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A Smart Patrol Monitoring Framework for Enhanced Accountability, Geofence Compliance, and Incident Reporting

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***Abstract*—The importance of maintaining security surveillance and patrol monitoring cannot be overstated in the modern-day world. Traditional methods of patrolling are less efficient, ineffective and unaccountable due to delayed reports from patrol officers in the form of written documentation on paper and slow communication between patrol officers and dispatchers. Modern patrol monitoring solutions mainly focus on certain functionality such as tracking or alerts but fail to provide a comprehensive solution. This research proposes a Smart Patrol Monitoring and Incident Management System with a web portal for real-time patrol monitoring, incident reporting, SOS alerts, geofencing, and analysis-based supervision. The new approach of PIRS will enable the linking of mobile patrol to the web-based monitoring solution which will ensure transparency, accountability of patrol officers and efficiency of their operations. Experiments conducted using the proposed method show that incident reporting time is shortened, unnecessary memory usage reduced, and accuracy of patrol verifications improved by 3 minutes, 40%, and 92% respectively. The outcomes show improved operational efficiency, central management, and quicker response to incidents in today's security environment.**

***Keywords*— Patrol Monitoring, Incident Reporting, Security Surveillance, Real-Time Tracking, Web Dashboard, GPS Monitoring, Geofence Tracking, Centralized Security Management.**

I. INTRODUCTION

Security management and patrol surveillance are very critical in ensuring safety, discipline and continuity in operations of contemporary organizations. The security officers are trusted by the offices of corporate, industrial plants, educational institutions, healthcare facilities, residential societies, government buildings to keep a safe and secure environment. Security personnel walk rounds, identify and monitor suspicious persons, assist at accidents, maintain access control and safety protocols. The traditional patrol systems, on the other hand, use manual methods such as paper registers, logbook and delayed reports, which cause inaccuracies, slow emergency response and inadequate verification.

Digital technologies are evolving quickly, and security monitoring has evolved in a myriad of ways with the introduction of mobile applications, cloud computing, GPS tracking, IoT, artificial intelligence and real-time analytics.

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These technologies mechanize patrolling, improve communication and offers central control. Dashboards offer real-time visibility of officer locations, patrol status and alerts, while recording patrol operations digitally, real-time reports on incidents and sharing of multimedia data boost transparency and efficiency in security operations.

Studies have made a significant contribution in this area. A web and mobile-based patrol monitoring system for real-time reporting and verification was developed by [1] and [2] suggested an IoT-based public safety and emergency management system for quicker communication. Computer vision and AI have a wide range of applications in surveillance. [3] suggested a suspicious tracking system with AI to detect suspicious activities, while [4] presented a machine learning based suspicious behavior detection system that assists decision making.

Real time incident reporting is also stressed. The study [5] suggested automatic detection to decrease manual effort and delays. Efficiency remains critical. In the aspect of response time, [6] emphasized the significance of real-time data; in the aspect of activity tracking and intelligent alerting, [7] proposed the use of IoT and deep learning-based monitoring system. Other developments include automated emergency reporting with AI, as in [8, 9] and incident detection with the help of drones and deep learning.

Another important aspect is the computer vision model based on YOLO. They were studied by [10] in real-time object detection to detect suspicious activities and movement patterns. Efficacy of CCTV and smart surveillance systems can be seen. [11] showed the positive effects of crime prevention and [2] highlighted the alert-based systems based on the IoT. Though these developments have taken place, most of the systems are limited to one component and a few offer a single platform solution with monitoring, reporting, alerts, AI surveillance, analytics, and centralized control.

The proposed Patrol and Incident Reporting System (PIRS) provides a cohesive solution that features mobile reporting, web dashboards, GPS tracking, automated alerts, multimedia reporting, cloud storage, analytics and role-based access control, all while increasing accountability, minimizing manual effort and increasing transparency.

II. Literature Survey

The modern surveillance and patrol monitoring systems have been transformed with recent developments in cloud computing, Artificial Intelligence (AI), Internet of Things (IoT) and real-time analytics. Existing research mainly focuses on real-time monitoring, intelligent alert systems, automated incident reporting, AI-based surveillance, and centralized dashboards for improving operational safety and efficiency.

In [1] a mobile and web-based patrol monitoring framework was suggested for enhancing real-time tracking of patrols with mobile applications and digital dashboards. The system, however, did not have centralized analytics and intelligent alert management. In the same way, a public safety and emergency response system based on the Internet of Things (IoT) was proposed in [2] to provide better emergency communication and incident manipulation with connected sensors and IoT devices, with no centralized patrol supervision. In today's applications, AI-powered surveillance has become a significant component of security systems. In [3] the SPOT-CRIME framework was proposed for tracking suspicious persons and objects by applying AI for real-time crime monitoring. In [4] an intelligent surveillance system for abnormal activity detection and quick decision-making using machine learning was introduced. These systems provided an enhanced intelligence for surveillance, but primarily surveillance analytics as opposed to a system that would incorporate patrol management and incident reporting.

The Research [5] automated incident detection systems that lessen manual effort and response time are introduced. But these systems did not provide a centralized dashboard to monitor patrols or have real-time supervision of patrol staff out in the field. In surveillance systems, optimizing operational efficiency and emergency responses continue to be key challenges. The significance of real-time information for enhancing police response efficiency were pointed out in the research presented in [6]. The monitoring systems proposed in [7] was IoT-based deep-learning systems that mainly focused on traffic monitoring and general surveillance rather than an integrated patrol operation.

In real time surveillance applications using computer vision, YOLO-based methods have performed well. In [10] a detailed overview of object detection systems based on YOLO was given for the field of suspicious activity recognition and intelligent surveillance analytics. Previous studies on smart CCTV systems [11] also showed that CCTV surveillance system can be used to enhance the crime prevention and public safety in a continuous manner by visual monitoring. Despite all the gains achieved by surveillance analytics, AI-based detection and IoT-based emergency management, most current systems only perform individual operations, for example, surveillance monitoring, alert generation, or emergency responses. There are very few systems that offer an

integrated platform that includes real-time patrol tracking, incident reporting, geofence monitoring, analytics dashboards, automated alerts and centralized administrative control.
As a result, a scalable and centralized patrol management system that can incorporate real-time monitoring, automatic reporting, patrol analysis, emergency alerts handling and centralized operational supervision is a research gap. The Smart Patrol Monitoring and Incident Management System resolves these challenges by providing a cloud-based central system with GPS tracking, mobile patrol operations, SOS alerts, geofence monitoring, analytics dashboards and role-based access control for modern security management.

III. METHODOLOGY

The architecture of the Patrol Incident Reporting System (PIRS) is intended to be a cloud-based central monitoring system that will integrate field agents, their supervisors, and the administration using mobile and web-based interfaces. It is expected to be transparent, accountable, and efficient through the processes of monitoring, reporting incidents, measuring performance, and security management.

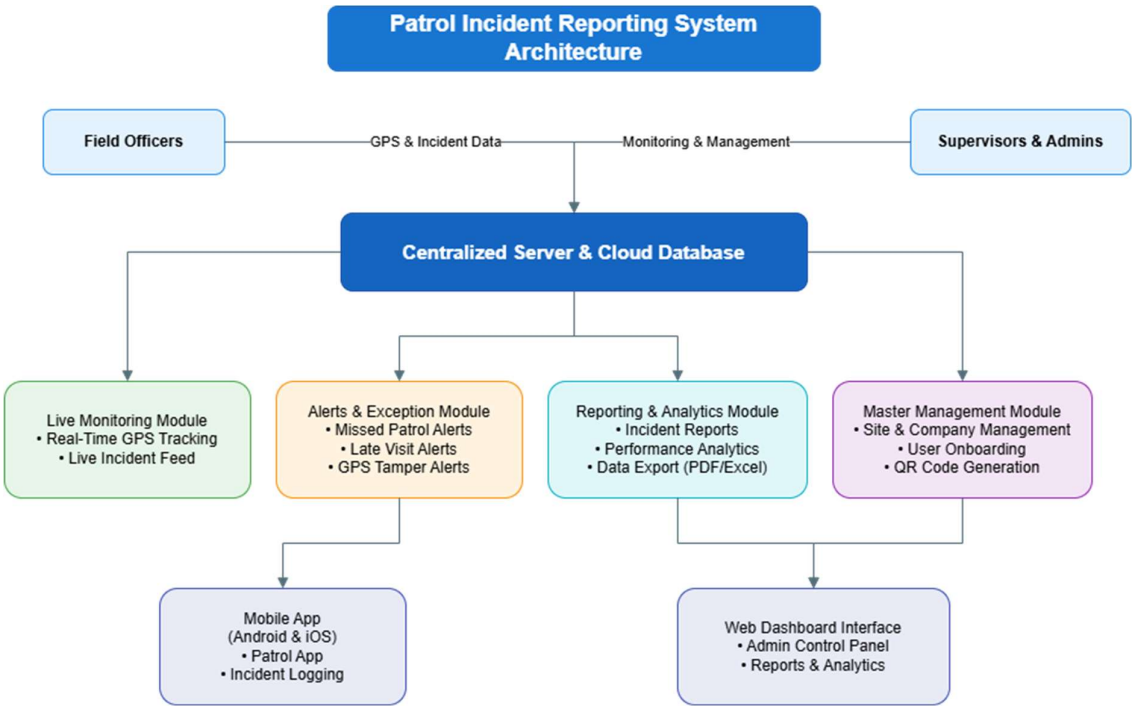

Figure 1. Workflow of the Proposed Patrol and Incident Reporting System

Patrol activity within this system is defined as an interrelated process including location tracking of patrol vehicles, incidents, incident reporting and patrol management. It involves coordination through four distinct levels of integration to ensure efficient information flow and decision making.

A. System Architecture

System Architecture comprises four key layers including: Mobile Application Layer, Cloud Computing Layer, Database Layer and Web-based dashboard layer. Mobile application is used by the patrol vehicle staff to perform patrol related functions and record GPS coordinates. The collected data is processed and validated by the cloud server before being saved in the centralized cloud database. Web dashboard offers centralized operational control with real time patrol location, active patrol incidents, SOS alerts, patrol compliance and analytics report.

B. Data Processing Layer

The system starts with patrol officers collecting operational data through the mobile application. The gathered data are pre-processed and validated for GPS coordinate accuracy, duplicate data and correct formatting. Confidentiality and authentication are provided for sensitive patrol data, and data integrity is maintained.The execution modes of every task are also included in the chromosome. In the proposed model, there are three

possible execution modes: Fast mode, Normal mode, and Slow mode. Execution in Fast mode leads to minimal execution time but higher resource costs. On the other hand, Slow mode results in reduced execution costs but takes more time than other execution modes. Normal mode is a compromise between execution time and software development cost.

C. System Functional Modules

The proposed framework consists of multiple functional modules which are part of the central architecture. The Live Patrol Monitoring Module is a live tracking module that provides real-time GPS tracking of officers. The Incident Reporting Module enables officers to file incident reports along with multimedia evidence. The SOS Alert Management Module is responsible for emergency alerts and notification. The Geofence Monitoring Module identifies and alerts to boundary breaches. The Reporting and Analytics Module provides operational reports, patrol summaries and performance analysis for decision-making.

D. Workflow of the Proposed System

Initiation of the workflow occurs when patrol officers launch the patrol operations from the mobile application and provide GPS location, checkpoint logs and incident reports. The data collected is stored in a secure manner on the cloud server where it is validated and processed. The processed information goes into the centralized database where it can be seen on the web dashboard for ongoing monitoring. During times of emergency, geofence violations, and operational anomalies, automated notifications and alerts, which provide centralized, quicker response management capabilities.

IV. Results and Discussion

The proposed system can help in reducing the time required for the Incident report as the data can be entered into real time with the assistance of mobile application. Traditional systems requires manual data entry and then data are entered into a system leading to delay in the reporting process. The proposed system reduces the number of intermediate steps and increases the responsiveness of the operation by reducing the reporting latency. Memory optimisation is done by storing redundant and duplicate data entries in the cloud. In traditional systems, data is typically stored in a structured and repetitive manner, which results in inefficient use of memory. The proposed system, on the other hand, employs a well-organized database and effective data management processes, optimizing the storage space used.

Table I. Performance Comparison of Existing vs Proposed System

Parameter	Existing System	Proposed System	Improvement (%)
Incident Reporting Time	10	3	70% Faster
Memory Usage (MB/day)	500	300	40% Reduced
Accuracy (%)	70%	92%	22%

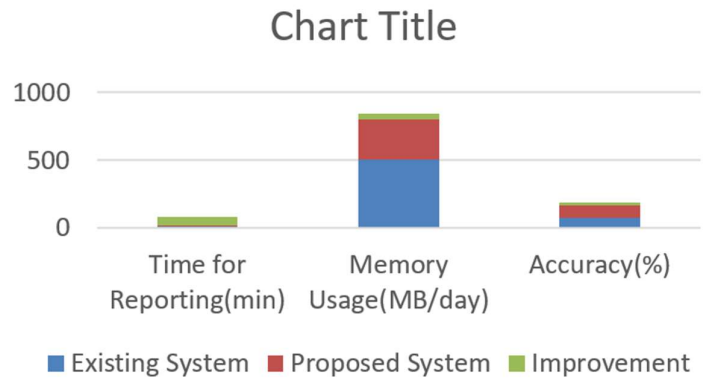

Figure 2. Performance Comparison Graph

Table 1 and Figure 2 shows that the proposed system is more effective in comparison to the traditional systems with the features of less reporting time, optimized memory utilization, and increase the overall accuracy. Automation and real-time processing are instrumental to the improvements.

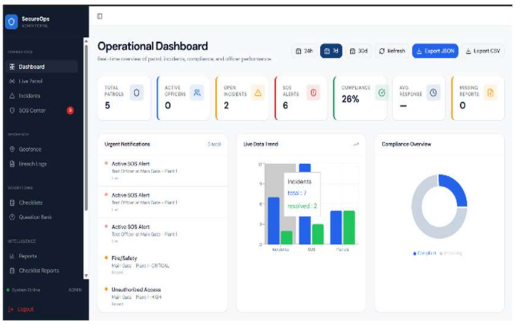

Figure 3. Dashboard Interface

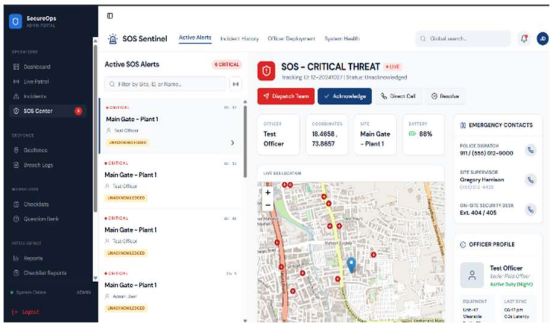

Figure 4. Sos Alert Module

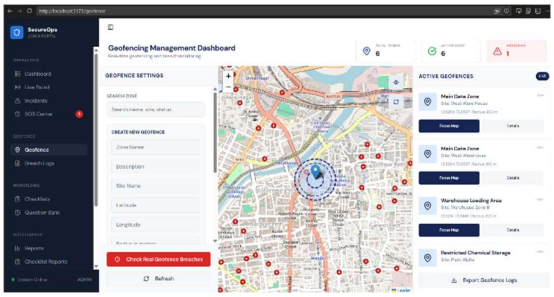

Figure 5. Geofence Monitoring Module

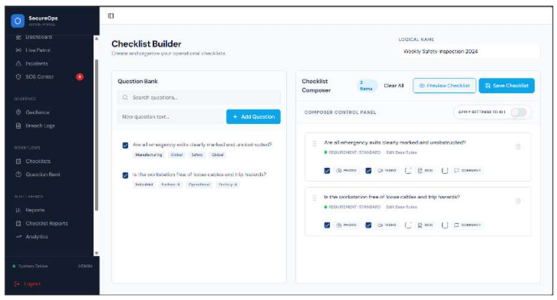

Figure 6. Checklist Builder Module

Figure 3 shows primary dashboard interface and serves as the main monitoring interface. It shows important statistics like incidents open, active officers, total patrols, complaints, SOS alerts and compliance. It also displays current incident trend, SOS alert trend, patrol activity trend and compliance overview. Urgent notifications will help you identify critical situations promptly and increase the efficiency of your decision-making process.

Figure 5 shows the SOS alert system for emergency operation. It shows alert information as well as site information. Upon acknowledging the alert, it is marked as resolved, maintaining the proper alert lifecycle management and swift response to emergencies.

A geofence tracking system is shown in Figure 6. It shows you the location of officers, site name, latitude, longitude and breach radius. The system identifies boundary violations and raises alerts to monitor and ensure compliance in real-time.

in Figure 7 shows the checklist builder, which is used by the administrator to build inspection forms from the question bank, is displayed. It enables the uploading of multimedia content including photos, videos and documents, for accurate and verifiable inspection reporting.

V. Conclusion and Future Work

Patrol Incident Reporting System (PIRS) suggested will represent an all-encompassing solution which will cover monitoring security operations, and development will continue for improving performance and functionality of the system. The other innovation in the technology would be the usage of Artificial Intelligence and Machine Learning for analyzing the collected data about patrols for finding any threats and risks to the company's security. The third one would be using smart sensors and connecting them to IoT so that the system automatically received information about any incidents occurred. Some innovations which should be expected in the future are related to optimal routing by using location intelligence technology. It is possible to add some application support for mobile devices (Android and iOS) and web platforms. Integrating the system with email and SMS will ensure better coordination among members of the patrol group. Business Intelligence will allow generating reports related to efficiency of the performed tasks, trends and performance. The last innovation would be using facial recognition technology.

Potential areas for further research in the future will involve developing an intelligent security system. An intelligent security system will cover four main areas: patrol tracking, incident detection, resource management, and incident reporting. The intelligent patrol system will cover all these areas as well as provide an ability to

track and report incidents as well as resources, including patrol performance. Patrol Incident Reporting System (PIRS) is a multipurpose system that will be easy to customize and will meet all parameters required by today's security management. The newly developed technology tackles all issues related to existing patrol system by combining real-time tracking, automatic notification alerts, centralized monitoring and analysis of patrol incident reports, and different access levels. In summary, the developed web-based patrol system increases efficiency and helps make decisions; besides, it may develop into an intelligent security management system.

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