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Full Length Article

Crowd Monitoring System With Iot And Cloud Integration

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Abstract: *The rapid growth in urbanization and increasing population in public spaces such as shopping malls, educational institutions, offices, and transportation hubs, effective crowd management has become essential. Smart cities require intelligent monitoring systems to ensure safety, avoid overcrowding, and maintain smooth movement of people within premises. A Smart Crowd Management System using IoT enables real-time monitoring of occupancy levels and provides timely alerts when crowd density exceeds safe limits. By integrating sensors, microcontrollers, and cloud-based applications, such systems help authorities track the number of people inside a facility and manage space utilization efficiently. The system can generate alerts when the occupancy reaches a predefined threshold and provide live updates through IoT platforms. This improves safety, enhances operational efficiency, and supports better decision-making in public and private infrastructures. IoT-based crowd monitoring solutions are cost-effective, scalable, and suitable for modern smart building environments.*

Keywords: *IoT, Crowd Management, Occupancy Monitoring, Smart Buildings, IR Sensors, NodeMCU, Blynk App.*

1. INTRODUCTION

The rapid growth of population and urbanization has significantly increased the usage of public spaces such as shopping malls, transportation hubs, educational institutions, hospitals, offices, and event venues. With this growth comes the challenge of managing large crowds efficiently and safely. Overcrowding not only causes inconvenience and delays but also creates serious safety hazards, especially during emergencies such as fire outbreaks, stampedes, or medical incidents. Therefore, effective crowd monitoring and management systems have become a critical requirement in modern infrastructure. Traditional crowd management methods mainly depend on manual supervision by security personnel or basic mechanical counters. These methods are often inaccurate, labor-intensive, and incapable of providing real-time data. Human error, delayed response, and lack of centralized monitoring further reduce the effectiveness of conventional systems. In situations involving sudden surges of people, manual monitoring becomes extremely difficult and unreliable. With advancements in technology, the concept of smart infrastructure has gained importance. Smart buildings and smart cities rely on intelligent systems that collect, process, and transmit real- time data to improve operational efficiency and safety. The Internet of Things (IoT) plays a vital role in enabling such intelligent systems. IoT refers to a network of interconnected devices that communicate and exchange data over the internet without human intervention. By integrating sensors, microcontrollers, and cloud- based platforms, IoT allows real-time monitoring and remote management of various systems.

1.2 Problem Statement:

In many public places such as malls, offices, educational institutions, and transportation hubs, monitoring the number of people present in a specific area is challenging. Manual crowd monitoring methods are inefficient, time-consuming, and prone to human error. Overcrowding can lead to safety risks, reduced comfort, and difficulties in managing emergency situations. Therefore, there is a need for an automated system that can monitor crowd levels in real time and provide alerts when occupancy exceeds safe limits.

1.3 Objectives:

The main objectives of this project are:
To design a smart crowd monitoring system using IoT technology.
To automatically count the number of people entering and exiting a premises using sensors.
To display real-time crowd data using an IoT platform.
To generate alerts when the occupancy exceeds the predefined limit.
To improve safety and efficiency in public spaces.

1.4 Motivation:

The increasing population in urban areas has made crowd management an important challenge for authorities and organizations. Traditional monitoring methods are not capable of providing real- time occupancy information.

The motivation behind this project is to develop a low-cost and efficient crowd monitoring system that can help organizations manage people flow effectively. By using IoT technology, the system can provide real-time data and improve safety in crowded environments.

1.5 Scope and Challenges

Scope:

The proposed system can be implemented in various environments, including:

Shopping malls
Educational institutions
Hospitals
Offices
Transportation hubs
Event venues

It helps authorities monitor occupancy levels and take necessary actions to prevent overcrowding**.**

Challenges:

Some challenges associated with the system include:

Accuracy of sensors in crowded environments
Dependence on network connectivity for IoT communication
Proper placement of sensors for accurate counting
Handling multiple entry and exit points in large buildings

2. LITERATURE REVIEW

Crowd management and people-counting technologies have gained significant attention in recent years due to rising concerns about safety, efficiency, and user experience in high-footfall environments. Traditional approaches to crowd monitoring mainly rely on manual observation or basic sensor systems, which often fall short in accuracy and scalability. The integration of advanced technologies such as the Internet of Things (IoT), computer vision, and wireless sensor networks has opened new avenues for real-time and automated crowd monitoring solutions. Recent research in this domain explores a variety of techniques for counting and tracking people. One common method is the use of **infrared (IR) sensors** and **ultrasonic sensors** for detecting the presence and movement of individuals at entry and exit points. Studies show that IR-based systems offer a cost-effective way to count people with reasonable accuracy in controlled environments. These sensor systems have been widely used for evaluating occupancy levels in buildings, public transport stations, and commercial establishments. Another prominent approach involves **computer vision and image processing** techniques using cameras and machine learning algorithms. Vision-based systems can provide detailed insights into crowd behavior, movement patterns, and density estimation. However, such systems often require significant computational resources, high-quality imaging conditions, and raise privacy concerns due to continuous video monitoring. Integration of IoT platforms for real-time data collection and remote monitoring has been highlighted in recent studies as a key factor for effective crowd management systems. IoT- enabled architectures allow sensor data to be transmitted to cloud applications where it can be visualized, analyzed, and acted upon. This enables stakeholders to receive alerts when occupancy exceeds predefined thresholds and make data-driven decisions to control crowd flow.

S.No	Author(s)	Year	Title / Study	Method/ Technology Used	Key Contribution / Findings
1	Mukati, Chourasiya, Solanki, Kushwaha	2024	IoT-Based People Counting and Building Management	IoT sensors, Arduino, automated light control	Developed a smart automated people counting device integrated with IoT that monitors occupancy and automatically controls lighting to improveenergy efficiency in buildings. (ResearchBib)

2	ObboAggrey, ArihoPius, Nabaasa Evarist	2022	Wireless Sensor Networks for Crowd Detection	Wireless Sensor Networks (WSNs)	Proposed the use of WSNs for crowd detection in resource-constrained environments and discussed challenges such as scalability, power consumption,and connectivity. (AJPO Journals)

2.2 EXISTING SYSTEM:

In many public places such as malls, auditoriums, metro stations, offices, and institutions, crowd management is mostly handled manually by security personnel or through basic people- counting systems. Some systems use IR sensors only for counting the number of people entering and exiting. However, the existing systems have several limitations:

They do not provide real-time updates to users or administrators.

They lack IoT integration to upload occupancy data to a cloud server.

They do not generate alerts when the crowd exceeds a safe limit.

There is no remote monitoring facility through mobile applications.

Due to these limitations, overcrowding may occur, leading to safety risks and inefficient space management.

2.3 Areas for Improvement:

Despite the advancements in crowd monitoring systems, several areas require improvement:

Many systems are expensive and require complex hardware.

Vision-based systems raise privacy concerns due to constant video surveillance.

Some systems lack real-time monitoring capabilities.

Integration with mobile applications and IoT platforms is still limited.

The proposed system addresses these issues by providing a low-cost IoT-based solution using sensors and wireless connectivity for real-time monitoring.

3. PROPOSED SYSTEM AND METHODOLOGY

3.3 Hardware Requirements:

Arduino Uno is a popular development board built around the ATmega328 microcontroller. It provides several digital and analog input/output pins that allow sensors, displays, and other electronic components to be connected easily for embedded and IoT applications. (datasheet). It has 14 digital input/output pins (of which 6 can be used as PWM outputs), 6 analog inputs, a 16 MHz ceramic resonator, a USB connection, a power jack, an ICSP header, and a reset button. It contains everything needed to support the microcontroller; simply connect it to a computer with a USB cable or power it with a AC-to-DC adapter or battery to get started.

ESP8266 Arduino Core:

As Arduino.cc began developing new MCU boards based on non-AVR processors like the ARM/SAM MCU and used in the Arduino Due, they needed to modify the Arduino IDE so that it would be relatively easy to change the IDE to support alternate toolchains to allow Arduino C/C++ to be compiled for these new processors. They did this with the introduction of the Board Manager and the SAM Core. A "core" is the collection of software components required by the Board Manager and the Arduino IDE to compile an Arduino C/C++ source file for the target MCU's machine language.

WI-FI:

The WI-FI module used in this project is ESP8266. It follows TCP/IP stack and is a microchip which is less in cost. This microchip allows microcontroller to connect to a WI-FI network, by using Hayes style command connections are done or made through

TCP/IP connection. ESP8266 has 1MB of built in flash, single chip devices able to connect WI-FI. Espressif systems are the manufacturers of this module, it is a 32 bit microcontroller. There are 16 GPIO pins in this module. This module follows RISC processor. It has 10 bit DAC. Later Espressif systems released a software development kit(SDK) which is used to programme on the chip, so that another microcontroller is not used. Some of the SDK's are Node MCU, Arduino, Micro Python, Zerynth and Mongoose OS. SPI, I2C, I2S, UART are used for communicating between two sensors or modules.

Figure 3.2: Wi-Fi module

NodeMCU is an open-source IoT platform. It includes firmware that runs on the ESP8266 Wi-Fi SoC from Espressif Systems, and hardware which is based on the ESP-12 module. The term "NodeMCU" by default refers to the firmware rather than the DevKit. The firmware uses the Lua scripting language. It is based on the eLua project and built on the Espressif Non-OS SDK for ESP8266. It uses many open source projects, such as lua - cjson, and spiffs.

LIQUID CRYSTAL DISPLAY:

LCD screen:
LCD screen consists of two lines with 16 characters each. Each character consists of 5x7 dot matrix. Contrast on display depends on the power supply voltage and whether messages are displayed in one or two lines. For that reason, variable voltage 0-Vdd is applied on pin marked as Vee. Trimmer potentiometer is usually used for that purpose. Some versions of displays have built in backlight (blue or green diodes). When used during operating, a resistor for current limitation should be used (like with any LE diode).

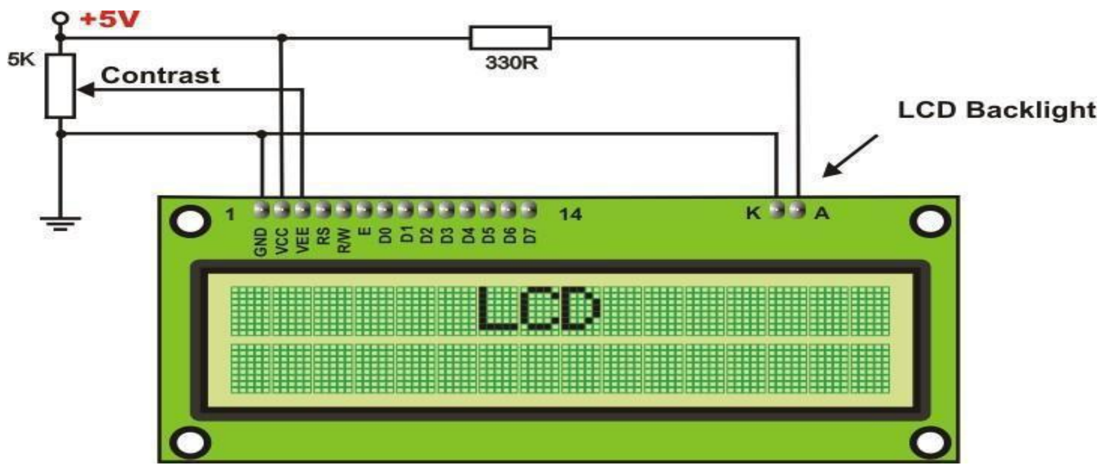

Figure 3.5: LCD screen

IR SENSOR:
IR the same principle in ALL Infra-Red proximity sensors. The basic idea is to send infra red light through IR-LEDs, which is then reflected by any object in front of the sensor.
Then all you have to do is to pick-up the reflected IR light. **For detecting the reflected IR light, we are going to use a very original technique: we are going to use another IR-LED,** to detect the IR light that was emitted from another led of the exact same type. This is an electrical property of Light Emitting Diodes (LEDs) which is the fact that a led produce a voltage difference across its leads when it is subjected to light. As if it was a photo-cell, but with much lower output current. In other words, the voltage generated by the leds can't be - in any way

- used to generate electrical power from light, It can barely be detected. that's why as you will notice in the schematic, we are going to use a Op-Amp (operational Amplifier) to accurately detect very small voltage changes.

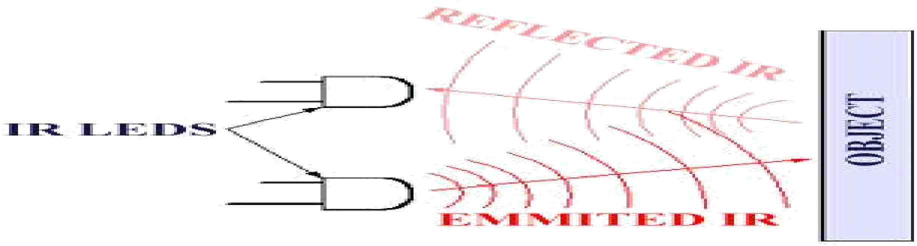

Figure 3.7: IR SENSORS

4. Software Requirement:

1 Arduino is an open-source electronics development platform that combines programmable microcontroller boards with a simple software environment. It allows users to read inputs from sensors and control outputs such as LEDs, motors, or displays through embedded programs.

2 Arduino boards can read inputs - light on a sensor, a finger on a button, or a Twitter message - and turn it into an output - activating a motor, turning on an LED, publishing something online. You can tell your board what to do by sending a set of instructions to the microcontroller on the board. To do so you use the Arduino programming language (based on Wiring), and the Arduino Software (IDE), based on Processing.

3 Over the years Arduino has been the brain of thousands of projects, from everyday objects to complex scientific instruments. A worldwide community of makers - students, hobbyists, artists, programmers, and professionals - has gathered around this open-source platform, their contributions have added up to an incredible amount of accessible knowledge that can be of great help to novices and experts alike.

4 Arduino was born at the Ivrea Interaction Design Institute as an easy tool for fast prototyping, aimed at students without a background in electronics and programming. As soon as it reached a wider community, the Arduino board started changing to adapt to new needs and challenges, differentiating its offer from simple 8-bit boards to products for IoT Applications, wearable, 3D printing, and embedded environments. All Arduino boards are completely open-source, empowering users to build them independently and eventually adapt them to their particular needs. The software, too, is open-source, and it is growing through the contributions of users worldwide.

Figure : Methodology

5. SYSTEM DESIGN

5.1 ER Diagrams:

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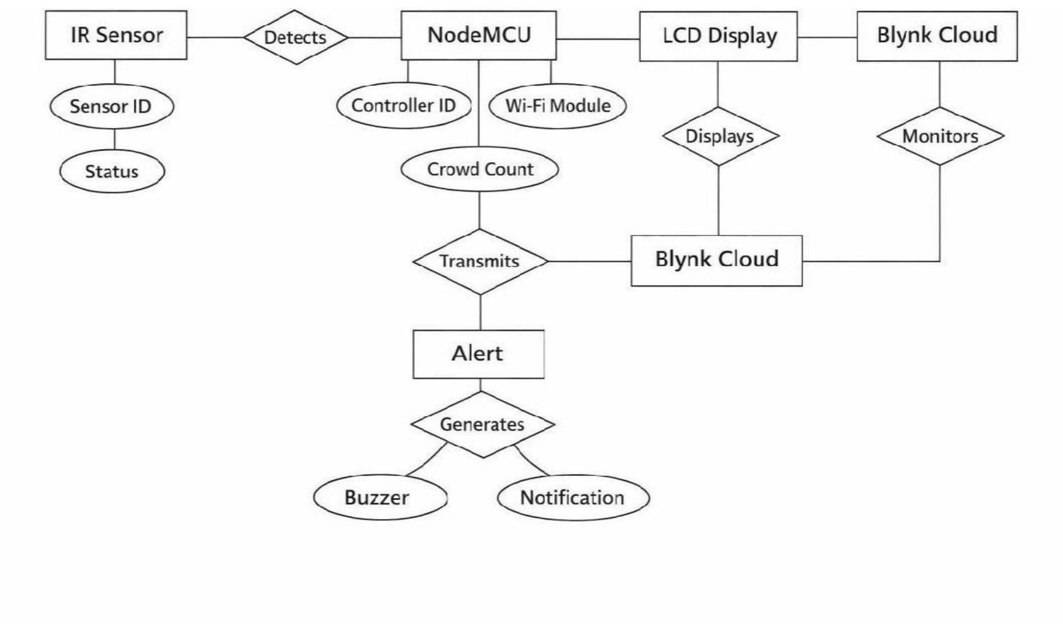

Figure 4.1: ER Diagram

The diagram shows how the IoT-based Crowd Monitoring System works. The IR sensor detects people entering or exiting and sends the signal to the NodeMCU controller. The NodeMCU processes the data, updates the crowd count, and displays it on the LCD display. The data is also sent to the Blynk Cloud through Wi-Fi so it can be monitored remotely. If the crowd exceeds the limit, the system generates an alert using a buzzer and sends a notification**.**

5.2 System Architecture:

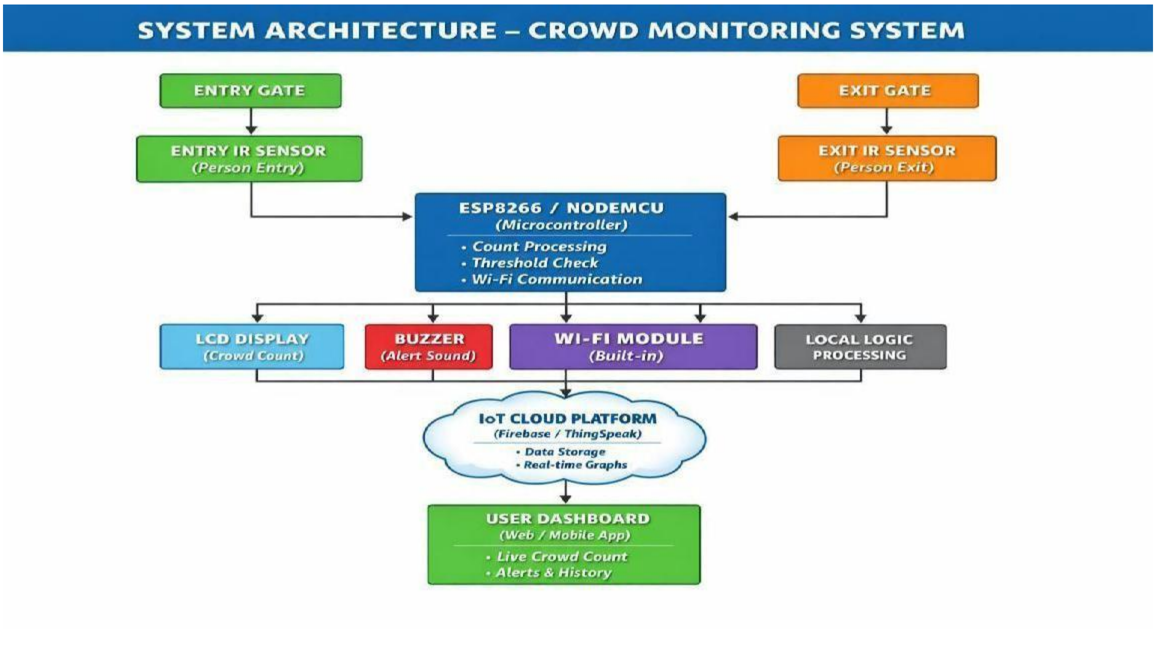

Figure 4.2: System Architecture

The diagram shows the **system architecture of the IoT-based Crowd Monitoring System**. IR sensors placed at the **entry and exit gates** detect people entering and leaving the area. These signals are processed by the **ESP8266/NodeMCU microcontroller**, which calculates the crowd count and checks the limit. The current count is displayed on the **LCD display**, and if the limit is exceeded, a **buzzer alert** is activated. The data is also sent through the **Wi-Fi module to the IoT cloud**

platform, where it can be viewed on the **user dashboard** for real-time monitoring.

5.3 Use Case Diagram:

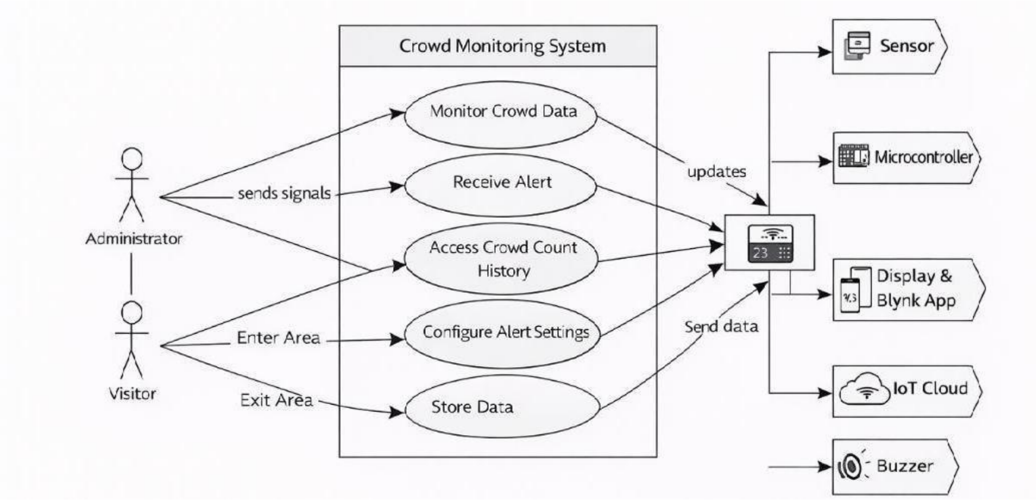

Figure 5.1: Use Case Diagram

6. RESULTS AND DISCUSSION

RESULTS:

Blynk was designed for the Internet of Things. It can control hardware remotely, it can display sensor data, it can store data, visualize it and do many other cool things.

There are three major components in the platform:

Blynk App - allows to you create amazing interfaces for your projects using various widgets we provide.

Blynk Server - responsible for all the communications between the smartphone and hardware. You can use our Blynk Cloud or run your private Blynkj server locally. It's open-source, could easily handle thousands of devices and can even be launched on a Raspberry Pi.

Blynk Libraries - for all the popular hardware platforms - enable communication with the server and process all the incoming and out coming commands.

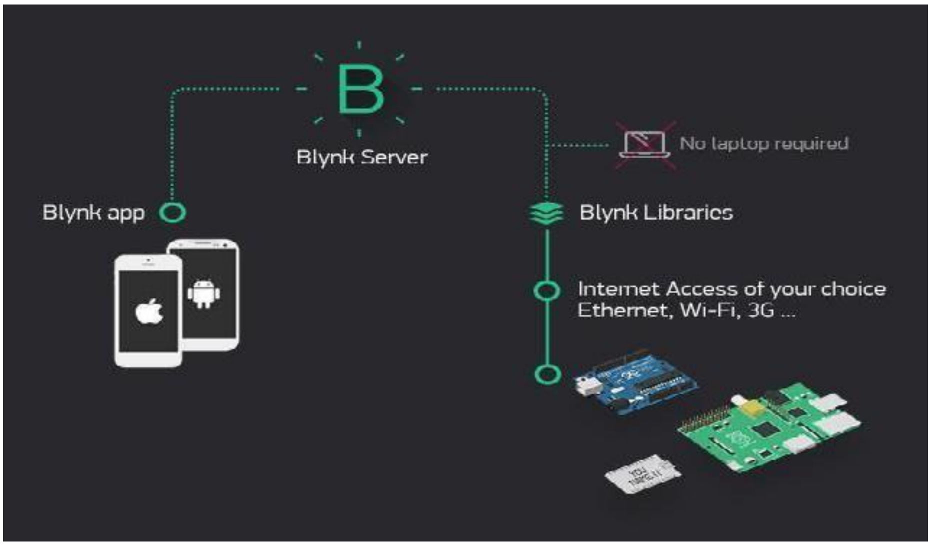

Figure 6.1: Blynk interfacing

7. CONCLUSION AND FUTURE WORK

7.1 Conclusion:

The Smart Crowd Management System using IoT provides an efficient and reliable solution for monitoring and controlling occupancy levels in public and private spaces. By integrating sensors with IoT technology, the system enables real-time tracking of the number of people inside a premises and generates alerts when the crowd exceeds a predefined safe limit.

This system reduces the need for manual supervision, minimizes overcrowding risks, and enhances overall safety and management efficiency. It supports smart infrastructure development by offering a scalable and cost-effective approach to occupancy monitoring. The implementation of such systems in malls, institutions, offices, transport hubs, and event venues can significantly improve crowd regulation and ensure better space utilization.

7.2 Future Work:

The proposed system can be further enhanced with advanced technologies and additional features, such as:

Integration of AI-based camera systems for higher accuracy in crowd counting.

Cloud data storage and analytics for long-term crowd pattern analysis.

SMS or email alert notifications for authorities during emergency situations.

Integration with automated doors or access control systems.

Development of a centralized dashboard for monitoring multiple locations simultaneously.

Use of machine learning algorithms to predict peak crowd hours and optimize management strategies.

With these improvements, the system can become more intelligent, scalable, and suitable for large-scale smart city applications.

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