TED UNIVERSITY

Faculty of Engineering

Department of Computer Engineering

CMPE 491

WorkerSecure

Project Analysis Report

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1. Introduction

In industrial environments, ensuring safety of workers has high importance. The project, **WorkerSecure**, aims to detect workers who do not wear necessary equipment such as helmets from camera footages by using image processing techniques. It will also include a real time alert system to notify personnel.

The project includes machine learning models and computer vision algorithms. It will be trained on different datasets to ensure adaptability. The system also provides timely alerts, enabling necessary actions to be taken.

This report shall provide an overview of the project and make the process clearer for the team and the customers.

2. Proposed System

2.1. Overview

The system has three main components to consider: A user interface for monitoring and administration, a module where image processing takes place and, the warning system to warn the workers immediately if any violation is detected. The detailed examination of all three components are as follows:

1. User Interface: The system needs a user interface to make the monitoring process easier. This user interface will be accessible to authorized personal only to prevent any privacy issue might occur. The interface provides real time monitoring of the live streaming from cameras placed around the working place. Therefore, it allows real time detections and a record of detected violations. Additionally, the user interface allows disabling or raising alarms in some cases if needed.

2. Module for Image Processing: This module is the base structure that makes the system functional. The system will rely object detection on YOLO (You look only once) architecture to specifically train and make recognitions to detect helmet-wearing workers and not wearing workers. This is because the ability of YOLO allows to perform object detection in at once with high accuracy and speed. YOLO model is trained with the specialized appropriate data sets from Kaggle to provide appropriate results of workers wearing work safety equipment in various environmental conditions.

To guarantee the system's reliability and accuracy, it must be ensured to optimize the system as much as possible. This optimization is crucial for performing under various settings such as lightning conditions and distances of workers from the cameras with as few errors as possible.

Also, the model will continuously capture data from the cameras and, after that it will process each frame using the pre-trained CNNs to detect if any violation is present.

3. Warning System: The image processing module will make detection of anomalies available to the user in the user interface and then, the system will trigger the warning system immediately in case of any violation is detected. After that, the warning system will warn the worker through alarms either visually or audibly. Additionally, the name of the workers caught violating rules might be stored in the database, if possible.

This section of the report provides information about its functional, non-functional, and pseudo requirements. After highlighting the requirements, some models are provided to create a better understanding of the system and to visualize it.

2.2. Functional Requirements

1. **Switching Between Recordings:** The user should be able to switch between different camera recordings. To do this, users can click on the "Surveillance Analysis" button from the website and then click on the "Switch to:" button.

2. **Contact**: The users should be able to contact out website for us to access their surveillance information. The users can contact using the contact button on the navigation bar from the website.

3. **Alarm**: Workers detected on camera who is not wearing a hard hat should be warned instantly or their names should be stored in the database. They can change its setting by clicking on the "Alarm Settings" button from the navigation bar.

4. **Detailed View**: The user should be able to use zoom and taking screenshot while watching camera recordings. They can perform zooming in and out by clicking on the Surveillance Analysis button from the navigation bar, and then they should click on "-"and "+" buttons right below the surveillance videos.

5. **Camera Locations**: The user should know what camera is from what part of the factory. They can see this by clicking on the Surveillance Analysis button from the navigation bar, and then they should see the information right next to the surveillance videos.

6. **Search Option**: Users should be able to search and filter the camera recordings based on date, time, location, and detected violations. They can do this clicking on the Surveillance Analysis button from the navigation bar, and then they should click on "Further Settings" button in the page.

2.3. Non-Functional Requirements

1. **Performance**: It is expected that the system will discover safety vulnerabilities in the workplace in real-time then t provides a short processing time for video analysis for presenting to staff. The goal is to deliver results quickly in the event of a safety incident. A safety monitoring system depends on its real-time detection performance.

2. **Accuracy**: Our helmet detection needs to have high accuracy. The number of false positives and false negatives must be reduced This means that people wearing helmets and people that are not wearing helmets must be identified in a definite manner. A properly working safety monitoring system depends on the accuracy.

3. **Reliability**: Requiring constant and dependable functioning, system's reliability must be guaranteed for extended periods of time. It is also expected that the system will function without interruption, and it will continue to be a main precaution for workplace safety. This should be achieved by operating continuously for extended periods of time without giving up on precision.

4. **Adaptability**: The design of the user interface should be easy to use, simple software management with simple interface should be prioritized. To make sure that staff can easily use the system, it must also have an intuitive user interface. The aim is to enhance general usability and minimize the learning curve for administrators by ensuring effective engagement with the system.

5. **Responsiveness**: Responsiveness is crucial for making sure that the system notifies safety violations through intended ways. The system's responsiveness is measured by its ability to deliver punctual notifications to staff in case of safety vulnerabilities. Achieving acceptable response times is a must for a workplace safety management.

2.4. Pseudo Requirements

1. **Immediate Alert System**: The system should be able to alert the worker immediately if any violation is detected through alarms.

2. **Safety Equipment Detecting System**: The system should be designed in a way that it can detect violations of equipment (like not wearing helmets) in the working environment. Additionally, the system should be able to detect various styles of helmets in order to not confuse them with other objects in the same colour or same shape and produce false results.

3. **Cannot Be Compatible with Wearable Devices**: The system should avoid providing wearable technology for the tracking, detecting, and warning processes to avoid privacy concerns of workers.

4. **No Training System**: The system should not include a worker training education to reduce the violations since the aim is to detect violations and warn the workers in real-time

rather than trying to minimize those violations with educating. Instead, the training might be accessible from an external system designed for workers by the factory.

5. **Works On Specific Devices**: The system should not aim to work on every device like smartphones, tablets, personal computers to be adaptable. Instead, it shall work on specific devices for safety purposes.

6. **Performance and Reliability**: The system should be designed to provide high performance including the real-time capabilities. Additionally, they system should be able to handle different environmental conditions such as detecting violations from various distances and performing well in different lighting settings.

2.5. System Models

2.5.1. Scenarios

Worker Safety Monitoring: This system actively observes construction site workers to ensure their compliance with safety regulations; specifically, the wearing of appropriate gear such as hardhats.
Identify workers and alert managers to instances where employees are not wearing the appropriate safety gear, thereby enhancing safety.

Day-Night Transition: The system actively adapts to varying levels of lighting at the work site during both day and night; this represents a situation.

Ensure the system's capability to accurately detect and identify objects across diverse lighting conditions: this is imperative.

Scalability Test: This scenario exemplifıes the process of enhancing system functionality by integrating additional cameras; this measure aims to effectively cover an extended area within a construction site.

The system's capacity must undergo evaluation and optimization to accommodate the management of growing data loads; moreover, it needs to sustain real-time processing from several cameras.

High Traffic Volume: The construction site system, must not only observe & evaluate the significant foot traffic it receives, but also manage the additional workload induced by this high volume.

Analyze the system's efficiency in high--traffic situations; maintain a steadfast commitment to accuracy.

System Updates: In this scenario, the latest model improvements necessitate a system update to ensure enhanced accuracy and reliability; it is imperative for optımal performence that these upgrades are implemented-a critical step towards maintaining peak operational efficiency.

Design a user-friendly update procedure: one that minimizes downtime; simultaneously maintains the system's currency and safety.

Hardware Failover: When a system hardware component fails, and a failover solution is required to keep the system operating without an interruption.
Use failover and redundancy techniques to reduce system downtime in the event of hardware breakdowns.

Alert Handling: A situation where security staff members are required to react as fast as possible for the possible security incidents and get alerts in real-time.

Streamline the alerting process for enabling quick and effective responses to security events.

2.5.2. Use Case Model

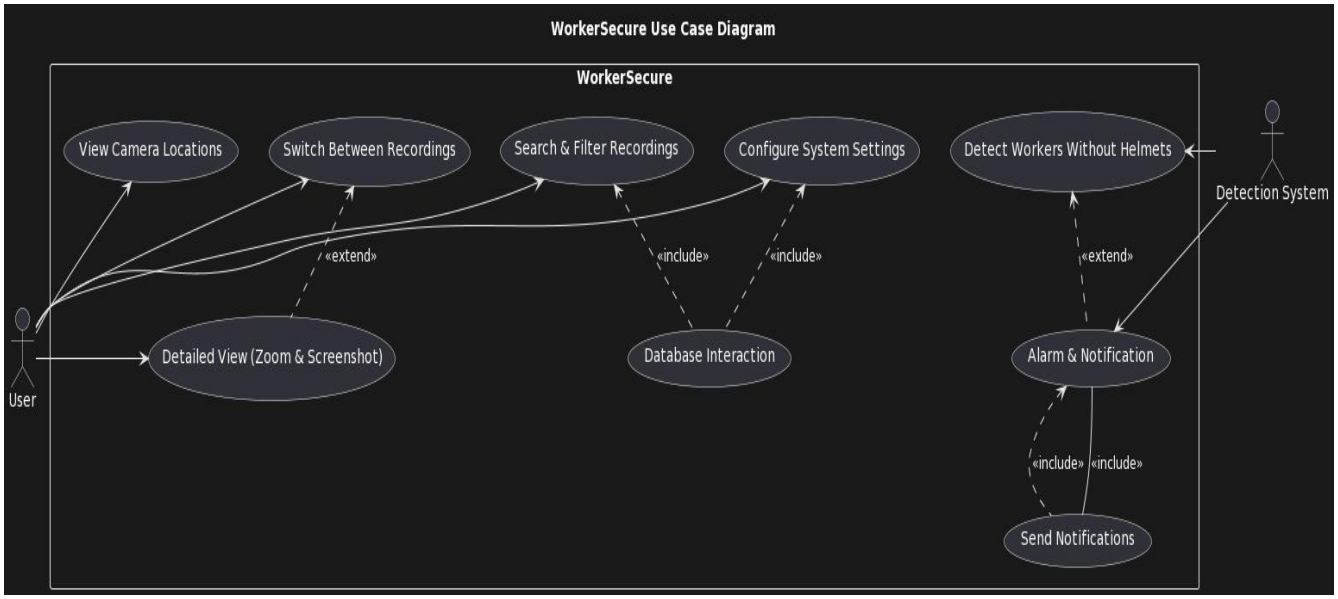

Figure 1: Use Case Diagram for WorkerSecure

2.5.3. Object and Class Model

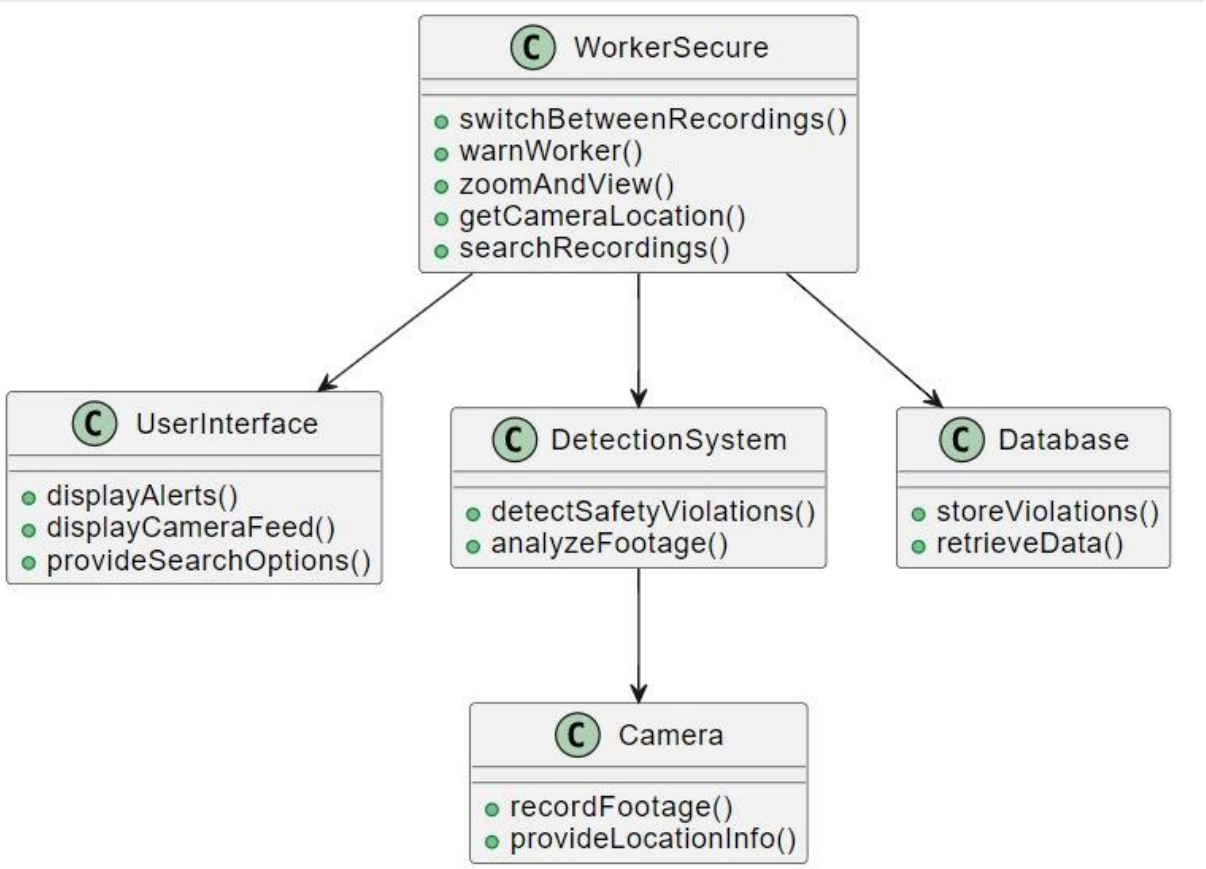

Figure 2: Object and Class Model for WorkerSecure

2.5.4. Dynamic Models

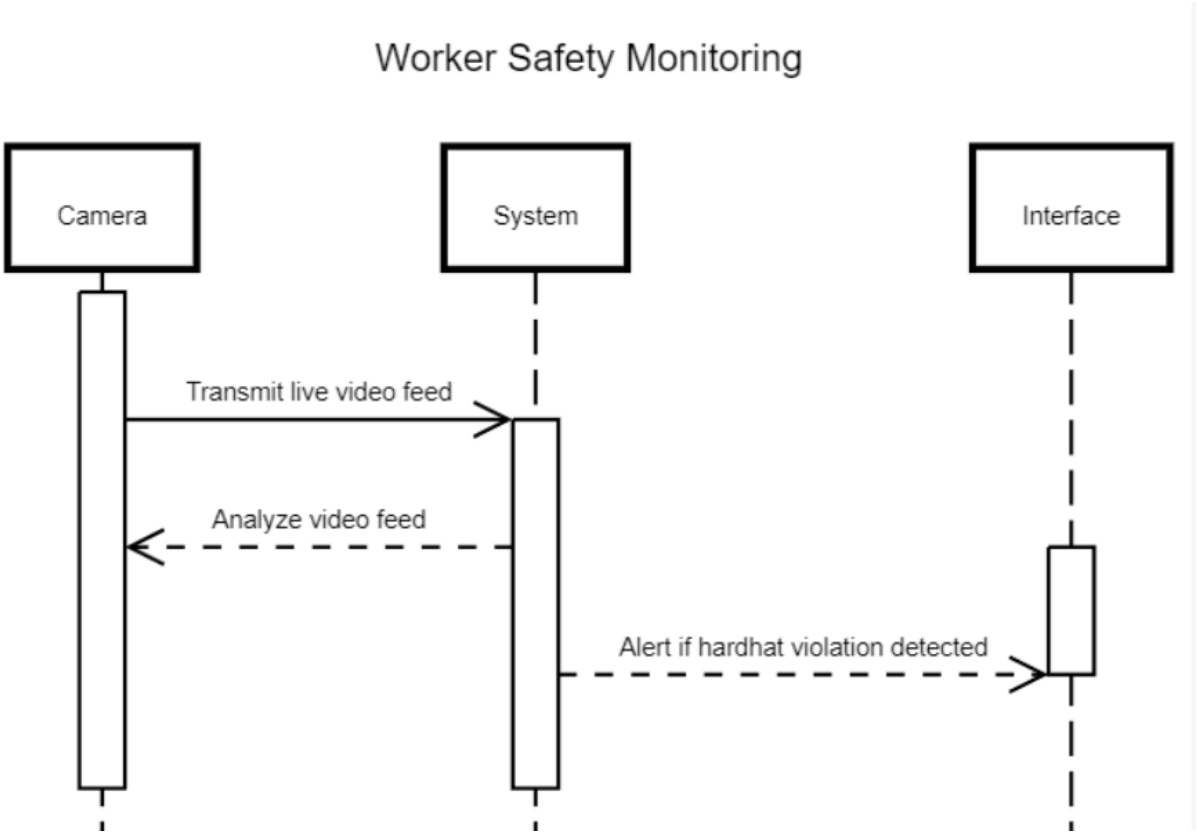

Figure 3: Worker Safety Monitoring Model

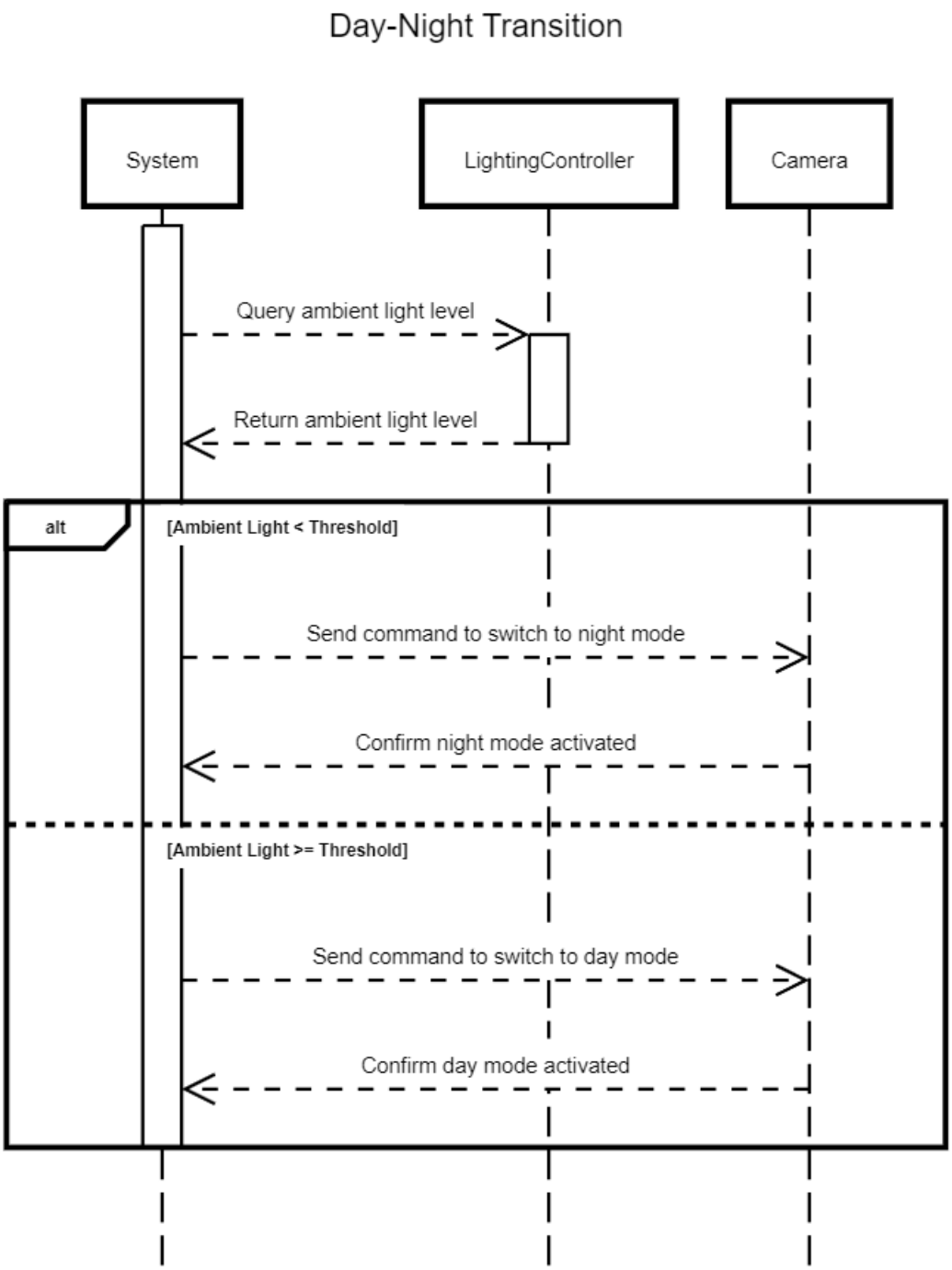

Figure 4: Day-Night Transition Model

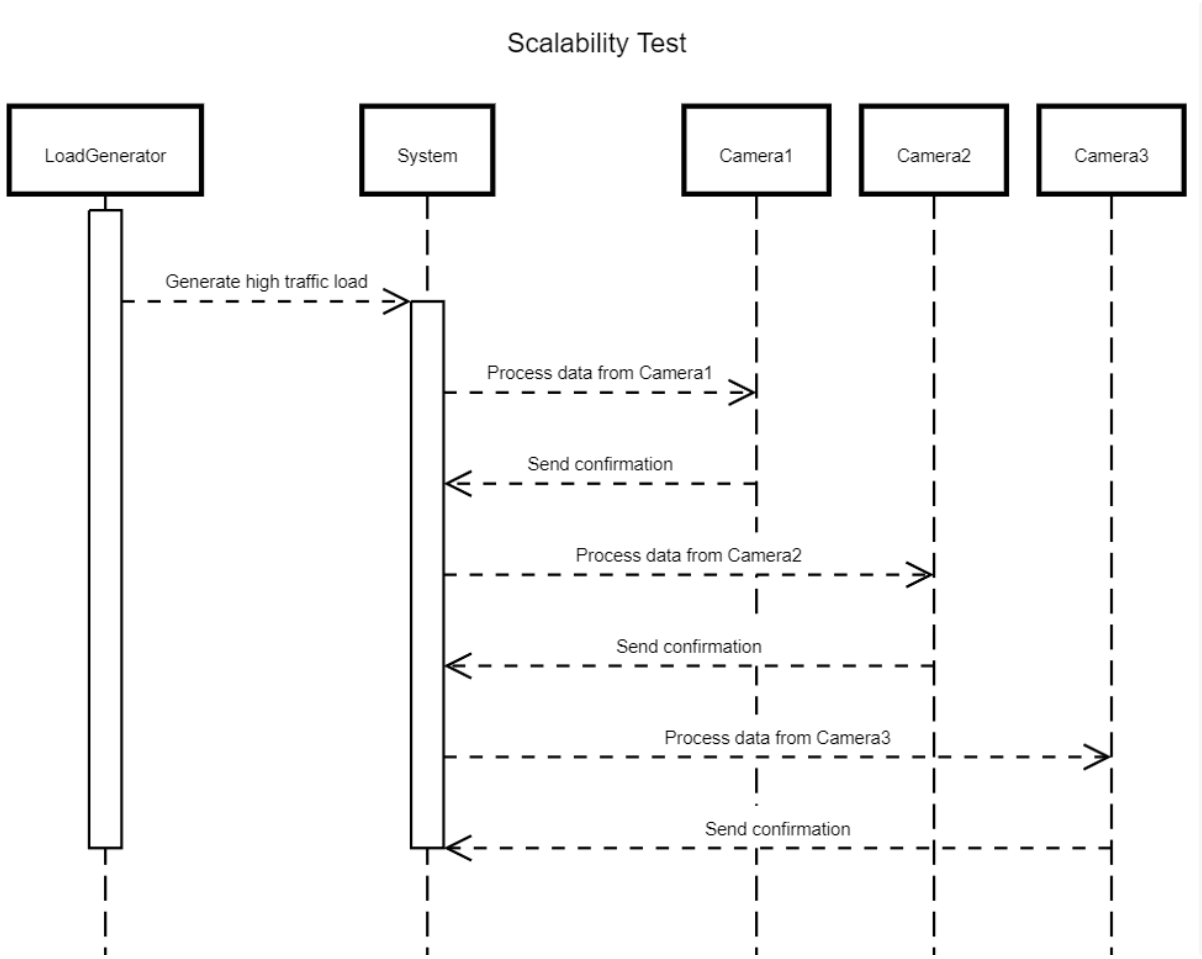

Figure 5: Scalability Test Model

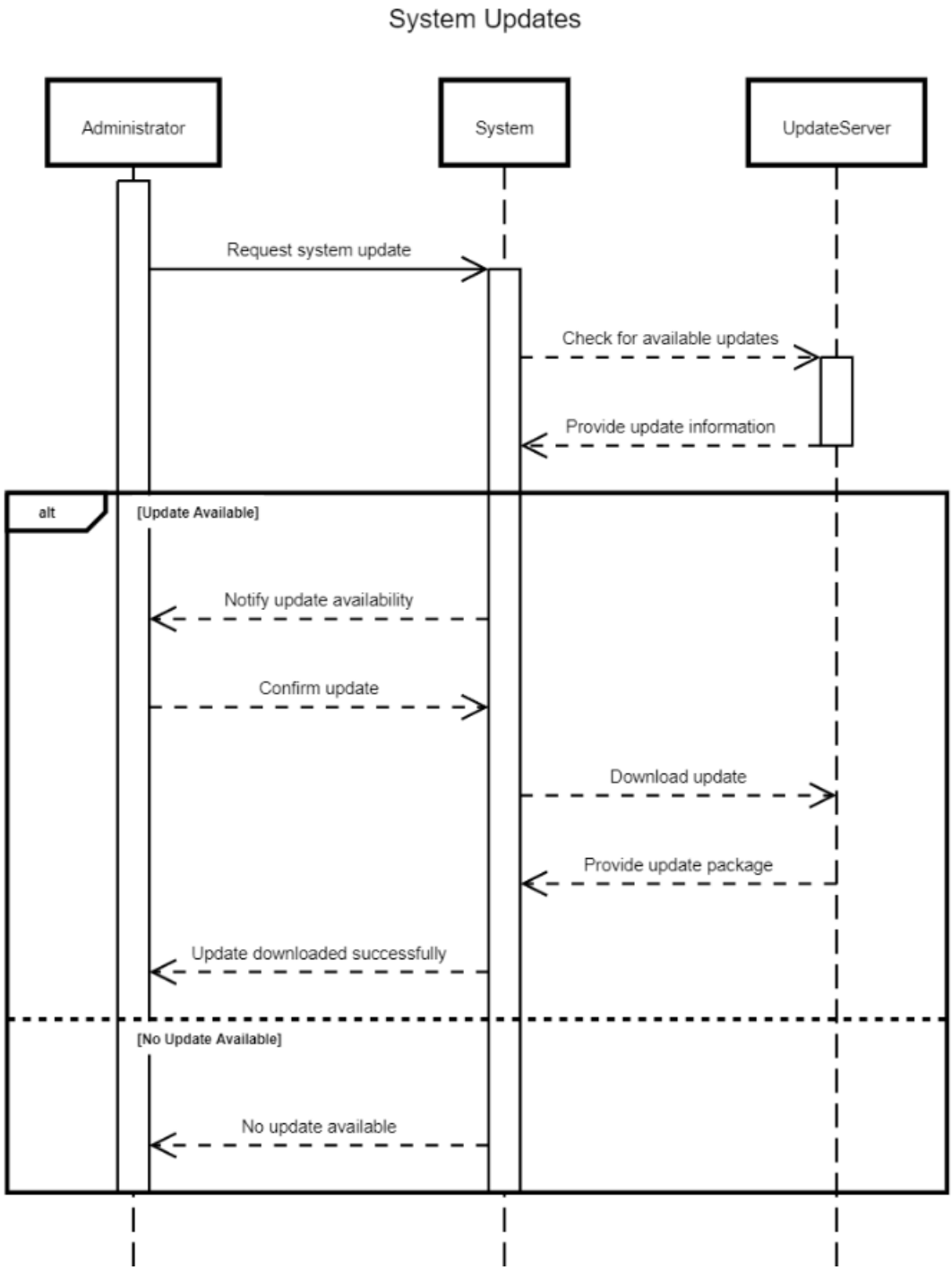

Figure 6: System Updates Model

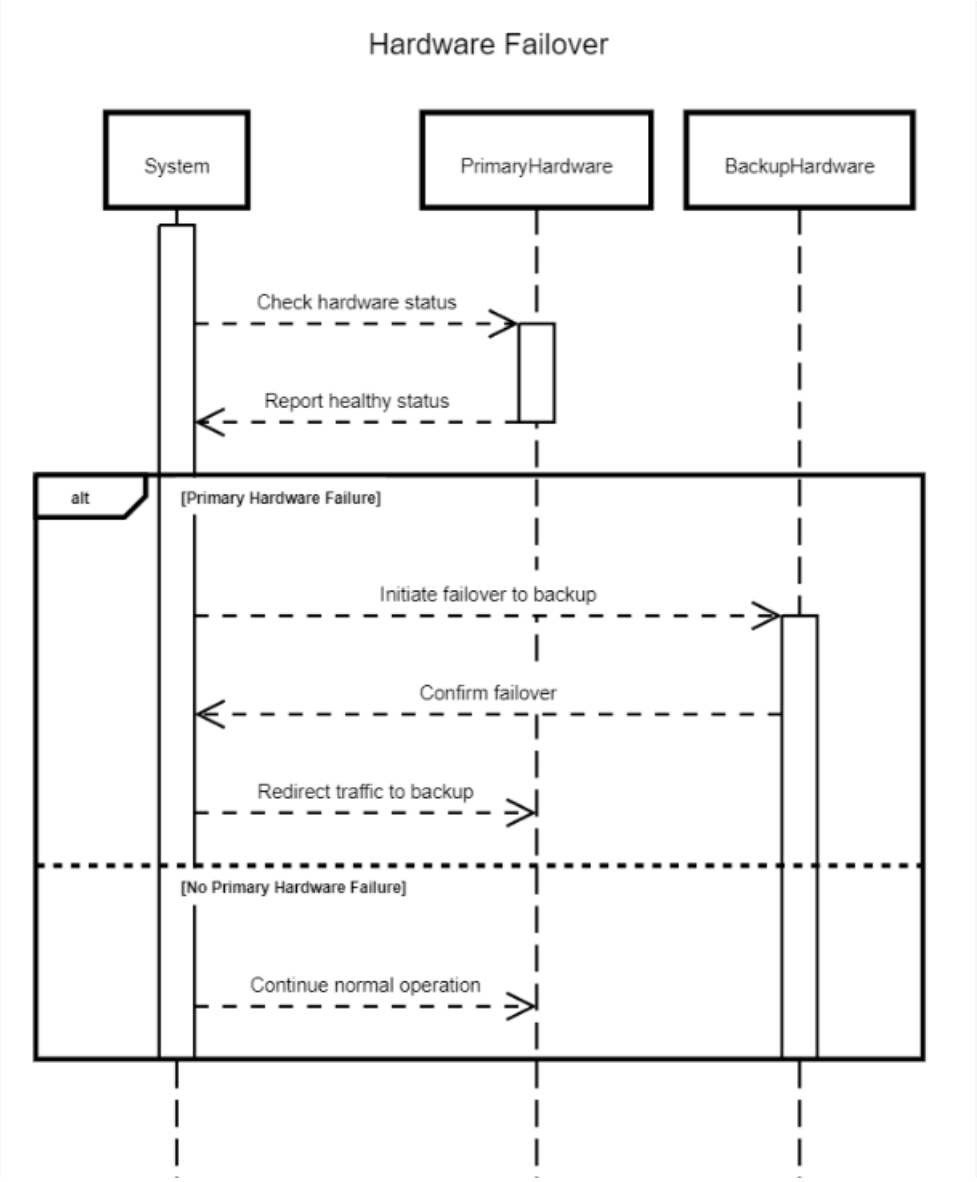

Figure 7: Hardware Failover Model

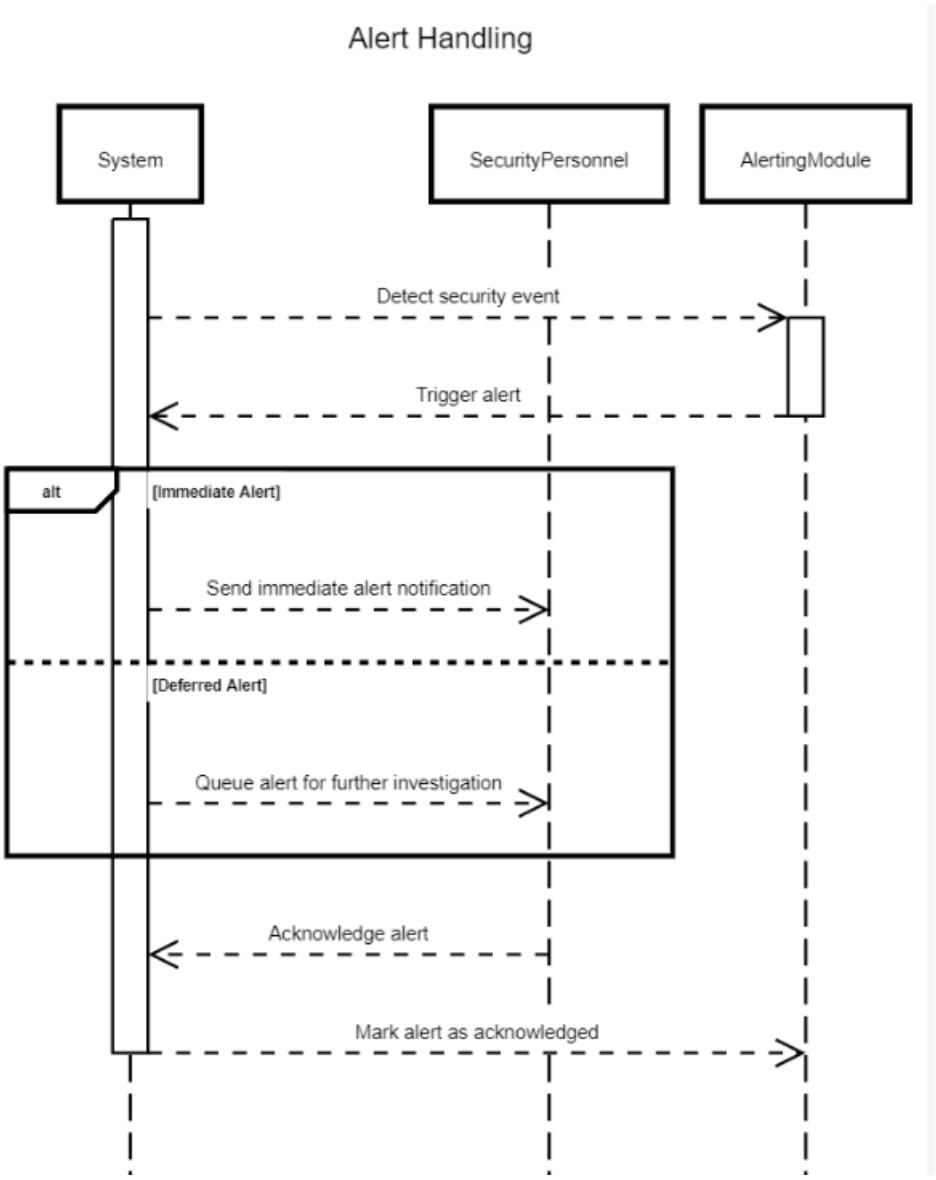

Figure 8: Alert Handling Model

2.5.5. User Interface – navigational paths and screen mock-ups

The figures used in this section might change throughout the project, according to the design team's decisions and the improvement of the project.

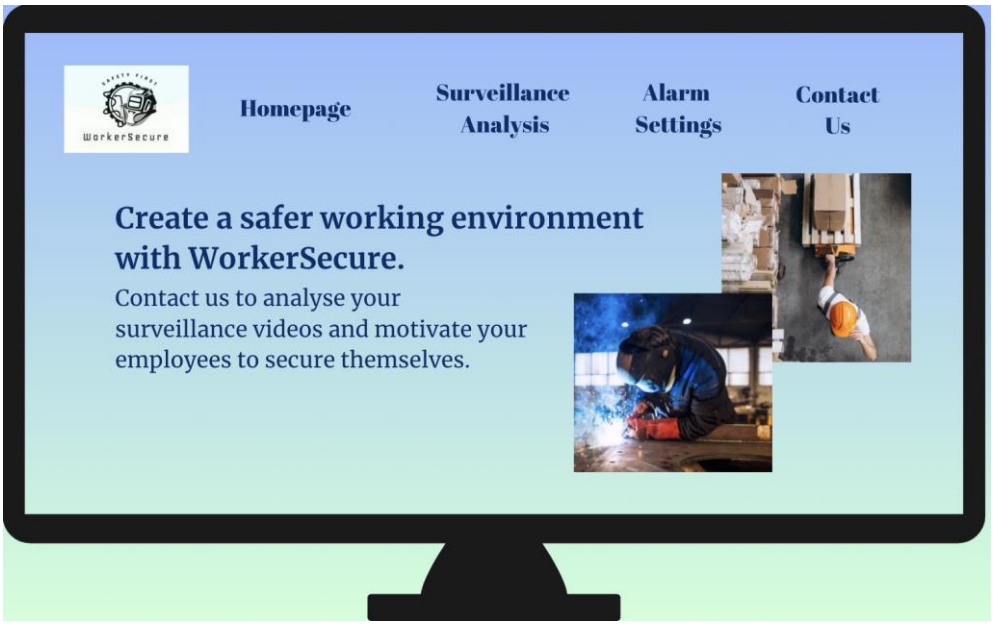

Figure 9: Main Page

The main page includes the advertisement and the general motto of WorkerSecure.

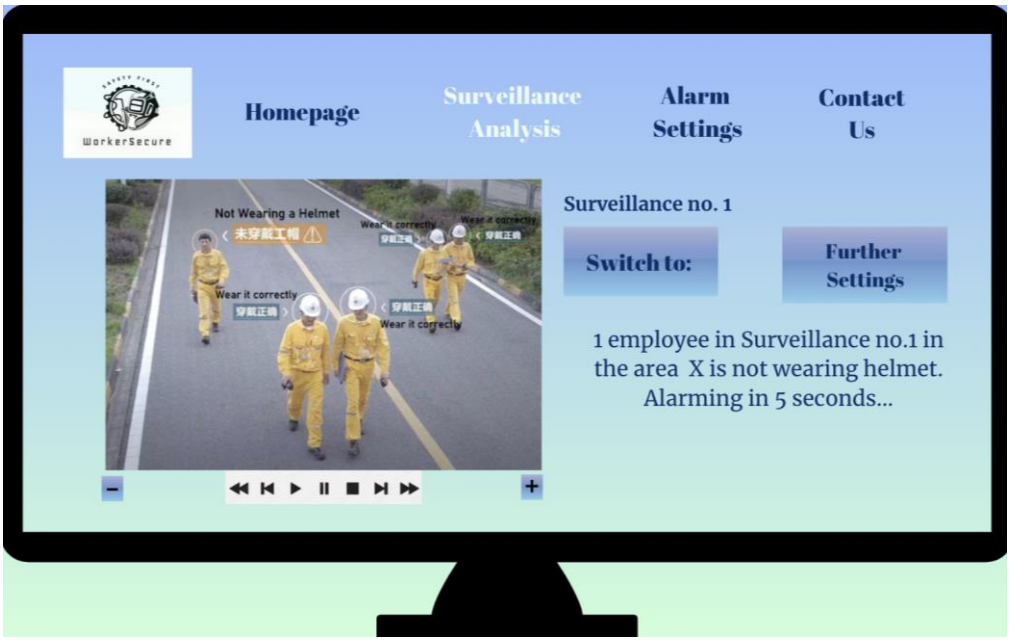

Figure 10: Surveillance Analysis Page

The Surveillance Analysis page shows the current Surveillance recording which is named as No.1, it shows play-stop button for the video, and inside the video there is a detecting system where it shows the worker who is not wearing a helmet. Right next to the play-stop bar, there are zoom in and out buttons.

The user can switch recordings from Switch To: button and fix other video settings from Further Settings button. Below those buttons, there is an informational message that explains where the detected worker is.

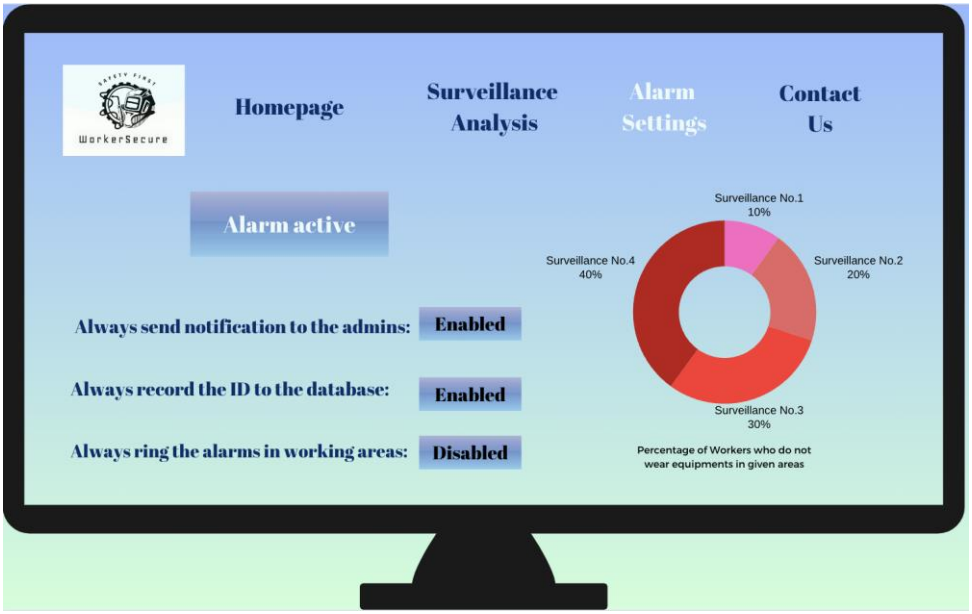

Figure 11: Alarm Settings Page

The Alarm Settings page shows some buttons for enabling or disabling some functions. The user can also turn on and off the alarm system in their working area. Right next to the settings, there is a graph shown to visualize which Surveillance cameras detected the workers most. In this way, companies can get an idea of which areas are more secure or not.

Figure 12: Contact Us Page

3. Glossary

- **Anomaly Detection**: Process of identifying abnormal patterns from expected norm, such as workers without helmets.
- **False Positive**: In WorkerSecure system, it means that the system incorrectly detected the absence of a helmet while it was present.
- **Image Processing**: Manipulation and analysis of visual information such as images or video frames to extract its features for the purpose of detection of safety violations.
- **Machine Learning**: An AI field that enables systems to learn from data and experience.
- **Safety Compliance**: Safety standards withing the working environment.
- **Sensitivity**: True Positive Rate. Meaning WorkerSecure correctly identified the workers who did not wear helmets.
- **Training Dataset**: The dataset that is used to train the ML algorithms.
- **Validation Dataset**: The dataset to test the system to ensure its reliability.
- **YOLO Architiecture:** You look only once. It is designed to detect objects in an image with high accuracy and real-time speed. It can perform detection in a single pass using neural network.

4. References

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