Automated Smart City/Community Cleaning system

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INTRODUCTION

We have heard about robotic vacuums and wireless floor cleaners for homes and offices. What if we can apply the same principle in cleaning streets in big Cities? Traditional approaches have robot cleaning frameworks for indoor environments, such as smart homes and offices, there are several established technologies and frameworks that can improve the quality of life for residents. There are fewer existing frameworks [1] specifically tailored for smart city cleaning compared to frameworks for indoor environments like homes and offices. Developing and implementing smart city cleaning solutions presents unique challenges due to the scale and complexity of urban environments. The smart city cleaning system can have several advantages such as Improving quality of life for residents, reduction of Operational Costs [2] etc. Our goal is to propose a method to build an efficient smart city cleaning system with multiple middleware technologies that is: Having Timely Response, Real-Time Monitoring, Scalable, Cost Efficient, Reduce Environmental Impact etc.

Overview of the proposed project:

1) Camera-Based Waste Detection

Each camera placed in a specific zone captures images or videos of the area. Machine learning models, trained to recognize waste in images (picture flow) process the camera data. This can be accomplished using object detection models or image classification models.

2) Alerting Nearby Robots

When the machine learning models detect waste in a camera's field of view, the system sends alerts to nearby robots. The alerts include information about the waste location and (possibly the waste size in the future).

3) Robot Response

Robots, upon receiving location Information, calculate their distance to the waste location (using GPS in the future work) using haversine distance in our project. The robot with the minimum distance to the waste location is selected to perform the cleaning task.

4) Waste Collection

The selected robot navigates to the waste location. Once at the waste location, it collects and disposes of the waste. The robot’s location is updated in the database and status is changed to free.

This system is an example of the practical application of modern technology to address environmental and waste management challenges in urban areas. It can help improve waste collection efficiency and reduce environmental impact. The Detailed Architecture and technologies used will be explained in the next section.

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SYSTEM ARCHITECTURE

The procedure begins with the cameras in different zones (we use a single camera for a single zone for test purpose). The cameras capture the video data is published to kafka middleware and the distributed data pre-processing server subscribes the data and inputs the picture data(screenshots) to the ML model (uses gRPC for remote model calling) and the video data is sent to HDFS.

The below figure represents the system architecture in detail.

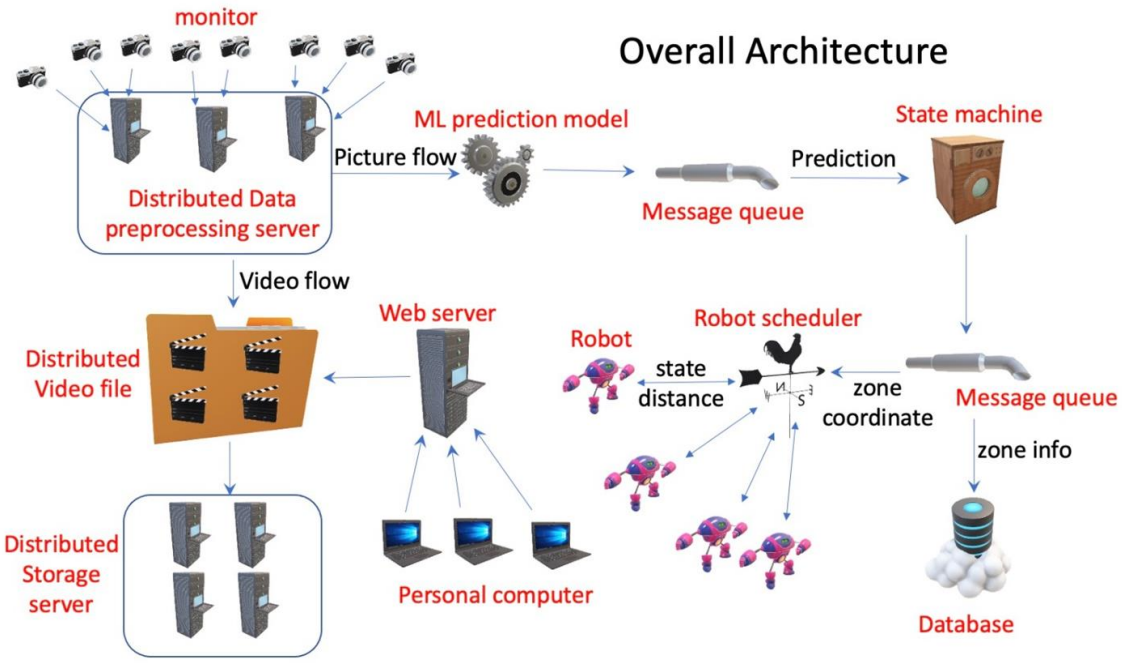

Fig 2.1. Block diagram of the Experiment system

2.1. Video Flow

Video streams from a Distributed Data pre-processing server, through the invocation of the Hadoop API, flow into HDFS and are stored there. A server running Spring Boot retrieves large

video objects from HDFS via RMI calls. Users can access the video content through their personal computers. Upon a user's access request, the video content is delivered back to the user through an HTTP Streaming Service method.

2.2. Picture Flow

Machine learning Prediction model | State Machine

The Python code demonstrates a basic image classification and trash detection process using a pre-trained MobileNetV2 model from TensorFlow's Keras. Since our project was not mainly for machine learning, we didn’t use a trash dataset and used a basic image classification script to show the presence of an object and to show the change in state machine. Then ML model outputs the prediction if the trash is present or not (0,1) and publishes the results via MQTT. The state machine script updates values in response to data received via MQTT. If there is a change from 0 to 1, the zone location is published via MQTT for further steps. The zone information can be further stored in MySQL database for future work (to check how many times wastes appeared in that zone etc.)

Robot Scheduler (Service middleware)

We have a Python script that involves several components, including MQTT communication, HTTP requests, threading, and interaction with a remote robot system. The script receive data over MQTT, process it (uses RESTful APIs to communicate with remote servers (Robots). It sends data to robots by making HTTP POST requests) and then assign the data to a robot for further cleaning job (navigation and cleaning). Each Robots are RESTful API endpoints for a robot cleaning system. It handles assignment of cleaning tasks to a robot and calculates distances to determine the robot's availability for cleaning tasks. The robot's state and location data are stored and updated in a JSON file.

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CONCLUSION & FUTURE SCOPE

This is a project aimed to automatically clean the wastes that appear in certain zones of a city/Community. This project is a simple yet effective framework for demonstrating the use of Middleware technologies such as HDFS, SpringBoot, MQtt, Rest APIs etc. for a smart city cleaning system.

Future research could focus on creating a distributed version of Pub/Sub for the many zones in a city, with the restriction that only client zones that have subscribed to the topic will be able to receive messages. Integration of cloud computing: scalability or data storage. In addition, IoT sensors can be used to send performance reports that include information like the areas cleaned, the amount of time it took, and so on. Smart Navigation and Obstacle Avoidance can be used for Robots to navigate to the destination. We can distribute the database in future making it more edge or Transmitting GPS data using 5G technology in real time.

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REFERENCES

[1] Clean sweep for robot in smart city Helsinki.

Article: https://www.c-mw.net/clean-sweep-for-robot-in-smart-city-helsinki/

[2] Smart Cleaners for Futuristic Smart Cities

Article: https://www.iotnewsportal.com/cities/smart-cleaners-for-futuristic-smart-cities.

Our Code:

https://github.com/CharlieChee/smart_city_cleaning