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Urban Street Cleanliness Assessment using Deep Learning

Arunadevi R[1]; Anisha G[2]; Malini M[3]; Merlin Preetha A[4]; Vaishnavi M[5]

[1]Department of Computer Science and Engineering & Parisutham Institute of Technology & Science, Thanjavur, India
[2]Department of Computer Science and Engineering & Parisutham Institute of Technology & Science, Thanjavur, India
[3]Department of Computer Science and Engineering & Parisutham Institute of Technology & Science, Thanjavur, India
[4]Department of Computer Science and Engineering & Parisutham Institute of Technology & Science, Thanjavur, India
[5]Department of Computer Science and Engineering & Parisutham Institute of Technology & Science, Thanjavur, India
[1] aruna.ap.cse.pits@gmail.com; [2] anishag2807@gmail.com; [3] merlinabhi18@gmail.com;
[4] malinisantha74@gmail.com; [5] riyishu@gmail.com

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Abstract*— Implementation of smart cities is going on all over India. The key focus in smart city is to automate the tasks required to monitor the management activities and effective usage of resources. One important task in the city management is keeping city clean and the man power utilised for it. An automatic garbage monitoring system would help the administration to plan and allocate work for garbage cleaners in an efficient way. CNN is used to identify the street garbage categories, count the number of garbage. And the system is much efficient manner with accuracy. The results are incorporated into the street cleanliness calculation framework to ultimately visualize the street cleanliness levels, which provides convenience for City Corporation to arrange clean up personnel effectively.
Keywords*— City Management, An automatic garbage monitoring system, Region Faster CNN, City Corporation, Urban Street Cleanliness

I. INTRODUCTION

Monitoring and assessing cleanliness of urban garbage areas is difficult and time consuming, as it relies primarily on manual inspections and photo recordings. Human intervention and stressful problems often occur during the testing process. It affected the quality of the sewer as with pedestrian vehicles and other materials, garbage does not have a relatively clear definition. There is always a certain amount of subjectivity to judge garbage, and the judgment result will differ depending on the situation. Since there are various scenes where dust is generated, the accuracy of test results will be affected. With the development of smart cities, to provide an automatic municipal waste detection method that will help reduce the urban waste problem [1].

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Deep learning originates in artificial neural networks. By establishing multiple hidden layers and training large amounts of data, useful features can be learned to achieve the expected classification effect. In recent years, deep learning has become a hot topic in the field of Object Detection. Girshick designed a deep learning object detection algorithm called Faster R-CNN based on region proposal. The algorithm has two main modules: the Region Proposal Network (RPN) proposal box extraction module and the Fast R-CNN detector module. RPN is a fully convolutional neural network. Its function is to find the possible object proposals in the map and extract the proposal box. Fast R-CNN is a proposal detector based on RPN extraction and it identifies the object of the proposal box. RPN shares the same convolutional layers by using a convolutional neural network based on object detection and a convolutional neural network that generates a suggestion window. The image is input to the convolutional neural network, and spread to the shared convolutional layer to get the feature map. The feature map extracted by the shared convolutional layer generates a suggestion window through RPN network, and gives region suggestions and region score. The feature map of the first step is input to the pooling layer in Fast R-CNN to extract area features. Combined with region suggestions and region scores, classification probabilities and bounding box regression are trained, the classification scores of the region are output, and the results are finally tested. Faster R-CNN is considered as one of the most precise image detection approaches. It has high detection accuracy and speed. Consequently, the street garbage detection approach in this paper adopts Faster R-CNN (Regional Convolutional Neural Network) as the underlying model to detect the type and quantity of street garbage [2].

II. LITERATURE SURVEY

Smart city management system using IoT with deep learning, this paper's aims to model implementation of an advanced Smart City system that consists of Smart Home equipped with security features, Smart Waste Management System and automated street lights. Because of the increasing instance of gun violence in the country as well as abroad, and added the feature of detecting guns outdoors uses neural networks, image classifier and object detection. The system is designed by merging the concept of the Internet of Things that control various components of the Smart City ranging from energy efficient Smart Home along with its security measures to identifying a gun from closed-circuit television (CCTV) footage to detect danger on streets of the city achieved by creating an image classifier by training a neural network. As there is no sensor currently available that can detect the presence of an object in a photo, an image classifier is used to detect guns in the photos taken by the CCTV camera [3]. Design and implementation of automatic garbage collecting robot background subtraction based computer vision algorithm, twenty-first centuries has endorsed for remarkable growth in technical as well as economic sectors, yet there remains the lack of proper waste management techniques in most countries. This paper focuses on implementation of a fully autonomous robotic device as part of the initial stage to ensure a hygienic environment for us to live in. The main idea was to design and implement a robotic device that collects garbage lying on corridors, large halls, or even a house, by recognizing the refuse using a computer vision system and picking up the same using a Robotic arm. This was realizable through expeditious background subtraction algorithms, which was later implemented on the computer vision module of a motor driven robot. The device embodies a tough chassis, a computer vision and video analysis module, microcontroller module, a sensor network and a precise robotic arm with actuators. The algorithms incorporated to the intelligence of the robot adopt the fundamentals of background subtraction algorithms in order to obtain accurate results accompanied with a faster computational speed. The Image processing unit was implemented using a Raspberry Pi 3 and a Pi Camera module [4].

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III. PROPOSED SYSTEM

With the development of smart cities, providing an automatic municipal waste detection method will help to reduce the urban waste problem. A novel Faster Regional Convolutional Neural Network (CNN) algorithm used to assess the garbage collection for image analysis and to improve the performance of the system. Therefore , garbage detection using deep learning involves capturing images from cameras, object recognition , prediction , and the transmission of predicted images to the city manager for arranging the clean-up personnel effectively [5]. Faster R-CNN is considered as one of the most precise image detection approaches. It has high detection accuracy and speed. Consequently, the street garbage detection approach in this paper adopts Faster R-CNN (Regional Convolutional Neural Network) as the underlying model to detect the type and quantity of street garbage. YOLOv3 is a real time item detection set of rules that identifies precise gadgets in videos, stay feeds, or images [6]. YOLO makes use of function found out via way of means of a deep Convolution Neural community to come across an item.

IV. SYSTEM ARCHITECTURE

System architecture is the conceptual model that defines the structure, behaviour, and more views of a system. An architecture description is a formal description and representation of a system, organized in a way that supports reasoning about the structures and behaviours of the system [7].

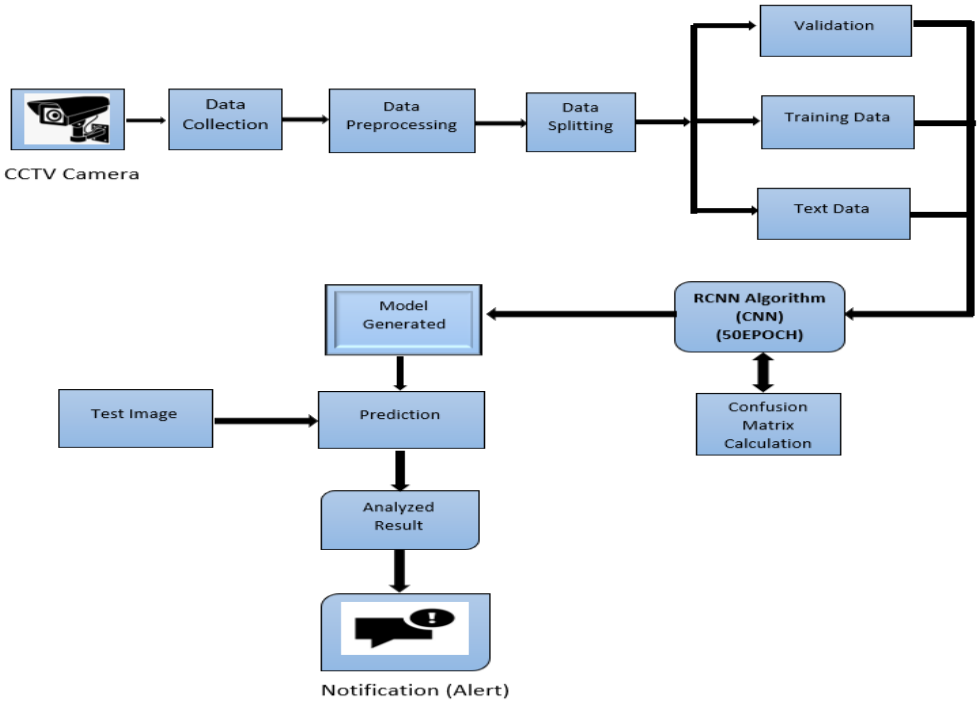

Fig.1 Architecture Diagram

A system architecture can consist of system components and the sub-systems developed, that will work together to implement the overall system. There have been efforts to formalize languages to describe system architecture; collectively these are called architecture description languages (ADLs). Fig.1 specifies the components of proposed system. A data flow diagram (DFD) maps out the flow of information for any process or system. It uses defined symbols like rectangles, circles and arrows, plus short text labels, to show data inputs, outputs, storage points and the routes between each destination.

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V. MODULE DESCRIPTION

A. Data Collection

Data collection is the process of gathering relevant data and arranging it to create data sets for machine learning. AI models are trained on image datasets with the goal of making predictions related to image classification, object detection, image segmentation, and more. The collected image data in the street garbage are stored in the "dataset-resized-zip" folder. The dataset-resized folder has five subfolders as like: cardboard, glass, metal, paper, plastic.

B. Data Pre-processing

Data preprocessing is a data mining technique that transforms raw data into an understandable and readable format. Steps in data pre-processing: 1. Acquire the dataset. 2. Import all the crucial libraries. 3. Import the dataset. 4. Identifying and Handling the missing values. 5. Encoding the categorical data. 6. Splitting the dataset. 7. Feature scaling.

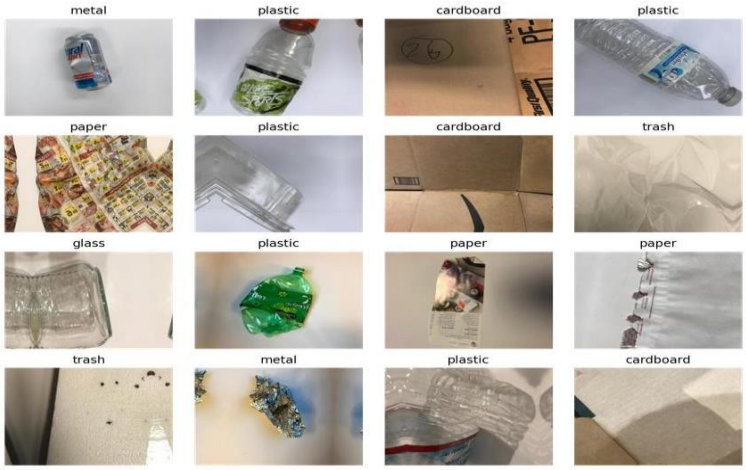

Fig.2 Data Pre-Processing

C. Training Data

Training data is the initial dataset used to train machine learning algorithms. A training dataset is an initial dataset that teaches the ML models to identify desired patterns or perform a particular task. A testing dataset is used to evaluate how effective the training was or how accurate the model.

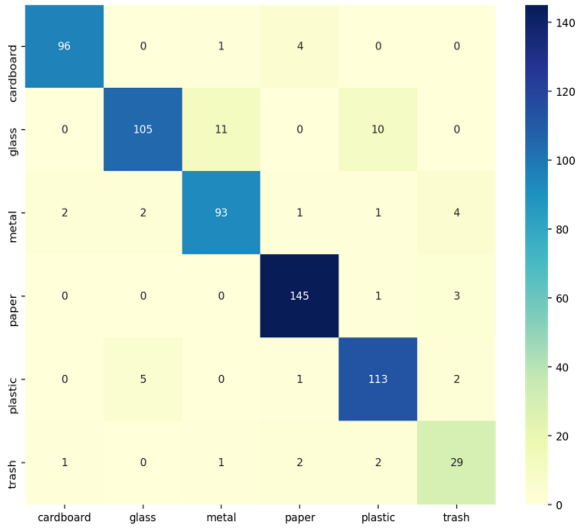

Fig.3 Training Data

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D. Prediction

Prediction refers to the output of an algorithm after it has trained on a historical dataset and applied to new data when forecasting the likelihood of a particular outcome. Prediction stage counts the garbage level.

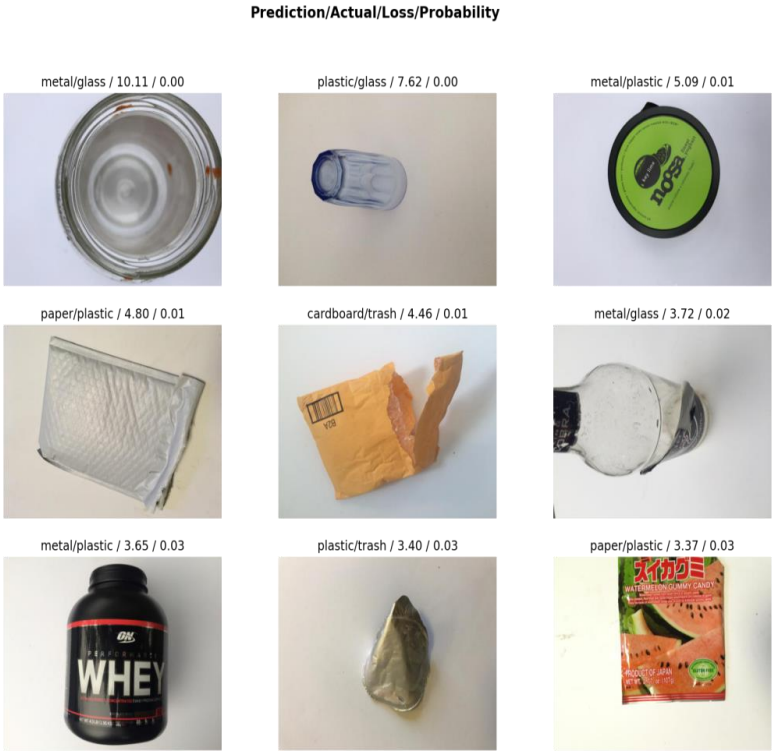

Fig.4 Prediction

Fig.5 Garbage Detection

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E. Telegram Notification

The results will be sent through telegram as the alert message for city manager to arrange clean up effectively.

Fig.6 Telegram Notification

VI. CONCLUSION AND FUTURE WORK

This thesis applied an object detection method for waste containers in different municipalities. The purpose of this research was to improve the previous detection model that was developed using SSD (Single Shot Detector). The Single Shot Detector algorithm was not able to detect the colour or classes. In this research, a significant amount of data and labelled them with associated classes. Based on the high accuracy and speed of the YOLOv3 model, it was decided to use this algorithm for detecting waste containers. The first step was training the BRA city data with a different number of images, obtaining 98 percent accuracy. In the next level, and trained a combined model using three cities (Toronto, Guelph, and BRA). However, this was challenging as using the three cities' data reduces the overall accuracy of the model. To improve the development of a single model, and need to collect additional images from different regions and annotate them accurately. Furthermore, to gain an accurate prediction of bounding boxes, a greater batch size is needed (which requires more GPU power). The future work of this research may be categorized into three sections. First, develop a single sizeable model to train all cities using newer YOLOv4. Second, the accuracy of bounding boxes prediction needs to be improved. The image processing unit will be implemented using Raspberry Pi 3 and a Pi Camera module for future enhancement. Finally, the proposed strategy should be implemented in real-time for automated waste container collection.

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