structure

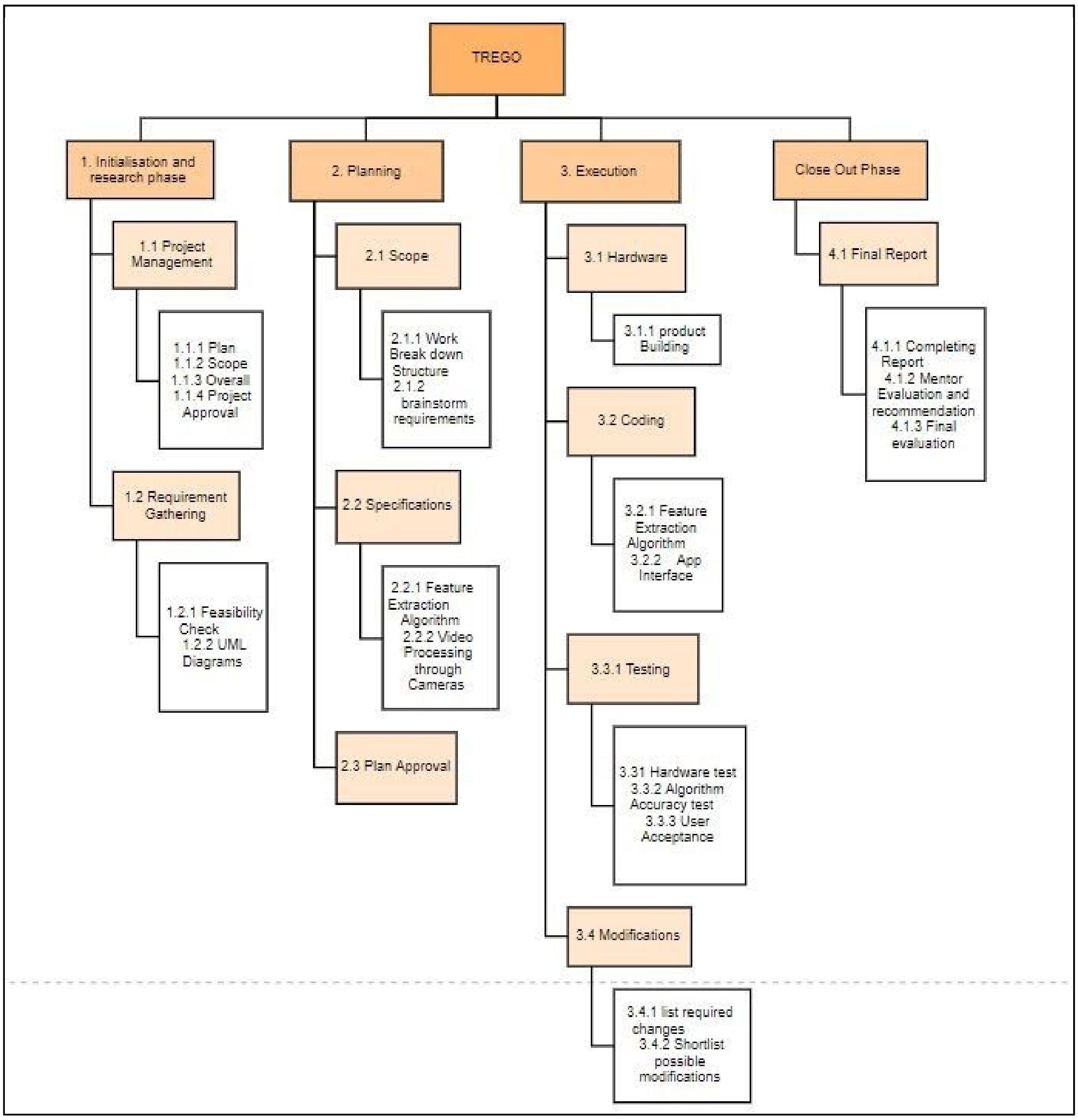


FIGURE 3.1: Work-Breakdown Structure

3.4 Tools and technologies

Software & OPen-Source Technologies used:

1. Qt designer
2. SQLite DB browser
3. PyQt5
4. Open Cv

5. Python 3.7.6
6. Tensorflow
7. Darknet Python YOLOv3
8. For Training of model:
    a. Coco dataset
    b. MOT-17 Dataset

Hardware used:

1. Camera

CHAPTER 4: DESIGN AND SPECIFICATIONS

4.1 System Architecture

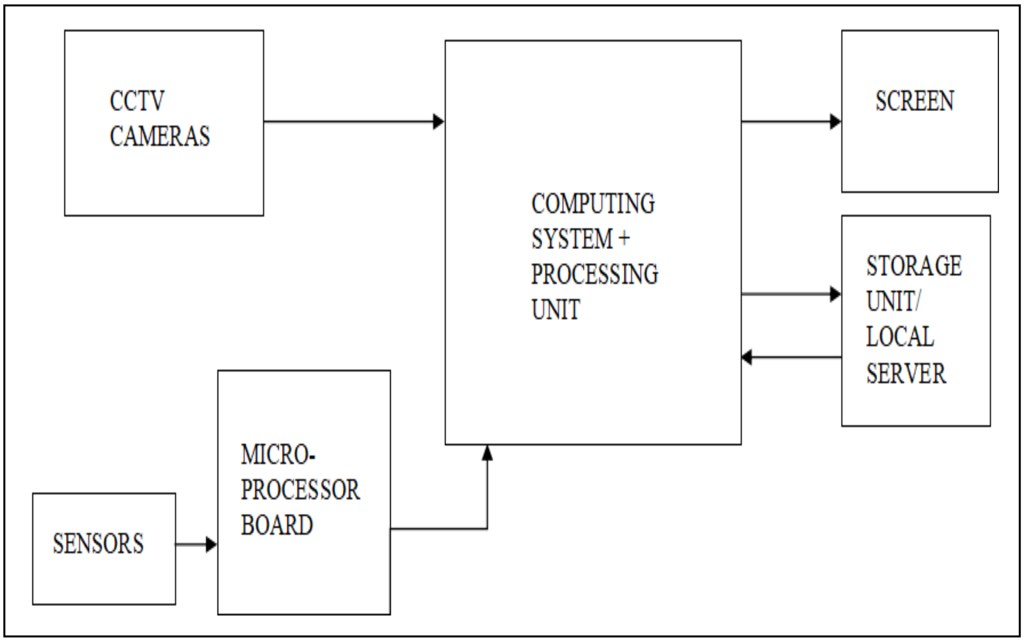


FIGURE 4.1: Block Diagram

4.2 Design Level Diagram

4.2.1.1 USE CASE Diagram

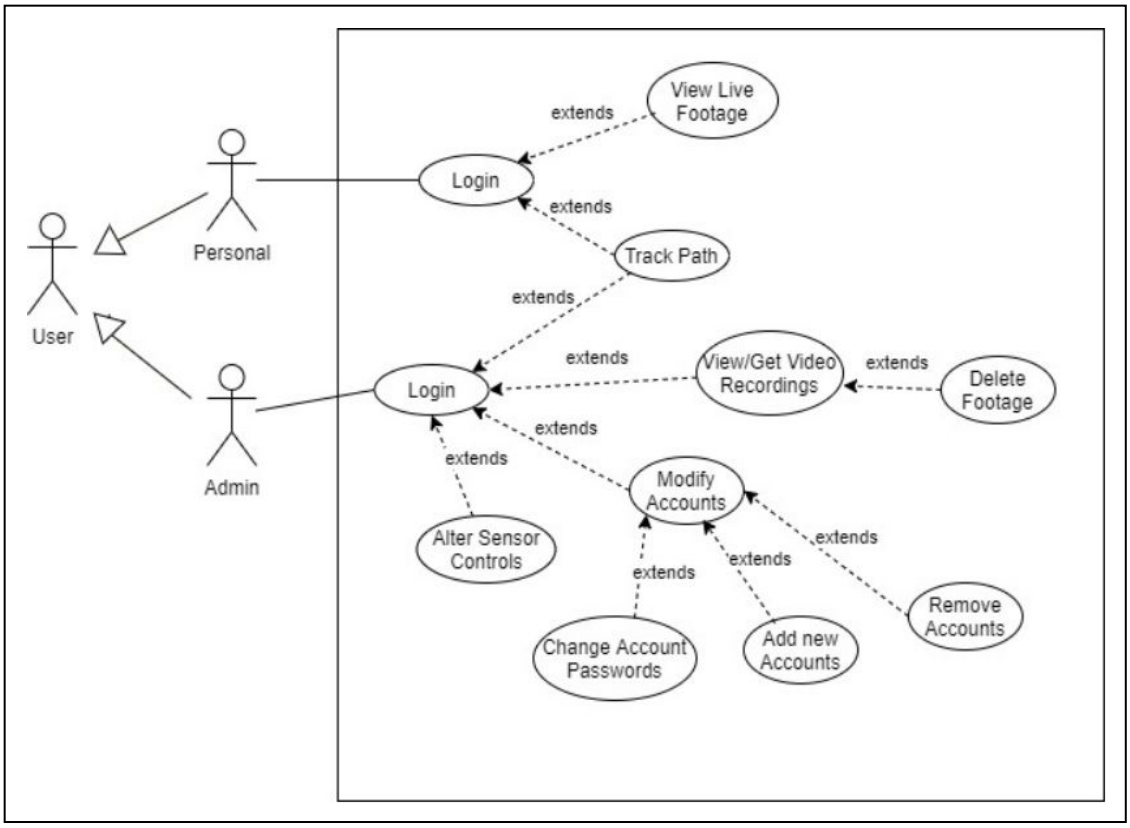


FIGURE 4.2: USE-CASE Diagram

4.2.1.2 Use Case Template-1

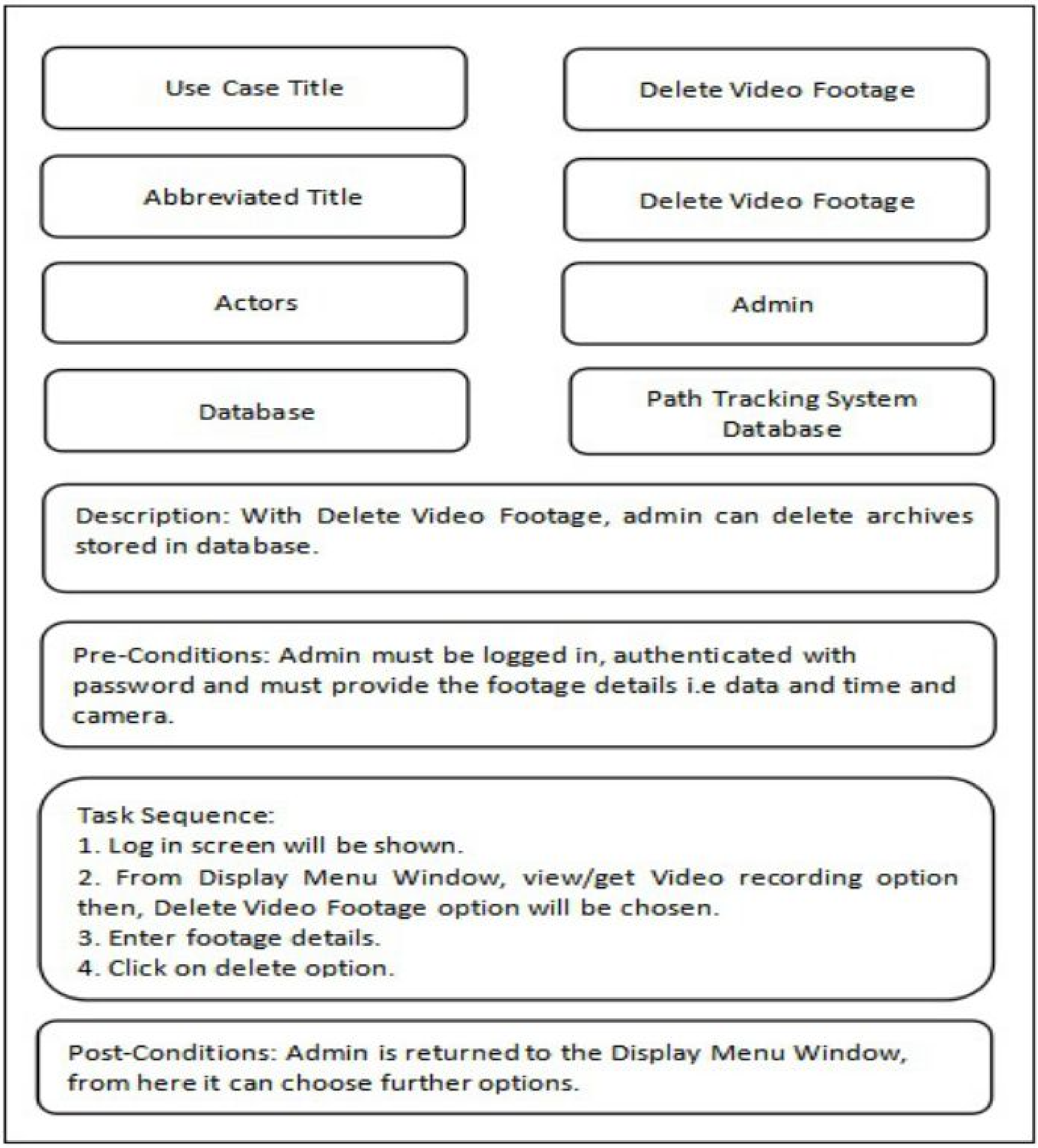


FIGURE 4.3: Use-case Template-1

4.2.1.3 Use Case Template-2

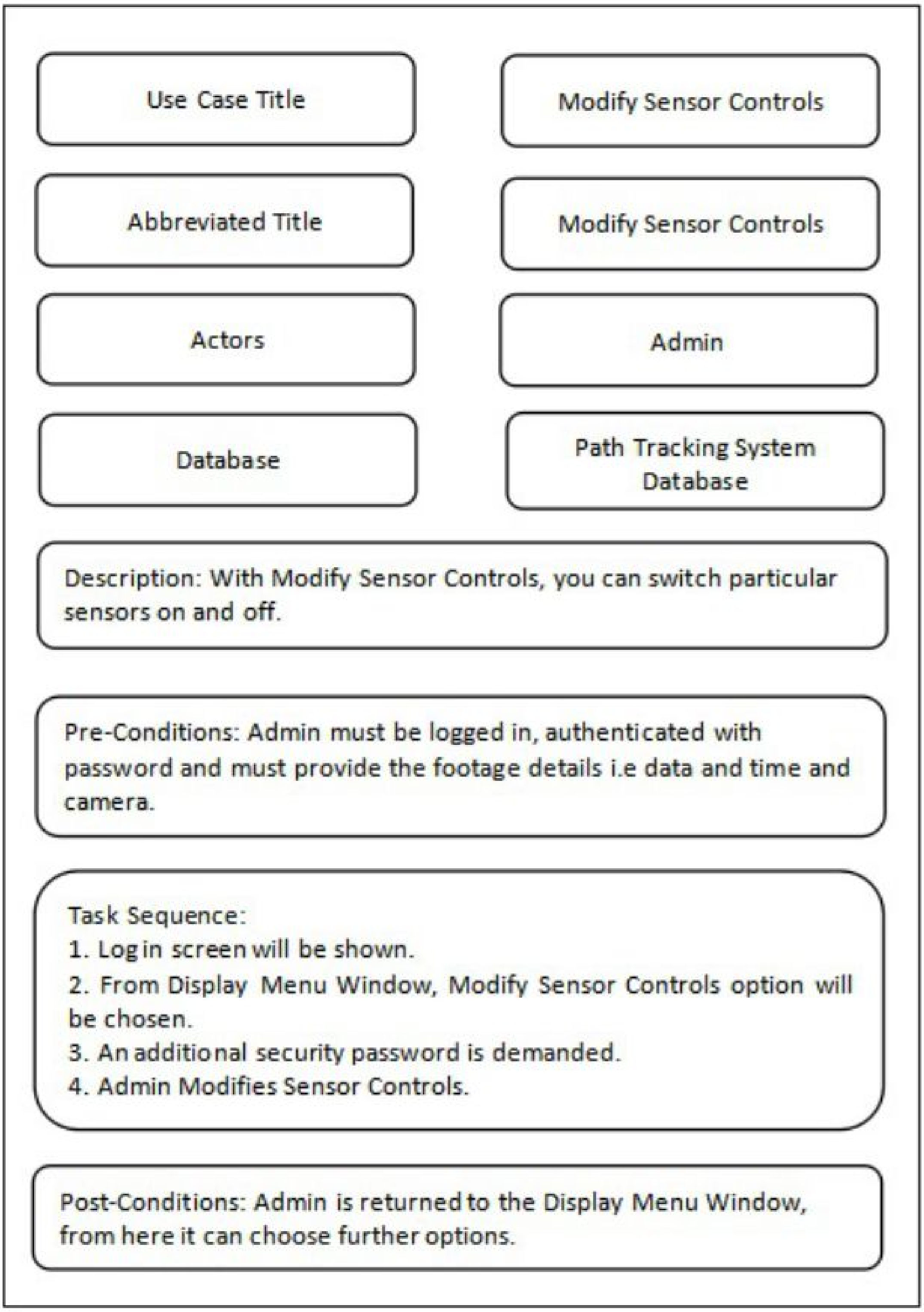


FIGURE 4.4: Use-case Template-2

4.2.2 Swimlane Diagrams

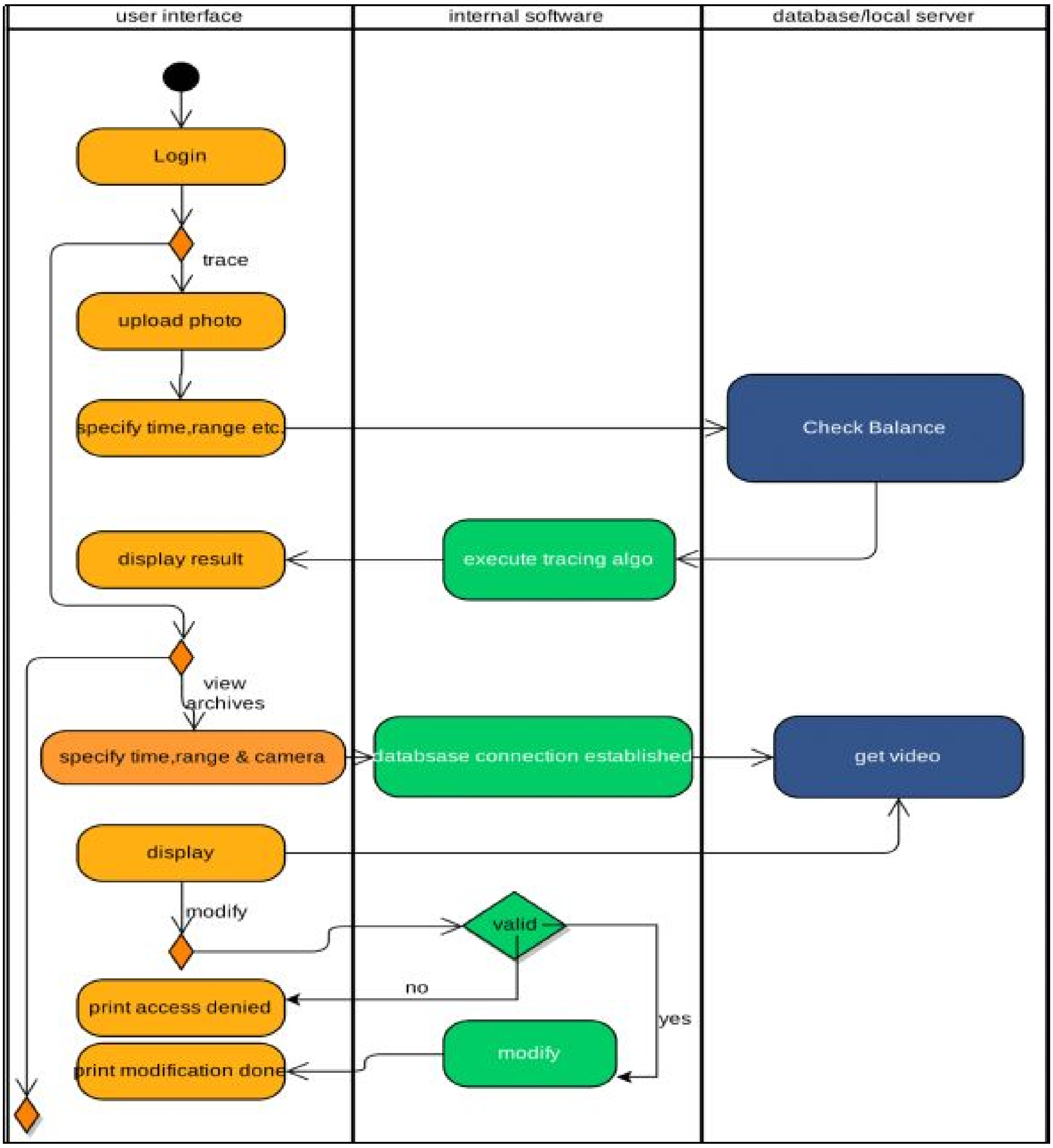


FIGURE 4.5: Swimlane Diagram-1

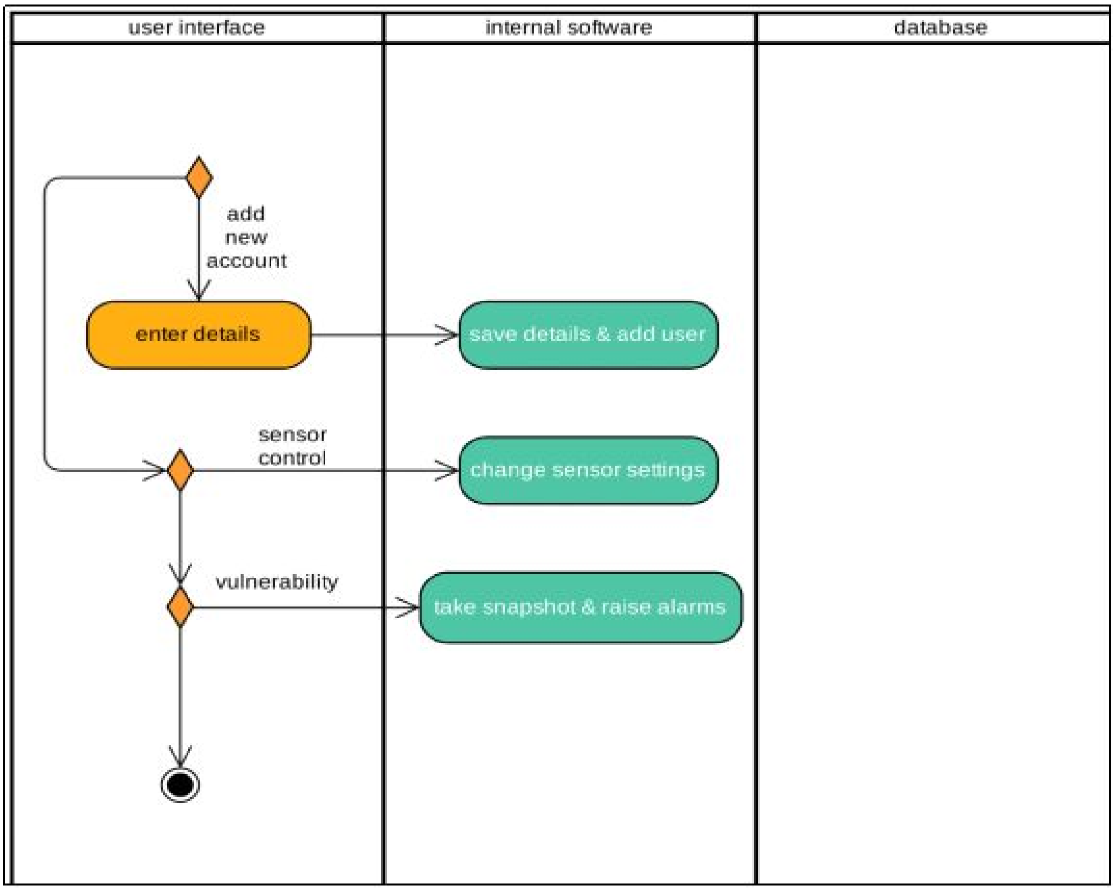


FIGURE 4.6: Swimlane Diagram-2

4.2.3 Activity Diagrams

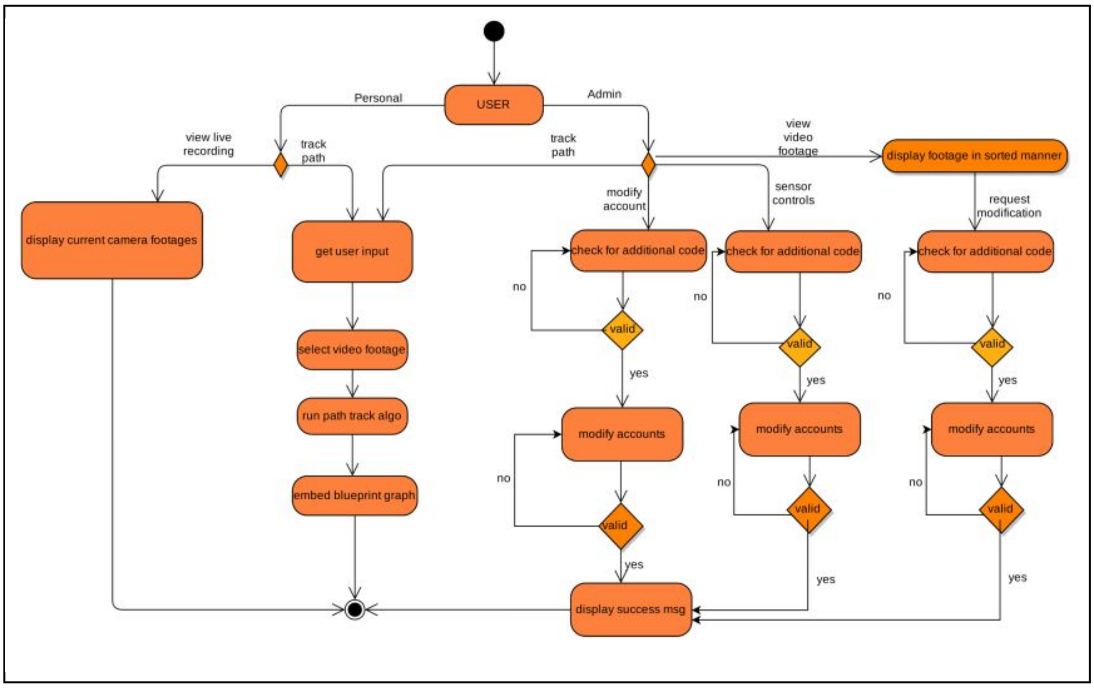


FIGURE 4.7: Activity DIagram

4.2.4 DFD

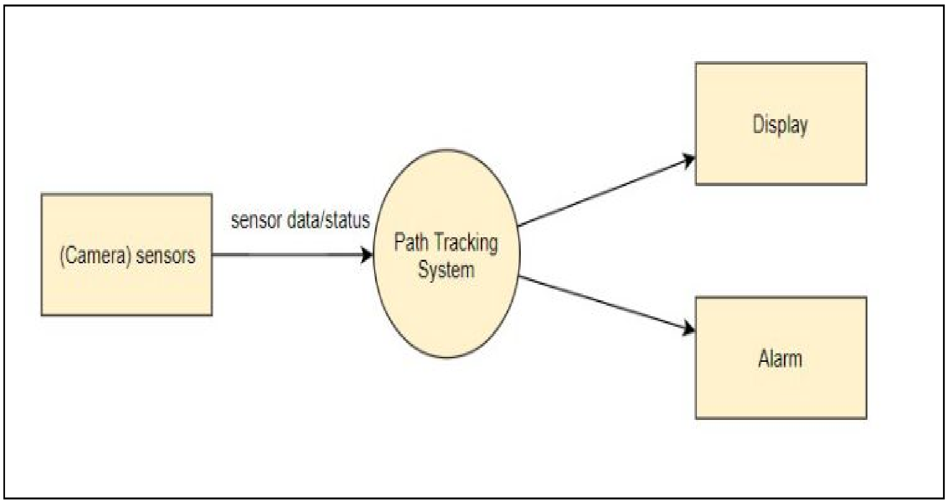


FIGURE 4.8: DFD level-0

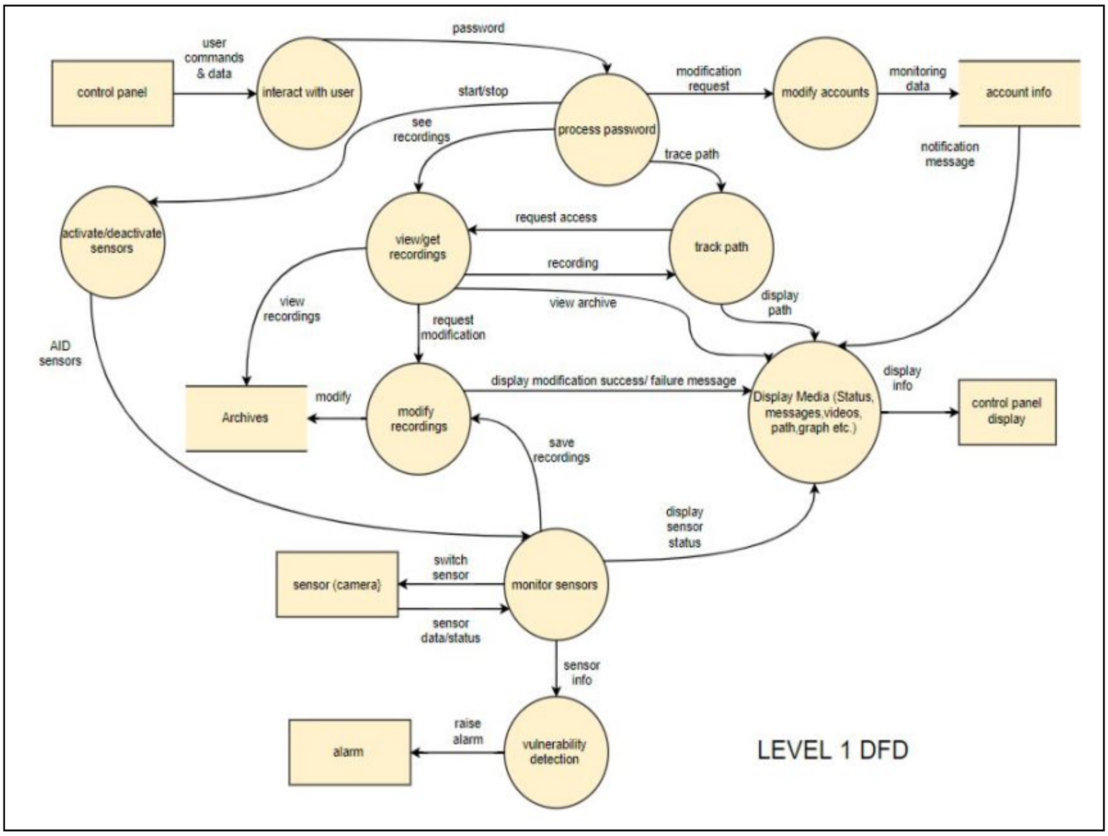


FIGURE 4.9: DFD level-1

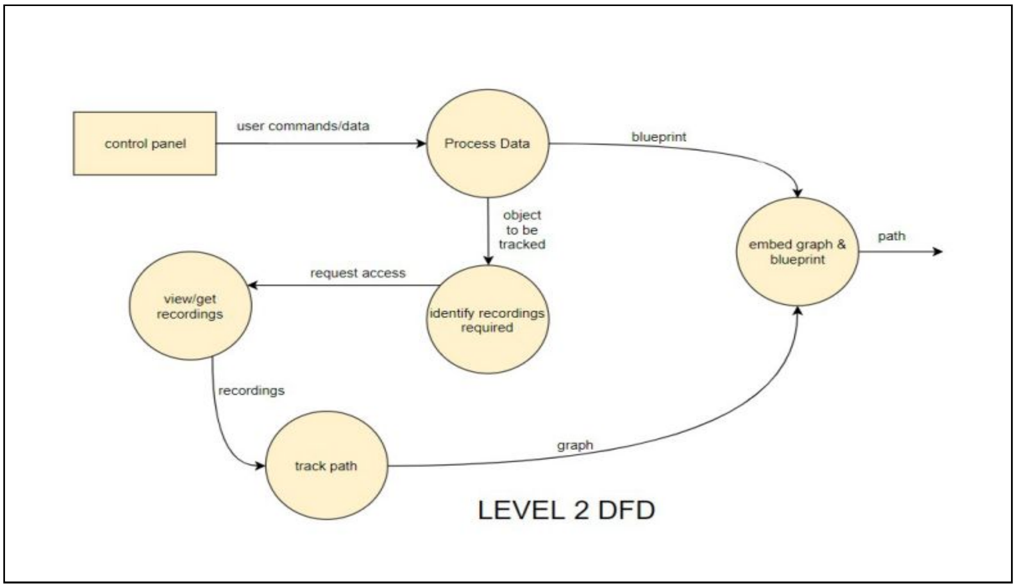


FIGURE 4.10: DFD level-2

4.2.5 State Chart Diagram

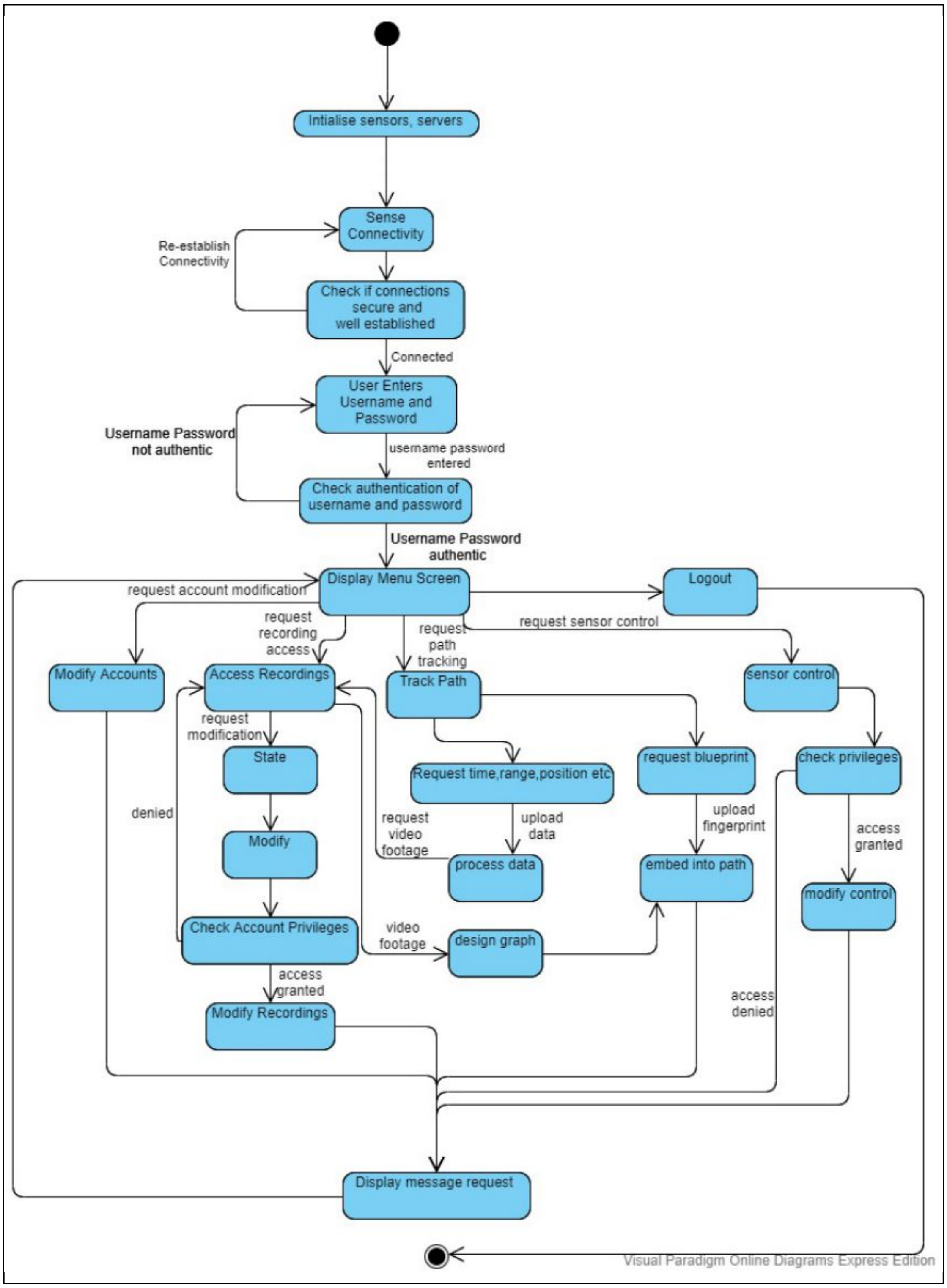


FIGURE 4.11: State Chart Diagram

4.2.6 Sequence Diagram

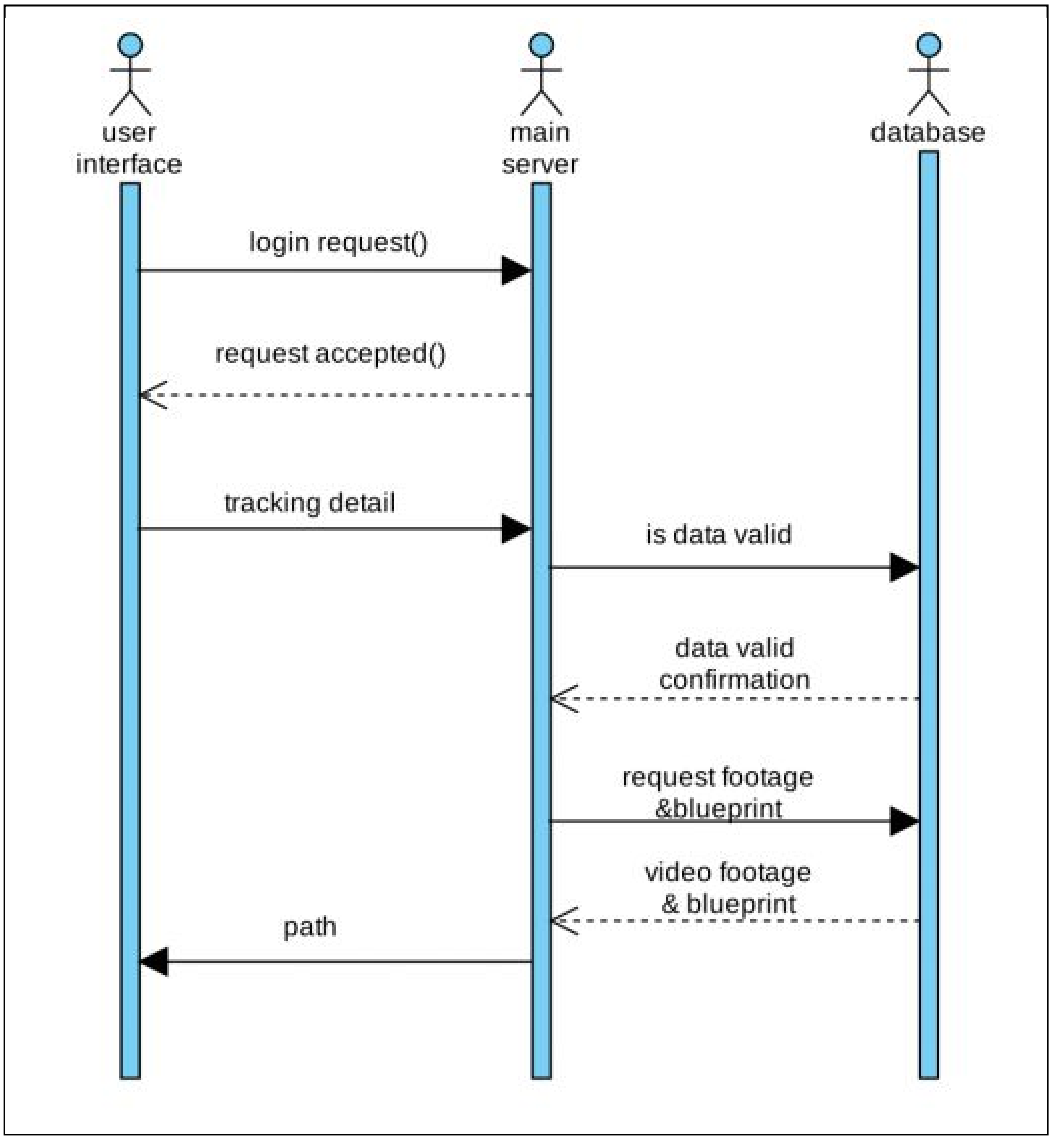


FIGURE 4.12: Sequence Diagram

4.2.7 Class Diagrams

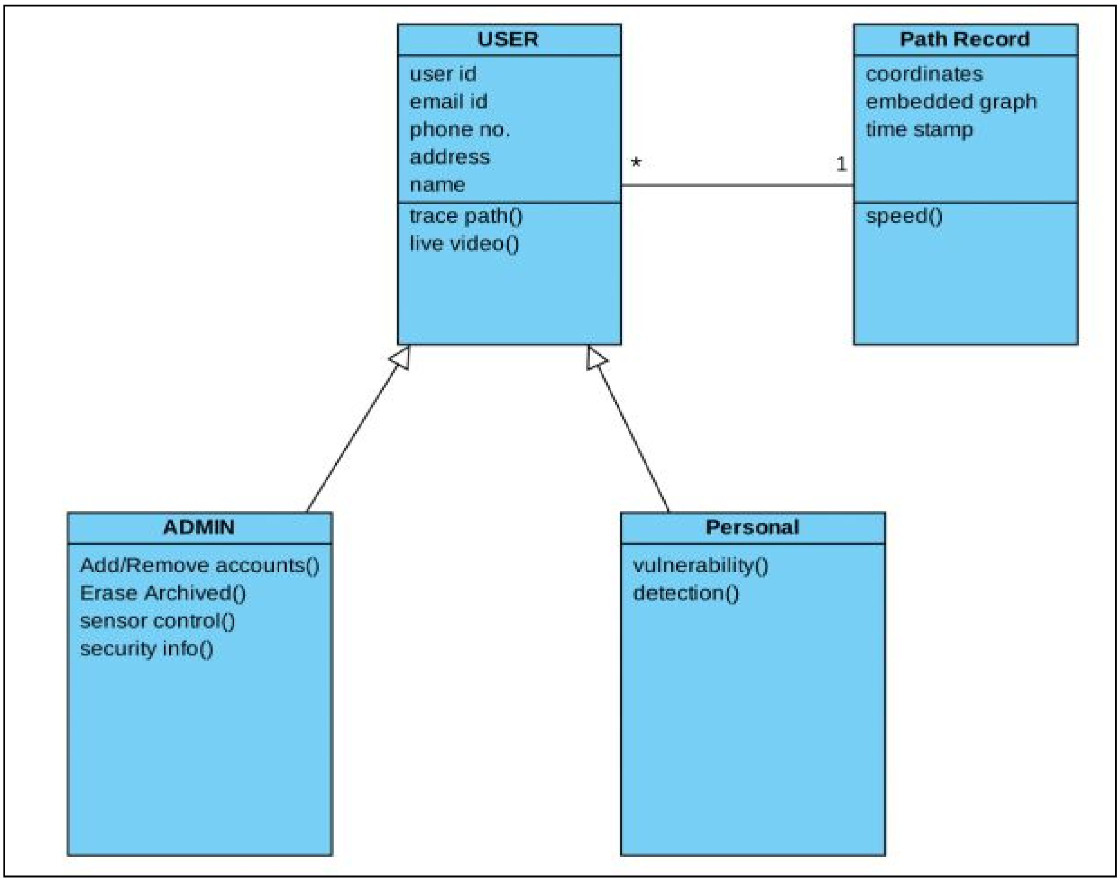


FIGURE 4.13: Class Diagram

4.2.8 Component Design

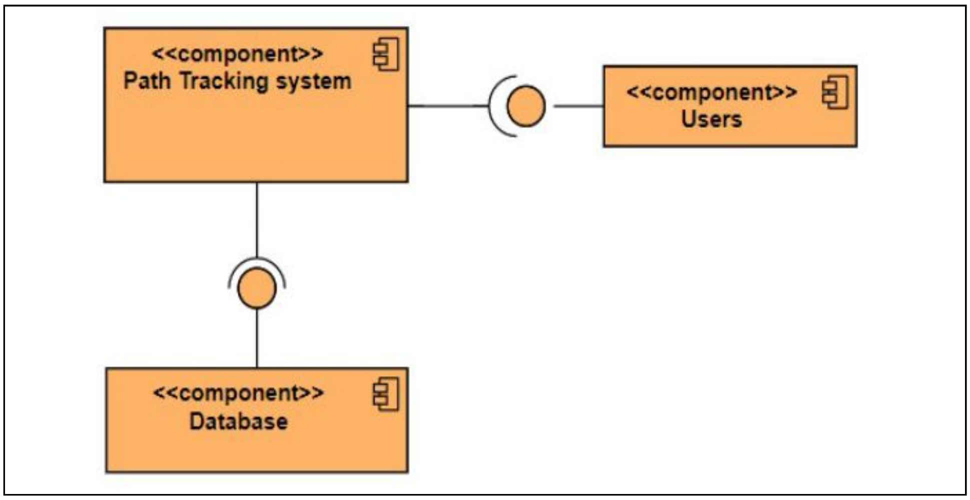


FIGURE 4.14: Component Diagram-1

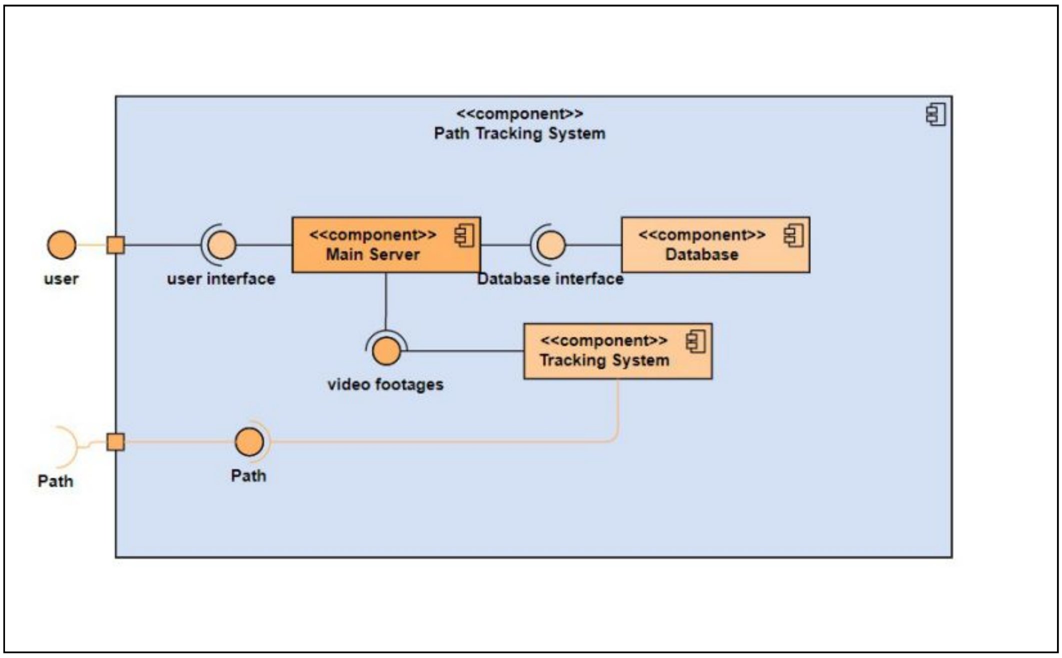


FIGURE 4.15: Component Diagram-2

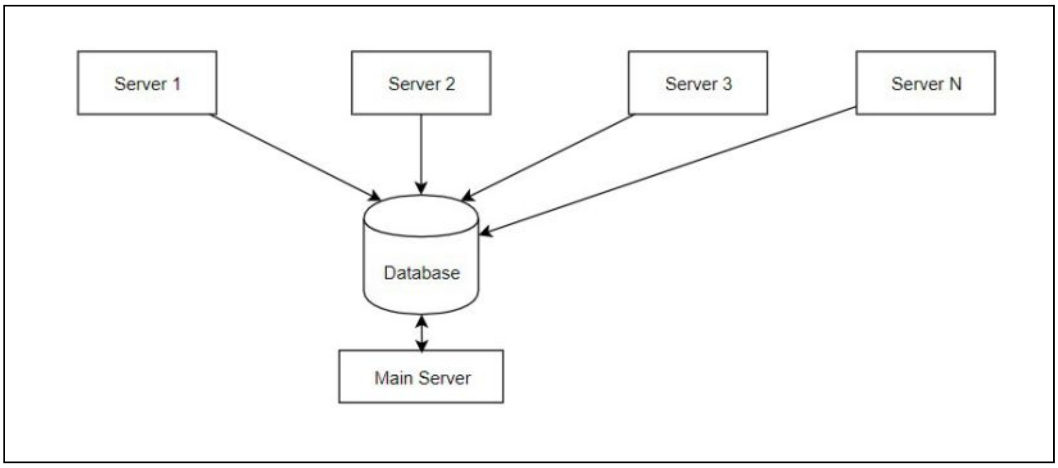


FIGURE 4.16: Component Diagram-3

4.3 User Interface Diagrams

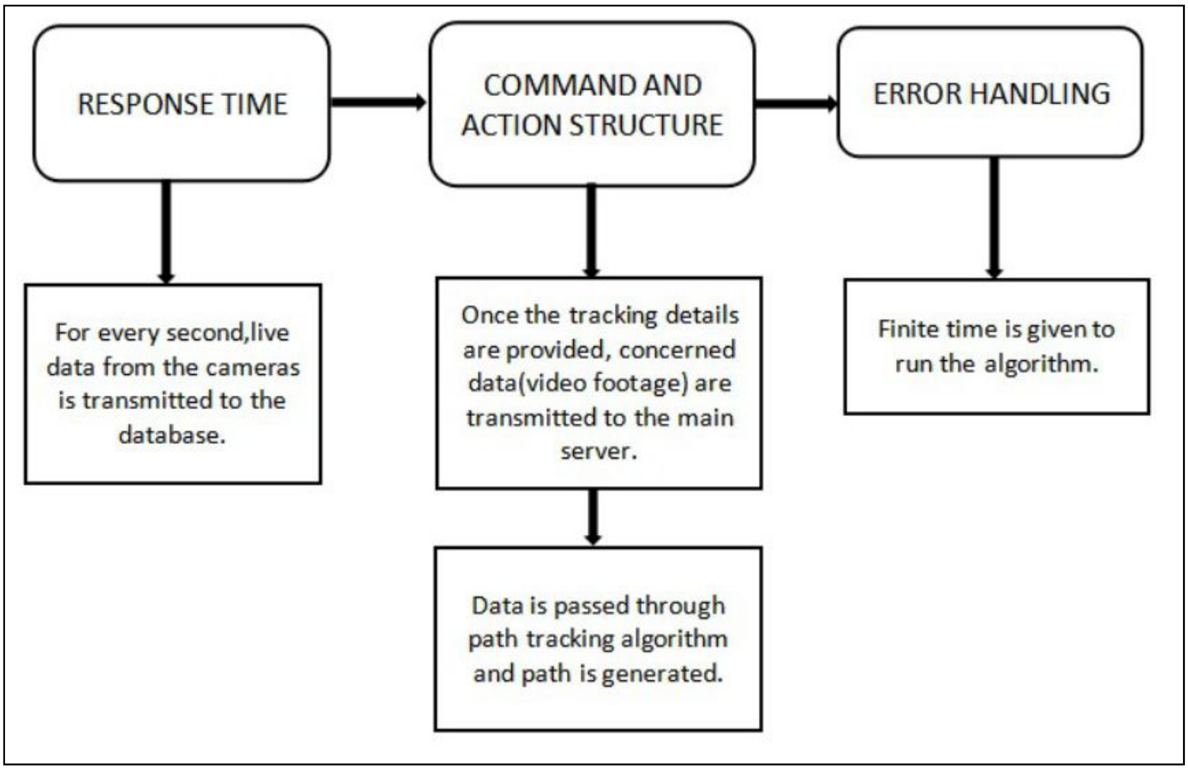


FIGURE 4.17: User Interface Diagram

4.4 Snapshots of Working Prototype

4.4.1 GUI

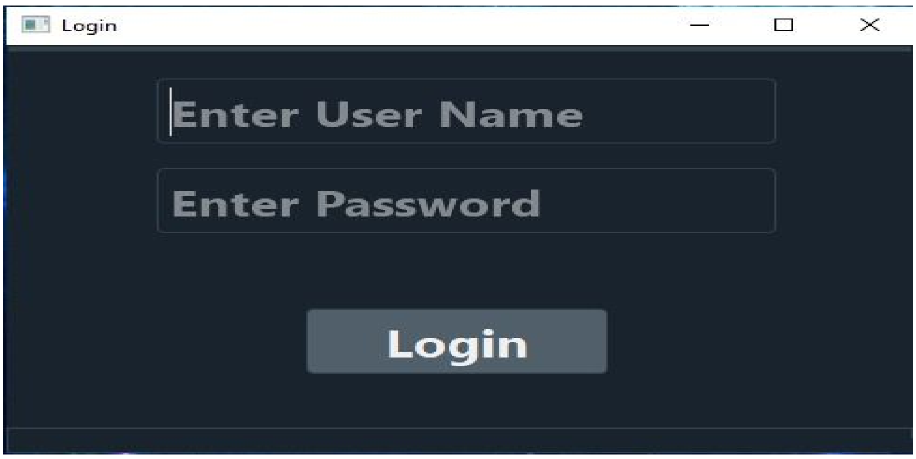


FIGURE 4.18: Login Screen

Case-1: Invalid Credentials

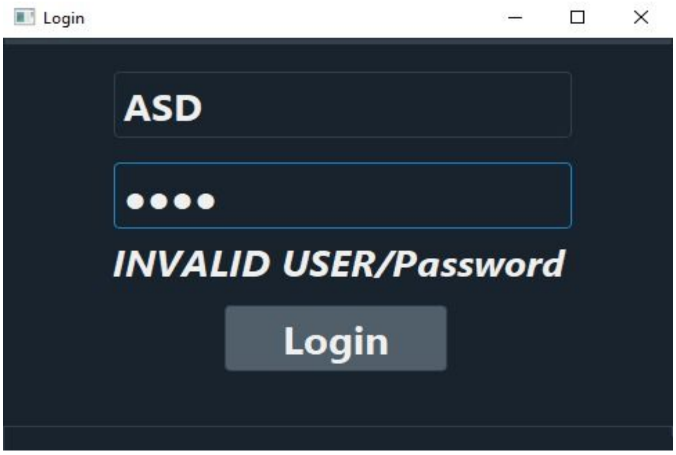


FIGURE 4.19: Invalid Credentials Result

Case-2: Valid Credentials

Case-2.1: Admin Login

Home/Theme Page: It gives the user 4 options for themes to select for the interface. The first one shown is the default theme.

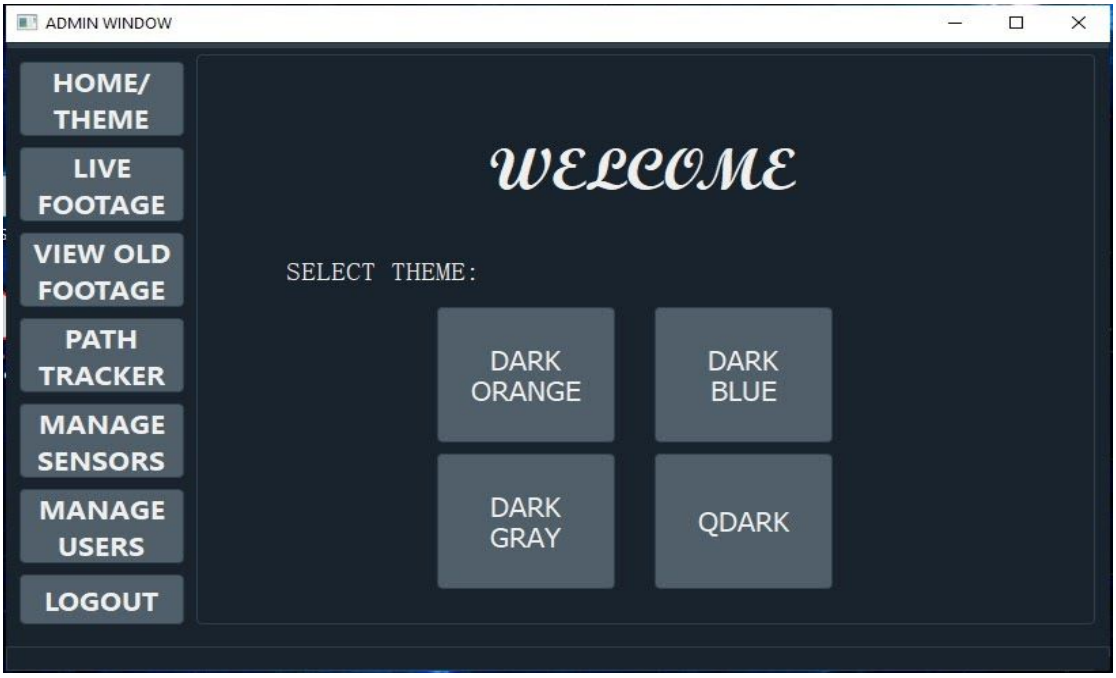


FIGURE 4.20: Default Home Page for Admin

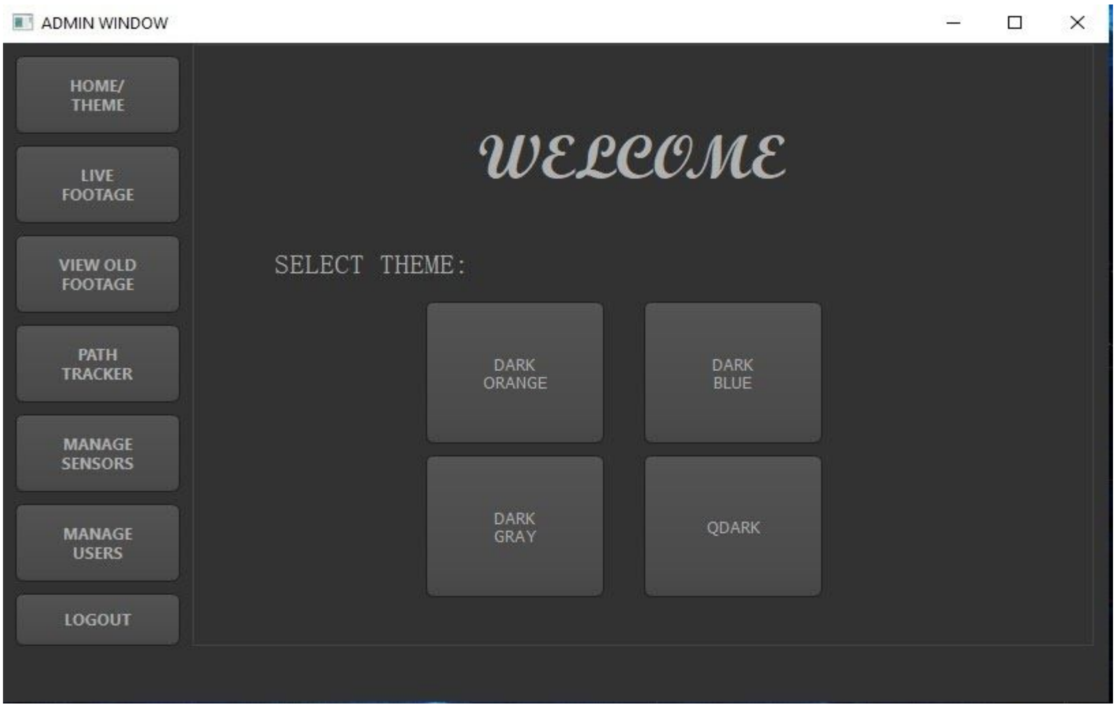


FIGURE 4.21: Theme-Dark Orange

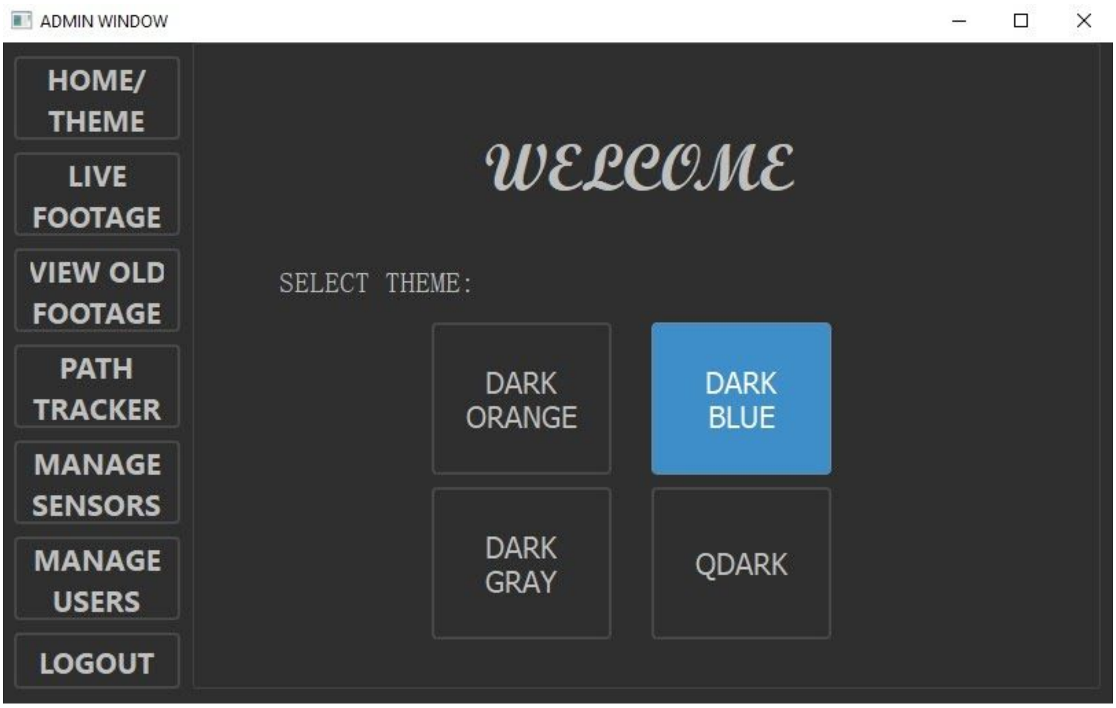


FIGURE 4.22: Theme-Dark Blue

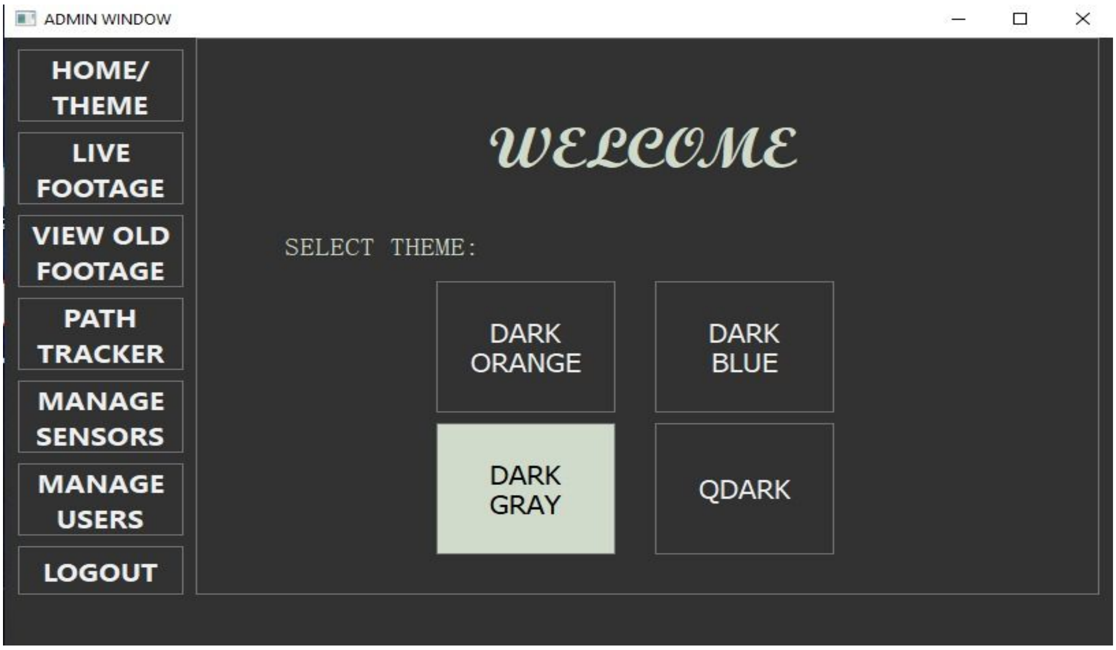


FIGURE 4.23: Theme-Dark Gray

Live Footage: From the camera dropdown menu you can select the camera id to view the live streaming from all the camera devices connected to the system, currently we have selected the laptop webcam for the working prototype.

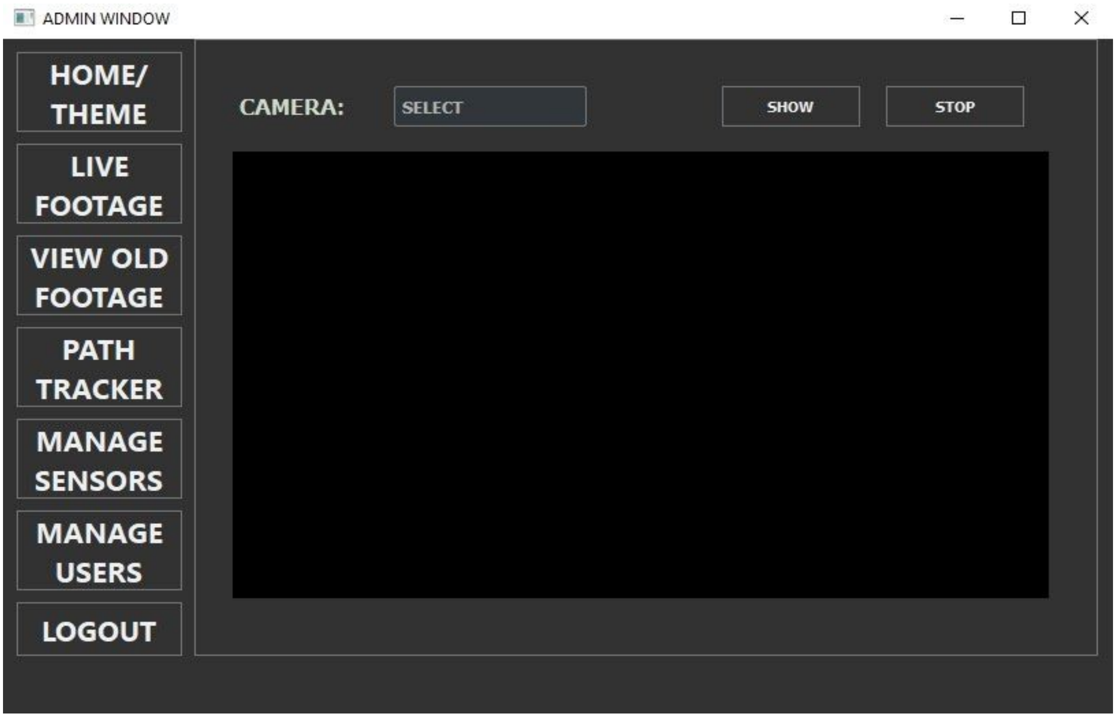


FIGURE 4.24: Screen For Live Footage

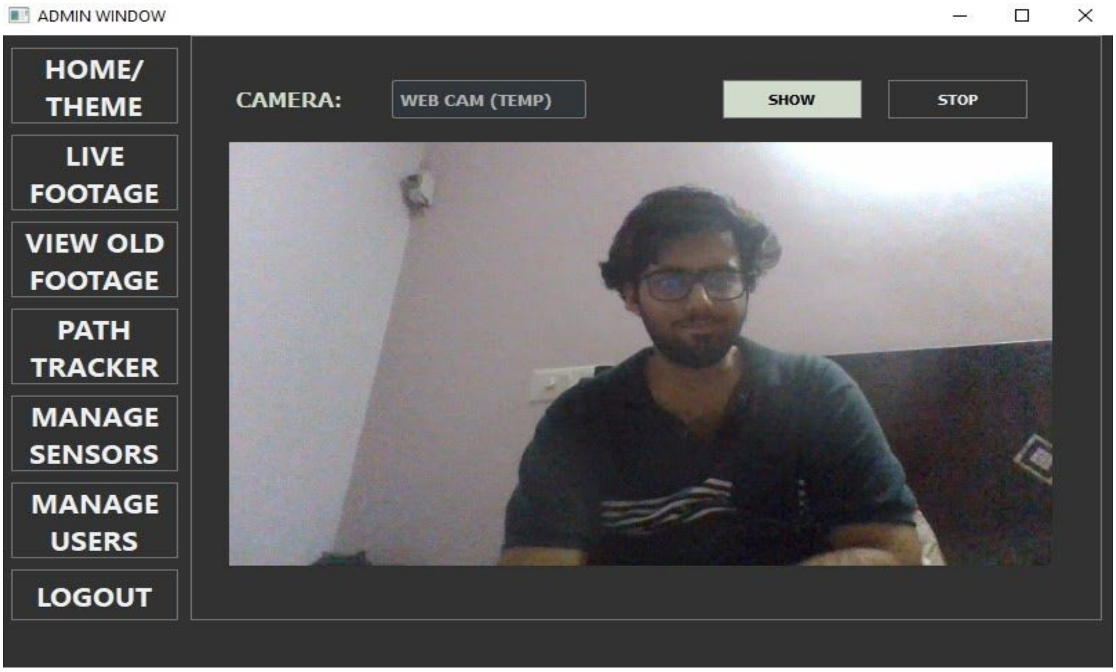
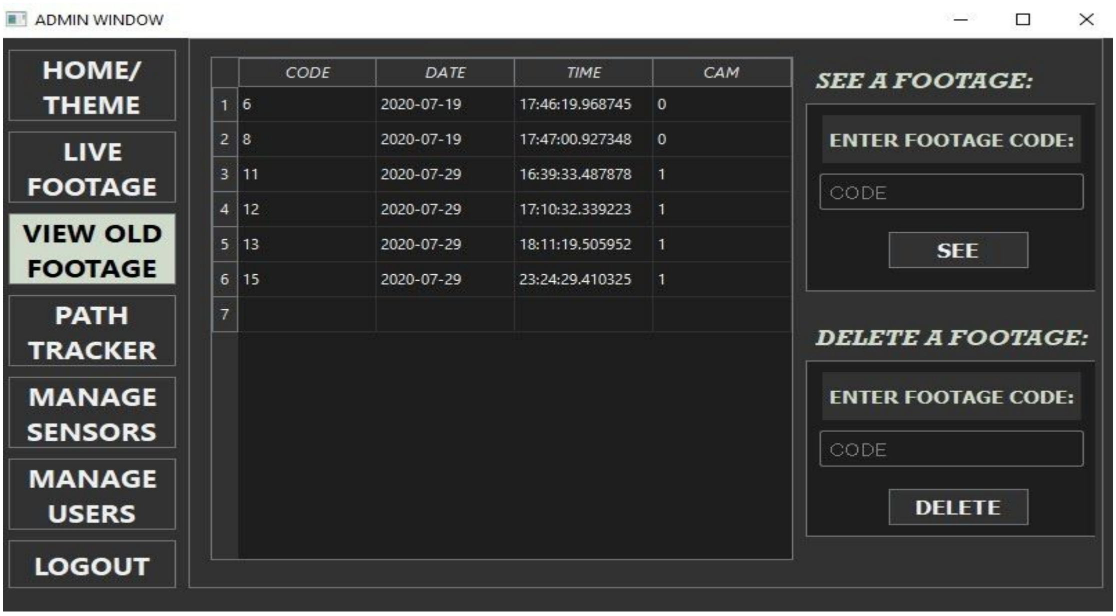


FIGURE 4.25: Live Footage using webcam

View Old Footage: This displays the record of old footage linked to the system, CAM ID-0 is set for uploads and CAM ID-1 for Webcam recordings. Else admin can also search a particular video using the search box. Moreover only the admin gets the option of deleting a particular footage from records using the delete box on bottom right.



	CODE	DATE	TIME	CAM
1	6	2020-07-19	17:46:19.968745	0
2	8	2020-07-19	17:47:00.927348	0
3	11	2020-07-29	16:39:33.487878	1
4	12	2020-07-29	17:10:32.339223	1
5	13	2020-07-29	18:11:19.505952	1
6	15	2020-07-29	23:24:29.410325	1
7				

FIGURE 4.26: Archives

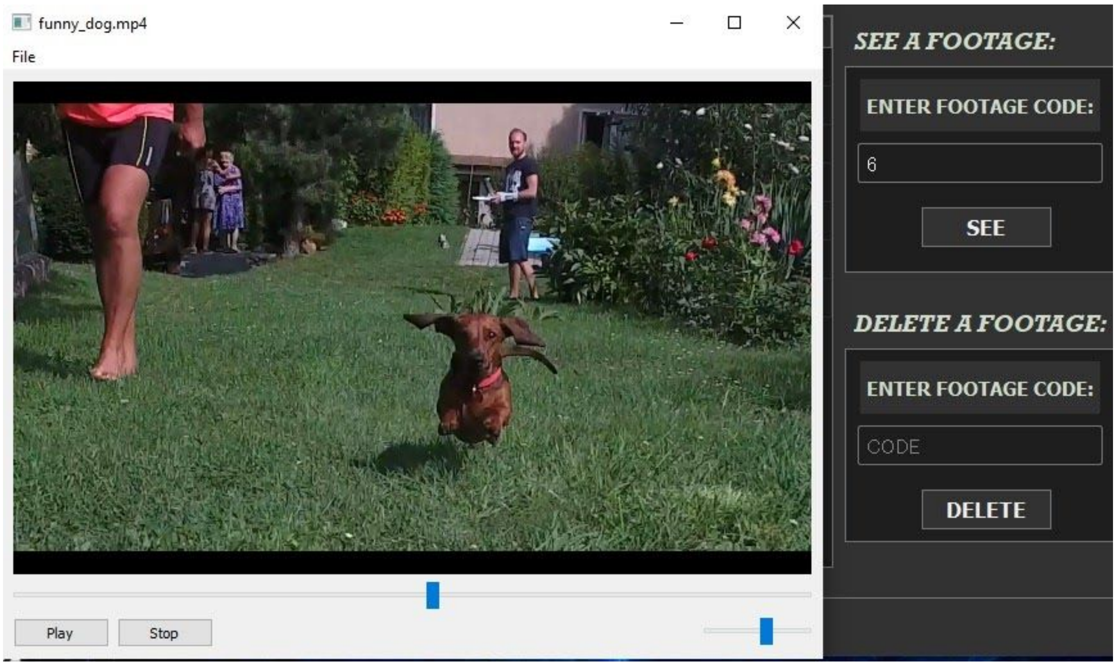


FIGURE 4.27: Viewing Archives

FIGURE 4.28: Deleting Archives using Footage ID

Path Tracker: It will show the paths traversed by various persons using multiple camera views. It hasn't been linked yet but the model is trained, and shows output separately.

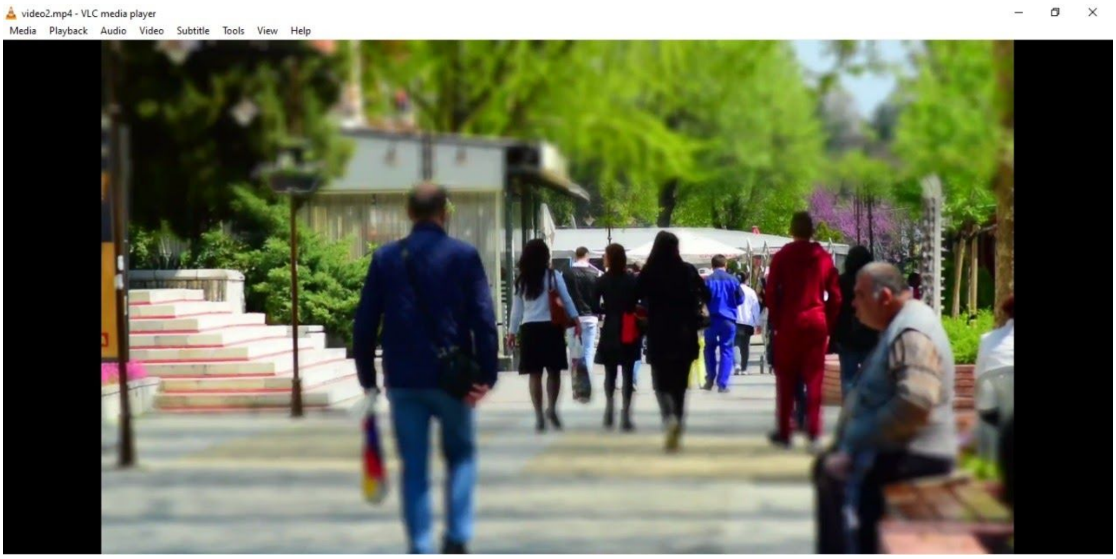


FIGURE 4.29: Input Video-1

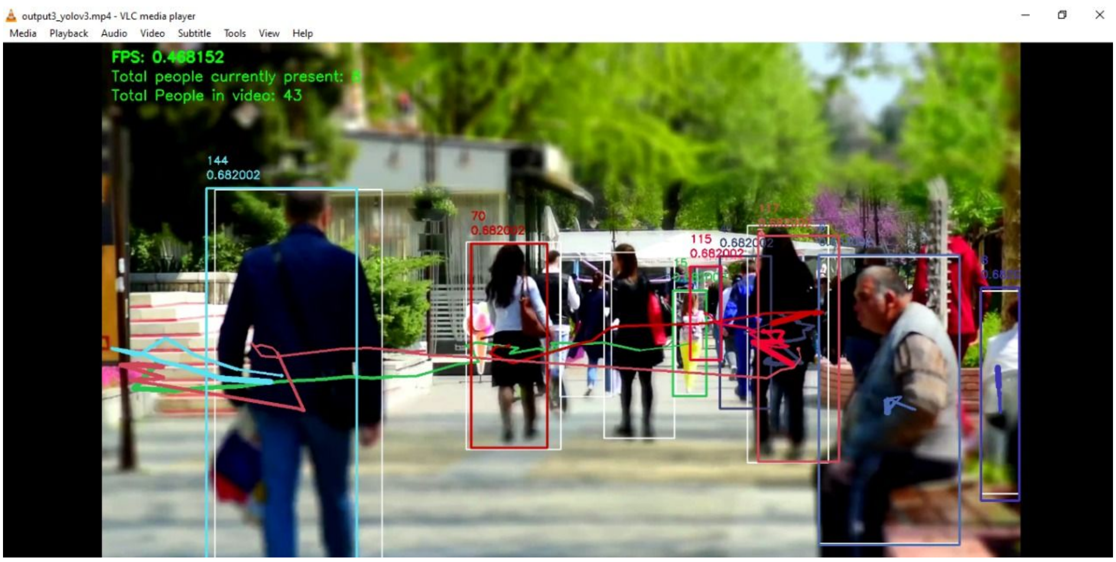


FIGURE 4.30: Output Video-1

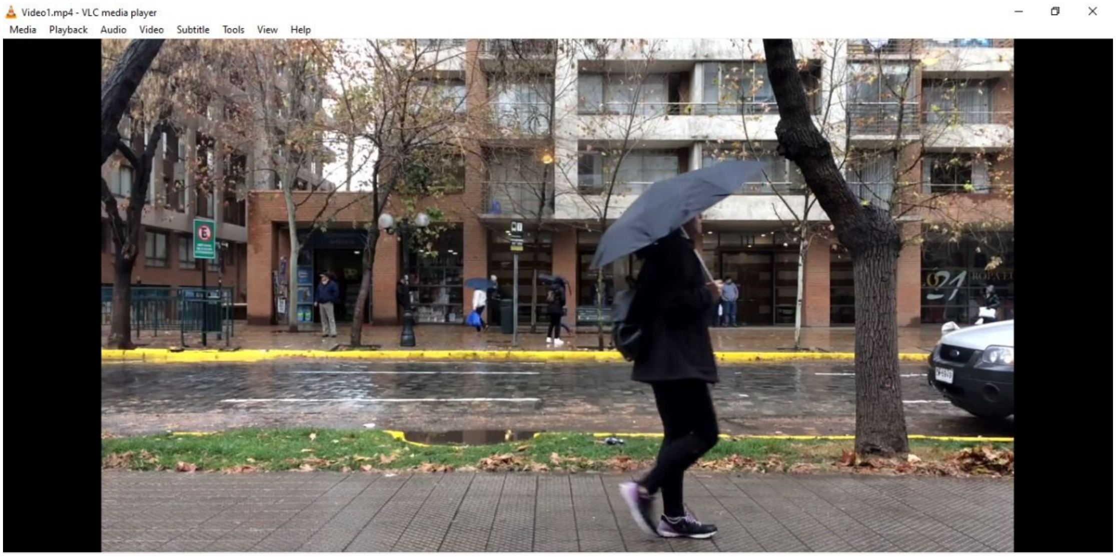


FIGURE 4.31: Input Video-2

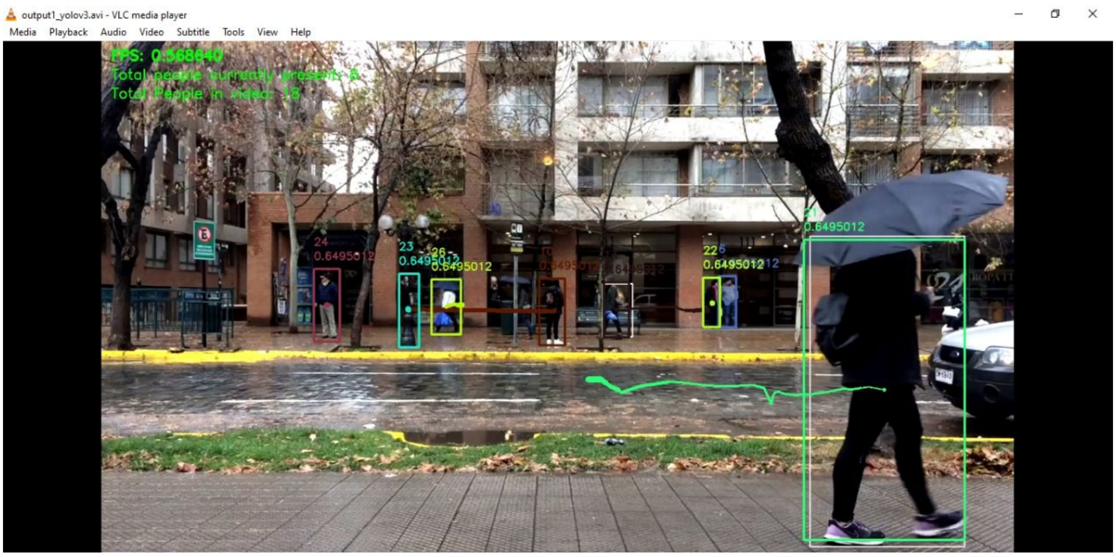


FIGURE 4.32: Output Video-2

Managing Users: Only admin screen shows this option of adding or deleting users, also to add a new user USERID should be unique only then it will create a new user and to delete the user must exist in the system.

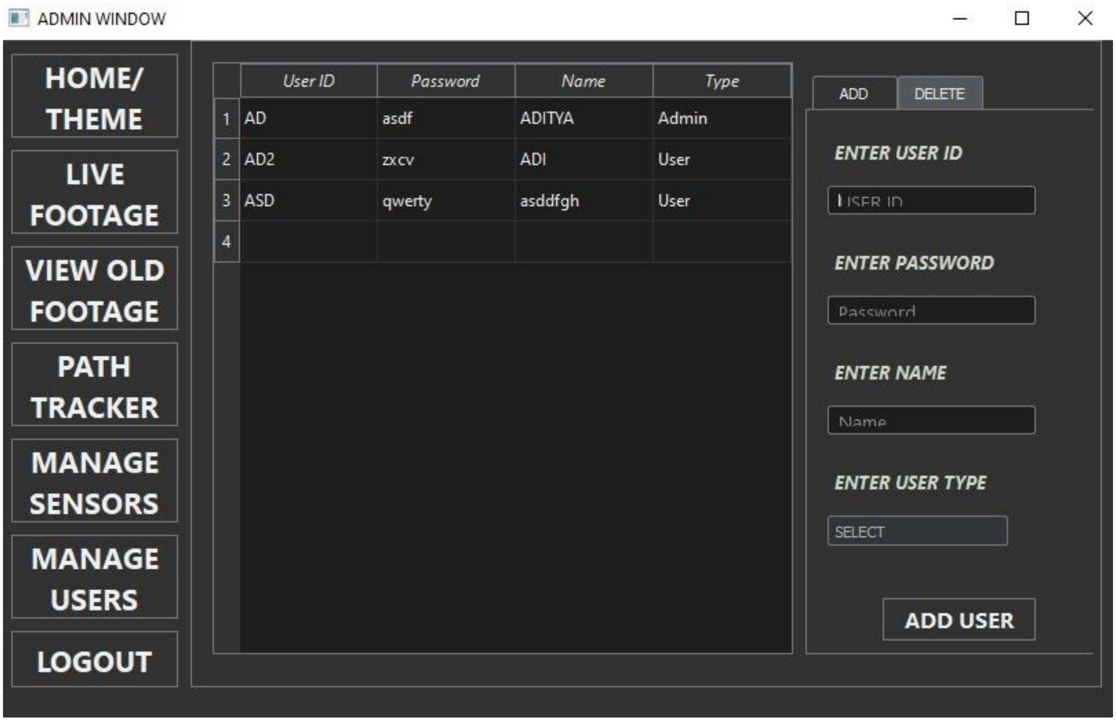


FIGURE 4.33: Managing users

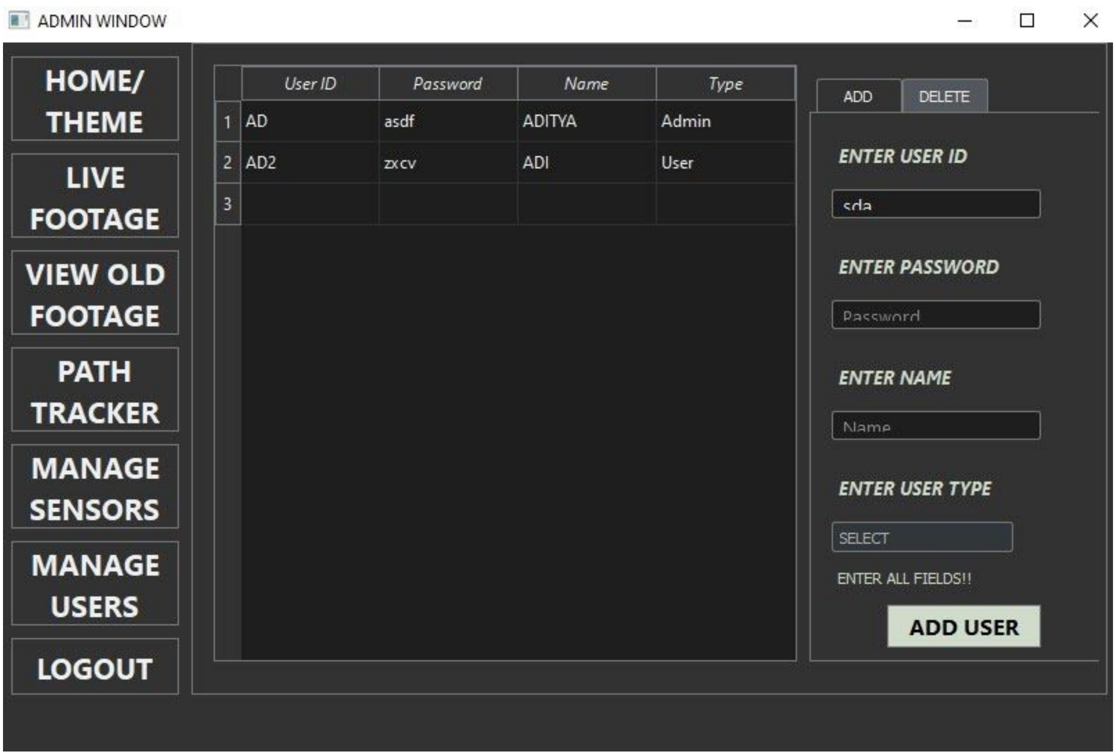


FIGURE 4.34: Adding a New User

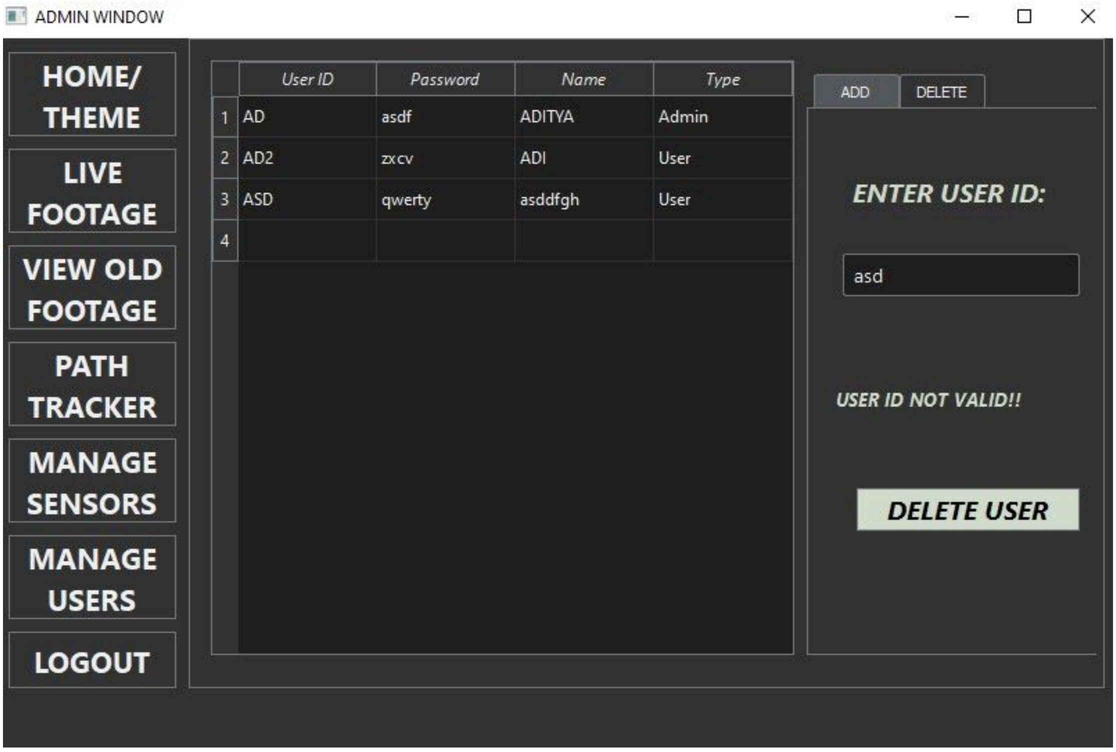


FIGURE 4.35: Deleting User

LOGOUT: It gives the user the option to logout of the account but if user says NO then he/she is directed to HOME/THEME Page.

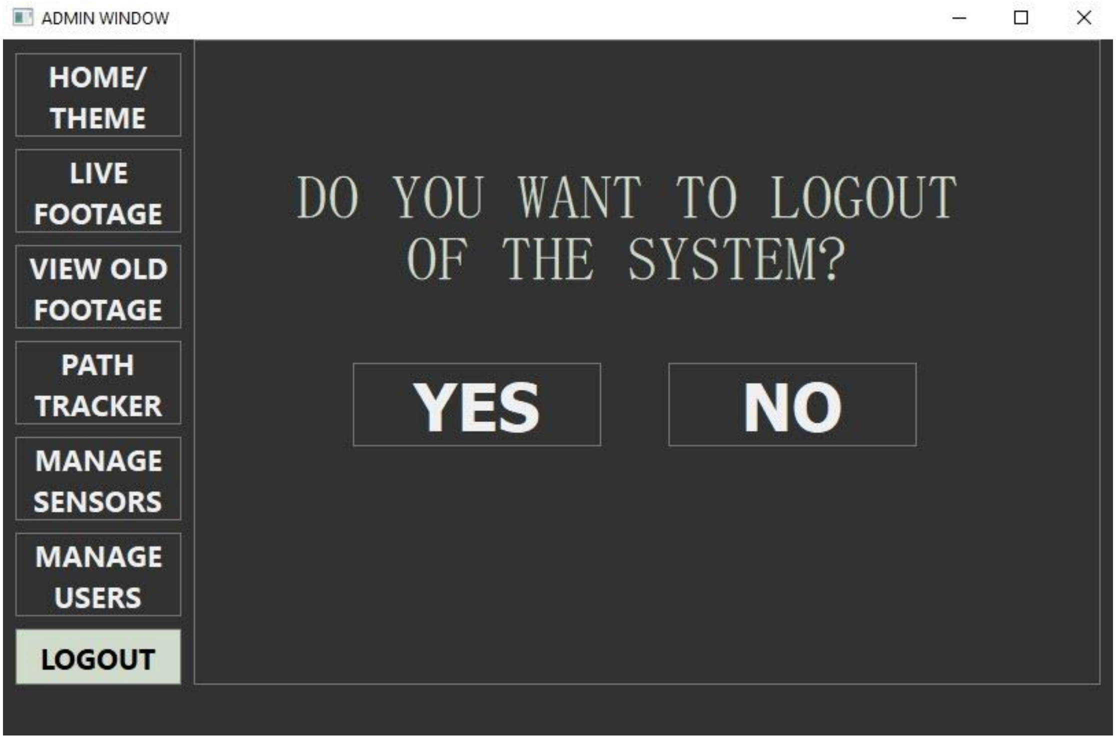


FIGURE 4.36: Logging Out

Case-2.2: User Login

User Home/Theme Page: Works similar to user home/theme page.

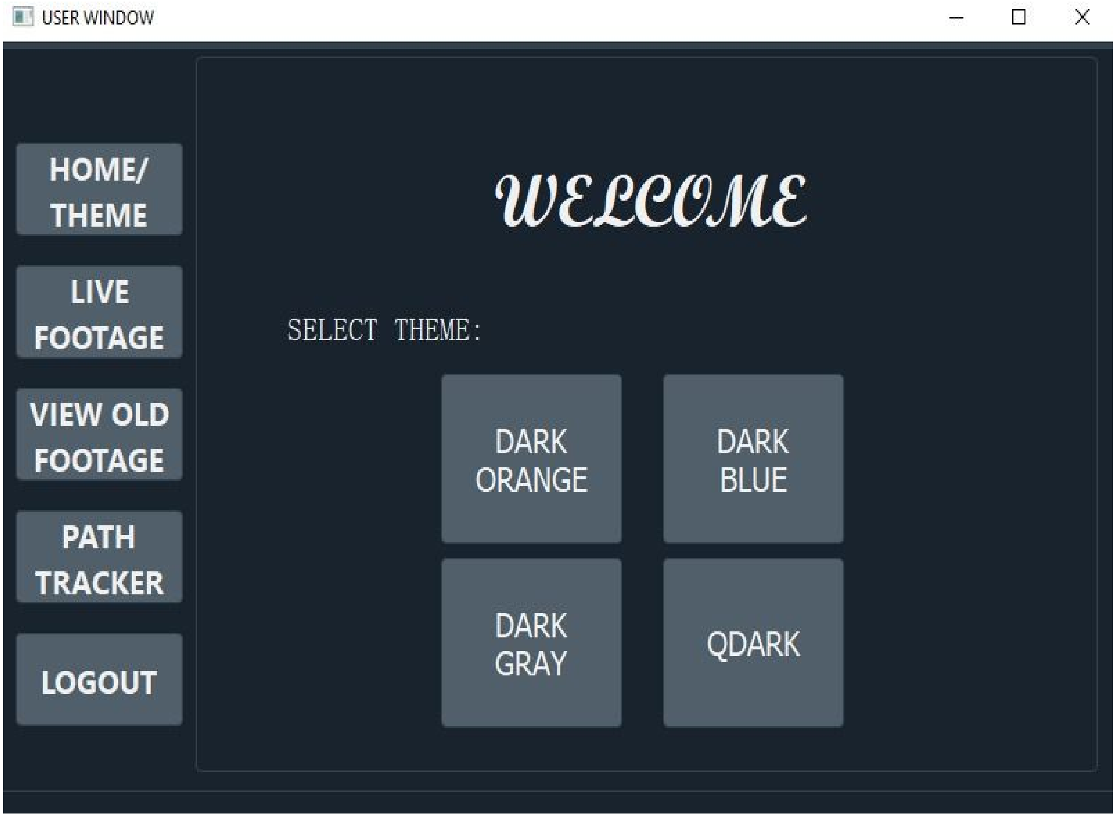


FIGURE 4.37: User Login

Live Footage: The **show button** will start recording and **stop button** will stop the recording. By selecting the camera id you will be able to view the live streaming.

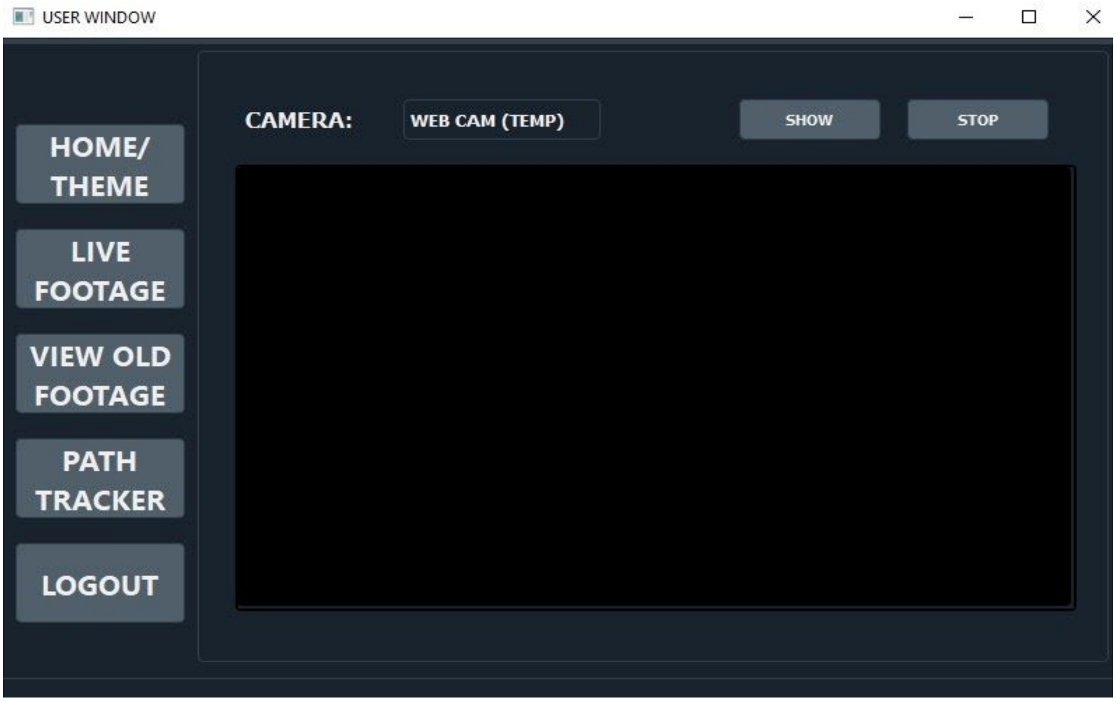


FIGURE 4.38: User Live Footage Screen

View Old Footage: It displays the record of old archives, with a search box on the right side of the screen, but no option of deleting archives as in admin is present.

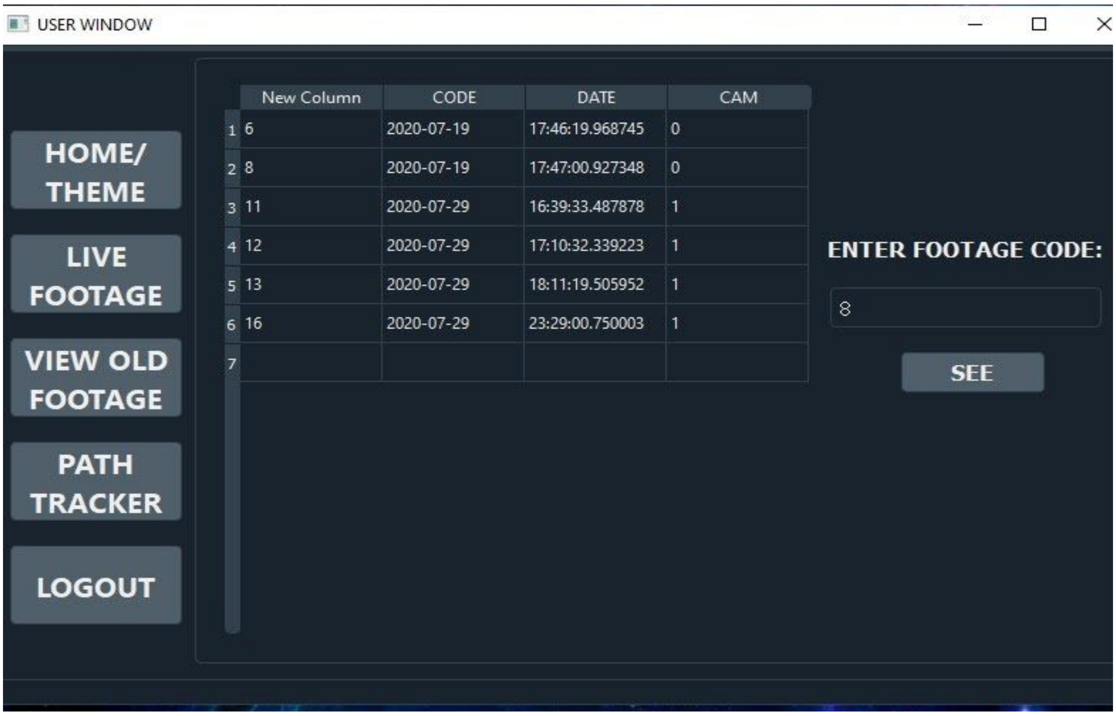


FIGURE 4.39: User Archives

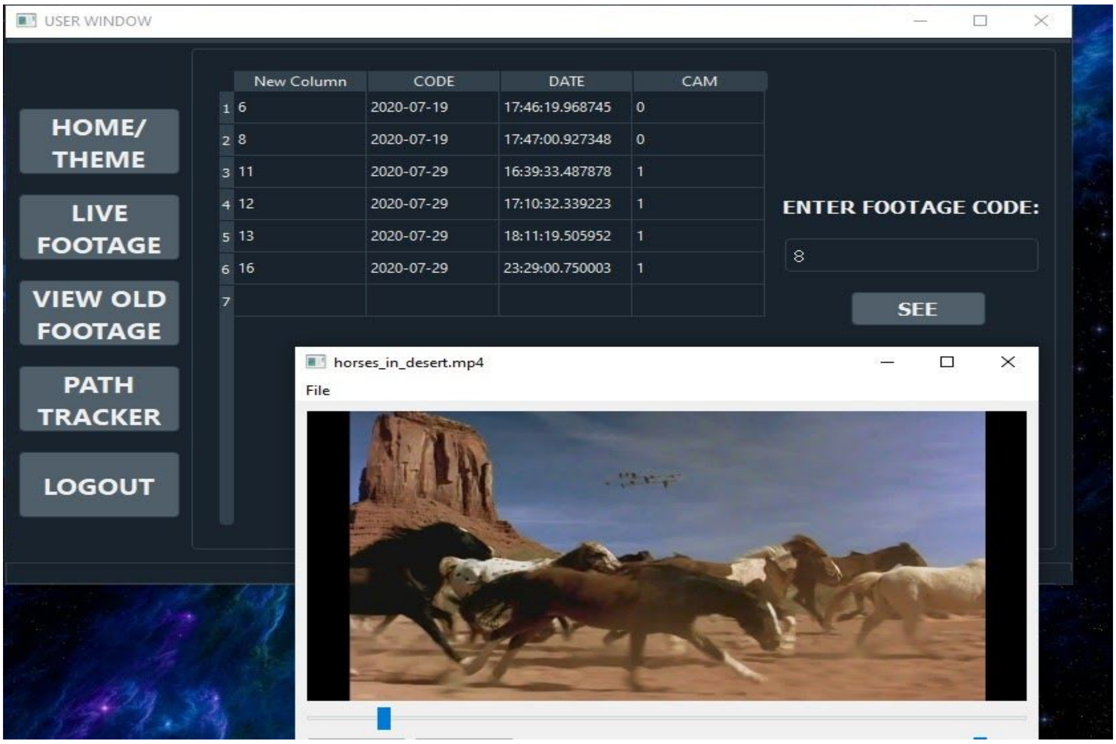


FIGURE 4.40: User Archive Search

Path Tracker: It works similar to that in the admin section.

LOGOUT:

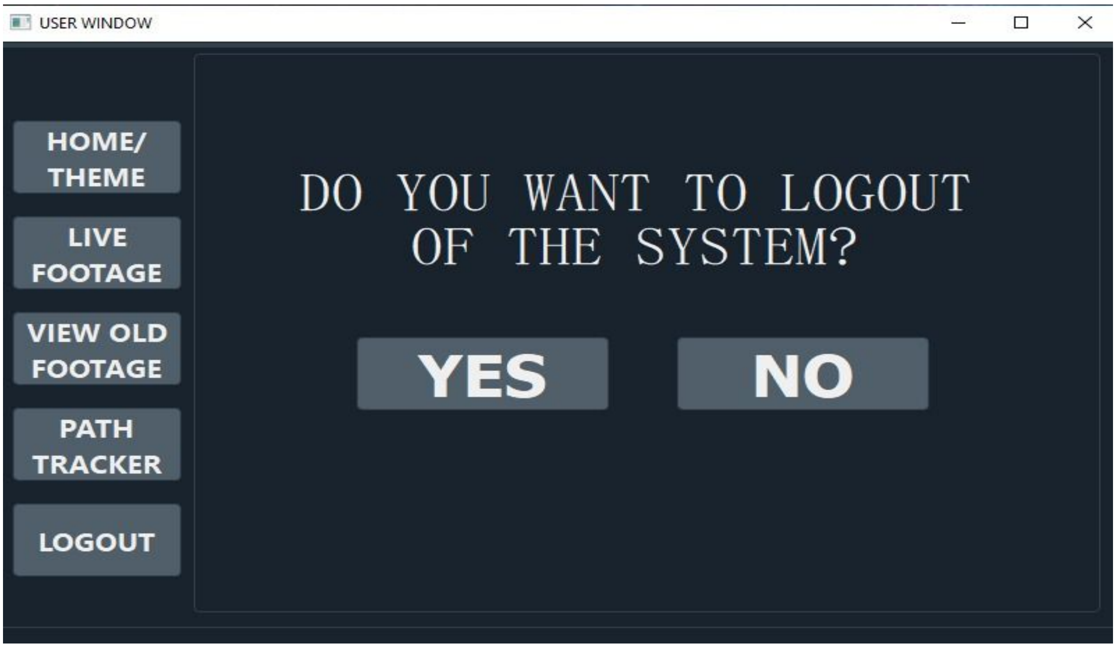


FIGURE 4.41: User Logout

CHAPTER 5: IMPLEMENTATION AND EXPERIMENTAL RESULTS

5.1 Experimental Setup

The experimental setup for this project is software intensive only, the video processes are downloaded from the internet or recorded at low level setup and the processor software is laptop only. the input feed is given to the model and it generates output video and a plot using the last 30 points is embedded onto the blueprint of the area of surveillance.

5.2 Experimental Analysis

5.2.1 Data

1. For the initial phase of the testing, we used already posted videos from the internet, which included videos of people walking, crowd videos.
2. After getting appropriate results the data was now the video captured from an experimental setup in house. These data values also provided results upto the expectations.

5.2.2 Performance Parameters

We are experimenting this Path Tracker on different test cases. There are majorly two types of test cases- basic test cases and corner test cases. The basic test cases include when the frequency of objects are at average scale, i.e. neither too many nor too less, objects appearing being captured by the camera at an instance. The corner test cases include, appearance of either too many objects or too few objects at an instance, before the camera.

5.3 Working of the Project

5.3.1 Procedural Workflow

Video recording from the CCTV cameras will be stored in a local server.

Then the snapshots of the videos will be taken. Using these snapshots we will detect no. of people in the compound and extract each person's facial details using

CNN(Convolutional Neural Networks). Then we will calculate the coordinates on which the person is seen according to the blueprint and make a path of that person. The graph obtained containing numerous paths will be embedded on the blueprint of the place and the path of that person in that particular compound will be visible to us.

5.3.2 Algorithmic Approaches Used

Step 1: Software is started.

Step 2: Software starts to analyse input coming from the local storage.

Step 3: Detects objects in the footage.

Step 4: Generates coordinates of their movements.

Step 5: Using the last 30 points/coordinates path of the object is plotted.

5.3.3 Project Deployment

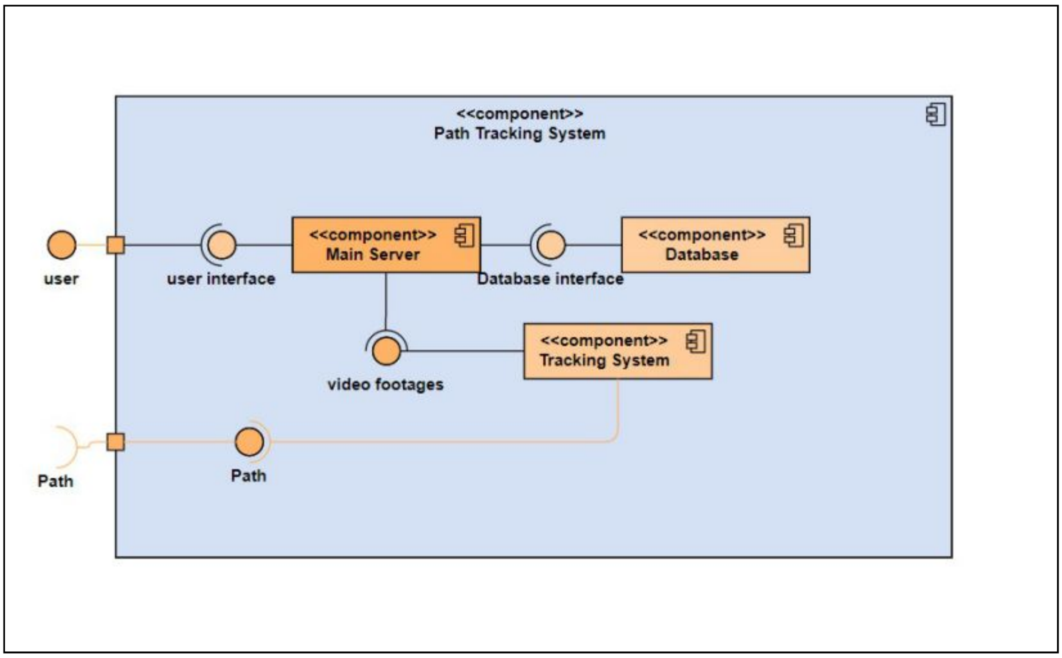


Figure 5.1: Component Diagram

5.3.4 System Screenshots

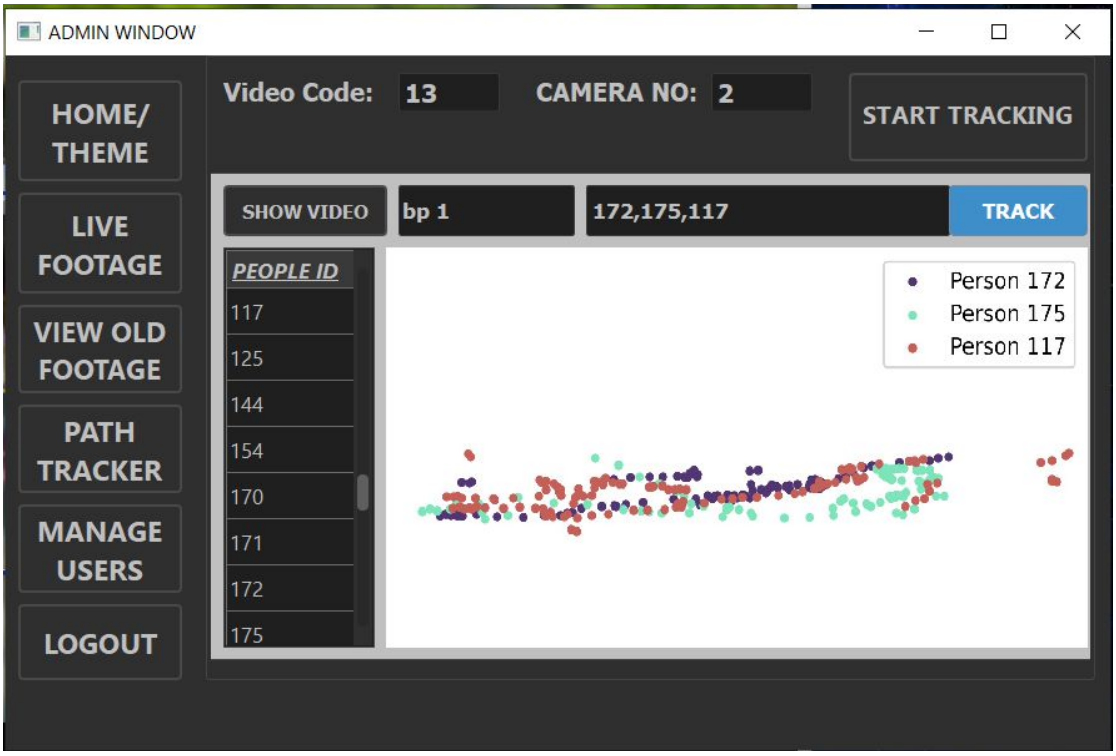


Figure 5.2: System Screenshot-1

Figure 5.3: System Screenshot-2

5.4 Testing Process

5.4.1 Test Plan

A test plan for software project is defined as a document that defines the objective, scope, emphasis and approach on a software testing effort.Components of Test plan include: Test plan id, features to be tested, test techniques, testing tasks, features pass or fail criteria, test deliverables, responsibilities, and schedule.

5.4.2 Features to be tested

- Receiving data from the hardware camera to software.
- Path Tracking algorithm.
- The path embedding on blueprint.

5.4.3 Test Strategy

Test strategy is a set of guidelines that explains test design and determines how testing needs to be done. So here we are going to test different modules of the application and check if there are any errors. If any errors are encountered, we will try to correct them with minimal changes that we can do in the project, making sure that these changes won't create any new errors.

5.4.4 Test Techniques

Unit Testing: Unit testing is a level of software testing where individual units/ components of the software are tested. The purpose is to validate that each unit of the software performs as designed. A unit is the smallest testable part of any software. It usually has one or a few inputs and usually a single output.

Modules to be tested are:

- Send Data

Send camera feed from cctv to local storage.

- Receive Data

Receive the input to path tracker from the local storage.

- Track Path

Get coordinates of the people/objects moving in the input video.

Integration Testing: Integration Testing is a level of software testing where individual units are combined and tested as a group. The purpose of this level of testing is to expose faults in the interaction between integrated units. Test drivers and test stubs are used to assist in Integration Testing.

Modules to be tested are:

● Data sharing

Test all modules under Data Sharing as a whole

● Software Services

Test all modules under App Services as a whole

● ML Algorithm Testing Test all modules under ML algorithm as a whole.

Acceptance Testing: Acceptance Testing is a level of software testing where a system
is tested for acceptability. The purpose of this test is to evaluate the system's compliance with the business requirements and assess whether it is acceptable for delivery. All modules are to be tested with real time user values.

Regression Testing: Regression Testing is a type of software testing that intends to ensure that changes (enhancements or defect fixes) to the software have not adversely affected it. The likelihood of any code change impacting functionalities that are not directly associated with the code is always there and it is essential that regression testing is conducted to make sure that fixing one thing has not broken another thing. During regression testing, new test cases are not created but previously created test cases are re-executed.

5.4.5 Test Cases

The test cases are elaborated in test report section 5.4.6.

5.4.6 Test Results

TABLE 5.1: Test Cases and Results

Test Case ID	**Scenario**	**Test Step**	**Expected Outcome**	**Actual Outcome**	**Type of testing**
T001	Check whether the tracker identifies all the objects in the footage.	Using already available videos on the internet and ran on our trained model for detection.	All the objects are identified differently.	Objects are identified differently, but some objects get missed.	Whitebox Testing
T002	Check whether path gets tracked	Using already available	Path of every object	Works as per the objectives.	Blackbox Testing

		videos on the internet and ran on our trained model for detection.	detected to be plotted then embedded on blueprint		
T003	Animals detected	Using already available videos on the internet and ran on our trained model for detection.	Yes should be detected.	Yes detected.	Whitebox Testing
T004	Check whether the selected object ids path gets traced	Using already available videos on the internet and ran on our trained model for detection.	Yes only the selected id's path to be displayed	Positive	Blackbox Testing.

5.5 Results and Discussions

Following results are achieved from the project:

- The device is successfully generating paths of all the object id selected.
- In case of some obstruction the object is identified as a new object the previous data is lost.
- The model is efficient in performance and other performance parameters also as mentioned earlier resulted in positive outcome on evaluation.
- The experimental setup of our project is easy and doesn't require much extra equipment, the major processing is performed on the user's laptop only thus the model is efficient in cost and has increased functionality as compared to other existing models.

5.6 Inferences Drawn

Our project satisfies all the basic functionality as we want but still there much to be improved and various new features must be added to make the user experience more pleasant. Moreover, with proper time, we would like this application to be built for other operating systems as well which includes Apple's IOS and various others.

5.7 Validation of Objectives

To check if the final product, satisfies all the objective of the project which were to

Table 5.2: Objectives and their validations

S.No.	Objectives	Result
1	Python subprogram for face detection, recognition and entry access denial, including areas of restricted/authorised visits.	Successful
2	Python subprogram for person detection and movement tracking, training ML models.	Successful
3	GUI design for integrating hardware data with software subprograms, online repository and server configuration; hence completing the project.	Successful

CHAPTER 6: CONCLUSIONS AND FUTURE SCOPE

6.1 Conclusions

The software is currently under development, GUI is complete with addition to 90% of functionalities.

6.2 Environmental Benefits

The product does not harm the environment in any sense, rather benefits in various areas, few described below:

1. The Person Recognition Based on Motion Behavior: This is an important application of computer vision of human identification which is based on a definite way of walking (gate).
2. Automated Surveillance through CCTV Cameras: The most widely applied area is to detect suspicious activities by monitoring the video sequences and also the unusual events.
3. Interaction of Human-Computer: The other application is gesture recognition, eye gaze tracking for corresponding data input to computers etc.
4. Traffic Monitoring through CCTV in real-time: This deals with a hard real-time application of traffic flow. The traffic video here is analyzed for gathering the current statistics of the traffic.
5. Vehicle Navigation: This is one of the interesting application areas. It deals with the problem of vehicle navigation without a driver. Path planning and obstacle avoidance can be done on the basis of video analysis.

6.3 Reflections

Various skills were enhanced by working on this project as team work, time management, decision making, multitasking etc. All these reflections from the project helped us to develop personally as well as on academic grounds.

6.4 Future Work Plan

Due to time constraints and unavailability of hardware, in future, we plan to extend the path tracing to multiple cameras. We also plan to add a sensor status interface, which is absent due to unavailability of hardware.

CHAPTER 7: PROJECT METRICS

7.1 Challenges Faced

1. Training the model was the most difficult challenge we faced, the model complexity was very high so it took quite a few days to train the model.
2. Output processing time, due to limited hardware resources the output i.e the path tracked over blueprint takes about 15-20 mins to process.
3. Challenges in visual object recognition (at the time) namely: viewpoint variation, illumination and background clutter.

7.2 Relevant Subjects

TABLE 7.1: Subject Code and Subject Name

Subject Code	Subject Name	Subject Description
UCS742	Deep Learning	Used the concepts of this subject for the path tracking module.
UCS615	Image Processing	Used image processing to detect humans in the video.
UCS503	Software Engineering	Used the concepts of Software Engineering for requirement analysis, designing, testing and planning for the project.
UML501	Machine Learning	Used the concepts of this subject for the path tracking module.

7.3 Interdisciplinary Knowledge Sharing

In this project, we have used the principles of database managing to build a database which contains the personal information of all the users, in order for them to login and view various security aspects. For the low level implementation, we used Sqlite3. For front end implementation we used python qtDesigner, and for the backend hard-coded python scripts on pyqt5.

7.4 Peer Assessment Matrix

Peer Assessment is a way to involve students in the evaluation process and students to lay out their views about their peers. A score out of 5 is allocated by a team member to the rest of the embers of the team in the table given below:

TABLE 7.2 :Peer Assessment Matrix

		Evaluation of		
		Aditya Thakur	Aditya Vashista	Akriti Sehgal
Evaluation by	Aditya Thakur	-	5	5
	Aditya Vashista	5	-	5
	Akriti Sehgal	5	5	-

7.5 Role Playing and Work Schedule

Aditya Thakur: Creation and Integration of Path Tracking Module, UML Diagrams, Poster.

Aditya Vashista: GUI, Creation and Integration of Path Tracking Module, Testing

Akriti Sehgal: GUI, Research, Documentation, Testing.

Figure 7.1: Group Gantt chart

7.6 Student Outcomes Description and Performance Indicators (A-K Mapping)

TABLE 7.3: Student Outcomes

SO	Description	Outcome
A2	Applying basic principles of science towards solving engineering problems.	Applied basic principles of science for solving engineering problems.
A3	Applying engineering techniques for solving	Used the concept of

	computing problems.	neural networks and machine learning for path tracking.
B1	Identify the constraints, assumptions and models for the problems.	Stated the constraints, assumptions and models.
B2	Use appropriate methods, tools and techniques for data collection.	Collected data using appropriate techniques.
B3	Analyze and interpret results with respect to assumptions, constraints and theory.	Analyzed and interpreted the results with respect to assumptions, constraints and theory.
C1	Design software system to address desired needs in different problem domains.	Designed the specified software system to fit the needs.
C2	Can understand scope and constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability.	Designed the system such that all the constraints were taken care of.
D1	Fulfill assigned responsibility in multidisciplinary teams.	Built the desired modules in separate teams.
D2	Can play different roles as a team player.	Played different roles as a team player.
E1	Identify engineering problems.	Clearly identified the engineering problems such as hand gesture and voice command recognition and interfacing.
E2	Develop appropriate models to formulate solutions.	Formulated practical solutions for the desired problems.
E3	Use analytical and computational methods to obtain solutions.	Yes, we were able to obtain solution by using experimental investigative technique and analysis.
F1	Showcase professional responsibility while interacting with peers and professional communities.	Showed professional responsibility while interacting with others.
F2	Able to evaluate the ethical dimensions of a problem.	Yes, our problem identified was ethical as it helped those who need our utmost care and support.

G1	Produce a variety of documents such as laboratory or project reports using appropriate formats.	Produced the required documentation.
G2	Deliver well-organized and effective oral presentation.	Delivered effective oral presentations.
H1	Aware of environmental and societal impact of engineering solutions.	Yes, our project was developed by considering both the aspects.
I1	Able to explore and utilize resources to enhance self-learning.	Yes, we were able to achieve it by team coordination and interdisciplinary knowledge gathering.
I2	Recognize the importance of life-long learning.	Yes, it is our major learning from capstone project.
J1	Comprehend the importance of contemporary issues.	Yes , we reviewed a variety of issues for our project development and it made us more aware of such issues.
K1	Write code in different programming languages.	Wrote codes in different languages and platforms.
K2	Apply different data structures and algorithmic techniques.	Applied different techniques studies in our course.
K3	Use software tools necessary for computer engineering domain	Applied and used the different software tools necessary.

7.7 Brief Analytical Assessment

Q1. What sources of information did your team explore to arrive at the list of possible Project Problems?

Ans: The group was aware of the understanding of the Capstone requirement and some of the problems that needed to be explored. We explored the literature, mostly journals and magazines from various organizations. Some part of the internet also played a part in arriving at the list of possible project problems.

Q2. What analytical, computational and/or experimental methods did your project team use to obtain solutions to the problems in the project?

Ans: Our project was divided into three parts consisting of building the path tracking module, the GUI and the integration of model and GUI. We used deep learning and machine learning techniques for the path tracker.

Q3. Did the project demand demonstration of knowledge of fundamentals, scientific and/or engineering principles? If yes, how did you apply?

Ans: We used quite a lot of engineering subjects. Deep Learning, Machine Learning and Image Processing were used in building the path tracking module. Software Engineering for the research, formulation and documentation of the solution.

Q4. How did your team share responsibility and communicate the information of schedule with others in the team to coordinate design and manufacturing dependencies?

Ans: Our team consisted of three members. We divided the project into subtasks, each

individual carrying out specific tasks and helping out each in the processes. Information was communicated via mails and face to face virtual meetings.

Q5. What resources did you use to learn new materials not taught in class for the course of the project?

Ans: We took online tutorials and online courses. Moreover we read through various blogs and guides to learn the new concepts.

Q6. Does the project make you appreciate the need to solve problems in real life using engineering and could the project development make you proficient with software development tools and environments?

Ans: Our project was built to make security surveillance easier by reducing their workload. Working on this project made us appreciate the need to solve real life problems using engineering. This project taught us a lot about new technologies and software engineering thereby making us proficient in the same.

APPENDIX A: REFERENCES

[1] Hussein, Mohamed & Abd-Almageed, W. & Ran, Yang & Davis, Larry. (2006). Real-Time Human Detection, Tracking, and Verification in Uncontrolled Camera Motion Environments. Proceedings of the Fourth IEEE International Conference on Computer Vision Systems, ICVS'06. 2006. 41- 41. 10.1109/ICVS.2006.52.

[2] M. Hussein, W. Abd-Almageed, Yang Ran and L. Davis, "Real-Time Human Detection, Tracking, and Verification in Uncontrolled Camera Motion Environments," Fourth IEEE International Conference on Computer Vision Systems (ICVS'06), New York, NY, USA, 2006, pp. 41-41, doi: 10.1109/ICVS.2006.52.

[3] Ozturk, Ovgu, Tomoaki Matsunami, Yasuhiro Suzuki, Toshihiko Yamasaki and Kiyoharu Aizawa. “Real-time tracking of humans and visualization of their future footsteps in public indoor environments.” *Multimedia Tools and Applications* 59 (2010): 65-88.

[4] Zhou, Yan & Zlatanova, Sisi & Wang, Zhe & Zhang, Yeting & Liu, Liu. (2016). MOVING HUMAN PATH TRACKING BASED ON VIDEO SURVEILLANCE IN 3D INDOOR SCENARIOS. ISPRS Annals of Photogrammetry, Remote Sensing and Spatial Information Sciences. III-4. 97-101. 10.5194/isprsannals-III-4-97-2016.

[5] A. K. S. Kushwaha, C. M. Sharma, M. Khare, R. K. Srivastava and A. Khare, "Automatic multiple human detection and tracking for visual surveillance system," 2012 International Conference on Informatics, Electronics & Vision (ICIEV), Dhaka, 2012, pp. 326-331, doi: 10.1109/ICIEV.2012.6317384.

[6] Al-Najdawi, Nijad & Tedmori, Sara & Edirisinghe, Eran & Bez, Helmut. (2012). An Automated Real-Time People Tracking System Based on KLT Features Detection. International Arab Journal of Information Technology. 9. 100-107.

[7] K. S. Kumar, S. Prasad, P. K. Saroj and R. C. Tripathi, "Multiple Cameras Using Real Time Object Tracking for Surveillance and Security System," 2010 3rd International Conference on Emerging Trends in Engineering and Technology, Goa, 2010, pp. 213-218, doi: 10.1109/ICETET.2010.30.

[8] W. Niu, L. Jiao, D. Han and Y. -. Wang, "Real-time multiperson tracking in video surveillance," Fourth International Conference on Information, Communications and Signal Processing, 2003 and the Fourth Pacific Rim Conference on Multimedia. Proceedings of the 2003 Joint, Singapore, 2003, pp. 1144-1148 vol.2, doi: 10.1109/ICICS.2003.1292639.

[9] Acharya, Debaditya & Khoshelham, Kourosh & Winter, Stephan. (2017). Real-time detection and tracking of pedestrians in CCTV images using a deep convolutional neural network.

[10] Various github repositories studied for reference:

DEBOJYOTI11/Automated-CCTV-surveillance: Using FaceRecognition to solve track indiviuals in CCTV footage., https://github.com/frozenparadox99/Tracker, ITCoders/Human-detection-and-Tracking: Human-detection-and-Tracking

APPENDIX B: PLAGIARISM REPORT

URKUND

Document Information

Analyzed document	RPG-136 fianl eval.pdf (D90539251)
Submitted	12/23/2020 1:18:00 PM
Submitted by	Jhilik
Submitter email	jhilik@thapar.edu
Similarity	8%
Analysis address	jhilik.thapar@analysis.urkund.com

Link to complete Plagiarism Report:

https://drive.google.com/file/d/1owWSbM35X7g_sKOPW9mz9Pk-mjSomxH2/view?usp=sharing