SMART LECTURE HALL SEAT DETECTION SYSTEM

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Introduction:

As the number of students in educational institutions rise and the classroom infrastructure is limited, it is increasingly important to make better use of the available space in classrooms. This is mainly due to the large number of students that attend lectures in lecture halls and the difficulty associated with finding open seats and monitoring how many seats are filled very quickly. Current methods to count open seats (for example, counting seats manually or using RFID-based attendance systems) take a long time, are often inaccurate, and are expensive to maintain. Therefore, there is a need for an automated, accurate and scalable solution for the effective management of classroom space.

The proposed system uses computer vision and deep learning to address this situation. The solution uses the existing CCTV infrastructure to provide real-time data on the number of people in classrooms through the use of the YOLOv8 algorithm (for detecting each person) and the StrongSORT algorithm to track multiple objects across video frames (i.e., students being tracked throughout the duration of a lecture). Once people have been detected and tracked using these algorithms, they are mapped to pre-defined seat coordinates using homography transformations, which allows the software to accurately report which seats are filled and which seats are unfilled. A real-time dashboard provides an easy-to-use interface that displays filled and unfilled seats using colours to highlight the use of existing CCTV infrastructure meaning that this solution does not require additional hardware purchases; therefore, this solution will be both cost-effective and scalable for use in smart campus environments.

Figure 1: Lecture Hall Frame

Objectives:

1. Designing and building a computer vision type system using CCTV video streams of lecture halls to identify students
2. Implementing YOLOv8 to accurately detect students in a real-time environment, while also utilizing classroom videos
3. Integrating StrongSORT, which will allow individuals to retain their identity as they move from frame to frame
4. Providing a real-time display of seat occupancy via a built-out dashboard
5. Creating a low-cost, scalable solution using only existing surveillance infrastructure, with no additional hardware

Methodology:

This project uses object detection technique based on deep learning, and detects real-time seat occupancy in a lecture hall. Detecting people in the frame by using a custom-trained YOLOv8 based model using over 6000 annoted images, the video stream is processed frame by frame to identify when there is a human present in the frame by highlighting each person who has been detected with. To improve robustness against partial visibility and occlusion, several reference points from each detected bounding box are used to accurately detect humans in the frame. Using Homography, a method of correcting the perspective distortion of the images captured by the camera due to the angle at which it was placed, the intended view of the camera is transformed into a normalized or top-down view. The top-down representation of the image allows for improved spatial alignment between seats in the picture and the actual physical alignment of the seats in the lecture hall. While there are limitations to how well the full transformation could be applied in practice due to the existing distortion in the captured images, the theoretical framework of Homography also provided guidance as to how to understand the spatial arrangement of the seating arrangement and assisted in designing the seat mapping logic. StrongSORT is used to generate IDs for people.

The seating layout is modelled using a row-by-row defined set of polygons to correspond to the actual seating arrangement in the lecture hall and is further subdivided into individual seat regions and mapped to the detected person coordinates by using point-in-polygon methodologies. To smooth out changes between frames we

use a temporal smoothing technique over each frame which stabilizes the fluctuations resulting from occupancy detection. The final output of this technique is presented on a structured dashboard user interface that provides dynamic data about occupancy.

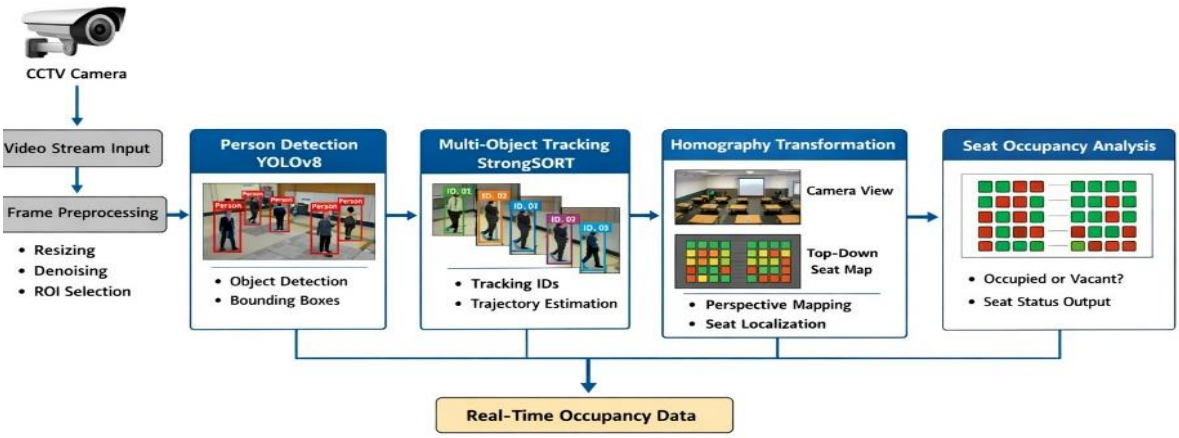

Figure 2: Methodology

Results and Conclusion:

In conclusion, this project presents a successful implementation of a computer vision-based system for determining whether a seat is occupied in real-time in a lecture hall. The YOLOv8 model was specifically trained for this application, enabling participants to be detected regardless of viewpoint difficulty (such as between partial occlusion and through an angled camera). The combination of StrongSORT with a spatial seat map that associates detected participants with specific seats allows for accurate occupancy determination. Another benefit of this work is that the use of Homography provides a theoretical justification for the correction of perspective distortions introduced by the perspective view of the scene. In addition, due to the application of temporal smoothing, the resulting performance of the system is continuous and consistent by reducing fluctuations in detected occupancy between frames.

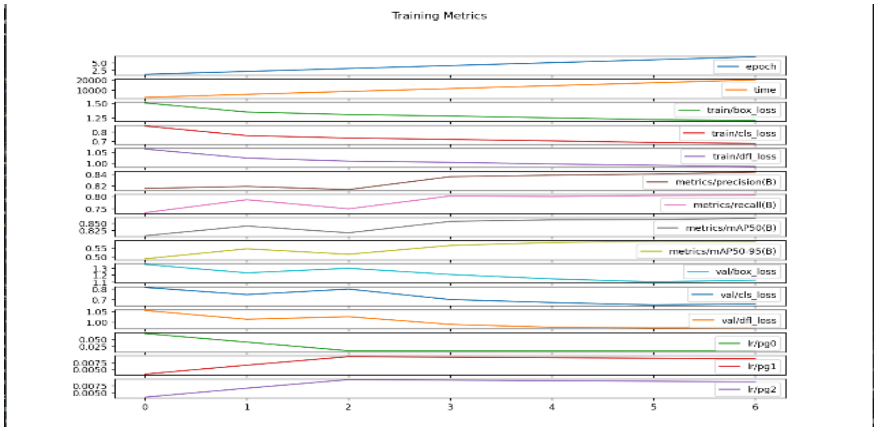

Figure 3: Training Metrics

Figure 4: Detection of Seat Occupants and Live Dashboard

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Future Scope:

The future scope of this project includes:

1) Combining a multiple camera system into a single CCTV system such that large classrooms are seamlessly covered by multiple cameras, while simultaneously eliminating any blind spots.

2) Utilizing advanced computer vision techniques for seat region detection (in place of manual seat coordinate definition).

3) Using enhanced tracking algorithms (such as depth sensors) to enhance accuracy in crowded situations.

4) Utilizing a cloud infrastructure to deploy all of these solutions allows for centralized monitoring of multiple classrooms through a single dashboard.

5) Implementing facial recognition techniques that are privacy aware for use in attendance automation.