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AI BASED SMART ENVIRONMENTAL MONITORING SYSTEM

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ABSTRACT

This project introduces an AI-based Smart Environmental Monitoring System that automatically detects and reports public safety issues in urban areas. It uses Artificial Intelligence (AI) and Internet of Things (IoT) technologies. The main goal of the system is to monitor environmental conditions and identify hazardous situations without the need for constant human supervision. The system addresses two common problems in public spaces: gatherings of stray dogs and open manholes. A camera module captures images of the environment, and a machine learning model analyses these images to detect dogs. When several dogs are identified in the same area, signaling a gathering, the system records the event and sends the information to a web-based complaint management system. Additionally, an ultrasonic sensor measures the distance between the sensor and the ground to check the condition of a manhole. If the distance suggests that the manhole is open, the system creates a complaint and sends it to the monitoring dashboard. There is also a web interface where administrators and officers can log in to view detected problems, check details like location, date, and time, and update the complaint status to resolved or pending. By combining sensor technology, machine learning, and web monitoring, this system improves the efficiency of detecting environmental hazards, reduces reliance on manual reporting, and allows for quicker responses from authorities. This approach supports smart city efforts by offering a practical solution for monitoring safety-related environmental conditions in urban areas.

Keywords:

Machine Learning (ML), Internet of Things (IoT), Environmental Monitoring, Object Detection, YOLO Algorithm, Smart City, Hazard Detection.

INTRODUCTION:

Urban areas are quickly expanding, which brings new challenges for public safety and infrastructure. Issues like gatherings of stray dogs and open manholes are common in many streets and public spaces. These problems can create serious risks for pedestrians and vehicles. Usually, people report these issues only after noticing them, leading to delays in response and resolution. As cities grow, there is a need for smarter systems that can monitor conditions and detect hazards in real time. This project suggests an AI-Based Smart Environmental Monitoring System that uses Artificial Intelligence and Internet of Things (IoT) technologies to automatically spot and report specific safety issues. The system focuses on two main situations: gatherings of stray dogs and the status of manholes in an area. A camera module captures images of the surroundings, and a machine learning model processes these images to detect dogs and identify when a group forms. Meanwhile, an ultrasonic sensor connected to a microcontroller monitors the condition of a manhole by measuring distance changes that show whether it is open or closed. When the system detects either condition, it automatically generates a complaint and sends the information to a web-based monitoring platform. The web application lets administrators and officers view detected issues, check details, and update the status of the complaint. By automating the detection and reporting process, the proposed system helps improve response time, lessens reliance on manual reporting, and supports safer and more efficient environmental monitoring in urban areas.

LITERATURE SURVEY:

Joseph Redmon, Santosh Divvala, Ross Girshick, and Ali Farhadi came up with a new technique called YOLO (You Only Look Once) for real-time object detection in 2016. The technique involves a fast and accurate method of detecting multiple objects in an image using a single convolutional neural network, thus it was ideal for surveillance and monitoring purposes, albeit it faced some challenges when detecting smaller objects [1]. In 2018, Joseph Redmon and Ali Farhadi improved on their earlier technique and developed YOLOv3 which uses multi-scale predictions and deep feature extraction to enhance detection accuracy [2]. In relation to smart city technology, Andrea Zanella, Nicola Bui, Angelo Castellani, Lorenzo Vangelista, and Michele Zorzi conducted research on Internet of Things in 2014 whereby they highlighted how connected sensors could gather data from the environment for better monitoring systems in cities [3]. In the same context, Mung Chiang and Tao Zhang analyzed the combination of fog computing technology with IoT systems in order to minimize data processing latencies in real-time monitoring [4]. Finally, in the context of basic computer vision concepts, Richard Szeliski in Computer Vision: Algorithms and Applications (2011), explored various concepts related to image analysis and object detection [5].

I. System Architecture:

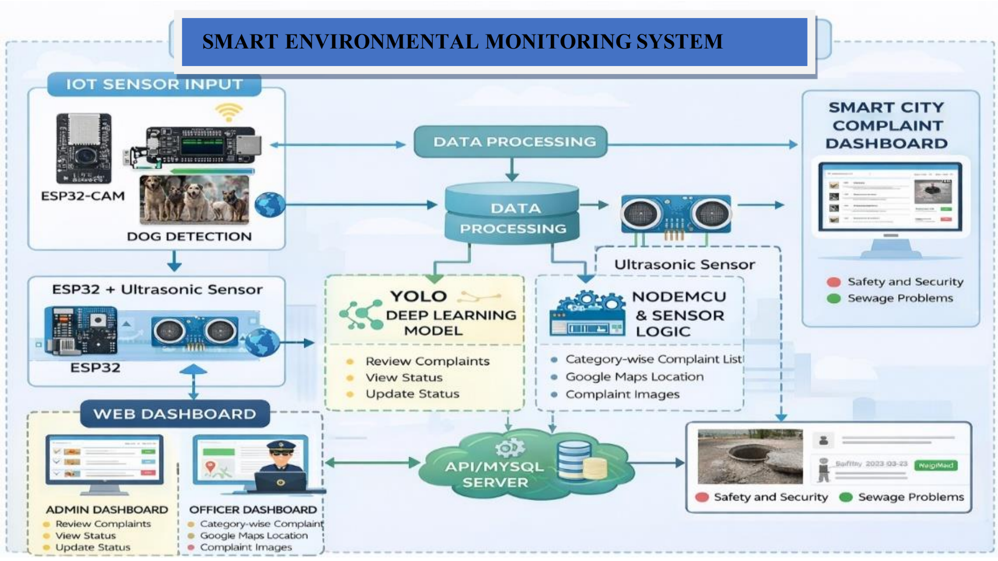

Fig.1: System Architecture

II. Implementation:

The deployment of the AI-Based Smart Environmental Health Monitoring System involves computer vision and IoT solutions to detect and communicate about environmental risks. The camera module captures images of the surrounding environment continuously. Images captured are analyzed via a machine learning model based on the YOLO algorithm for detection of stray dogs within the environment. Upon detection of more than one dog at the same place, the system alerts by sending data to the web-based monitoring system.

Detection of open manholes requires an ultrasonic sensor to detect the distance between the sensor and the ground surface. Distance values are continuously passed through the ESP32 module. Should there be detection of more distance than the predefined value, then it means that the manhole is open.

The identified cases are then forwarded to the server via the network and saved into the database. The web-based dashboard that is created by using the programming languages like HTML and PHP helps the administers or concerned parties login to access information about the identified hazards. The display shows information on the nature of the threat, date, time, and location. They may also change the status of the complaint to either solved or pending.

Combining the use of cameras, sensors, and the web-based management of complaints, the suggested system ensures a seamless monitoring of the environmental safety in urban locations.

Algorithm:

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YOLO algorithm is an object detection algorithm in computer vision based on deep learning. It is widely used for the detection and localization of objects in real-time. As compared to conventional object detection algorithms that work on images through different stages, YOLO works on the whole image at once, which increases the speed of detection processes. The image input to the YOLO algorithm is divided into a grid of S × S cells, each cell responsible for predicting the bounding boxes and classes for objects found in that specific region of the image. A bounding box prediction includes several parameters, including center position x, y, box width w, and height h and probability that there is an object in the box. As YOLO is fast and accurate in its detection of several objects, it is extensively used in surveillance cameras.

For this project, the YOLO algorithm will be used to detect stray dogs in public spaces using image data from the camera module. The camera constantly takes frames from the surrounding area, and these frames will be analyzed using the YOLO detection algorithm to determine the presence of any objects in the scene. If there are any detected stray dogs and there are multiple stray dogs in one place, then the system will log the activity and send the data to the monitoring dashboard. In determining the confidence score of a predicted bounding box during the detection process, we use the formula:

Confidence = P(Object) × IoU

where P(Object) denotes the likelihood of an object appearing within the predicted bounding box and IoU (Intersection over Union) denotes the overlap between the predicted bounding box and the object's real boundaries. The value of the IoU is determined using the formula:

IoU= Area of Overlap/Area of Union

These computations aid in determining the extent to which the predicted bounding box corresponds to the actual position of the target object. Through fast image processing and effective localization of objects within images, the YOLO algorithm facilitates real-time hazard detection in the suggested intelligent monitoring system.

III. RESULTS

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Fig.8: The Open Manhole Detection using Ultrasonic Sensor

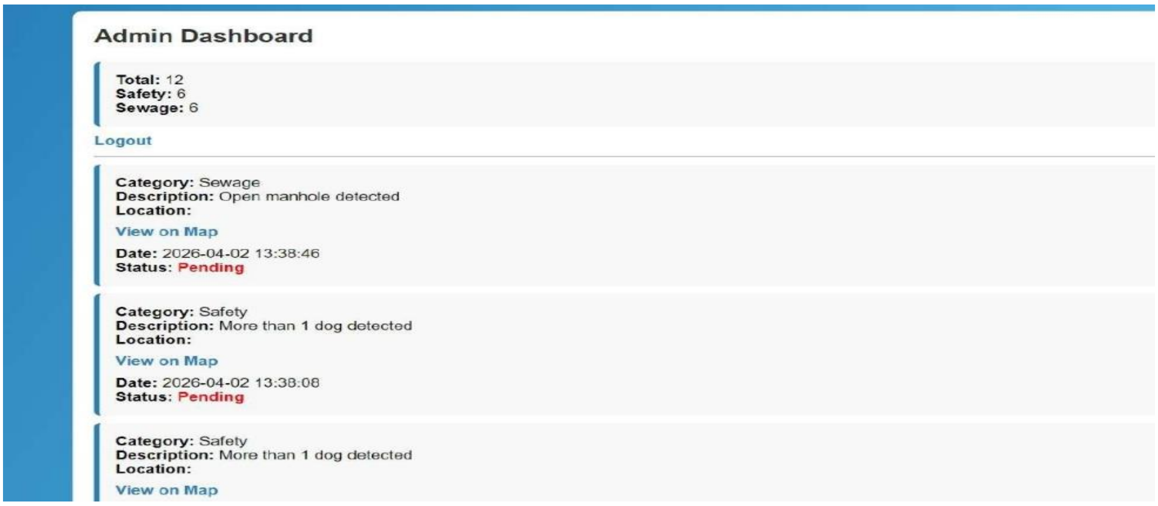

Fig.9: The Dashboard of the Admin

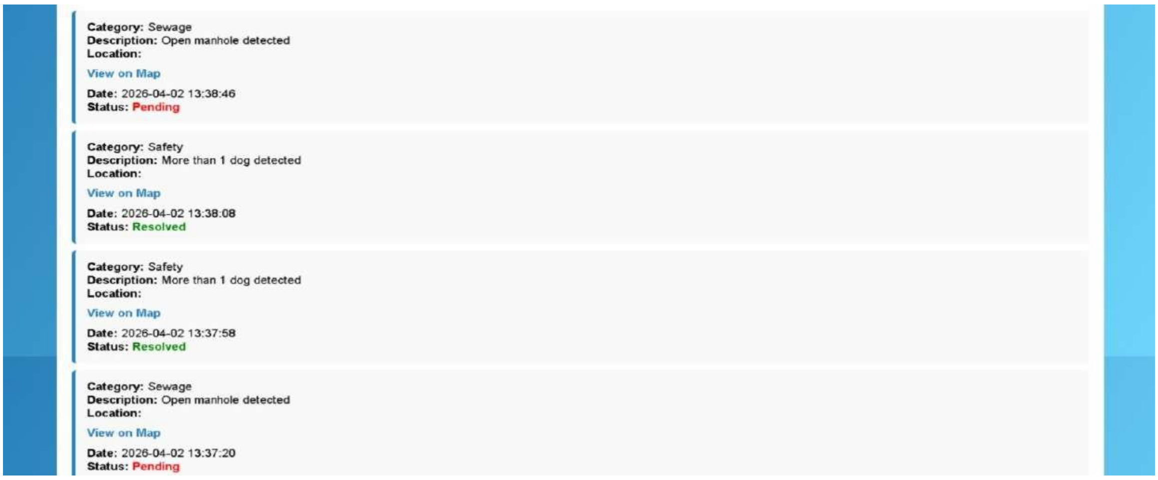

Fig.10: The Dashboard of Admin to View Complaint Categories

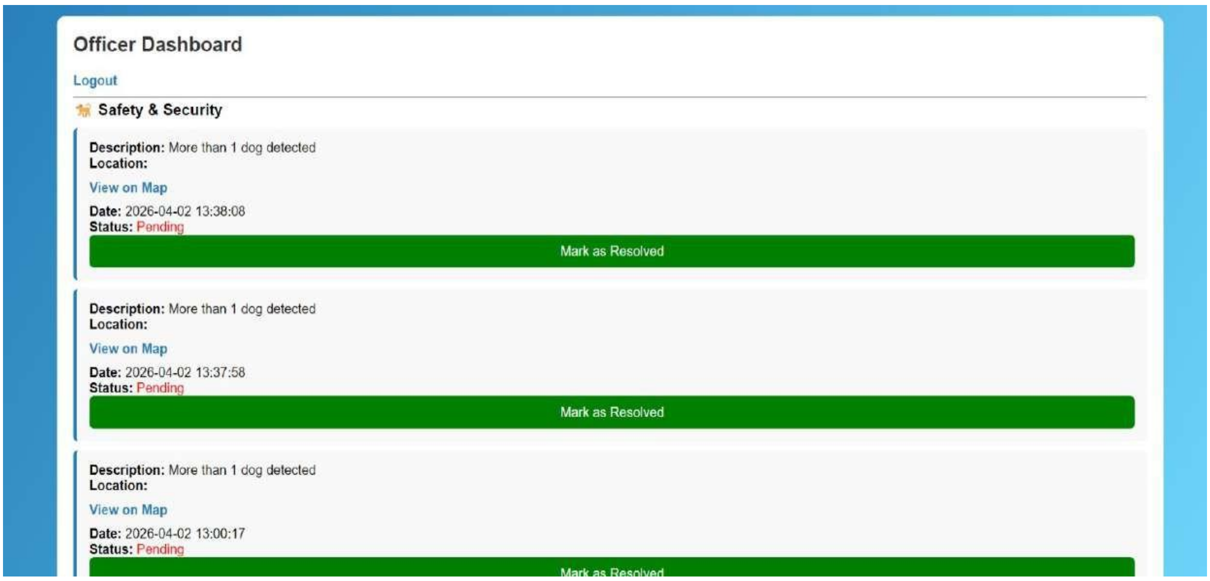

Fig.12: The Dashboard of the Officer to view complaints

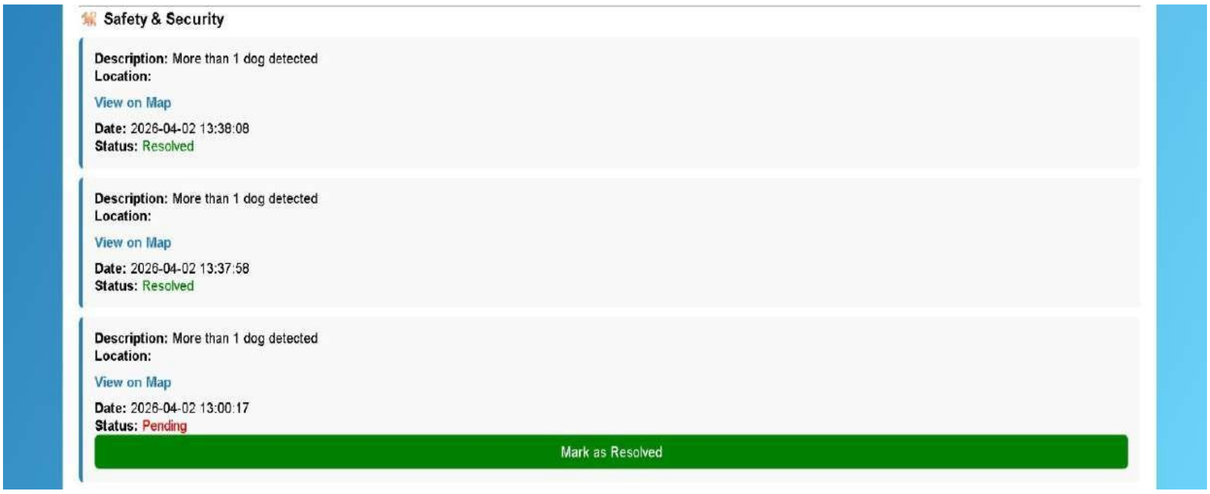

Fig.14: This is Officer Dashboard to Update Resolved and Unresolved Complaints.

CONCLUSION:

AI-Based Smart Environmental Monitoring System suggests a framework that utilizes artificial intelligence to automate the process of recognizing environmental problems in cities. In order to recognize the problem, AI technology uses computer vision and Internet of Things (IoT). Stray dogs' congregation or open manholes can be recognized by AI with no need for continuous human supervision. Utilization of a camera module and an ultrasonic sensor allows the AI to automatically recognize problems and send alerts. Complaints related to environmental problems are stored in the system and are made accessible to city authorities via the web interface that is created on the basis of HTML and PHP languages.

FUTURE SCOPE:

Further improvements in the proposed system could involve the use of additional sensors along with the incorporation of advanced AI methodologies to keep track of a variety of other environmental factors in urban settings. In the future, the detection of garbage disposal, road damages, water leakages, air pollution, or any other kind of hazard could be achieved through the use of additional sensors and computer vision algorithms. An expansion of the current application to a mobile application would enable the authorities to receive real-time notifications about any problems. The system can be upgraded with GPS to offer proper location-based monitoring.

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