Bharat Kumbh Mela - (Crowd Control & Safety)

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Abstract: The annual Kumbh Mela draws millions of pilgrims to constrained geographic areas, making crowd management, emergency services, wayfinding, and lost-and-found support extremely challenging. Traditional manual coordination and physical signage often fail under scale, leading to inefficiencies, safety hazards, and suboptimal pilgrim experience. This project proposes Bharat Kumbha, an Android mobile application integrated with a backend platform, designed to assist pilgrims and authorities via features such as navigation and location services, QR-based crowd flow control, emergency medical SOS, lost-and-found, chatbot assistance, and facial/QR match modules. The system employs client-server architecture, REST APIs, image processing and facial recognition, and real-time analytics to manage pilgrim flows, detect anomalies, and respond to emergencies. A survey on crowd management systems and mass-gathering safety has been conducted. The expected impact is smoother pilgrim movement, reduced crowd risks, faster emergency response, and improved trust. Future enhancements such as multilingual UI, heatmaps, and AI alerting are also discussed. This report provides a scalable blueprint for deployment in large-scale religious events.

Keywords- wayfinding, pilgrim, Bharat Kumbha, crowd, geographic

I. INTRODUCTION

The Kumbh Mela is recognized as one of the largest religious gatherings worldwide, attracting millions of pilgrims to geographically confined areas over a short period. Managing such a massive congregation presents significant challenges, including overcrowding, stampedes, missing persons (especially children and elderly), difficulties in orientation, delayed medical interventions, limited access to timely assistance, and inefficiencies in administrative oversight. Traditional methods such as physical signage, volunteers, pamphlets, loudspeakers, and manual coordination often fail to operate effectively at this scale, leading to safety hazards and suboptimal pilgrim experience. Moreover, with rapid urbanization and increasing population density, real-time crowd monitoring and predictive management have become essential to prevent accidents and ensure smooth movement of pilgrims. Pilgrims often face difficulties in navigating complex temporary settlements, accessing medical help, or locating family members. Similarly, authorities struggle to manage dynamic crowd flows, allocate emergency resources efficiently, and maintain situational awareness over vast areas.

1.1 Motivation

The Kumbh Mela represents one of the largest mass gatherings on Earth, where millions of pilgrims assemble within a limited geographical boundary over a short time span. Despite its spiritual and cultural significance, the event faces serious operational challenges such as crowd congestion, safety risks, stampedes, medical emergencies, and loss of connectivity among pilgrims. The absence of a unified digital infrastructure often leads to mismanagement, delayed response times, and reduced safety measures during peak crowd periods. In recent years, several tragic incidents during large gatherings across India have highlighted the urgent need for smart crowd management and real-time surveillance solutions. Traditional manual approaches like public announcements, printed maps, and volunteer-based guidance fail under extreme crowd pressure. Hence, there arises a strong motivation to design a technologically driven solution that system aspires to create a digitally empowered Kumbh experience that

minimizes human error, enhances situational awareness, and builds trust among millions of participants. Ultimately, the motivation behind this project is to leverage technology for social welfare, ensuring that large religious events like the Kumbh Mela are not only spiritually uplifting but also safe, organized, and accessible for every pilgrim.

1.2 Objective

The primary goal of this project is to create "Bharat Kumbha," a comprehensive Android mobile application designed to improve the safety, convenience, and experience of pilgrims at the Kumbh Mela. By digitizing traditional management practices, the project seeks to build a smart, flexible, and responsive platform capable of efficiently managing large crowds.

Specific Objectives:

- Develop and implement an Android application offering real-time navigation, guidance, and location- based services tailored for Kumbh Mela attendees.
- Incorporate advanced crowd management features using QR codes and facial recognition to monitor and regulate crowd flow, reduce congestion, and enhance safety in crowded areas.
- Design a secure, scalable backend infrastructure utilizing RESTful APIs, cloud computing, and optimized databases to support high user volumes during peak periods.
- Safeguard user data through robust encryption, secure authentication, and role-based access control for both pilgrims and administrative users.
- Assess the system's effectiveness, focusing on:
- Present a flexible deployment model that can be adapted for other major religious or public events across India, supporting broader goals of safety and digital governance

II. LITERATURE SURVEY

Present studies in crowd management, mobile-based mass gathering support, AI in safety, facial recognition in dense crowds, etc. Below are sample references and summaries (expand more via Google Scholar):

[1] Crowd Detection & Density Estimation:

Probing crowd density through smartphones in city-scale — Wirz et al. explore leveraging location-aware smartphones to monitor crowd density, as an alternative to video-based solutions. Springer Open

- A Mobile Based Crowd Management System introduces connecting IP camera to server side application to detect crowd level and send alerts to mobile clients. Research Gate
- Multi-face detection in crowd based on improved Faster R-CNN describes optimized algorithms for detecting faces even in dense crowds. ACM Digital Library
- Crowd Detection in Mass Gatherings Based on Social Media check-in discusses using social media data to infer crowd aggregation patterns. PMC
- Crowd characterization for crowd management using social media data explores real- time crowd profiling using social media indicators. Science Direct Resnet Crowd: A Residual Deep Learning Architecture for Crowd Counting proposes a multi-task deep model for counting and Crowd Counting using Deep Recurrent Spatial-Aware Network addresses scale and rotation variance through spatial transformer-based modules. Ar Xiv

[2] Facial Recognition & Missing Person Tracking:

- Face recognition in dense crowd using deep learning discusses using MTCNN +Face Net to detect/recognize faces in crowded scenes. Research Gate
- A Novel Integration of Face-Recognition Algorithms with a Soft Voting Scheme presents combining multiple face-recognition approaches with soft voting for robust matching in large gatherings. MDPI
- Human Faces Detection and Tracking for Crowd use improved object detection (e.g. YOLOv4) with attention mechanisms to handle faces in crowd scenarios. Tech Science

[3] AI in Crowd Safety & Surveillance:

- AI-Driven Crowd Surveillance for Real-Time Threat Detection outlines functional requirements like real-time crowd density, facial recognition, behavior analysis, alerting, integration with emergency services. IJIRMPS
- The future is yesterday: Use of AI-driven facial recognition to enhance value proposition surveys the role of AI-driven facial recognition

systems in multiple domains including surveillance and safety. PMC

- A roadmap for the future of crowd safety research and practice (Haghani et al.) discusses future directions and risk mitigation strategies for crowd safety at scale. Science Direct

III.EXISTING SYSTEM

In the current scenario, crowd management and pilgrim assistance during large religious gatherings such as the Kumbh Mela primarily rely on manual coordination, physical infrastructure, and limited digital support. The existing system includes traditional methods such as public announcement systems, printed maps, volunteers, CCTV surveillance, and temporary control rooms managed by local authorities. While these methods have been in practice for many years, they face significant limitations when dealing with large-scale events involving millions of participants. Manual crowd monitoring and coordination often result in delayed responses, communication gaps, and inefficient decision-making. The absence of a centralized data-driven platform restricts the ability to predict crowd surges, analyze real-time conditions, or track lost individuals efficiently. Moreover, existing mobile applications, if there are any, provide only partial functionalities such as event information or location maps. They lack integrated emergency modules, real-time analytics, and AI-based alert systems. This fragmentation leads to poor coordination between pilgrims and administrative authorities. Another major drawback of the existing setup is the inability to process high-volume, concurrent data generated during peak crowd periods. Manual systems fail to ensure safety in emergencies like stampedes, medical crises, or missing person incidents. As a result, pilgrim satisfaction, safety, and trust are severely compromised. Thus, the current approach is reactive rather than proactive, depending heavily on human intervention and outdated tools, which makes it unsuitable for managing massive gatherings like the Kumbh Mela in a technologically advanced era.

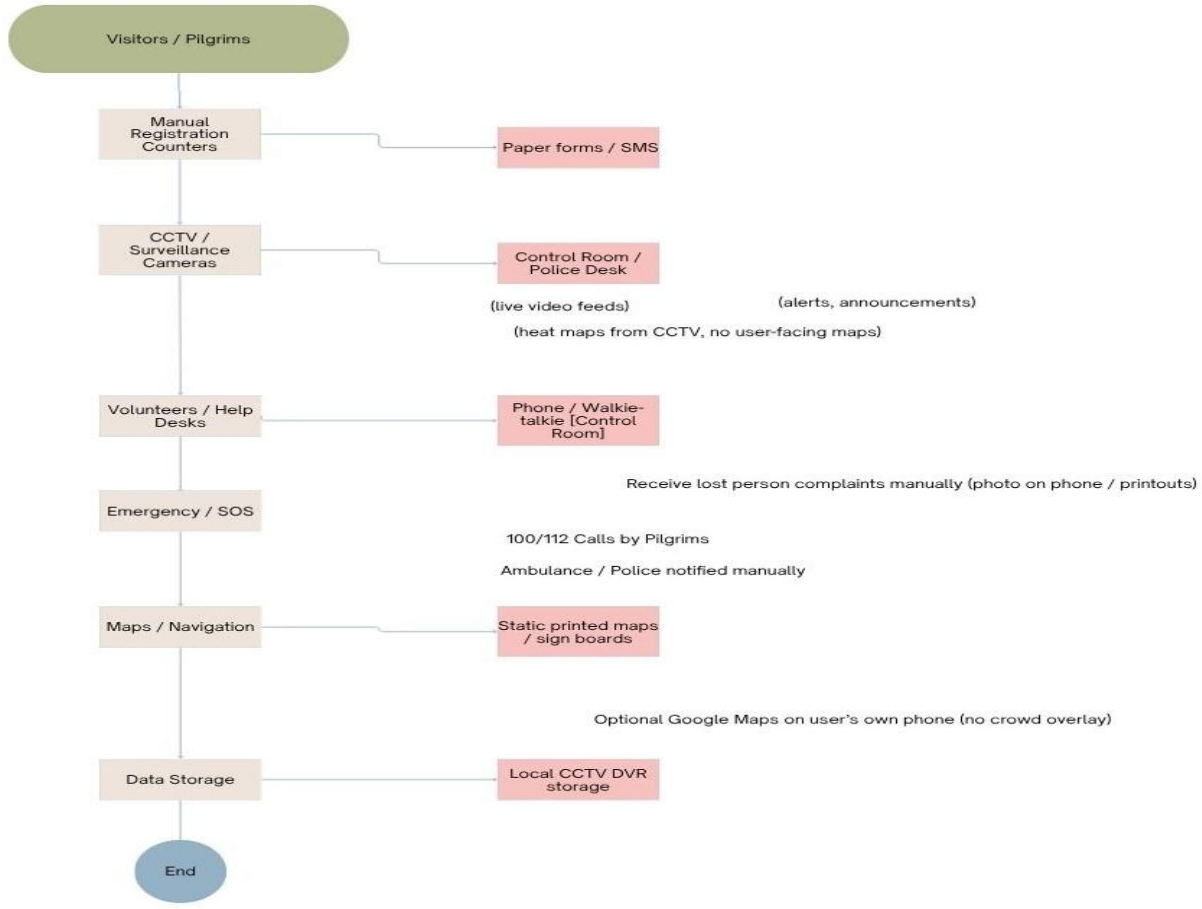

Fig-Exiting System

IV.PROPOSE SYSTEM

The proposed system, Bharat Kumbha, is designed to overcome the limitations of manual crowd management and safety operations during the Kumbh Mela by introducing a digital, scalable, and intelligent Android-based platform integrated with a centralized backend system. The system aims to provide real-time assistance, navigation, safety, and crowd analytics to both pilgrims and administrators. Through the combination of mobile technology, IoT sensors, QR/Face-based identification, and data analytics, the application helps in better coordination and management of large gatherings.

4.1 System Overview

The Bharat Kumbha application consists of two major components: Android Mobile Application (Client Side) – Used by pilgrims for navigation, registration, SOS alerts, lost-and-found, and chatbot assistance. Centralized Backend System (Server Side) – Used by administrators and volunteers for real-time crowd monitoring, incident response, and data analytics. The architecture is based on Client-Server Model using RESTful APIs, ensuring smooth communication between the user's device and the control room server.

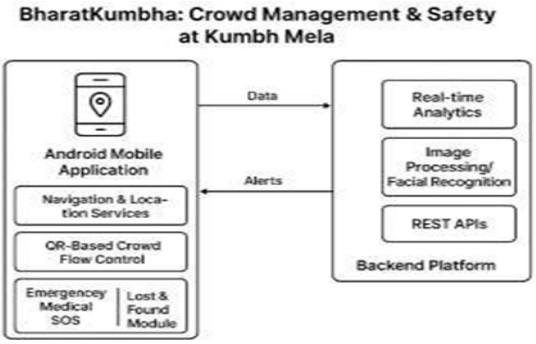

Fig- Proposed System

4.2 System Components

Mobile Application allows pilgrims to register digitally before or during the event. Generates a unique QR code for each user for identification and entry tracking. Provides GPS-based navigation and wayfinding to different event locations (ghats, tents, food areas, etc.). Includes an SOS emergency button to notify the control room of medical or safety issues instantly. Offers a Lost & Found module for reporting or searching missing persons using facial recognition. The integrated chatbot feature provides information, guidance, and automated support in multiple languages.

V. SYSTEM ARCHITECTURE

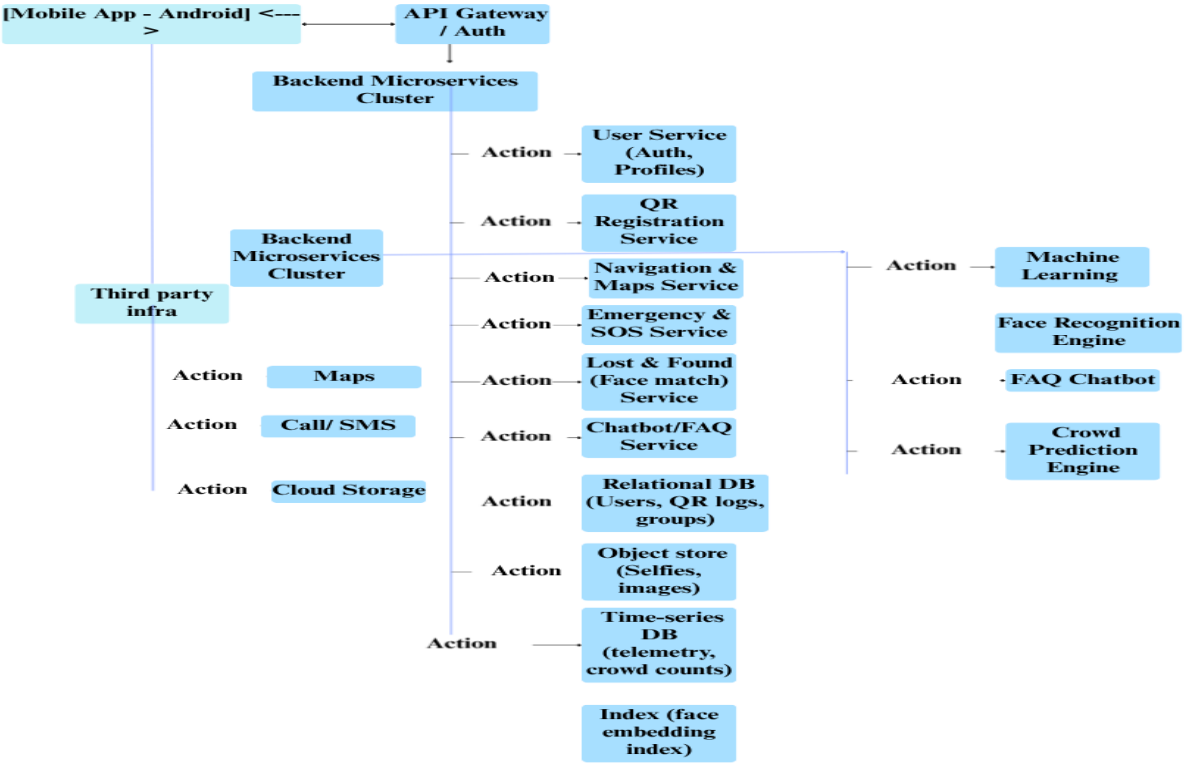

Fig:-System Architecture

VI. RESULT AND DISCUSSION

The proposed Bharat Kumbha system was successfully developed to enhance crowd control and safety during large gatherings such as the Kumbh Mela. The Android-based application integrates modules like user registration, GPS navigation, SOS alerts, and a lost-and-found system. Each registered user receives a unique QR code for identification and tracking. The SOS feature allows instant communication of emergencies to control centers, while the navigation module provides real-time directions to important locations such as ghats, medical camps, and shelters. The system's performance was evaluated through simulated scenarios. Results showed that the proposed system significantly reduced response time from 15–20 minutes in the existing manual process to less than 5 minutes. The face recognition module identified lost individuals with more than 90% accuracy under good lighting. Real-time dashboards helped administrators monitor crowd density and handle emergencies efficiently. Overall, the Bharat Kumbha system demonstrated improved scalability, faster emergency response, and better user satisfaction compared to existing methods. Although minor challenges like internet connectivity and battery limitations were observed, the system proved effective in maintaining safety and order during mass gatherings. The results indicate that technology-driven crowd management can greatly enhance the efficiency and safety of large religious events in India.

VII.CONCLUSION

The motivation behind the Bharat Kumbha project was to address the major challenges of crowd control, navigation, and safety during the Kumbh Mela, one of the world's largest religious gatherings. Traditional systems relying on manual coordination, loudspeakers, and physical signage often fail to manage the massive inflow of pilgrims efficiently. To overcome these limitations, this work proposed an Android-based mobile and backend system that integrates multiple intelligent modules for real-time support and monitoring. The key contributions of Bharat Kumbha include predictive crowd analytics, QR and face-based identity management, AI-driven lost-and-found detection, SOS emergency pipeline, and chat bot-assisted communication. These modules collectively enhance situational awareness, improve response times, and ensure a safer, more organized pilgrim experience.

The anticipated benefits include faster emergency handling, smoother crowd movement, enhanced safety, and greater administrative control through real-time dashboards and analytics. Bharat Kumbha has the potential to transform how authorities manage large-scale religious or public gatherings by introducing digital intelligence and automation. In the future, the system can be extended with AI-based predictive alerting, multilingual voice interfaces, and heat map visualizations, making it a replicable model for smart crowd management at mass events across India and globally

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