Project Name	**Classroom Occupancy Monitoring and Behavior Analysis System**
Project Website (if any)	
Students' Names and IDs	**Alanood Alharmoodi - 100053854** **Rodha Alhosani - 100058376** **Shaikha Alhammadi - 100058710** **Yasmine Benkhelifa - 100059531**
Group number	**CS06**
Reporting period	**Week 5 to week 8**

Section One: Summary

Our project proposes to develop a smart system that can monitor classroom occupancy and student behaviour in real-time. Our goal is to create a more productive system that alerts educators to important events, such as overcrowding, disengagement, unusual student behaviour, eating or drinking in the lab, or getting too near to a restricted area in the lab. We will use existing CCTV cameras to capture video footage which will then be analysed by machine learning models. The system will include a user-friendly interface that allows educators to easily view live data, set up alerts, and review historical events.

Our focus is to ensure that the system provides real-time analysis and reporting, giving educators immediate insights into classroom activity and helping to maintain a safe and effective learning environment. Key deliverables for this project include a functional AI model for human recognition and object detection, a user-friendly interface for real-time monitoring and data visualization, and a reporting system for historical data analysis. The estimated budget covers the costs for any additional CCTV cameras.

Over the past eight weeks, our team has been thoroughly exploring literature in several key areas: computer vision, deep learning algorithms, machine learning (ML) and artificial intelligence (AI). The in-depth analysis was essential for gaining a solid understanding of the techniques most relevant to our project, particularly in human detection, object detection, and activity recognition using video data from CCTV cameras.

Section Two: Progress

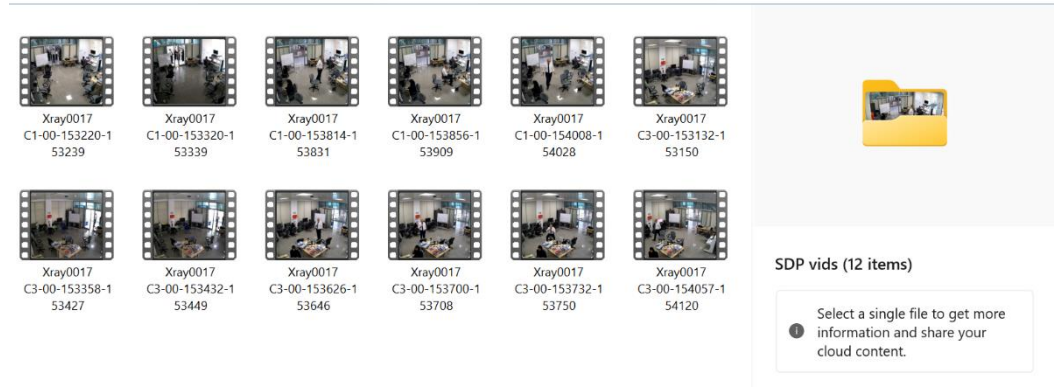
We have made significant progress in developing our project, beginning with the collection of CCTV footage from our teacher assistant. These footages were essential as it provided us with the real-world data, we needed to start our analysis. Using python in the VS Code environment, we set out to detect people and objects in the footage. To achieve this, we utilized popular computer libraries like OpenCV and used them in pre-trained machine learning models. Our focus was on techniques such as background subtraction and contour detection which helped us accurately identify and track individuals from the footage.

Section Two: Activities and Progress

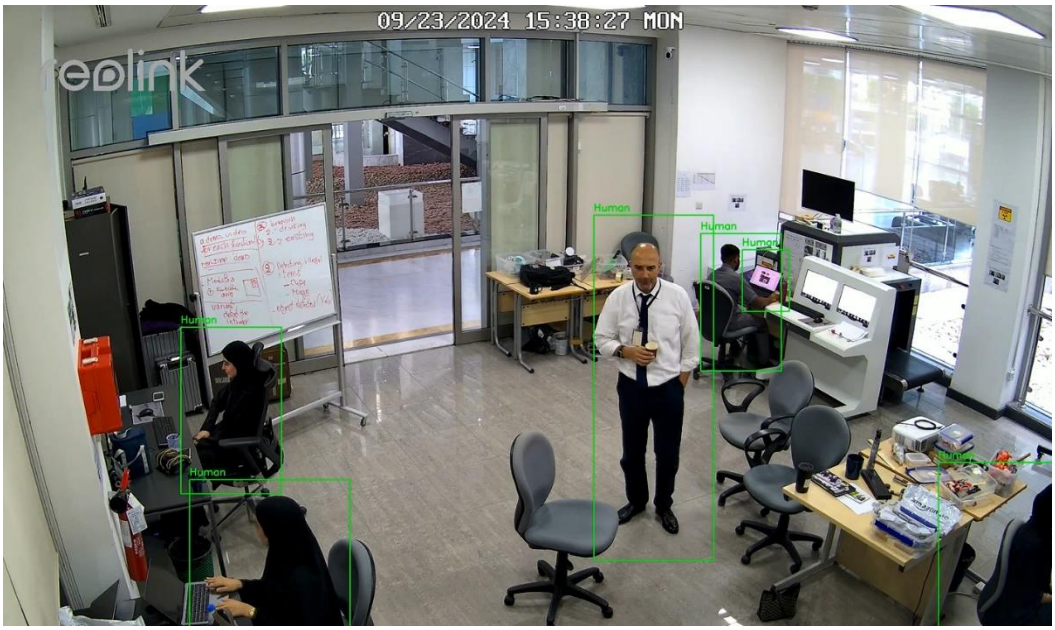
According to our project plan, we are moving forward effectively in our development process and we are on track to create a comprehensive system that enhances classroom monitoring. The following shows the completed activities and those currently in progress:

Completed activities:

- CCTV footage collection



- Human detection implementation



- Object detection (cups)

Activities in progress:

- Face recognition
- Behavior detection
- Restricted Area Detection
- User-friendly interface

Section Three: Institutional & Project Partner Issues

No issues to report.

Section Five: Outcomes and Lessons Learned

Outcomes:

Effective Monitoring of Classroom Occupancy:

This system detects and monitors the number of people in real time, thereby ensuring safety and achieving the optimization of classroom occupancy.

Comprehensive Behavior Monitoring:

The technology continually monitors person behavior, allowing instructors to see patterns that may indicate disengagement or issues. By looking at these behaviors, instructors can get useful information that will enable them to take proactive steps, resulting in a better environment for learning.

Improved Safety Features:

The continuous safety monitoring system effectively alerts against unauthorized access and aggressive behaviors, contributing to a safer learning atmosphere for all faculty.

Enhanced Data Accessibility:

Educators may easily collect data on classroom occupancy and person behavior. By collecting data, instructors may immediately access data which affect decision-making and classroom management, resulting in a more responsive learning environment.

Integration with Existing Infrastructure:

The project successfully used the existing CCTV cameras, which was able to reduce costs and make the implementation process more efficient. This approach showcases how effectively using current technology may improve performance.

Lessons learned:

Need for Real-Time Data:

The project underscored the critical importance of real-time data in classroom management. Access to immediate information significantly increases the speed at which educators can respond to emerging issues.

Optimizing Algorithms:

To get higher accuracy, the behavior detection algorithms' first iterations needed to be further improved. Efficient monitoring and reaction need constant learning and optimization of these algorithms.

Section Six: Evaluation

Once the "Classroom Occupancy Monitoring and Behavior Analysis System" is completed, we will focus on key performance indicators and some validation methods. First, the accuracy of detection will be checked by comparing the findings from the system against manually analysed data on the effectiveness of detecting persons and their behavior in the classroom. Next, accuracy and recall will be then calculated in detail to further see how many actions detected were correct, and how many real correct actions were recognized, hence getting a better view of the system's capability to identify effective activities with the least false positives and negatives. Then, performance in real time will also be measured by timing how fast the system interprets video data and sends warnings to ensure all responses are given in due time.

This will allow us to monitor the error rate in tracking false detections-for example, detecting an object as a person-and indicate specific areas where improvement is needed. Secondly, we are going to evaluate how well the system detects forbidden behaviors-for example unauthorized access or disruptions-by comparing the logged events with actual events occurring in the classroom. This log in Excel will be checked for cross-validation against real-time video data to confirm that all actions are logged correctly with correct timestamps and classifications.

User feedback will be imperative; we will collect the insights from educators on the usability of the system, the effectiveness of the dashboard interface in presenting the data, and the accuracy of real-time alerts and logs. Finally, we will test the system for reliability over a long period of time in order to verify that performance and precision will be constant, without crashes or large numbers of errors. This way, focusing our efforts on these domains will show us how effective and ready for real-life application the system is, while at the same time showing the points that need further elaboration.

Section Seven: Dissemination

Our team aims to publicize our findings and insights in a way that is beneficial to our target stakeholders. To extend the reach and impact on our project we aim to:

- Partner with Educational Institutions such as Khalifa University:

  Collaborating with an educational institution such as Khalifa University will be a great way to showcase our accomplishments as well as benefit our stakeholders. This is because our project will provide educational institutions the means to monitor student behaviors, review past behaviors to enforce new policies, enforce spatial rules and much more.

- Publications:

  Another method we are considering disseminating our project is by being open to the possibility of submitting our work in academic journals, and research conferences.

Section Eight: Risks, Issues and Challenges

Risks:

- Inaccurate detection could lead to false positives and missed behaviors. This could compromise the reliability and reduce the users' trust in our system.
- Regarding the illegal area, errors in mapping or flagging a person in an illegal area could cause issues in policy enforcement.
- Security concerns, including misuse or unauthorized access to recorded videos.
- System scalability is a concern, and the risk of performance issues including lags, glitches, and so on.

Challenges and Issues:

- The main issue we were faced with during our first seven weeks is that objects that are a similar colour to the background are difficult to detect. Additionally, objects that are partially obstructed are difficult to detect. This makes it a challenge to ensure high accuracy, especially when the lighting is too dim or too bright.

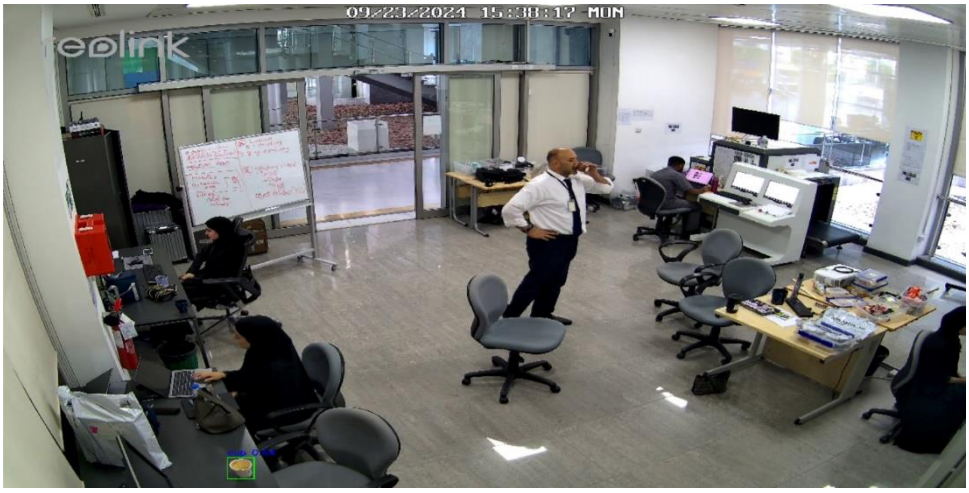


Figure 1: Just a Single Object Being Detected

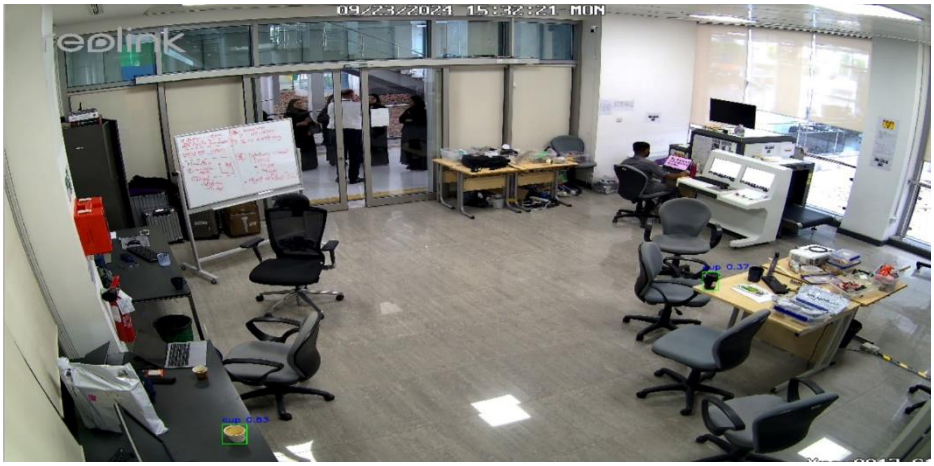


Figure 2: Just Two Objects being Detected

- To detect a person walking close to an illegal area and correctly being flagged, we must have an accurate mapping and layout of the classroom. This can be a challenge to implement.
- Implementing a GUI that logs activities in excel can be a challenge especially if there are performance issues such as lags and glitches.

Section Nine: Collaboration and Support

The work done in our project is in collaboration with "KU Machine Intelligence Lab" and supported by Khalifa University, the name of the project is "Classroom Occupancy and Behavior Analysis System". Additionally, we find collaboration and support through:

- Team Meetings

This is a weekly meeting where all team members are present and involved. Here, we are able to tackle challenges with one another, set new goals for the upcoming week, and share new ideas. This allows us to be aligned with one another, strategize, and encourage each other.

- Advisory Sessions:

We meet with our project advisor once a week, where we are expected to come show him our weekly progress and express to him where we found difficulties. In these meetings we gain clarification and find solutions to certain problems. Additionally, we are expected to meet with Dr. Naoufel every four weeks, where project milestones are reviewed, and plans are made to tackle upcoming objectives. The expertise and guidance of Dr. Naoufel gives us strategic directions and helps us refine project methodologies.

Section Ten: Financial Statement

The project operates within a budget of 0 AED due to the existing infrastructure available at the university lab, which includes the necessary CCTV cameras. Specifically, three Reolink 5MP E1 Outdoor WiFi cameras are already installed and will be used for video capture, reducing the financial investment required. Furthermore, the university provides access to essential servers and workstations for processing the video data and running detection algorithms, further cutting down on costs.

As of now, there are no expected expenses for this project. This financial statement aims to ensure transparency and demonstrate the efficient use of available resources without incurring additional costs throughout the project lifecycle.

Section Eleven: Next Steps

After thoroughly understanding and researching the project and successfully collecting video data using the cameras in the lab, we proceeded to implement the key functionalities of the system. However, during the implementation of person and object detection, specifically on cup detection, we encountered several errors that need to be addressed in our next steps.

1. Illegal Object Detection:

Our initial focus for object detection was detecting cups as prohibited items in the lab environment. We utilized YOLO models, which are designed for fast, real-time object detection by processing the entire image in a single forward pass through the network.

While the system successfully identified cups in some instances, several challenges emerged. The primary issue was the system's limitation in detecting only one cup at a time, even when multiple cups were visible in the frame. This issue likely stems from the model's inability to generalize across varying object positions, sizes, and occlusions in the training data.

In addition, the system encountered misclassification errors, such as detecting a chair as a toilet, as shown in figure 3. This error highlights the need for better training data and model adjustments. Our current dataset may not provide sufficient diversity in object representations, leading to these misclassifications.

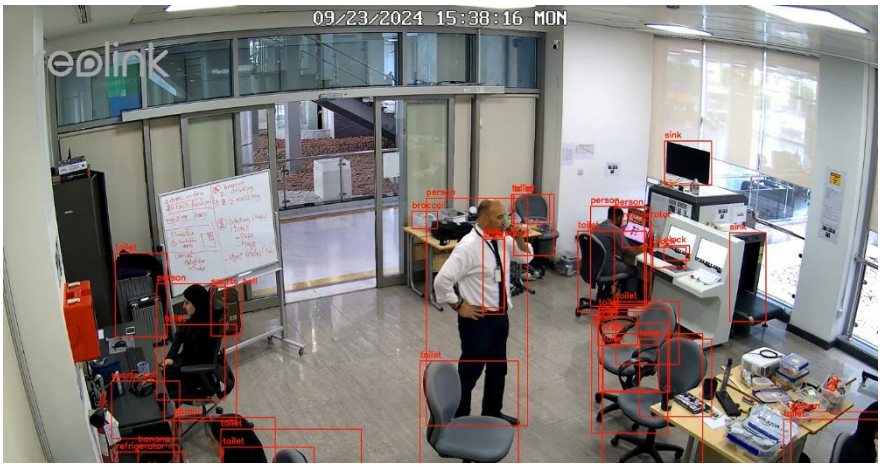


Figure 3

To address these challenges, our next steps involve:

- **Refining the Dataset**: We will expand and balance our dataset to include a wider variety of objects, angles, and scenarios. This will help the YOLO model learn to distinguish between similar-looking objects and multiple instances in the frame.
- **Improving YOLO Models**: We will fine-tune the pre-trained YOLO models by applying techniques such as transfer learning, where we train the model further using our specific dataset to enhance its detection capabilities.
- **Adjusting Detection Parameters**: We will modify YOLO's non-max suppression threshold and confidence score to improve multi-object detection accuracy and reduce false positives. This will allow the system to detect and classify multiple objects accurately within the same frame while minimizing erroneous classifications.

By optimizing these components, we aim to increase detection accuracy, enabling the system to handle multiple objects in a scene while avoiding misclassifications like identifying laptops as people.

2. Person Detection:

After addressing object detection, we will focus on person detection using YOLO models. The aim is to accurately identify human presence in the lab while minimizing false identifications, such as mistaking objects for people.

We will:

- **Fine-tune the YOLO model** through transfer learning, using lab-specific data to help the model distinguish people from other objects more effectively.
- Adjust key parameters, such as the confidence threshold and non-max suppression, to reduce false positives and detect multiple people accurately.
- **Retrain the model** on custom data from the lab environment to adapt to different lighting and angles.

These steps will improve person detection, ensuring reliable identification of individuals entering or leaving the lab while minimizing errors.

3. Behavior Detection:

Once person detection is functional, we will develop behavior detection algorithms to monitor prohibited actions within the lab, such as eating, drinking, or engaging in other restricted activities. This phase will involve:

- **Training the system** to recognize specific gestures and movements that indicate rule violations using a combination of action recognition techniques and the YOLO model.
- **Dataset Preparation**: We'll capture and label video data showing both acceptable and unacceptable behaviors in the lab (sitting, standing, eating). This labeled data will be used to train the system to detect patterns that signify prohibited actions.
- **Model Fine-tuning**: We will fine-tune the behavior detection model to identify subtle actions, such as raising a cup or taking a bite, that indicate rule violations.
- **Real-Time Alerts**: Once an unwanted behavior is detected, the system will trigger an alert, allowing for immediate intervention.

4. Restricted Area Detection:

The final phase will involve integrating a system to detect unauthorized access to restricted areas within the lab. This will require:

- **Defining virtual boundaries** within the camera's field of view using zoning techniques. These zones will correspond to areas within the lab where entry is restricted.
- **Movement Monitoring**: Using YOLO models, the system will continuously monitor the movements of individuals in the lab. If a person crosses a defined boundary into a restricted zone, the system will instantly flag the breach.
- **Real-Time Alerts**: Once a breach is detected, the system will generate an alert. This feature enhances lab safety by preventing unauthorized access to sensitive areas.

5. Real-Time System Implementation:

After achieving reliable person, object, and behaviour detection using pre-recorded videos, the next step will be to implement a real-time detection system using the three cameras installed in the lab. This will:

- Integrate live camera feeds into the system, allowing continuous monitoring of object and behaviour detection.
- Ensure immediate detection and alerts for unauthorized actions and breaches in real time.
- Optimize the system for efficient real-time processing, ensuring low-latency detection and prompt responses.

6. Detection and Behaviour Log:

After finalizing object, person, and behaviour detection functionalities, an Excel log system will be implemented to record all detected actions. The log will:

- **Document detected activities** such as object detection, person detection, and identified behaviors, along with time stamps.
- **Provide a detailed event history**: The log will help track rule violations, unauthorized access, and any other incidents, offering insights into lab operations and security.
- **Enable monitoring and reporting**: The log will serve as a record for later review, allowing educators or lab managers to evaluate past events, identify patterns, and ensure compliance with lab regulations in real time.

Our immediate next steps involve resolving the detection errors, enhancing the system's accuracy, and ensuring that both person and object identification work reliably in real time. Each of these steps will be accompanied by continuous testing and refinement to improve detection accuracy. The ultimate goal is to create a comprehensive classroom occupancy and behaviour monitoring system that enhances lab safety and operational efficiency.