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 2 to week 8**

Section One: Summary

Continuing from SDP1, the goal is to enhance the AI-driven monitoring system by incorporating new features such as occupancy detection, recognizing behaviors like drinking, eating, texting, and talking on the phone. It will also identify when individuals are wearing the required helmet and safety jacket in restricted areas and send real-time alerts. Additionally, the system will be able to detect cheating behaviors in classrooms. The user interface will be improved, and email notifications will be added for immediate updates. The project will use advanced computer vision techniques like YOLOv8 for object detection and Tkinter for the interface. Key deliverables include a fully functional system, a user-friendly interface, real-time alerts, and a comprehensive project report. The estimated budget covers the costs for any additional CCTV cameras.

Our team researched methods to improve data collection and avoid underfitting or overfitting. We focused on Machine Learning fundamentals, emphasizing data augmentation, dataset balancing, and the importance of using regularization techniques like dropout and L2 regularization. We also explored best practices for splitting data into training, validation, and testing sets, as well as fine-tuning hyperparameters to enhance model accuracy. This research guided our approach to ensure the system's detection models are robust and generalize well without overfitting to noise.

Section Two: Progress

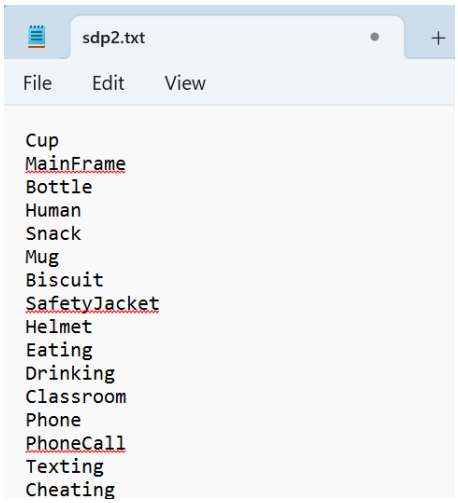
The team made significant progress in the development of Senior Design Project II. They began by meeting with Dr. Naoufel to discuss the next steps and evaluate the best approach for the project. Following this, internal team meetings were held to plan upcoming tasks, distribute responsibilities, and identify additional behavior classes to integrate into the system. After obtaining approval from Dr. Naoufel for the newly proposed classes, the team collaborated with Dr. Maregu to collect data from the CCTV system in the R Building lab. The team also expanded the dataset by collecting data from a classroom environment and focusing on safety equipment-related classes. Once the data was collected, it was divided among team members for labeling to ensure accuracy and consistency in the annotations. This labeling process using makesense.ai formed the foundation for the subsequent model training. Lastly, testing videos were gathered for use after the model's training phase, and the team proceeded to train the model using YOLOv8.

Section Two: Activities and Progress

As per our project plan, we are making steady progress in our development process and are on schedule to build a comprehensive system that improves classroom monitoring. Below are the activities that have been completed and those that are currently underway:

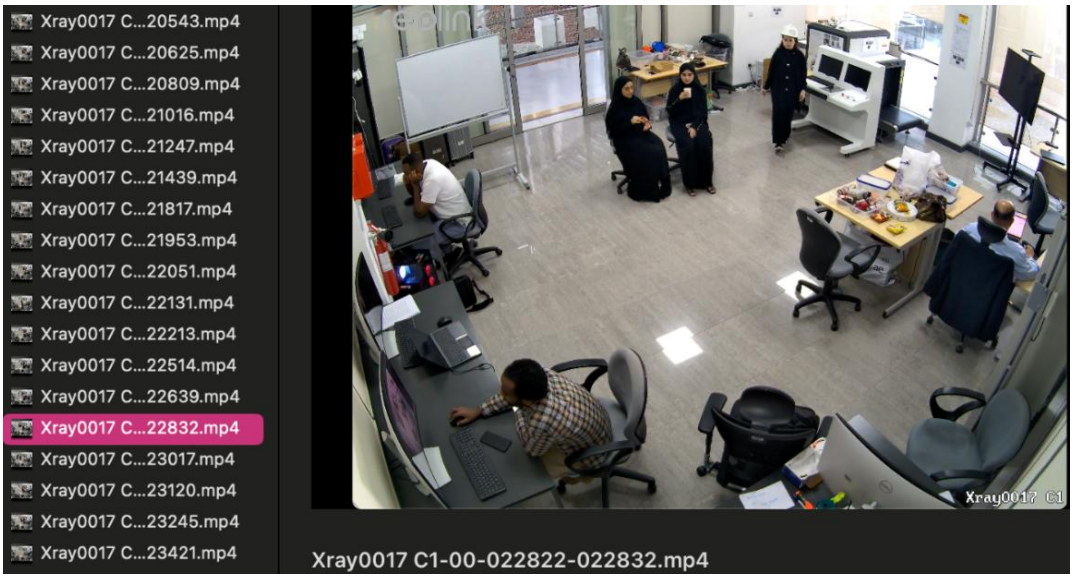
Completed activities:

- Added more behavior classes

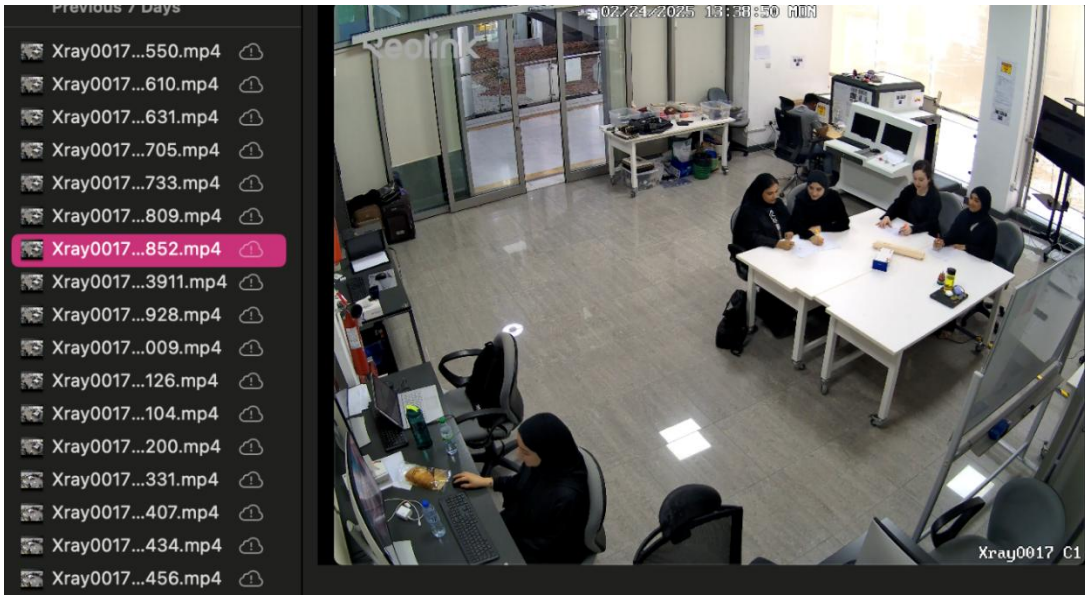


- More CCTV footage collection

We started by collecting data on our new introduced behavior classes and safe equipment



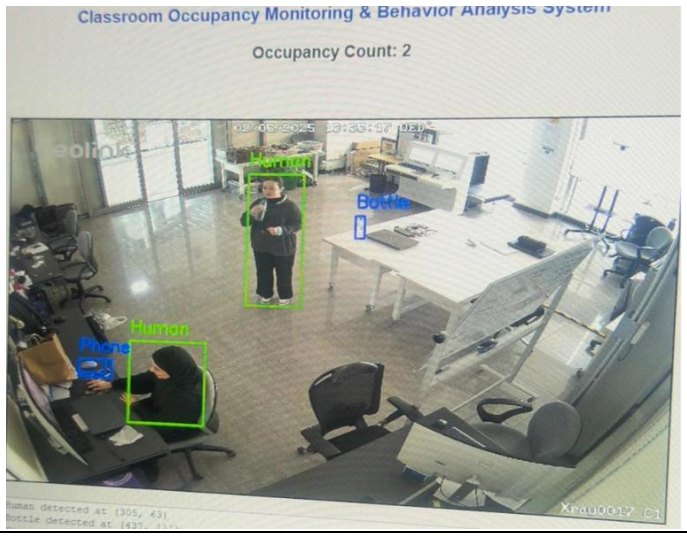
- Collected data ‘Cheating’ class



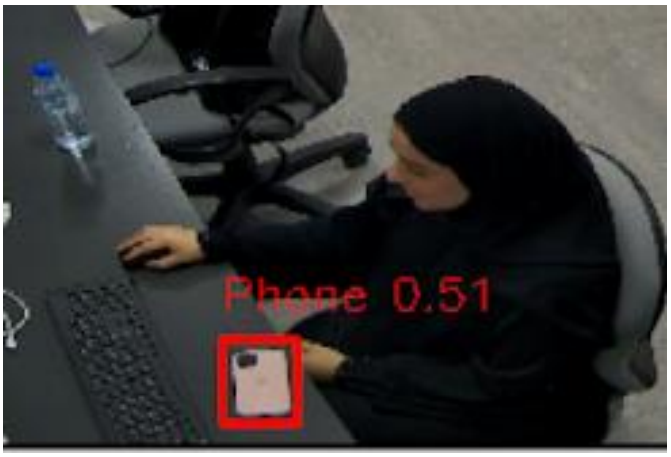
Completed Progress:

- Safety Jacket and Helmet detected

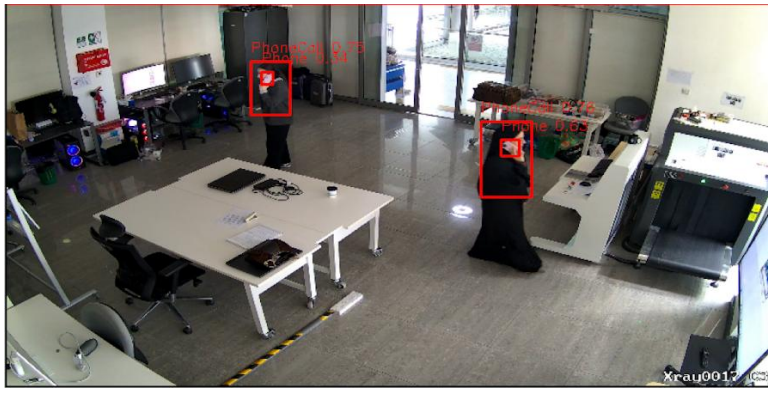
- Counting the correct occupancy in the classroom



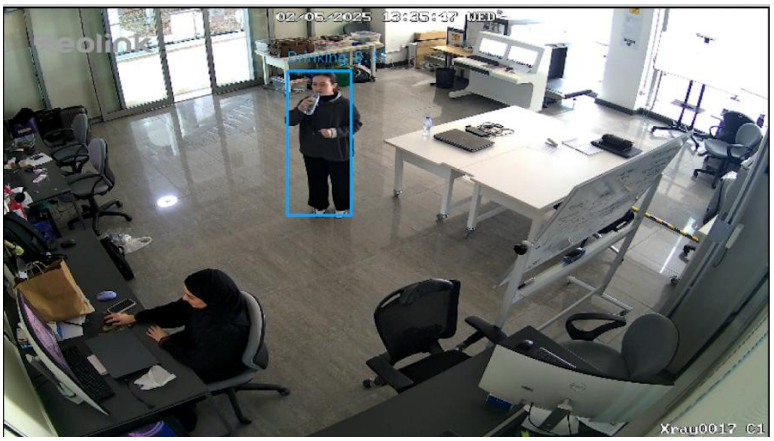
- Phone detected



- Phone call detected



- Drinking detected



- Eating detected

- Cheating detected

Section Three: Institutional & Project Partner Issues

No issues to report.

Section Five: Outcomes and Lessons Learned

Outcomes:

1. Detection Capabilities were Enhanced:
    - We successfully added new objects to be detected, such as phones, safety jackets and helmets to ensure personal protective equipment is worn in restricted areas.
    - Occupancy counting was also integrated into our system for attendance monitoring and safety purposes.
    - Behavior detection was successfully integrated into our system, which includes behaviors such as phone calls, drinking, eating, cheating, and more.
2. Model Performance Enhancement:
    - Our team addressed overfitting by improving the diversity of the dataset and implementing augmentation techniques.

In addition to the outcomes mentioned above, we are working on implementing an automated email notification system for immediate alerts and optimize real-time analysis to reduce latency.

Lessons learned:

1. Data Quality and Diversity is Important:

- Diverse and balanced datasets were the key to enhance model generalization.
- Our team had to collect additional data on numerous occasions to ensure the system correctly identified underrepresented behaviors.

2. Importance of Continuous Testing and Evaluation:

- Regular validation using performance indicators such as precision, recall, and F1-score helped us make sure the system met acceptable accuracy levels.
- Using testing videos for real-world testing highlighted which areas we need to improve on, which helped us understand the importance of an iterative development approach.

3. Collaboration and Effective Teamwork is Important:

- Frequent meetings with Dr. Naufel and Dr. Maregu, as well as internal team discussions played a crucial role in problem-solving.

Section Six: Evaluation

Once the "Classroom Monitoring and Behavior Analysis System" is fully implemented, we'll focus on evaluating its effectiveness using key performance indicators and validation techniques. The first step is to assess the accuracy of the system's behavior detection by comparing the system's results with manually analyzed data. This will help us determine how well the system detects activities like eating, drinking, texting, and phone calls. We will also calculate the system's precision and recall, which will give us a clear picture of its ability to identify these behaviors correctly, minimizing false positives and negatives.

The team will also test the system's real-time performance by measuring how quickly it processes video data and issues alerts. The goal here is to ensure that the system responds quickly and efficiently to detected behaviors, particularly when it comes to actions like unauthorized access or when a human leaves the classroom.

Additionally, we'll monitor the system's error rate, especially when it mistakenly detects an object as a person and use this information to pinpoint areas that need improvement. Evaluating how well the system tracks prohibited behaviors, like unauthorized access or disruptions, will involve comparing the system's event logs with actual classroom events. We will cross-check these logs against real-time video data to confirm that actions are logged correctly with accurate timestamps and classifications.

User feedback will be essential in refining the system. Educators' insights on the system's usability, the dashboard interface, and the accuracy of alerts and logs will guide us in making necessary adjustments. Lastly, we will test the system's reliability over an extended period to ensure consistent performance and precision without crashes or errors. This evaluation process will not only show how ready the system is for real-world implementation but also highlight areas for further development.

Section Seven: Dissemination

Our team is committed to sharing the findings and insights in ways that are beneficial to our target stakeholders. To expand the reach and impact of our project, we aim to:

- Collaborate with Educational Institutions like Khalifa University: Partnering with institutions such as Khalifa University will help us showcase our achievements and directly benefit our stakeholders. Our project will provide educational institutions with a powerful tool to monitor classroom behavior, review past behaviors to enforce policies, and ensure compliance with spatial rules, among other uses.

- Publications: We are also considering submitting our work to academic journals and research conferences. By publishing our findings, we can contribute to the broader field of classroom monitoring and behavior analysis while gaining feedback from experts in the field.

Section Eight: Risks, Issues and Challenges

Risks:

- False Positives and Missed Detections: Inaccurate detections could lead to false alarms or missed violations, potentially compromising the system's reliability and reducing user trust.

- Errors in Restricted Area Mapping: Improper detection of a person in the restricted "MainFrame" zone could cause issues in policy enforcement, such as flagging a compliant individual or failing to recognize an actual violation.

- Security Concerns: Risks include unauthorized access to recorded videos, misuse of data, or potential breaches that could expose sensitive information.

- Scalability and Performance Risks: As the system expands to monitor larger environments, we may encounter performance bottlenecks such as lags, glitches, or slow processing times, which could affect real-time responsiveness.

Challenges and Issues:

During the development process, several challenges emerged that required ongoing refinement:

- Overfitting: The model had difficulty generalizing to new data. It performed well on the training set but showed reduced accuracy when applied to unseen scenarios. To address this, we collected a more diverse dataset to improve generalization.

- Need for Additional Data Collection: To enhance detection accuracy, we gathered more data, particularly focusing on underrepresented behaviors and object categories. Ensuring a balanced dataset helped minimize biases in the model.

- Misclassification of Behaviors and Objects: Certain objects and behaviors were occasionally misclassified due to similarities in appearance, overlapping objects, or partial occlusions, leading to incorrect detections. We refined the model using better labelling and augmentation techniques to mitigate these issues.

- Object Detection in Complex Environments:
    - Objects that closely match the background color posed detection challenges, reducing accuracy.
    - Partial occlusions made it difficult for the model to detect objects that were obstructed by other elements.
    - Extreme lighting conditions—either too dim or too bright—affected detection performance, necessitating additional data pre-processing and adaptive techniques.

By addressing these challenges and risks through continuous refinement, additional data collection, and system optimizations, the project aims to enhance accuracy, reliability, and overall performance for real-world deployment.

Section Nine: Collaboration and Support

Our project, titled "Classroom Occupancy and Behavior Analysis System," is a collaborative effort with the KU Machine Intelligence Lab and is supported by Khalifa University. The following support structures are key to our progress:

- Team Meetings

We hold weekly meetings where all team members participate. These sessions allow us to address challenges together, set new goals for the week, and brainstorm ideas. This collaborative environment ensures that we stay aligned, strategize effectively, and motivate one another.

- Advisory Sessions

Every week, we meet with our project advisor to present our progress and discuss any obstacles we've encountered. These sessions provide clarity and help us find solutions to ongoing issues. Additionally, we meet with Dr. Naoufel every two weeks to review project milestones and plan for future tasks. Dr. Naoufel's expertise offers valuable strategic guidance and assists us in refining our approach to the project.

Section Ten: Financial Statement

The project is operating within a budget of 0 AED, thanks to the existing infrastructure provided by the university lab, which includes the necessary CCTV cameras. Specifically, three Reolink 5MP E1 Outdoor WiFi cameras have already been installed and will be utilized for video capture, minimizing the need for additional financial investment. In addition, the university offers access to vital servers and workstations for processing the video data and running detection algorithms, further reducing costs.

At this point, no additional expenses are anticipated for the project. This financial summary highlights the efficient use of available resources and ensures transparency, with no extra costs expected throughout the project's duration.

Section Eleven: Next Steps

After completing the training and testing phases, the next step is to refine the model by addressing any remaining limitations and enhancing the overall system functionality. If necessary, the team will collect additional datasets to improve the accuracy of certain classifications, ensuring that all detected behaviors and objects are reliably identified under various conditions.

A key focus will be on developing a user-friendly interface that allows for seamless interaction with the system. This interface will integrate real-time monitoring and provide instant feedback on detected events

The core functionalities of the interface will include:

- Automated Alerts for Safety Violations: The system will trigger an alert if an individual enters the restricted "MainFrame" zone without the required safety equipment, such as a helmet or safety jacket.

- Email Notification System: All critical alerts, including unauthorized access, cheating incidents, and detections of prohibited objects, will be sent directly to instructors via email, ensuring immediate action can be taken.

- Real time Analysis: The system will move from processing pre-recorded videos to implementing real-time analysis. This transition will significantly enhance its capability to monitor classroom activity as it occurs, allowing for instant responses to violations and creating a more effective monitoring solution.

- Detection and Behavior Log: After finalizing object, person, and behavior detection functionalities, an Excel log system will be implemented to systematically record all detected actions. This log will serve as a structured record of monitored activities, enhancing system transparency and usability.

The log will:

- Document Detected Activities: Record instances of object detection, person detection, and identified behaviors along with precise timestamps.
- Provide a Detailed Event History: Track rule violations, unauthorized access, and any other incidents, offering insights into lab operations and security.
- Enable Monitoring and Reporting: Serve as a structured record for later review, allowing educators and lab managers to evaluate past events, identify patterns, and ensure compliance with regulations in real time.

These next steps are aimed to improve the system’s accuracy, efficiency, and usability, transforming it into a powerful tool for real-time classroom occupancy and behavior analysis.