Survey on Cleanliness Assessment of Urban Street using Mobile Edge Computing and Deep Learning

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Abstract - During the smart city building process, city managers spend a lot of energy and money on cleaning street garbage. High-resolution cameras are installed on current poles or vehicles to collect street images that are stored and extracted using mobile edge servers. These images are transmitted to a cloud data center for analysis via city networks. At the same time, the faster convolution neural network (faster R-CNN) is used to classify the categories of street garbage and count the number of garbage. Then the results are integrated into the street cleanliness assessment system to represent the cleanliness rate which makes the city administrator to efficiently coordinate the cleanup works.

***Key Words*: Smart cities, street cleaning, garbage detection, deep learning, mobile edge computing**

1. INTRODUCTION

A smart city is an urban area that uses technologies such as the Internet of Things, cloud computing[2] and other digital systems to effectively control and analyze a city's infrastructure and atmosphere[6]. The smart city concept combines information and communication technology with multiple network-connected physical devices to improve the performance of municipal operations and services [4]. Street cleanliness[3] stands for a city's moral outlook and humanistic climate. Keeping the streets clean is perfect for new town growth. Most major cities actually make public street cleanliness one of the key challenges of modern life. The European City Sweeping Network Summit also emphasizes that prompt street cleaning is an effective way to improve community cleanliness[6]. Currently, the large number of streets is rendering the volume of garbage[8] uncontrollable on highways. Whereas, the method of detecting waste on the streets is not automatic and requires human intervention at virtually every point [4]. Citizens manually monitor the garbage position and send information to city officials, then town managers agree to sweep garbage to local municipal staff. Some towns have put up cameras at street crossroads to see if there's any trash in the city. Such manual methods, however, cannot understand the cleanliness of the garbage on all city streets on time. For this cause, researchers[1][2] around the world are researching automatic methods, using a cleaning vehicle[4] with cameras to periodically capture the streets and gather street information, such as street pictures, geographic location, date and time. Additionally, current object recognition algorithms are used in remote cloud application to identify photos. Eventually, the findings of the identification should be submitted for decision taking to the city administrators.

1.1 overview

In summary, the main contributions of this paper are described as follows:

I. We define a novel architecture for edge computing. The boundary layer between the device and cloud servers. We build edge servers to manage a portion of resources in the edge layer from mobile devices. It can also momentarily store data resources and transmit data resources over time.

II. Uses faster R-CNN to classify types of street garbage and count the amount of garbage. A multilayer measurement approach is used across various levels. The entire city is divided into 5 layers: city, area, block, street, point.

III. Our self maintains a public garbage data collection that can be used as a standard for testing the identification of street garbage and street cleaning the program validates the viability and usefulness of the suggested solution. The findings are useful to enhance and maximize the cleanliness of the streets in town.

2. PRELIMINARIES

A. MOBILE EDGE COMPUTING

With the rapid construction of smart cities, the Internet generates a large amount of data. Traditional cloud computing requires that data must be transmitted to the cloud center for centralized processing. Remote cloud is a smart brain for processing big data [31]. Since the cloud center is usually far away from end users, it is largely unable to provide low latency. In order to solve this problem, mobile edge computing has been proposed to deploy computing resources to devices close to the terminal. The European Telecommunications Standards Institute (ETSI) [9] definesmobile edge computing (MEC) as a distributed mobile cloud computing (MCC) system.

The computing resources are close to mobile devices, and functions such as computing, storage, and processing are added to the wireless network side. In fact, mobile edge computing is based on cloud computing. Itonly calculates a small part of service. It is especially important for big data analysis. For example, when a user uploads a video or makes a comment, he/she can send it to a remote server through an edge virtual server. The edge virtual server can extract the video content and estimate the possibility that other people want to watch the video. If the probability is high, the edge server will cache this video locally so that anyone interested in this video can get the video directly from its cache instead of receiving it from a remote server, which saves transmission resources and reduces latency. In this paper, we use mobile edge computing to process street images in advance and filter out pictures that meet our needs, which has a good effect on recognition efficiency.

B. *MULTI-LEVEL ASSESSMENT MODEL*

To measure the cleanliness of the urban streets, our street cleanliness assessment approach provides a multi-level assessment model across different layers. This model can be divided into five layers as shown in Fig. 1. Layer 1 is the first layer, it is defined as the city area and sets the scope of assessment. Layer 1 covers all the streets in the city. Layer 2 is the second layer where a city is divided into multiple areas and each region is an administrative area. Layer 3 is the third layer where each area is divided into multiple blocks according to the sub-administrative area. Each block is uniquely identified by a combination on administrative area and block name. Layer 4 is the fourth Layer where each block has several streets. Layer 5 is the bottom layer where each street has several data collection points

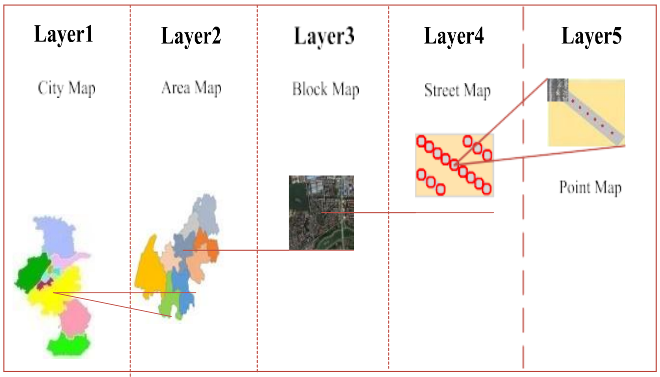

Fig -1: Multi-level assessment model.

C. *DEEP NETWORK*

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. 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 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.

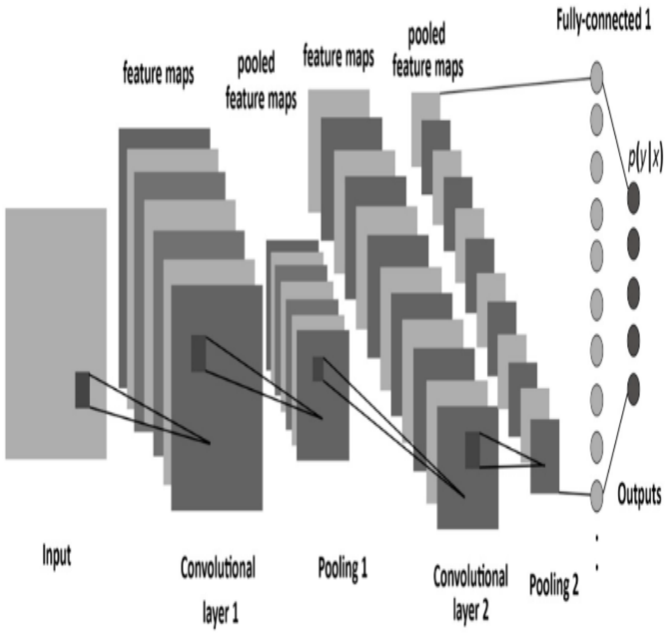

Fig -2: CNN model.

- 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 net-work, and gives region suggestions and region scores;
- 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

D. APPROACH OVERVIEW

The approach is mainly composed of three parts, as described in the following:

- The first step is data collection and scheduling feed-back in the local management. The city administrators control the mobile station to collect the street garbage image data and respond to the level of streetcleanliness presented by cloud center in real time. Then municipal cleaning personnel is arranged nearby.
- The second step is called data preprocessing. During this step, we use the edge server to store the image data captured by the mobile station temporarily and carry out road judgment of the images from the mobile station in advance. Then, the edge server filters out the images containing road areas. We use linear normalization to get the same size images and these images are sent to the cloud center for garbage detection.
- The third step is the model establishment and cleanliness calculation. During this step, the cloud server provides an object detection algorithm. Then a model is trained by selecting appropriate parameters and iterations to detect garbage on the street. In the garbage detection stage, we design a counting function to count the quantities of garbage detected. Finally, based on the results of the above detection, street cleanliness level is calculated with respect to different levels

LITERATURE SURVEY

In [1] The framework provides an idea for realizing sustainable development of a smart city. The conceptual model could also be used to synchronize and optimize city's investments. We have studied about practical usage of smart cities.

[2] The proposed vision is achieved by providing a common access mechanism to the heterogeneous data sources offered by the city, which reduces the complexity of accessing the city's data whilst bringing citizens closely to a prosumer (double consumer and producer) role and allowing to integrate legacy data into the cities' data ecosystem.

[3] This system is proposed to classify waste in an automatic way as an application of computer vision in Colombian high schools. Computer vision system classifies waste automatically in three modules 1. Image acquisition, 2. Image processing 3. Robotic modules.

[4] The purpose of this research paper is to propose the Anti-Litterbugs Campaign as a more viable alternative to improve and maintain urban cleanliness.

[5] The proposed a system examines initiatives by the UK national government to facilitate urban technological innovation through a range of strategies, particularly the TSB Future Cities Demonstrator Competition.

[6] The cleanliness status of streets is collected using mobile stations connected via city network analysed in cloud and presented to the city administrator.

[7] This paper proposes combining Smart City and Lifecycle concepts to improve vertical service provisioning and horizontal integration between different sectors, across different phases while creating a suitable platform for information and knowledge sharing within the same event and with other similar events

[8] Disposal and beneficial-use options for street sweeping residuals collected as part of routine roadway maintenance activities in Florida, USA, were assessed by characterizing approximately 200 samples collected from 20 municipalities.

[9] This paper develops a conceptual framework to examine and analyze two leading cases from the US and Asia. Through the lens of this new framework the paper identifies heterogeneous and heterogeneous characteristics in the process of planning and developing a smart city.

3. CONCLUSION

The emergence of new technology has driven a variety of cities into smart cities. Street cleanliness is one of smart cities concerns. As a result, this study suggests a innovative solution to urban street cleanliness, leveraging mobile edge computing and deep learning. A visual street cleanliness road map is shown, such an automatic device will quickly let city officials realize the street's cleaning condition.

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