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# URBAN STREET CLEANLINESS ASSESSMENT USING MOBILE EDGE COMPUTING AND DEEP LEARNING

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***Abstract*— The Object detection is a central task in computer vision, with applications ranging acrossthe process of smart city construction, city managers always spend a lot of energy and money cleaning street garbage due to the random appearances of street garbage, As deep networks solutions become deeper and more complex, they are often limited by the amount of training data available. With this in mind, to spur advances in analyzing and understanding images, Open CV or Google AI has publicly released the Open Images dataset. Open Images follows the tradition of PASCAL VOC, Image Net and COCO, now at an unprecedented scale. In this project we to implement the Consequently, visual street cleanliness assessment is particularly important. However, existing assessment approaches have some clear disadvantages, such as the collection of street garbage information is not automated, and street cleanliness information is not real-time best performing algorithm for automatically detecting objects. Finally, the results are incorporated into the street cleanliness calculation framework to ultimately visualize street cleanliness levels, which provides convenience for city managers to arrange clean-up personnel effectively.**

***Index Terms- Smart cities, street cleaning, garbage detection, deep learning, mobile edge computing***

## I. INTRODUCTION

It concerning the cleanliness of the street (usually defined as pavements and adjoining edges of roads and grassed and planted areas) . Therefore, it involves street-sweeping (whether manual or machine), litter-picking, the uplift of fly-tipped refuse and the removal of graffiti and flyposting. When the street cleaning service is ineffective, the evidence is visible. And it could cause a significant impact on the quality of life and the attractiveness of its neighborhoods, towns and cities. Moreover, people believe that there are the links between environmental problems and other forms of disorder and crime in cities. On the other hand, good quality street cleaning service in a city provides and contributes the good environmental quality in its communities and neighborhoods, which can help urban development, make places attractive to tourists, investors and mobile workers . Moreover, the effective street cleanliness could reduce the costs in cleaning underground water systems for cities. For this reason, researchers around the world are studying automated approaches, using a cleaning vehicle with cameras to capture the streets regularly and collect street information, such as street pictures, geographical location, date and time. Besides, existing object detection algorithms are used to detect images in the remote cloud platform. Finally, the detection results are sent to the city managers for decision making.

## II. RELATED WORK

Smart city construction has become the focus of the whole society. Smart cities use intelligent methods to sense and handle urban activities through the Internet of Things, cloud computing and other technologies, which can improve the quality of service in all aspects of society and economy. Meanwhile, smart cities can also achieve the purpose of reducing costs and resource consumption. Currently, many scholars in the world have done many researches related to smart cities. Zygiaris et al. proposed a planning framework called "Smart City Reference Model". Urban planners can use the framework to define the smart city concept and apply an urban layout to green, interconnected, open, integrated, smart, and innovative concepts. The framework provides an idea for realizing sustainable development of a smart city. The recent practical application is to analyze smart city planning in big cities such as Barcelona, Amsterdam, and Edinburgh. Hefnawy et al. combined a smart city and life cycle concept to create a suitable information and knowledge sharing platform in a smart city. It aims to solve the problem of unreasonable arrangement, lacking planning and internal coordination of large activities in the city, which can achieve the goal of organizational consistency and efficiency.

In addition, Large companies also attempt to put into the research of the smart city. China Telecommunication carried out the development plan of smart city, focusing on 12 theme applications including smart community, smart transportation, smart energy, smart medical services and etc. IBM launched the Watson "Big Data and Analysis Platform" to help solve smart city problems such as smart transportation and air pollution. Microsoft launched the "Future City" plan to solve challenges such as environmental deterioration and traffic congestion by acquiring, integrating and analyzing multiple heterogeneous big data in the city. However, to the best of our knowledge, there is no specific research topic on urban cleanliness for the construction of a smart city. Mittal et al. launched a street garbage project that aims to segment a pile of garbage roughly in the images. They label these images and divide two parts of images that contain garbage or do not contain garbage, then they use CNN (Convolutional Neural Network) to segment the

area containing garbage in the image. Besides, they use the Bing Image Search API to create their data set and get an accuracy of 87.69%, a sensitivity of 83.96% and a specificity of 90.06%. Their method focuses on the segmentation of a pile of garbage, but there are many errors in segmentation judgment and they do not provide details of the garbage type. Rad et al. proposed a fully automated computer vision application based on garbage quantification, They collect different types of garbage images from streets and sidewalks through a data acquisition system established on the top of a vehicle. Then they use classification detection algorithm OverFeat-GoogLeNet which is based on deep CNN to train different types of garbage that they label, and finally, they can detect the garbage that appears on the street accurately. However, at present, they are only able to detect street garbage, and they have not carried out an urban street cleanliness assessment. Also, researchers are thinking about how to use technology to achieve urban cleaning and urban street cleanliness assessment. Borozdukhin et al. proposed a method to solve the optimization of garbage disposal in big cities. The method searches for the time-optimized dynamic route for garbage collection trucks by establishing a mathematical model of dynamic optimal paths, which can make the garbage collection trucks spend shorter time from the garbage collection area to the landfill area. However, the system only considers the route selection of garbage collection trucks and it does not consider the urban cleanliness assessment. Clean Street LA is an initiative by the London city Mayor and the system uses ESRI and GIS tool to map and plot the street cleanliness status block by block. Multiple layers and grids are created to reflect different parts of the city. Cleanliness information on the streets with a cleanliness score is visualized on a map. This information is used to decide on the area that requires attention. However, the limitation of the system is that the monitoring is limited to garbage bins and cannot be extended to monitor the streets. In a mobile app was developed to evaluate street cleanliness and waste collection. This app is based on a plan of indicators that can be used to evaluate the street cleanliness and waste collection service of Santander municipality. Specific methodologies for calculating and evaluating 59 indicators have been developed to obtain information regarding the status of the different elements of the service. Pearson correlation coefficient results suggest that an inverse relationship between the street cleanliness index value.

## III. DETAILS OF PROPOSED OPERATIONS

We describe a novel edge computing framework. There is an edge layer between cloud servers and terminals. We configure edge servers (microdata centers) to handle a part of services from devices at the edge layer. It can also store data resources temporarily and transmit data resources in time. Faster R-CNN is used to identify street garbage categories and count the number of garbage. A multilayer assessment model across different layers is used. The whole city is divided into 5 layers: city, area, block, street, point. Every layer will carry out street cleanliness calculation. We provide a public garbage data set collected by ourselves, which can be used as a benchmark for evaluating street garbage detection and street cleaning. Furthermore, we use the data set to give a visual street cleaning map for Mysore District, In Karnataka, India. The application validates the feasibility and usability of the proposed approach. The results are useful for improving and optimizing city street cleanliness. The rest of this paper is organized as follows: Existing work and their limitations are discussed in Section . Section provides some preliminary knowledge including mobile edge computing, multi-layer assessment model, and deep networks. Urban street garbage detection and cleanliness assessment approach. An image classification or image recognition model simply detects the probability of an object in an image. In contrast to this, object localization refers to identifying the location of an object in the image. An object localization algorithm will output the coordinates of the location of an object with respect to the image. In computer vision, the most popular way to localize an object in an image is to represent its location with the help of bounding boxes.significant.

## IV. PROPOSED METHODOLOGY

Smart city construction has become the focus of the whole society. Smart cities use intelligent methods to sense and handle urban activities through the Internet of Things, cloud computing and other technologies, which can improve the quality of service in all aspects of society and economy. Meanwhile, smart cities can also achieve the purpose of reducing costs and resource consumption. Currently, many scholars in the world have done many researches related to smart cities. Bangalore proposed a planning framework called “Smart City Reference Model”. Urban planners can use the framework to define the smart city concept and apply an urban layout to green, interconnected, open, integrated, smart, and innovative concepts. The framework provides an idea for realizing sustainable development of a smart city. The recent practical application is to analyze smart city planning in big cities such as Mumbai, Chennai, and Kolkatacombined a smart city and life cycle concept to create a suitable information and knowledge sharing platform in a smart city. It aims to solve the problem of unreasonable arrangement, lacking planning and internal coordination of large activities in the city, which can achieve the goal of organizational consistency and efficiency. In this case of the Challenge, we have to build to build the best performing algorithm for automatically detecting relationships triplets.

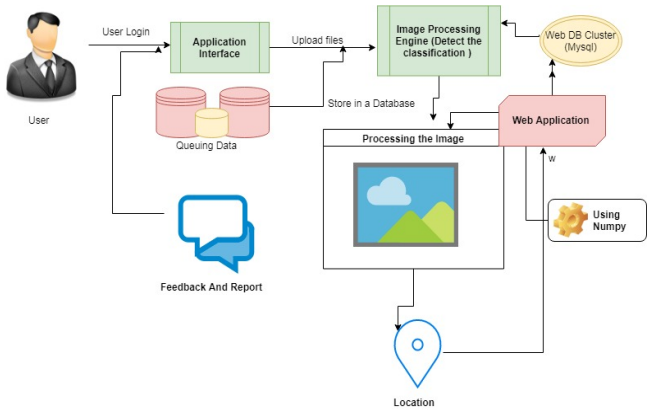


Figure 1: Proposed Methodology

## V. METHODOLOGY

**Convolutional Neural Networks (CNN)**

Convolutional Neural Networks (CNN) is one of the variants of neural networks used heavily in the field of Computer Vision. It derives its name from the type of hidden layers it consists of. The hidden layers of a CNN typically consist of convolutional layers, pooling layers, fully connected layers, and normalization layers. Here it simply means that instead of using the normal activation functions defined above, convolution and pooling functions are used as activation functions.To understand it in detail one needs to understand what convolution and pooling are. Both of these concepts are borrowed from the field of Computer Vision.

**Region-based Convolutional Neural Networks(R-CNN)**

R-CNN is a state-of-the-art visual object detection system that combines bottom-up region proposals with rich features computed by a convolutional neural networks. At the time of its release, R-CNN improved the previous best detection performance on PASCAL VOC 2012 by 30% relative, going from 40.9% to 53.3% mean average precision. Unlike the previous best results, R-CNN achieves this performance without using contextual rescoring or an ensemble of feature types.To bypass the problem of selecting a huge number of regions, Ross Girshick et al.proposed a method where we use selective search to extract just 2000 regions from the image and he called them region proposals. Therefore, now, instead of trying to classify a huge number of regions, you can just work with 2000 regions. R-CNN algorithms have truly been a game-changer for object detection tasks. There has suddenly been a spike in recent years in the amount of computer vision applications being created, and R-CNN is at the heart of most of them.

## VI. IMPLEMENTATION

**Upload Images**

Uploading the image is done by user. Authorized person is uploading the new arrivals to system that are listed to users. images can be uploaded with its attributes.

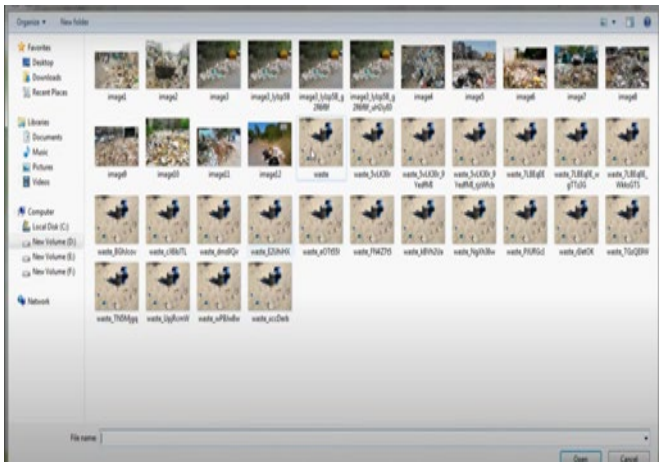

Figure 2: Upload Images

**Approach Overview**

Edge computing can reduce latency and resources. Compared with traditional cloud computing, the main differenceis that some services are processed on the edge in advancewhen a large amount of data is generated. R-CNN is alsowidely used in image recognition. Based on the abovework, we design a novel urban street garbage detection andcleanliness assessment approach.


Figure 3: Approach Overview

**Data Collection and Mobile Edge Processing**

During the data collection stage, the main task is to collect garbage and street images needed by the assessmentapproach We use edge servers to complete two tasks. The first taskis to improve the performance of the entire system. Duringthis stage, when object detection is performed, image datacollected is first input into the CNN networks and then thesize of pictures is modified to the suitable size. We believethat if image data is preprocessed in the edge server, it canreduce the overall time of the entire system.


Figure 4: Data collection and mobile edge processing

**Image Detection Using Neural Network (R-CNN)**

We have already introduced that our streetgarbage detection is based on the Faster R-CNN algorithm.Below, we describe the detection algorithm in detail fromthree parts: networks design,network training, and street garbagedetection.


Figure 5: Image Detection Using Neural Network

**OPENCV**

A library of programming functions mainly aimed at real-time computer vision. OpenCV is a cross-platform library using which we can develop real-time computer vision applications. It mainly focuses on image processing.

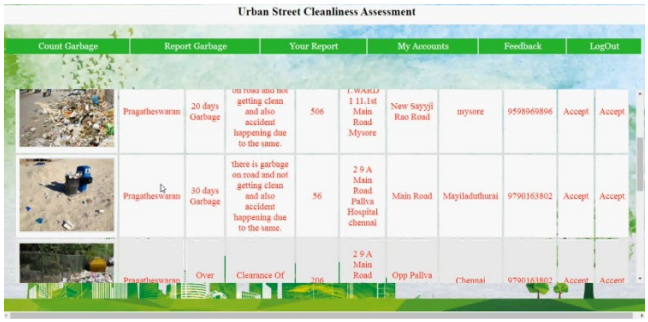


Figure 6: Open CV

VII.CONCLUSION

The development of novel technologies has driven a number of cities into the way to smart cities. Street cleanliness is one of the concerns for smart cities. Consequently, this paper proposes a novel urban street cleanliness assessment approach using mobile edge computing and deep learning. A visual street cleanliness road diagram is presented, such an automated system can help city administrators to know the cleaning state of the street easily. Several directions for future work are possible. These directions are described as follows:

We plan to develop a solution that can automatically implement image filtering preprocessing at the mobile edge because manual filtering greatly affects the real-time transmission and wastes time. Our model contains common street garbage data. However, the model does not play a great role In the Uncommon garbage data. Thus the Training data needs to be Further expanded the Accuracy of the Model.

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