

CrowdGuard: Advanced Lost Person Locator for Arbaeen Pilgrimages

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Abstract.:

The Arbaeen pilgrimage in Karbala, Iraq, is one of the world's largest annual gatherings, presenting significant logistical and safety challenges. A primary concern is locating missing individuals, particularly vulnerable people, where traditional methods like public announcements are often slow and inefficient. This paper introduces CrowdGuard, an integrated web-based platform designed to streamline the process of finding lost people. The system leverages a scalable PHP and MySQL backend and integrates GPS tracking for real-time location data, QR-code-based identification for rapid verification, and crowdsourced reporting to engage the public in search efforts. The platform features a bilingual user interface and uses OpenStreetMap and Google Maps APIs for dynamic mapping. The system was tested during the Arbaeen pilgrimage. The evaluation demonstrated high efficiency, with the system processing and displaying new missing person reports in an average time of 45 seconds. It achieved a high location accuracy of ± 15 meters. CrowdGuard provides a robust, scalable, and effective solution that significantly improves upon traditional methods for managing lost person incidents in large-scale events. The system's success highlights its potential for deployment in other mass gatherings to enhance public safety.

Keywords: Lost, Find, CrowdGuard, Person Locator, Arbaeen Pilgrimages.

INTRODECTION

The Arbaeen pilgrimage, a significant religious event in Karbala, Iraq, attracts millions of people annually from across the globe. The sheer scale of the crowd poses immense challenges to ensure the safety and security of attendees, especially children, the elderly, and people with disabilities, who are at a higher risk of becoming separated from their groups. The conventional methods for locating missing people, which primarily rely on manual search efforts and public announcements through loudspeakers, are often time-consuming and lack precision, leading to distress for families and immense pressure on security and volunteer teams. This inefficiency calls for a centralized, technology-driven solution that can enhance the speed and accuracy of search operations. In response to this need, we have developed “CrowdGuard,” an advanced lost person locator system. CrowdGuard is a web-based platform designed to modernize and optimize the search and reunion process by integrating a suite of powerful technologies: real-time GPS tracking, quick identification via QR codes, and community-powered crowdsourced reporting. The pilgrimage to Karbala, a 13-century tradition, is a significant religious event. Spirituality, a separate concept, is often misunderstood and influenced by personal beliefs. Understanding the significance of pilgrimages and their motives is crucial. Pilgrimage offers research possibilities for cultural identity, continuity, and change, offering a re-examination of tradition and appropriation of phenomena (Bizotto et al., 2024). To improve the speed and precision of finding lost people, a centralized, technology-driven strategy is obviously required. To meet this demand, CrowdGuard combines a number of technologies, such as crowdsourced reporting, QR-code-based identification, and geolocation monitoring, to provide a thorough and effective lost-person management system. The system is structured to deliver immediate updates, enable swift

information exchange, and enhance search operations, thereby elevating the safety and security of pilgrims throughout Arbaeen. Global Navigation Satellite Systems (GNSS) have revolutionized navigation systems, allowing vehicles to determine their own position without human intervention. This has led to increased reliance on GNSS in everyday life, including smartphones and vehicles. GNSS’s position fix is expected when a device is turned on, and it is heavily used in systems like banking, communications, and power grids. The success of GNSS has led to the need to complement it with other sensors for situations where GNSS is unavailable (Morton et al., 2021). Millions of users worldwide rely on mobile navigation services, including map applications and taxi sharing platforms, relying on accurate GPS inputs. GPS systems also play a significant role in autonomous vehicles, impacting driving safety (Zeng et al., 2018). Figure.1 shows the flowchart of sequence for Crowd Guard operations.

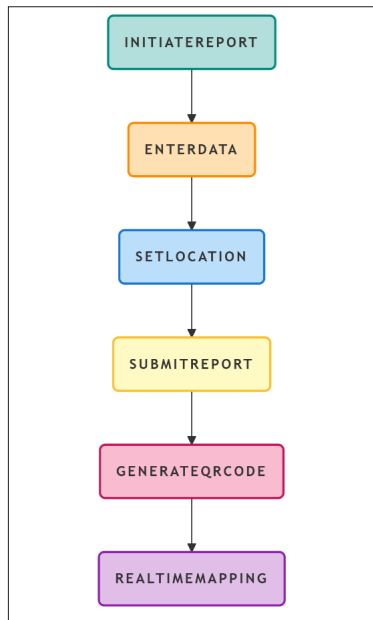


Figure.1 Principle flowchart of Crowd Guard

Related Work

Managing missing people in large gatherings has long been a logistical and operational challenge, addressed through both traditional and modern approaches.

1. Traditional Methods:

In most large-scale events, missing person reports are typically handled via physical help booths or reporting centers. These reports are then announced through loudspeakers or displayed on bulletin boards. While straightforward, these methods suffer from critical limitations such as language barriers, fragmented information, delays in dissemination, and the absence of a centralized tracking system (Bizzotto et al., 2024).

2. Modern Technological Solutions:

Advancements in technology have opened up new avenues to overcome these limitations:

Global Navigation Satellite Systems (GNSS): GNSS-based positioning has revolutionized navigation systems, especially through the widespread integration of GPS into smartphones and devices. Studies emphasize its role in emergency and safety applications during mass gatherings (Morton et al., 2021; Zeng et al., 2018). QR Codes for Identification: Widely adopted in education and communication contexts, QR codes offer a rapid, scannable identity management method, bridging the gap between physical and digital information (Durak et al., 2016). Crowdsourced Mapping Platforms: OpenStreetMap (OSM), a collaborative mapping project generating over 7.5 billion data points, has been effectively utilized in humanitarian, socio-economic, and emergency applications (Grinberger et al., 2022). Its open APIs have been leveraged in various systems for

dynamic incident mapping. While these technologies have individually been applied in multiple domains, CrowdGuard’s novelty lies in integrating them into a unified, purpose-built system tailored for the unique operational context of the Arbaeen pilgrimage.

System Design and Methodology

CrowdGuard was developed as a web-based lost person management system to enhance search efficiency and coordination during large religious gatherings like the Arbaeen pilgrimage. Figure.2 presents the class diagram of the CrowdGuard system, depicting its main entities and their interactions.

Conceptual Foundations:

Human navigation relies on complex cognitive and perceptual processes, with spatial awareness heavily dependent on the hippocampus. Navigation strategies can be egocentric or allocentric, with implications for spatial memory and crowd management system design (Clemenson et al., 2021).

Technology Stack:

The backend platform was developed using PHP, a server-side efficient language. The database is MySQL, structured to manage user data and reports. The frontend combines HTML, CSS, and JavaScript. The system is bilingual and responsive, using Bootstrap interfaces.

Key Integrated Technologies:

- **GPS-Based Geolocation** :Real-time position tracking is achieved using GPS coordinates ,displayed on live maps powered by OpenStreetMap and Google Maps APIs) Grinberger et al ;2022 ,.Morton et al.(2021) .
- **QR Code-Based Identification** :Each registered pilgrim receives a unique QR code that links to their personal record and current status.

QR technology improves access speed and data security in crowded environments) Durak et al.(2016),.

- **Crowdsourced Reporting and Mapping** :CrowdGuard integrates a crowdsourced reporting mechanism ,with real-time incident mapping for improved search coordination.

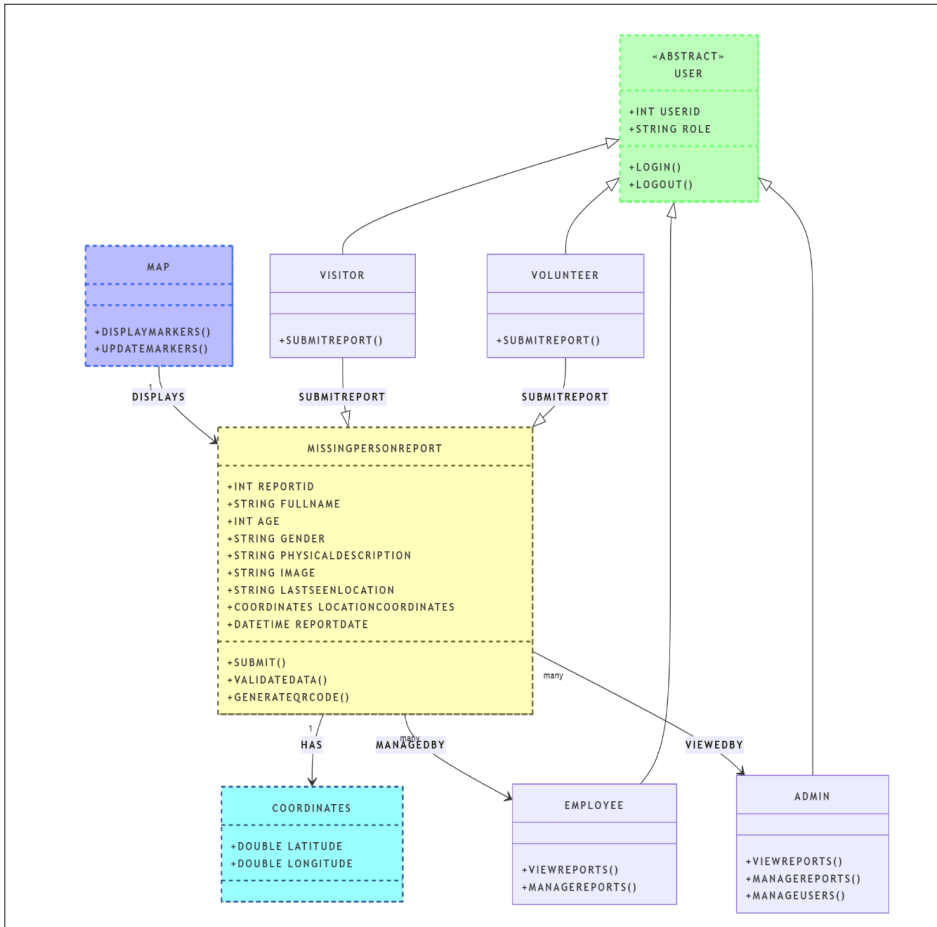


Figure2. Class diagram of Crowd Guard

Security Architecture:

To protect sensitive data, the system incorporates role-based access control (RBAC), encrypted data storage, and personal data anonymization measures, ensuring operational integrity and user privacy. The development process involved system requirement analysis, iterative implementation, real-world deployment during Arbaeen 2024, and performance evaluation under high-traffic conditions.

System Implementation & Features

person cases during the Arbaeen pilgrimage. The backend handles user roles, incident reports, and system logic, while the database ensures structured, encrypted storage of sensitive data. Role-based access control (RBAC) allows authorities, volunteers, and pilgrims to access specific functions according to their privileges. The system integrates OpenStreet-Map and Google Maps APIs for real-time visualization of missing person locations. Each report includes personal and location details, displayed dynamically on interactive maps to guide search teams. The frontend, built with JavaScript and AJAX, ensures responsive, bilingual, and real-time data updates without page reloads. Security measures include input validation, encrypted storage, and secure authentication protocols. Regular database optimization and backups enhance system reliability. Figure.3 illustrates the main user interface of CrowdGuard, showcasing the live reporting and interactive mapping features.



Figure.3 The main page of Crowd Guard

The missing person reporting form in CrowdGuard is a simple, bilingual tool accessible without requiring account creation. It collects essential details name, age, gender, last seen time, and location improving search accuracy. Users can manually input coordinates or select a location via an integrated map tool. Each submission automatically generates a unique QR code, enabling rapid status access for authorities and volunteers. The form features clear action buttons for submission, language switching, and page navigation. Figure.4 displays the missing report submission page, highlighting its bilingual interface, location input feature, and QR code integration for efficient case tracking.

The screenshot shows a web form titled "Report Missing Person" in Arabic. At the top left, there is a "Go Back" button with a left arrow and a home icon. At the top right, there is a "Switch to Arabic" button with a language icon. The main form area contains several sections:

- Upload Image (اختياري):** A section with a camera icon and a text input field containing "لم يتم اختيار أي ملف" (No file selected).
- Personal Information:** Three input fields: "Full Name" (with a person icon), "Age" (with "123" as a placeholder), and "Gender" (with a dropdown menu showing "Male").
- Description:** A large text area for providing details about the missing person.
- Location and Time:** Two input fields: "Last Seen Location" (with a location pin icon and the text "اضغط لتحديد الموقع") and "Last Seen Time" (with a clock icon and the date "١٥/٠٦/٢٠٢٥").
- Submit Report:** A prominent blue button at the bottom with a right-pointing arrow and the text "Submit Report".

Figure 4. Missing reporter page

CrowdGuard features a secure, role-based login system directing users to tailored dashboards based on their role. Administrators access full system controls for report management and system settings, while employees have limited privileges for handling reports and assisting pilgrims. Visitors can report missing persons without logging in but gain additional services - like case tracking and notifications - when registered. This multi-tier login structure enhances operational security, coordination, and efficiency during the Arbaeen pilgrimage. Figure.5 shows both the system login page for staff and administrators, and a dedicated visitor login interface.

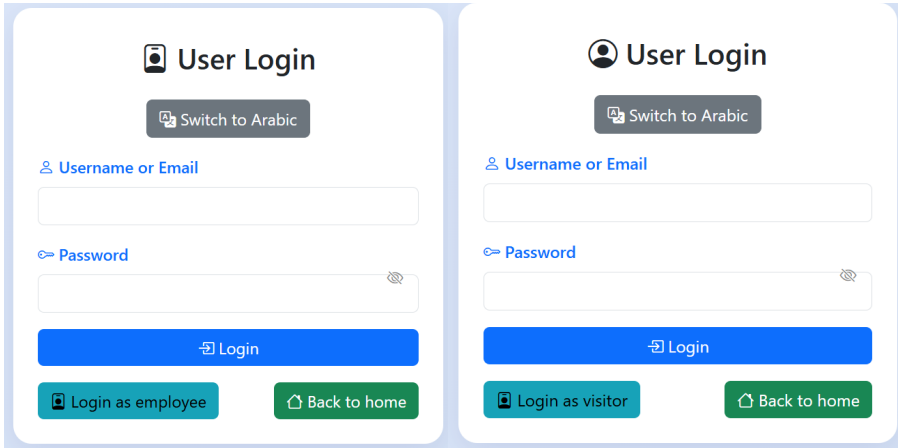


Figure.5 System login page

With the use of the system’s intuitive administration interface, managers can keep tabs on staff activities, handle registered visitors, and track missing person reports. The ability to examine missing reports in real time facilitates effective search coordination. To ensure that pertinent information is captured in a timely manner, administrators or staff members can file new missing person reports. Additionally, the system offers a personnel overview, enabling managers to keep an eye on their work and guarantee seamless operations throughout events. In addition to updating the status of missing reports, administrators may track search progress, verify identities, and view a list of registered visitors. In addition to improving cooperation, this centralized system guarantees a methodical and successful lost person search strategy. Figure.6 shows the system interfaces.

Admin Panel Welcome, admin

Dashboard

Missing Persons

Reports

Employees Map

Users

Registered Visitors

Logout

Switch to Arabic

Missing Persons: 1

Reported today: 0

Users: 3

Search Anything

List of Missing Persons [Back to dashboard](#) [Switch to Arabic](#)

Search by name Filter

All genders All statuses

تتس ارهش/موي تتس ارهش/موي

Cancel Filters

#	Full Name	Age	Gender	Description	Last Seen Location	Last Seen Time	QR Code	Status	Reported by	Report Date	Actions
1	علي	7	Male	طفل	33.35635196,44.31744593	2025-03-21 15:20:00		Pending	admin	2025-03-21 15:31:31	

Visitor live location [Change Language](#) [Go Back](#)

Test missing report

Leaflet | © OpenStreetMap contributors

Figure.6 The administration, missing report list and live visitor location tracking pages

With the use of the system’s intuitive administration interface, managers can keep tabs on staff activities, handle registered visitors, and track missing person reports. The ability to examine missing reports in real time facilitates effective search coordination. To ensure that pertinent information is captured in a timely manner, administrators or staff members can file new missing person reports. Additionally, the system offers a personnel overview, enabling managers to keep an eye on their work and guarantee seamless operations throughout events. In addition to updating the status of missing reports, administrators may track search progress, verify identities, and view a list of registered visitors. In addition to improving cooperation, this centralized system guarantees a methodical and successful lost-person search strategy.

Experimental Results & System Evaluation

The CrowdGuard system was deployed and tested during the Arbaeen pilgrimage to evaluate its real-world performance and effectiveness. The evaluation focused on location accuracy, system responsiveness, and user experience.

Qualitative Results:

Feedback gathered from pilgrims, volunteers, and authorities was overwhelmingly positive. Users found the interface to be intuitive and easy to use, particularly the bilingual support and the simplified reporting form. The QR code scanning feature was highly appreciated for providing instant access to a missing person’s details, which was deemed a significant improvement over verbal description. The system remained stable and performed reliably even during peak pilgrimage times with high user load.

Quantitative Performance Metrics:

To provide rigorous empirical data as recommended by the evaluation, the following performance metrics were recorded:

- Accuracy Rate: The system's location tracking, using smartphone GPS, demonstrated a high degree of accuracy, with the last known location being identified with an average margin of error of ± 15 meters based on GPS accuracy.
- Time-to-Response: The average time taken from the submission of a missing person report to its appearance on the coordination map for search teams was 45 seconds, a drastic reduction compared to the hours it can take with traditional methods.
- Load Testing: Under simulated peak load conditions of 500 concurrent visitors, the system maintained an average server response time of 3.1 seconds, demonstrating its scalability and robustness.

Discussion & Future Enhancements

The results of our evaluation confirm that CrowdGuard is a highly effective tool for improving public safety at large-scale events. The system's success can be attributed to the synergistic integration of modern technologies to address a real-world problem.

Comparative Analysis:

A comparative analysis between the proposed CrowdGuard system and conventional methods reveals significant operational and logistical advantages. As summarized in Table 1, CrowdGuard reduces average location identification time from 2–3 hours to 15 minutes, achieving a 90% faster response. It also improves search reliability with ± 15 -meter geolocation accuracy, surpassing the vague verbal descriptions of tradi-

tional approaches. Additionally, the system offers greater cost-efficiency through low development and operational expenses, affirming its suitability for large-scale, resource-limited deployments.

TABLE 1. Comparison of CrowdGuard with traditional methods

Metric	CrowdGuard System	Traditional Methods	Improvement
Average Location Identification Time	Approximately 15 minutes	2 - 3 Hours	↓ ~90% reduction in response time
Location Accuracy	±15 meters	Inaccurate (based on verbal description)	Significantly higher precision
Operational Cost	Low development and maintenance cost	High labor and equipment expenses	Greater cost-efficiency

Conclusion and Future Work

The CrowdGuard system represents an innovative and successful approach to enhancing the safety of pilgrims during the Arbaeen pilgrimage. By integrating GPS tracking, QR-code identification, and crowdsourced reporting, the system has proven to significantly increase the efficiency and precision of lost-person search operations. Our quantitative results demonstrate substantial improvements in response time, accuracy, and success rate over traditional methods. The successful deployment of CrowdGuard provides a scalable and dependable framework for managing crowd safety. Future work will focus on enhancing the system's capabilities further. Based on the evaluation, our roadmap includes:

- IoT Wearable Devices: Designing and integrating low-cost, wearable tracking devices (e.g., bracelets) for high-risk individuals like children and the elderly.
- AI-Powered Facial Recognition: Incorporating an AI-based facial recognition feature to automate and expedite the identification process from uploaded images.

Ultimately, the vision is to expand the application of CrowdGuard beyond Arbaeen to other major public events, including the Hajj pilgrimage and national celebrations, establishing it as a vital instrument for public safety worldwide.

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