

Kumbh Connect: A Smart Web Application for Pilgrim Services and Event Management at Nashik Kumbh 2027

Wakchaure Krushna Devidas¹, Nisal Samiksha Sharad²,

Thakare Mayur Ramrao³, Nimse Sapna Ratan⁴

Student, Computer Engineering¹⁻⁴

Matoshri College of Engineering & Research Centre, Eklhare, Nashik

Abstract: *Mass gatherings such as the Kumbh Mela present exceptional logistical, public health, and safety challenges. Recent work across public health, computer vision, IoT, and smart city practices has demonstrated practical techniques for crowd estimation, automation of lost-and-found processes, and integrated emergency response. This paper surveys the relevant literature (2000–2025), organizes prior work by module, presents chronological timelines and comparative tables of past research and deployed platforms, identifies gaps, and proposes integration principles for the Nashik Kumbh 2027 Portal. Key findings highlight the value of hybrid systems that combine automated analytics (vision, IoT) with human workflows (sector kiosks, PHEOC) and emphasize privacy-by-design, offline resilience and API-driven interoperability.*

Keywords: Kumbh Mela, mass gatherings, crowd analytics, lost & found, PHEOC, GIS navigation, IoT, literature timeline

I. INTRODUCTION

The Kumbh Mela is one of the world’s largest periodic human gatherings: events draw millions of pilgrims over days or weeks, producing challenges for crowd safety, missing-person management, and health surveillance. Traditional manual processes (paper registers, physical kiosks, radio coordination) struggle under such scale. Modern digital approaches — mobile reporting, CCTV + AI analytics, IoT sensing, GIS overlays and centralized dashboards (PHEOC) — offer new capabilities but require careful integration, privacy governance and offline resilience to succeed in the field. This survey compiles prior research and deployments relevant to three core modules for the Nashik Kumbh 2027 Portal: (A) Lost & Found, (B) Medical & Emergency Response (PHEOC), and (C) Admin/Visitor Services (directions, attractions, parking, toilets), and presents timelines and comparative tables to guide the pre-phase design.

II. METHODOLOGY

Sources were selected from open access peer-reviewed articles, conference preprints, government/field reports, and reputable news outlets covering recent Kumbh deployments (especially Maha Kumbh 2025). Search keywords included: “Kumbh Mela crowd counting”, “mass gathering public health PHEOC”, “lost and found AI Kumbh”, “crowd IoT parking management”, and “digital Maha Kumbh 2025”. Emphasis was placed on works that are directly applicable to large Indian mass-gathering contexts. Where possible, I used accessible full texts and field reports to ensure practical recommendations. Key load-bearing references used throughout: Kazi et al. (mobile health at Kumbh), CrowdNet (dense crowd counting), Elbery et al. (IoT crowd management), Pandey et al. (Kumbh case study), and the ILDM field report on Maha Kumbh 2025.



Timeline of Past Research(2000 – 2025)

Table No.:- 1

No	Year	Reference	Contribution / What they did	Pros	Cons
1	2013	Wirz et al., <i>EPJ Data Sci.</i> (smartphone sensing)	Participatory sensing using smartphones to estimate crowd density at city scale.	Low-cost, uses user devices; complements CCTV.	Requires smartphone penetration and opt-in.
2	2016	Boominathan et al., <i>CrowdNet</i> (CVPR / arXiv)	Deep CNN for dense crowd counting from still images.	Strong baseline for vision-based density maps.	Needs good camera positions; occlusion issues.
3	2016	Kazi et al., <i>J. Public Health</i> (Kumbh mobile health)	Mobile tech for disease surveillance & health delivery at Kumbh.	Field-tested PHEOC integration model.	Manual data entry; limited connectivity tests.
4	2016	IISc / Kumbh experiment (data collection)	Multi-sensor data collection and analysis at Kumbh events.	Good sensor/IoT blueprint.	Research focus; integration engineering needed.
5	2019	Smart IoT camera & CV works (Rimboux et al.)	IoT camera pipeline for detection/annotation.	Edge analytics concept for cameras.	Hardware deployment complexity.
6	2020	Pandey et al., <i>Kumbh case study</i> (dense counting)	Orthographic projection + dense crowd counting specific to Kumbh.	Kumbh-specific modeling — directly relevant.	Focused on vision; limited system integration.
7	2021	Elbery et al., IoT-VCM (IEEE TVT)	IoT vehicle crowd/parking management, routing, departure control.	Useful for parking & traffic at pilgrimage hubs.	Vehicle-centric; pedestrian issues separate.
8	2022	Fan et al., crowd density survey (Sciencedirect)	Comprehensive survey on crowd counting methods.	Good technology comparison and evaluation metrics.	Rapid field changes due to new models.
9	2023	Fiandeiro et al., crowd counting review (open)	Updated survey of modern crowd density estimation.	Recent techniques & benchmarks.	Mostly algorithmic, not deployment centric.
10	2024	Choubey (IISc PhD thesis) — sensing & simulation	Simulation and pedestrian sensing in Indian mass gatherings.	Simulation scenarios for worst-case planning.	Thesis scope; adaptation required.
11	2025	ILDm field report on Maha Kumbh 2025 (field report)	Extensive operational lessons: PHEOC, lost & found, CCTV & AI use.	Direct operational recommendations for Kumbh scale.	Event-specific; local differences apply.
12	2025	ResearchGate preprint: ML for real-time crowd control (Kumbh 2025)	ML pipelines for CCTV analytics and incident detection.	Recent, Kumbh-focused; modern ML methods.	Preprint; limited peer review.



Timeline & Table of Past Platforms / Deployments

Table No.: 2

No	Year	Platform	What they provided	Pros	Cons
1	2013	Kumbh Mela (Prayagraj) health deployments (early mobile reporting)	Mobile health reporting & field clinics.	Field-tested PHEOC concepts.	Manual workflows heavy.
2	2016	Kumbh data collection experiments (IISc / Ujjain)	Sensor + crowd data experiments.	Research data for modeling.	Not a public portal.
3	2019	Prayagraj Kumbh digital dashboards & CCTV oversight (Smart Kumbh pilots)	Surveillance + admin dashboards.	Government scale, CCTV integration.	Limited public interactive features.
4	2020	Local Kumbh management portals (Nashik 2015 remnant)	Schedules, static maps.	Lightweight & simple.	Not dynamic; no AI/analytics.
5	2024	Digital Maha Kumbh (Govt. of UP digital push)	Centralized "Digital Maha Kumbh" initiative — apps, dashboards.	High-scale integrated effort.	Complex governance; privacy concerns.
6	2025	Maha Kumbh 2025 — AI lost & found centers; CCTV+AI analytics (Prayagraj)	AI lost & found; 2,760 CCTV cameras; chatbots; PHEOC.	Demonstrated large-scale AI deployments & reunifications.	Privacy & accuracy tradeoffs; operational cost.
7	2025	ILDm Field Report & lessons (operational practices)	Field lessons, PHEOC workflows, sanitation, logs.	Rich operational guidance for Nashik planners.	Event-specific recommendations need adaptation.

Related Work

A. Lost & Found / Identification & Reunification

Centralized kiosks + database: Field reports from large Kumbh deployments recommend sectorized kiosks feeding a central searchable repository, which reduces duplication and accelerates reunification. ILDM 2025 and Economic Times reporting on IT-assisted lost & found illustrate this approach.

Image matching and AI: Vision systems help match submitted photos with CCTV frames using face embeddings; CrowdVision and recent Kumbh AI deployments have proven operational utility but emphasize human verification to reduce false positives. See AI lost and found coverage (Maha Kumbh 2025) and face-matching literature.

Representative references: Kazi et al. (2017) for operational reporting mechanics at Kumbh; Economic Times coverage (2025) for AI lost and found; Pandey et al. (2020) for image/camera crowd work.

B. Crowd Monitoring & Navigation (direction to ghats, crowd-aware routing)

Vision-based density maps (CrowdNet, subsequent surveys): Deep CNNs produce per-pixel density maps used as overlays for administrative dashboards and public guidance. The CrowdNet model and recent surveys (Fan 2022, Fiandero 2023) capture the algorithmic state-of-the-art.

IoT and vehicle management (parking): IoT-VCM frameworks show how connected vehicle/parking sensors reduce congestion at departure zones and apply similar principles for parking management around ghat clusters.

Representative references: CrowdNet (2016), Fan (2022) survey, and Elbery et al. (2021) IoT framework.



C. Medical & Emergency Response (PHEOC)

Mobile surveillance and PHEOC: Kazi et al. (2017) demonstrated mobile case reporting integrated with an operations center to accelerate referrals and situational awareness. Field reports and WHO/PMC guidance recommend a PHEOC that ingests clinic logs, ambulance GPS, and syndromic signals.

Field reports (ILDM 2025): Documented PHEOC setups at Maha Kumbh 2025, ambulance coordination, and the need for bed/triage dashboards for rapid decision-making.

Representative references: Kazi et al. (2017), Elachola et al. (PHEOC operational guidance), and ILDM field report (2025).

D. Admin Dashboards & Visitor Services (Accommodation, toilets, attractions)

GIS overlays and ghat pages: Past Kumbh portals and smart city dashboards show the value of rich ghat pages, offline maps and multilingual UIs. The Prayagraj 2025 dashboards and Digital Maha Kumbh material are key references.

Service availability and feedback loops: Combining manual volunteer reports with simple sensor-based updates has proven pragmatic (toilet cleanliness, parking occupancy). Field practice suggests that a lightweight manual reporting workflow is often sufficient and easier to deploy quickly than sensors.

E. Privacy, Ethics & Governance

All literature and recent deployments stress explicit data retention policies, opt-in flows for biometric data, human verification for identity matches, and role-based access with auditing. Recent deployments (Maha Kumbh 2025) used AI at scale but highlighted public concerns and the need for its governance.

Comparison & Synthesis

What works (proven in the field):

Hybrid architectures combining automated vision/IoT analytics with human kiosks and PHEOC coordination produce the best operational outcomes (faster reunification and better triage). ILDM 2025 and Kazi 2017 showed real-world benefits.

Sectorization (dividing the mela area into manageable sectors with local kiosks + central DB) reduces duplication and improves lookup times (field reports).

Mobile reporting (apps + SMS/USSD fallback) reliably increases reporting coverage for health incidents and lost-person reports in remote areas.

Key gaps (research and practice):

Privacy-preserving identity matching at scale: face recognition in outdoor, occluded, and low-lighting conditions remains imperfect and controversial. Recent Kumbh solutions have been operationally successful but have relied on human verification.

Interoperability: PHEOC, municipal registries, and police systems often run incompatible data schemas; API standards and FHIR-like conventions are needed.

Offline resilience and low bandwidth: Many research solutions assume continuous connectivity; practical systems must support offline caching and SMS fallbacks. Kazi et al. and field reports stress this.

Economics of wearables on a massive scale: RFID/BLE benefits for vulnerable groups are clear, but large-scale distribution logistics and costs require policy decisions and pilot studies.

Proposed Integration Principles for Nashik Kumbh 2027 Portal

Based on the above evidence, the portal design should follow these guiding principles:

Modular API-first architecture: Central APIs for Lost & Found, PHEOC, GIS, and analytics; sector caches for offline operation and resilience. (Supports interoperability & edge operation.)

Hybrid sensing and analytics: Use of CCTV+AI for high-value sectors, smartphone participatory sensing for macro flows, and municipal/IOT feeds for parking/toilet status. All of these are fed into a unified analytics engine.



Human-in-loop for sensitive decisions: All identity matches flagged by AI must go through human verification (kiosk operator/police officer) before reunification. Documents and logs decisions for audits.

Offline and low-bandwidth UX: Implement SMS/USSD reporting and local caching of essential maps and forms and provide multilingual and voice options. (Kazi et al. field reports).

Privacy-by-design and governance: Short retention windows for sensitive imagery, role-based access, opt-in biometric uploads, and clear public notices (Marathi/Hindi/English).

Pilot and phased rollout: Start with core features (Lost and Found form + sector kiosks; PHEOC case logging; GIS map of ghats + toilets + parking) and add AI/vision features after pilot validation. The ILDM recommends piloting complex AI in limited sectors.

III. CONCLUSION & FUTURE DIRECTIONS

The literature and recent field deployments (especially the Maha Kumbh 2025) show that an integrated digital platform can substantially improve safety, reunification rates, and operational visibility at Kumbh-scale events. The Nashik Kumbh 2027 Portal should adopt a pragmatic hybrid approach: robust, human-centric workflows augmented by AI/IoT, which demonstrably reduce operator load and improve outcomes. Future research directions include privacy-preserving face matching (differential privacy/secure embeddings), resilient offline-first architectures, standardized PHEOC APIs (FHIR/JSON), and cost-benefit analysis of wearables at scale.

REFERENCES

- [1] D. S. Kazi et al., "Using mobile technology to optimize disease surveillance and healthcare delivery at India's Kumbh Mela: a case study," *J. Public Health (Oxford)*, vol. 39, no. 3, pp. 616–623, 2017. [PMC](#)
- [2] L. Boominathan, S. S. Kruthiventi and R. V. Babu, "CrowdNet: A Deep Convolutional Network for Dense Crowd Counting," *Proc. CVPR / arXiv*, 2016. [arXiv+1](#)
- [3] Pandey, M.; Pandey, N. Singh and A. Trivedi, "Kumbh Mela: a case study for dense crowd counting and modeling," *Multimedia Tools Appl.*, 2020. [dl.acm.org](#)
- [4] Elbery, H. S. Hassanein, N. Zorba and H. A. Rakha, "IoT-Based Crowd Management Framework for Departure Control and Navigation," (IoT-VCM), 2021. [ResearchGate+1](#)
- [5] ILDM, "Field Work Report on Maha Kumbh Mela 2025," Institute of Leadership and Development Management, Apr. 2025. [ildm.kerala.gov.in](#)
- [6] "Maha Kumbh 2025: AI-powered lost and found centre established for devotees," *The Economic Times*, Jan. 16, 2025. [The Economic Times](#)
- [7] Z. Fan et al., "A survey of crowd counting and density estimation based on computer vision," (2022). [ScienceDirect](#)
- [8] M. Wirz, T. Roggen and G. Tröster, "Probing crowd density through smartphones in city-scale participatory sensing," *EPJ Data Science*, 2013. [Queen's Telecommunications Research Lab](#)
- [9] Public Health Emergency Operations Center — a critical component," (PHEOC guidance) — PubMed/PMC (Elachola et al.). [PubMed](#)
- [10] S. Mehta, V. Kumar and A. Patel, "Leveraging Machine Learning for Real-Time Crowd Control and Safety at Kumbh Mela," ResearchGate preprint, 2025. [ResearchGate](#)
- [11] Rimboux et al., "Smart IoT Cameras for Crowd Analysis," 2019. [ResearchGate](#)
- [12] (Additional relevant news & reports) Reuters, Guardian coverage of Maha Kumbh 2025 digital initiatives. [Reuters+1](#)

