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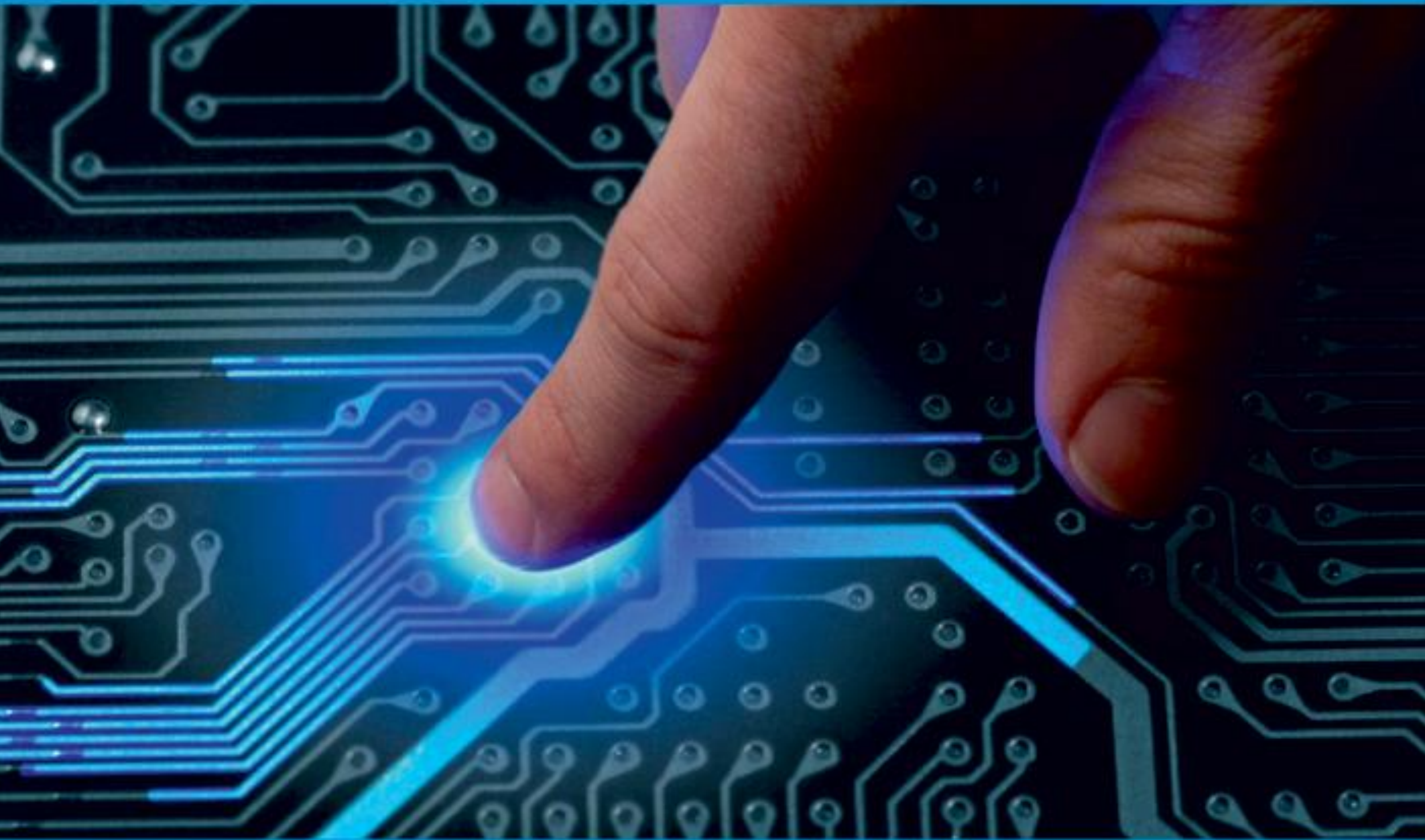

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Intelligent Public Space Crowd Monitoring and Alert System

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ABSTRACT: The contemporary challenge of effectively managing crowd dynamics within public spaces, compounded by the Missing Part in existing systems, necessitates a paradigm shift. This project endeavors to address this gap through the creation of an "Intelligent Public Space Crowd Monitoring and Alert System." Fusing advanced computer vision and machine learning, the system aims to proactively detect anomalies, such as sudden crowd surges and prolonged congregations. By leveraging facial recognition, it enhances individual tracking, offering a dynamic solution adaptable to diverse public environments. The project aspires to redefine the landscape of public safety and operational efficiency in crowded settings**.**

KEYWORDS: You Only Look Once (YOLO), Count Detection, SMTP Network(Simple Mail Transfer Protocol), Image Frames

I. INTRODUCTION

Public spaces in growing urban environments face significant challenges in crowd monitoring and safety, particularly with the increasing frequency of large events. This paper introduces the "Intelligent Public Space Crowd Monitoring and Alert System," a novel approach utilizing the YOLO (You Only Look Once) algorithm for real-time monitoring. Deep learning, specifically region-based Convolutional Neural Networks (CNNs), plays a crucial role in the system, enabling accurate and efficient object detection and localization within crowded spaces. YOLO serves as the foundation for this real-time detection, facilitating rapid identification of individuals, groups, and objects. While existing YOLO-based systems effectively estimate crowd density, they lack capabilities for in-depth crowd behavior analysis and real-time anomaly detection. This paper addresses this gap by strategically integrating YOLO and CNN, enabling proactive crowd monitoring, swift anomaly identification, and timely emergency response. This ultimately enhances public safety, optimizes resource allocation, and facilitates data-driven decision-making. The project aims to develop a scalable, adaptable, and data-driven solution for diverse public spaces, providing authorities with actionable insights into crowd dynamics for proactive risk management, efficient resource allocation, and a secure environment. Additionally, the integration of a Gmail-based alert notification system further strengthens the system's effectiveness in proactive risk management, ensuring public safety and security in urban environments.

II. RELATED WORK

In [1] authors propose's a batch processing method for wearable health crowd-sensing (WHCS) to tackle security and efficiency concerns. It offers anonymized data transmission, resistance to attacks, and reduced bandwidth usage through aggregate verification. This energy-efficient method improves WHCS data processing.

In [5] authors checks employed controlled experiments to investigate pedestrian flow behavior under high-density conditions. They aimed to understand crowd movement patterns and the influence of density on flow dynamics. This research provides valuable knowledge for improving crowd management and pedestrian safety in high-density environments.

In [7] authors explore's crowd disasters using physics-based modeling. They aimed to understand crowd movement, especially in high-density situations, to prevent such disasters. By applying physics principles, they analyzed crowd

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dynamics to identify factors causing "crowd turbulence" and predict potential bottlenecks. This research aimed to improve crowd management strategies for events and public spaces with heavy pedestrian traffic.

In [9] Authors reviewed cutting-edge modeling techniques for simulating crowd movement, particularly during evacuations. Their focus was on improving crowd management and evacuation efficiency. By analyzing these advanced models, they aimed to design safer evacuation plans, understand crowd behavior for optimized routes, and develop better management strategies for high-density scenarios.

In [10] authors addressed high-density crowd counting in videos using a convolutional neural network (CNN). Their focus was on feature fusion, a technique to improve accuracy in counting people in crowded scenes. This method aims to provide accurate crowd counts even when individuals are close together or obscured, making it useful for crowd management, traffic analysis, and security applications.

In [13] authors explored using Bluetooth on mobile phones for collaborative crowd density estimation. They leveraged existing Bluetooth connections to develop a cost-effective, real-time method for estimating crowd density without needing additional infrastructure. This information can be valuable for improved crowd management.

III. PROPOSED ALGORITHM

This algorithm detects crowds in uneven areas by counting heads and automatically sends email alerts to security personnel when exceeding a threshold, triggering potential intervention. Here's the algorithm outline:

Video Capture: Strategically placed cameras capture high-definition video feeds of the public space. These compressed feeds are transmitted via wired/wireless networks to a central processing unit for real-time analysis using object detection, crowd behavior analysis, and anomaly detection tools.

Frame Segmentation: For real-time crowd monitoring, OpenCV facilitates frame segmentation, dividing video streams into frames for efficient analysis, YOLO integration, and object detection. This enables individual and group tracking, anomaly detection, and enhanced public space safety management.

Crowd Density Calculation: YOLO facilitates real-time crowd density calculation by counting individuals within video footage. This involves pre-trained models like YOLOv8, which provide high accuracy and real-time processing. The number of people is then divided by the area, resulting in a quantitative density measure for informed crowd management and social distancing enforcement.

Model Creation: CNNs are crucial for public space monitoring, enabling object detection, crowd density estimation, anomaly identification, and behavior analysis. R-CNN, YOLO, SSD, and CSRNet models excel in these tasks, facilitating real-time monitoring and proactive security measures through efficient inference frameworks like TensorFlow Lite.

Suspicious activity detection: CNNs power suspicious activity detection in public spaces. Trained on video footage, these models analyze visual data, extract features, and distinguish normal from suspicious behavior through thresholding and post-processing. This enables real-time anomaly detection and alert generation for enhanced public safety.

Alert Message: The email-based alert system analyzes video footage using YOLO and CNN for real-time detection. Upon identifying suspicious activity or overcrowding, it triggers emails with details and visual evidence to designated personnel, enabling swift response and informed decision-making. This scalable system ensures continuous monitoring and effective public safety management.

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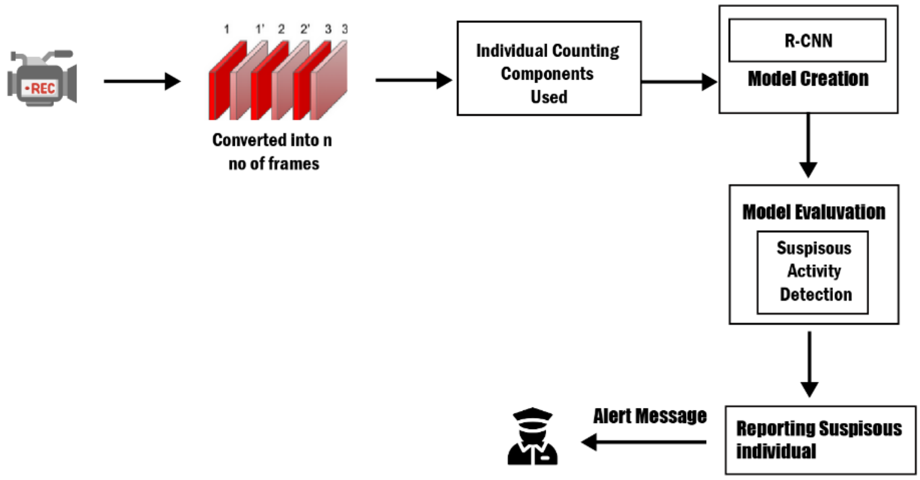

IV. PSEUDO CODE

```
Step 1: Install library:
            Install ultralytics
Step 2: Import libraries:
          Import YOLO, object_counter, cv2, smtplib, email libraries
          Import matplotlib for plotting.
Step 3: Load YOLO model:
   Load pre-trained YOLO model (yolov8n.pt).
Step 4: Open video capture:
   Open video file (pexels_videos_2670.mp4).
Step 5: Define region of interest:
            region_points = [(20, 400), (2000, 404), (2000, 360), (20, 360)]
Step 6: Initialize video writer:
          video_writer = cv2.VideoWriter("object_counting_output.avi",
             cv2.VideoWriter_fourcc(*'mp4v'), fps,
Step 7:  Initialize object counter:
          counter.set_args(view_img=True,
            reg_pts=region_points,
            classes_names=model.names,
Step 8: Set email settings:
   Define sender email, receiver email, password,
   object count threshold.
Step 9: Initialize object count list
          object_count_threshold = .
Step 10: Function to plot object count graph:
           plt.figure(figsize=(10, 6))
              plt.plot(object_counts, label='Number of Objects')
Step 11: Loop through video frames:
          While video is open:
          Read a frame from the video
          If frame is empty, break the loop.
Step 12: Track objects in the frame:
          Track objects using YOLO model
Step 13: Count objects within the defined region
          Count objects within the region using the counter
Step 14: Write the frame with object count to video output
           im0 = counter.start_counting(im0, tracks)
              video_writer.write(im0)
Step 15: Update object count list
```

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```
        if boxes_count > object_count_threshold:
         object_counts.append(boxes_count)
Step 16: Check if objects are detected
      If objects are detected:
        If object count is greater than the threshold:
        Save the current frame as an image (crowd_image.jpg)
        Create a multi-part email message with subject and body
        Attach the saved image to the email
        Connect to SMTP server and send the email
        Print "Email sent successfully"
Step 17: Call the plotting function
      Plot the object count graph.
Step 18: Release resources
      video_writer.release()
        cv2.destroyAllWindows()
Step 19: Close the plot
       Close the matplotlib plot
```

V. SIMULATION RESULTS

A real-time crowd monitoring system using YOLO from Ultralytics for object detection. This system effectively tracked objects within a designated area in Fig.1. When the object count surpassed a threshold, an email notification with a captured image Fig. 2 was sent via SMTP mail configuration to security personnel, providing crucial evidence for informed decision-making Fig. 3. This versatile system is applicable for crowd control and social distancing enforcement in events, public transportation hubs, and public spaces. Ultralytics' YOLOv8 model and real-time monitoring offer a robust and efficient approach. Future research will focus on integrating automated response systems and anomaly detection for further improvement.

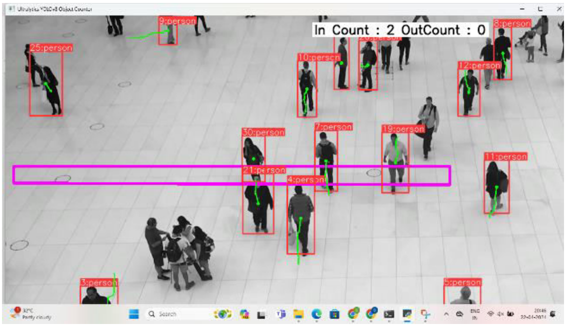


Fig. 1

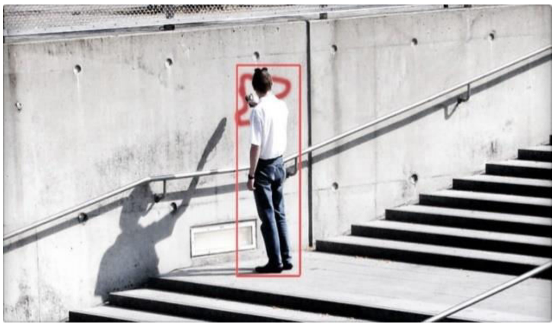
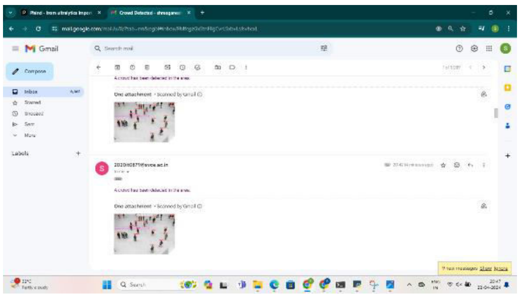


Fig. 2



VI. CONCLUSION AND FUTURE WORK

A simulation evaluated a real-time crowd monitoring system utilizing Ultralytics' YOLO for object detection. The system effectively tracked objects within a designated area (Figure 6.1). Upon exceeding a predefined threshold, email notifications with captured images (Figure 6.3) were sent to security personnel via SMTP mail configuration. These

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images provided crucial visual evidence, enabling informed decision-making regarding crowd management. This versatile system demonstrates applicability for crowd control and social distancing enforcement in diverse settings like events, public transportation hubs, and public spaces. The simulation successfully triggered email alerts, showcasing the system's potential for real-world deployment

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