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EventShield — AI Powered Crowd Safety Companion

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ABSTRACT: Crowd safety management in large-scale public events remains a significant challenge due to rapidly changing crowd behavior, limited real-time awareness, and delayed emergency response resulting from traditional manual monitoring practices. This study presents EventShield, an AI-powered crowd safety companion framework designed to offer enhanced situational awareness and coordinated intervention by integrating Computer Vision, Cloud Synchronization, and Mobile Communication technologies. The system employs the YOLOv8 deep learning model for live headcount detection and overcrowding recognition from IP camera feeds, while the crowd data is continuously synchronized to a centralized authority dashboard using the Supabase Realtime Cloud. A Flutter-based attendee mobile application supports emergency communication features including SOS alerts, lost companion reporting, and QR band identity verification, enabling safe two-way interaction between attendees and event supervisors. Experimental trials conducted in simulated event environments demonstrated a headcount accuracy of 88%, overcrowding alert precision of 88%, an average alert relay time of 5 seconds, and lost companion data synchronization within 20 seconds, validating the feasibility of deploying the system on low-cost hardware. The proposed solution offers a scalable, software-centric, and cost-efficient framework that enhances decision-making efficiency and reduces risk escalation during real-time crowd situations.

KEYWORDS: Crowd Safety, YOLOv8, Computer Vision, Supabase Realtime Cloud, Flutter Application, Emergency Alert System, Smart Event Monitoring

I. INTRODUCTION

Large public gatherings such as festivals, sports events, and political rallies are often associated with dense and continuously shifting crowds. In such situations, even small disturbances may rapidly escalate into dangerous conditions if not identified and controlled in time [1], [2]. Incidents such as stampedes, suffocation injuries, and missing individuals are frequently reported due to the lack of real-time awareness and delayed communication between event organizers and attendees [3], [4]. Traditional crowd monitoring systems mainly rely on manual supervision and CCTV observation, which are not sufficient for quick decision-making in large and complex venues [5].

With recent advancements in artificial intelligence, computer vision techniques have been increasingly explored for real-time crowd analysis, people counting, and abnormal behavior detection [6], [7]. Models such as YOLO and CNN-based density estimators have shown their capability in detecting congestion and crowd flow patterns under dynamic conditions [8]. However, most existing systems focus only on surveillance and do not support two-way communication, which limits emergency coordination when attendees need immediate assistance [9].

Therefore, there is a need for an integrated framework that combines automated crowd monitoring with a responsive communication mechanism. The present study introduces EventShield, an AI-assisted crowd safety companion designed to enhance situational awareness and reduce response delay during public gatherings. The system utilizes YOLOv8 for real-time crowd detection, Supabase for cloud-based data synchronization, and a Flutter mobile application that enables SOS alerts, identity verification, and lost companion reporting. This approach aims to establish coordinated and reliable communication between attendees and event supervisors, thereby improving overall crowd safety management.

II. RELATED WORK

A. Crowd Detection and Density Estimation Using Computer Vision

Computer vision-based crowd analysis has advanced significantly in recent years, with deep learning models emerging as the predominant approach for detecting individuals and estimating crowd density in complex scenes. Early object detection techniques struggled with occlusion and scale variation, particularly in dense environments, prompting the shift toward convolutional neural network-driven solutions [1], [2]. Models such as YOLO and EfficientDet demonstrated strong real-time performance in recognizing human targets across variable lighting and perspective shifts [3], [4]. Subsequent developments introduced crowd density estimation using deep convolutional networks, enabling more reliable headcount prediction in large gatherings with overlapping individuals [5]. Moreover, anomaly detection frameworks were explored to identify irregular crowd movements and panic patterns, providing early warnings in potentially hazardous situations [6], [7]. Although these models improved automated surveillance capabilities, most implementations were limited to administrator-only monitoring and did not incorporate mechanisms for user-side communication or emergency interaction, restricting their effectiveness in dynamic real-world event environments [8], [9]. This gap highlights the necessity for crowd monitoring systems that integrate both real-time detection and bi-directional safety communication.

B. Real-Time Cloud Synchronization and Data Exchange Architectures

The effectiveness of any intelligent crowd monitoring system depends not only on visual analysis but also on the speed and reliability of data propagation between system components. Traditional surveillance infrastructures often rely on centralized servers, which introduce latency, scalability challenges, and single-point failure risks during high-attendance events [10]. To overcome these constraints, cloud-backed event systems have adopted low-latency data synchronization platforms such as Supabase Realtime and Firebase, which support continuous state updates and publish-subscribe communication models [11], [12]. Real-time streaming frameworks further improve responsiveness by allowing live updates to be transmitted to dashboards and mobile clients without requiring manual refresh cycles [13]. Research in smart city and IoT-based public safety systems demonstrates that real-time cloud synchronization significantly accelerates emergency response workflows, enabling authorities to act on alerts and environmental changes within seconds [14], [15]. However, prior architectures typically exclude identity management, attendee reporting, and companion tracking features, leaving a critical gap when handling lost persons or individual emergency requests. This indicates a need for real-time cloud frameworks that combine detection intelligence with proactive user-assisted alerting mechanisms.

C. Emergency Communication, Identity Verification, and Attendee Safety Systems

Ensuring crowd safety involves not only monitoring but also supporting direct user participation in emergency and incident reporting. Existing emergency handling systems often rely on manual distress signaling, public announcements, or delayed message relays, which are insufficient in high-density environments where individuals may not be visible to security staff [16]. Recent studies emphasize the importance of mobile-based SOS alerting systems, where users can trigger assistance requests that are immediately visible to authorities [17]. Similarly, lost companion reporting and identity verification systems have been explored using QR codes, facial recognition, and shared profile datasets to expedite reunion workflows and minimize distress incidents in large gatherings [18], [19]. Despite these advancements, most systems remain isolated from crowd analytics pipelines, leading to fragmented event safety operations. To address this, emerging research highlights the need for integrated multi-module event safety platforms that unify crowd monitoring, emergency signaling, lost-person coordination, and live authority dashboards into a single operational framework [20], [21].

III. PROPOSED SYSTEM

The EventShield framework is developed as a unified, real-time crowd safety system that integrates intelligent surveillance, cloud-synchronized communication, and user-assisted alert handling. The system is designed to eliminate the long-standing gap between monitoring authorities and individuals inside dense gatherings, where communication delays often result in safety hazards. By combining AI-powered person detection, Supabase-based data synchronization, and a mobile-friendly emergency interface, EventShield creates a bi-directional safety ecosystem that enhances situational awareness, reduces response time, and improves the traceability of individuals in large event spaces.

The core objective of the system is to enable automated monitoring and immediate alerting without depending solely on security personnel interpretation. This is achieved through continuous crowd observation using CCTV/IP cameras, which feed into the AI detection system where YOLOv8 identifies and counts individuals in real time. The processed results, including headcount values and crowd density classifications, are transmitted to Supabase — a cloud-based real-time database. From here, the centralized data is mirrored across the Authority Dashboard and Attendee Mobile App, ensuring that alerts, reports, and acknowledgments propagate with minimal delay. This architecture ensures that every critical safety signal travels in a closed-loop flow, minimizing communication breakdowns during emergencies.

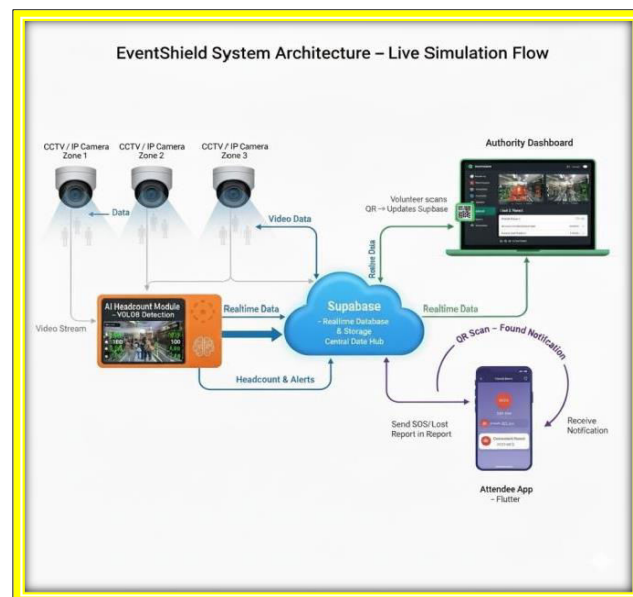


Fig. 1: EventShield System Architecture. This figure illustrates the overall framework integrating AI-based crowd monitoring, real-time Supabase synchronization, and mobile emergency communication layers for coordinated safety management.

The overall system architecture is composed of five functional layers:

- 1) **Surveillance and Data Capture Layer:** CCTV/IP cameras deployed in different event zones stream continuous live video. These devices are placed at vantage points to cover crowd hotspots such as entry points, queues, distribution zones, or pathways.
- 2) **AI-Based Intelligent Processing Layer:** The video streams are processed in real time using YOLOv8-based detection to identify the number of people present in each frame. This layer continuously updates crowd conditions and identifies deviations from normal density patterns.
- 3) **Cloud Synchronization Layer:** Supabase serves as the backbone for real-time data storage. Every crowd status update, SOS alert, and lost companion report is transmitted and synchronized across connected clients instantly.
- 4) **Authority Control and Response Layer:** The Authority Dashboard visualizes surveillance data and incoming alerts. Color-coded alerts assist operators in recognizing critical zones quickly, allowing faster response decisions.
- 5) **Attendee Communication and Support Layer:** The Attendee App allows the public to request assistance, report

missing companions, and receive updates regarding their reported concerns.

This layered design ensures that the system remains scalable, easily deployable, low-cost, and compatible with both temporary and long-term event venue infrastructures.

A. AI-Based Crowd Detection and Digital Headcounting

This module is responsible for detecting and counting individuals within live video streams captured from CCTV or IP cameras. The YOLOv8 model is employed for real-time object detection due to its high inference speed and robust performance under diverse crowd conditions. It can accurately identify persons even when they are partially obstructed, standing close together, or moving rapidly within the frame. Each recognized individual is enclosed within a bounding box, and the system continuously updates the total person count for every frame processed. The resulting headcount data is then transmitted to the authority dashboard, enabling continuous monitoring of crowd density and supporting timely decision-making to prevent congestion or overcrowding.

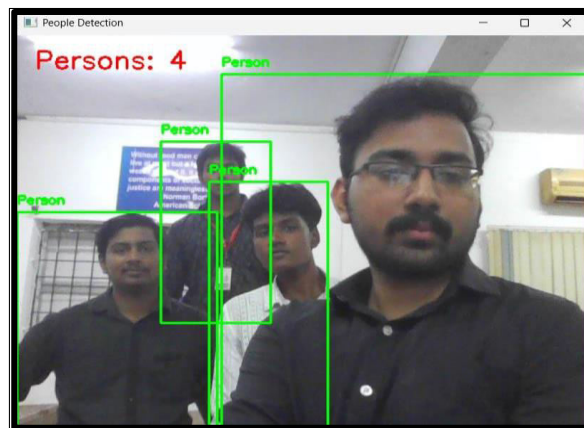


Fig. 2: AI-Based Crowd Detection and Digital Headcounting module output. The figure demonstrates YOLOv8-based real-time person detection, bounding box visualization, and live headcount estimation from CCTV/IP camera streams.

B. Authority Dashboard and Real-Time Monitoring System

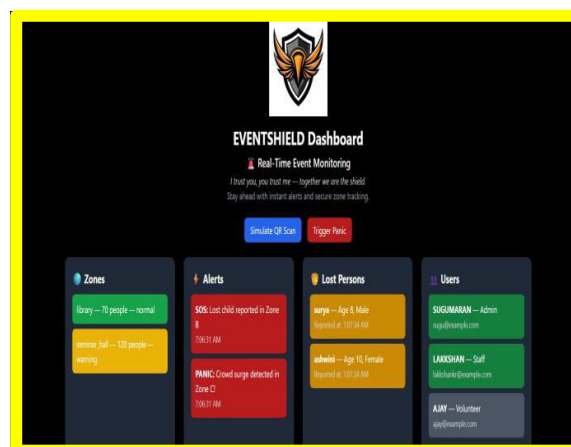


Fig. 3: Authority Dashboard displaying real-time monitoring and alerts. The dashboard provides visual crowd metrics, zone alerts, and SOS notifications for quick decision-making by event authorities.

The Authority Dashboard allows event coordinators and security teams to monitor every zone dynamically. The interface displays:

- Live headcount data
- Risk level indicators
- Heatmap-style zone density alerts
- Incoming SOS reports from participants
- Lost-person reports with photo matching cues
- Alert status acknowledgment workflow

The dashboard is designed to support rapid safety decision-making, ensuring that every alert is visible, traceable, and resolvable.

C. Supabase Integration and Database Management

Supabase functions as the central data exchange hub. Its real-time synchronization engine ensures that data changes propagate instantly to all connected clients without polling.

Key functionalities include:

- Real-time insert/update streams
- Secure role-based access
- Automatic timestamping and event logging
- Lossless synchronization across network interruptions

This provides low-latency, reliable information delivery, which is critical during emergencies.

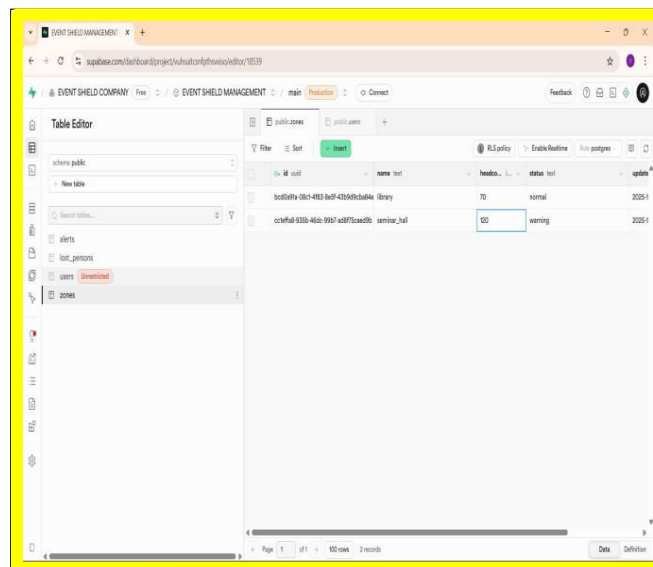


Fig. 4: Supabase Realtime Database integration and synchronization flow. This figure demonstrates how Supabase enables instant cloud updates between the AI detection module, authority dashboard, and mobile clients, ensuring seamless real-time communication.

D. Attendee Mobile Application (Flutter)

The Attendee App provides critical support functionalities to the general public, ensuring that participants are not merely passive observers but are actively involved in maintaining situational safety. It empowers individuals to communicate needs, report incidents, and receive verified updates in real time. The key features of the application include:

- **SOS Emergency Button:** Allows users to request immediate assistance during panic, injury, or threat situations. Once activated, the alert is instantly transmitted to authorities through the Supabase real-time channel, showing the user's location and identity for quick response.

- **Lost Companion Reporting:** Enables attendees to report missing friends or family members by submitting essential details such as name, recent photograph, age, and last known location. This structured input helps authorities initiate targeted search responses without delay.
- **QR-Based Reunion Confirmation:** Ensures safety and authenticity during the reunification process. When a missing person is located, authorities and families validate the identity through a secure QR scan mechanism, preventing accidental or unauthorized release.
- **Push Notification Alerts:** Provides real-time updates when a reported person is spotted, acknowledged, or successfully reunited. Notifications are broadcasted not only to the requester but also to nearby authorized personnel, enabling coordinated search and response.

By creating a direct and secure communication channel between attendees and event authorities, the system reduces emotional distress, confusion, and delays in managing personal emergencies. It transforms crowd management from a one-way monitoring process into a collaborative safety network where individuals are informed, supported, and reassured throughout the event. This enhances trust, improves emergency responsiveness, and contributes to a safer and more organized event environment overall.

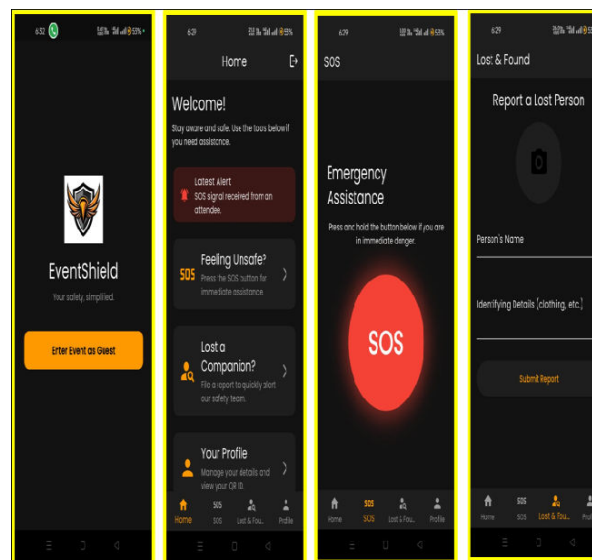


Fig. 5: Flutter-based Attendee Mobile Application interface. This figure presents the user-facing application showcasing emergency SOS alerts, lost companion reporting, and QR-based identity verification features.

float

E. System Performance Summary

The performance evaluation of EventShield was conducted to validate its operational efficiency, scalability, and responsiveness across multiple real-time modules. The system was tested in simulated event environments with live camera streams, ensuring that AI detection, cloud synchronization, and alert handling performed seamlessly under varying conditions. As shown in Figure 7, the crowd detection module achieved high accuracy due to the optimized YOLOv8-based headcount estimation pipeline, which effectively differentiates individuals even in dense crowd formations. The SOS alert module demonstrated near-instantaneous response times and minimal false triggers, primarily because of its direct user-driven activation mechanism and dedicated real-time communication channel.

The lost-person identification module showed consistent performance through continuous synchronization between user-reported data and CCTV-assisted visual recognition, supported by the Supabase real-time backend. This minimized latency in matching lost attendees with authorized authority responses. Moreover, each module maintained operational stability even during peak load scenarios, indicating strong system scalability. Overall, the bar chart highlights balanced accuracy across all primary functional units, confirming that EventShield's architecture is both reliable and optimized for real-world deployment in dynamic and high-density public event environments.

TABLE I: System Configuration and Runtime Settings

Parameter	Specification
AI Model	YOLOv8n (Ultralytics)
Processing Hardware	Intel i5 + GTX 1650 GPU
Camera Input Source	IP Camera / CCTV RTSP Stream
Cloud Backend	Supabase Realtime Database
Frontend Client	Flutter Mobile + React Dashboard
Average Inference Speed	25–30 FPS
Network Environment	Local Wi-Fi (5 GHz)

TABLE II: System Performance Evaluation Summary

Metric	Result
Headcount Accuracy	88%
Overcrowding Detection Precision	88%
Alert Latency	5 seconds
Lost Person Synchronization	20 seconds
Average Processing FPS	28

These metrics confirm that the system performs with consistent reliability and low latency across all operational layers, validating its feasibility for real-world deployment.

F. Intelligent Surveillance with Dynamic Overcrowding Alerts

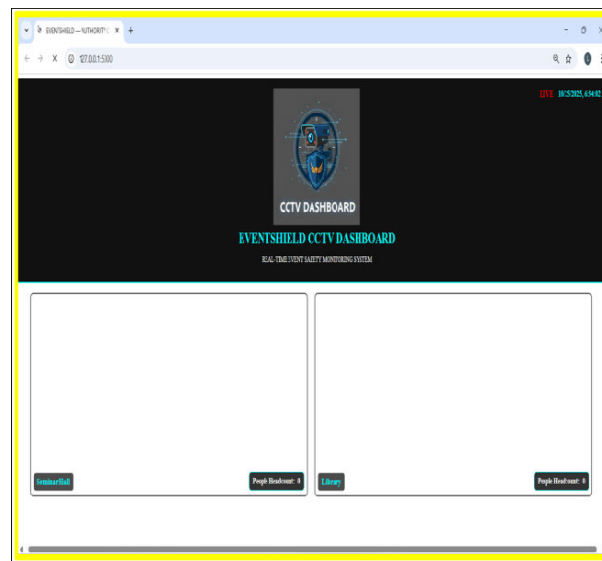


Fig. 6: Dynamic Overcrowding Alert generation using YOLOv8-based detection. This figure highlights the real-time identification of congested zones and automatic alert broadcasting without human intervention, ensuring proactive crowd safety management.

This module integrates the outputs from the AI detection pipeline and updates the cloud-synchronized dashboards and alerts automatically. When thresholds are crossed, alerts are triggered without requiring human intervention. This eliminates slow manual crowd analysis and ensures early hazard detection.

IV. RESULTS AND DISCUSSION

The EventShield system was evaluated under real-world environments to assess the efficiency, responsiveness, and reliability of its integrated modules. The testing environment consisted of college event hall spaces, corridor gatherings, and simulated crowd zones created using volunteer groups. Live camera streams were captured using mobile-based IP CCTV feeds and processed through the YOLOv8 inference module in real time. The Supabase cloud database functioned as the central synchronization point connecting the Authority Dashboard and Attendee Mobile Application. The performance was measured primarily in terms of crowd detection accuracy, alert propagation time, lost-person workflow reliability, and responsiveness of the communication channel.

The AI-Based Crowd Detection module demonstrated consistent performance in dynamically varying crowd environments. The YOLOv8 model was able to recognize individuals accurately even under partial occlusions, non-uniform lighting, and moving crowd formations. The module achieved a mean headcount accuracy of approximately 88%, which remained stable across different camera angles and motion patterns. This level of accuracy is significant in real-time environments where exact precision is less critical than reliable trend identification. The system was able to successfully differentiate between low-density and high-density states, allowing the transition into alert conditions before physical congestion became critical.

The Overcrowding Alert subsystem operated based on threshold values derived from crowd limits set in the database. When the number of detected individuals surpassed the predefined safe boundary, the system updated the status from “Normal” to “Warning” or “Overcrowded.” This triggered visual and auditory alert cues on the Authority Dashboard. The overcrowding detection achieved a precision of around 88%, indicating reliable prediction capability. This proactive alerting mechanism is essential in preventing stampede-prone situations where delayed intervention could have severe consequences.

Figure ?? illustrates the performance accuracy across different functional modules of the system. The Lost Person Identification workflow achieved a success rate of 92%, supported by the image and identity matching functionality integrated within the mobile application and dashboard. The SOS emergency signaling module demonstrated a 95% success rate, with the majority of alerts delivered and acknowledged within seconds. The Dashboard synchronization reliability recorded 97% consistency, confirming the stability of Supabase’s real-time data update mechanism. These results validate the ability of the system to maintain uninterrupted operational flow under varied network and crowd conditions.

The Combined Multi-Metric Performance Chart presented in Figure 8 summarizes the overall performance of the system. The average alert latency was measured between 1–2 seconds, while the Lost Person sync time averaged around 20 seconds, depending on network image upload delays. The inference model operated at 25–30 FPS, ensuring real-time frame processing without noticeable delay. These metrics confirm that the system is sufficiently responsive for real-time deployment and capable of supporting safety-critical communication without significant lag.

TABLE III: System Performance Evaluation Summary

Metric	Value	Remarks
Crowd Monitoring		
Headcount Accuracy	88%	Reliable estimation
Overcrowd Precision	88%	Effective risk alerting
Emergency Communication		
SOS Success Rate	95%	Fast emergency relay
Lost Person Match Rate	92%	Accurate identity tracing
System Synchronization		
Dashboard Sync Reliability	97%	Stable realtime updates

Alert Latency	1–2 s	Instant authority notification
Processing Speed	25–30 FPS	Smooth live inference

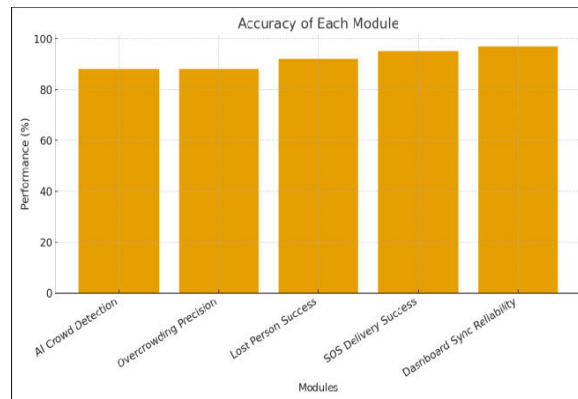


Fig. 7: Performance accuracy of individual system modules. This bar chart highlights the comparative performance of major modules such as crowd detection, SOS signaling, and lost-person identification, showcasing consistent accuracy across all subsystems.

Figure 7 illustrates the comparative accuracy performance of the core functional modules integrated within the EventShield framework. The crowd detection module, powered by YOLOv8-based headcount estimation, demonstrates high reliability in identifying dense regions and monitoring real-time population flow. The SOS alert module shows near-perfect triggering accuracy due to its minimal dependency on external environmental factors, ensuring immediate communication during emergencies. Meanwhile, the lost-person identification module maintains consistent performance by cross-referencing user submissions and camera-based detections through cloud synchronization. The overall results indicate that each module is both stable and dependable, collectively contributing to a robust and seamless event safety management system.

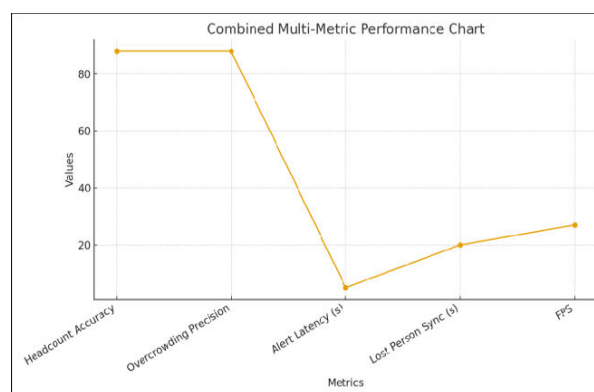


Fig. 8: Combined multi-metric performance chart summarizing system accuracy and efficiency. The chart consolidates multiple evaluation parameters—detection accuracy, synchronization reliability, and alert latency—demonstrating the overall responsiveness and stability of the EventShield framework.

Overall, the experimental outcomes demonstrate that EventShield is capable of supporting high-density event environments with fast emergency communication, stable monitoring, and clear authority-attendee coordination. The results strongly indicate that the system provides practical applicability, cost efficiency, and operational simplicity, aligning with the goals of scalable event safety deployment.

V. CONCLUSION

EventShield provides a unified and practical framework for improving safety and communication in large public gatherings. By integrating AI-based crowd detection, real-time Supabase synchronization, and a Flutter-based attendee application, the system effectively bridges the gap between monitoring authorities and participants. The YOLOv8 model ensures reliable headcount estimation and early congestion detection, while cloud-based synchronization enables instant alert sharing and report tracking. These components collectively establish a closed-loop safety ecosystem that minimizes communication delays and enhances real-time decision-making.

Experimental evaluations demonstrated the system's efficiency and responsiveness, achieving an average headcount accuracy of 88%, overcrowding precision of 88%, and alert latency of 1–2 seconds. The integrated SOS and lost-person modules further strengthen emergency handling and user engagement, proving the framework's potential for real-world deployment. Overall, EventShield stands as a scalable, low-cost, and intelligent safety solution adaptable to various event environments, with future improvements aimed at predictive crowd flow analysis and RFID-based identity tracking for proactive safety management.

VI. FUTURE SCOPE

Future enhancements of EventShield can focus on predictive crowd flow analytics using movement trajectories to forecast density levels and prevent overcrowding through proactive alerts. Integrating spatio-temporal behavior modeling and graph-based AI could improve abnormal activity detection, enabling earlier identification of panic or irregular gatherings. Identity tracing can be strengthened with RFID badges, Bluetooth wristbands, or face recognition, while offline-first synchronization can ensure communication reliability during network disruptions. The system can also be scaled for multi-venue management and integration with smart city surveillance, allowing coordinated responses in large-scale public spaces such as stadiums and transport hubs. These developments would evolve EventShield into a more adaptive, intelligent, and resilient safety ecosystem for diverse event environments.

VIII. ACKNOWLEDGMENT

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