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Using YOLOv5 for Garbage Classification

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***Abstract*—At present, people's daily garbage is increasing day by day. How to intelligently classify garbage can save manpower and improve work efficiency. In this paper, a garbage classification model based on YOLOv5 object detection network named GC-YOLOv5 is designed. First, according to the common daily garbage category, five typical kinds of garbage were selected, data cleaned, labeled, and constructed a garbage dataset. Second, the GC-YOLOv5 was built and trained on our datasets. Third, in view of the convenience of multi-terminal access in the cloud and the reduction of computing pressure on edge devices, we deploy the garbage classification model in the cloud. The experimental results show that GC-YOLOv5 can accurately identify the garbage's types and find out the location of garbage.**

***Index Terms*—deep learning, YOLOv5, garbage classification**

I. Introduction

"Garbage besieged city" and "garbage besieged village" are increasingly becoming intractable problems that plague many cities and villages in China and other developing countries. How to intelligently sort and dispose of these wastes is vital interest to people [1]. Garbage classification is a symbol of social progress and ecological civilization, and it is an important way for everyone to protect and improve the environment. Classifying garbage is an important link in the construction of ecological civilization, which is of great significance in reducing garbage storage, reducing disposal costs and protecting land resources.

With the development of computer vision and object detection technology, intelligent object recognition application has gradually become a part of modern life. Since convolutional neural network (CNN) has been widely applied in various fields, especially in the field of computer vision [2]. In the field of object detection, the detection accuracy of the CNN model is better than that of the traditional detection methods.

Based on the above analysis, a better garbage classification model, namely garbage classification YOLOv5 [3] (GC-YOLOv5), is proposed in this paper. This paper establishes a garbage dataset with five kinds of common garbage [4], such as batteries, orange peel, waste paper, paper cups and bottles, as shown in Fig. 1. The characteristic information of the input image is extracted by CNN, and the image is divided into $N \times N$ grids. If the center of an object falls on a grid, that grid is responsible for predicting the object. After garbage detection, the model will deploy to the cloud in real time for other subsequent operations, for example, sorting, storage and so on.

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(a) Dry garbage (b) Wet garbage

Fig. 1. Garbage dataset instances.

II. Algorithm Model

The system flow of this paper is shown in Fig. 2 below. First, garbage image acquisition are made by crawling web page pictures, and then through data cleaning and labeling, a garbage dataset was constructed. Second, after training, GC-YOLOv5 model was obtained for garbage detection. Finally, the model was deployed in the cloud.

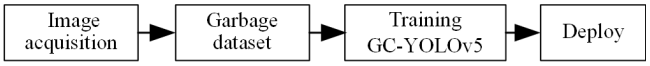


Fig. 2. System flow.

A. YOLOv5 Object Detection Algorithm

In the field of object detection, YOLO [5] is a typical detection algorithm based on deep learning. It has a good global receptive field, grid division, anchor frame matching and multi-semantic fusion detection mechanism. Compared with traditional object detection methods, YOLO model directly predicts the bounding box and probabilistic probability of image objects through CNN, so as to effectively improve detection accuracy [6].

However, YOLOv1 also has some problems, such as weak generalization ability and low detection accuracy [7]. After that, YOLOv2 [8] and YOLOv3 [9] were introduced to improve these problems step by step. Compared with YOLOv2, YOLOv3 has a great improvement in detection performance [10]–[12].

YOLOv4 [13] and the latest YOLOv5 appeared in the YOLO series. YOLOv5 is based on PyTorch framework, and its detection speed is very fast, which can reach 140

fps [14]. Compared with the previous YOLO series, YOLOv5 is faster and accuracy, and its model is light and suitable for deployment to embedded devices [15]. YOLOv5 adopts the same Mosaic data enhancement method as YOLOv4. By stitching the input images by random scaling, random cropping and random arrangement, the detection performance of small targets is improved.

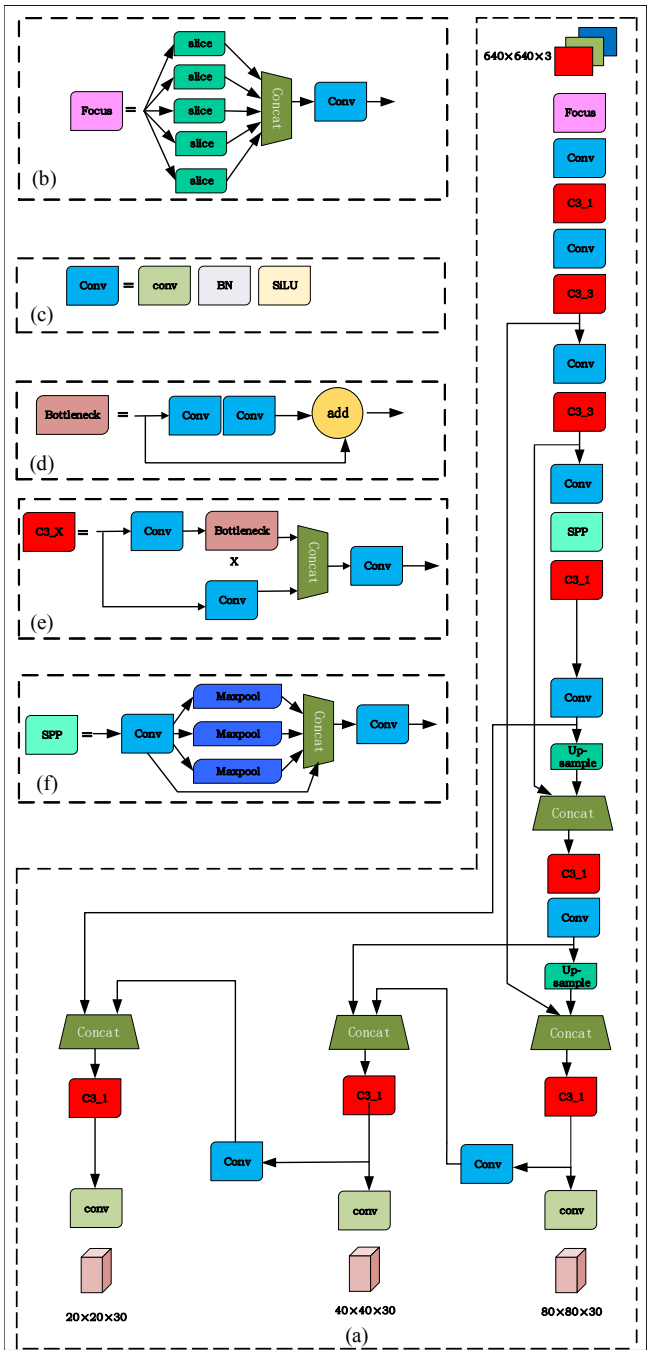


Fig. 3. The structure of GC-YOLOv5.

B. Garbage Classification Model

YOLOv5 has four structures: YOLOv5s, YOLOv5m, YOLOv5l and YOLOv5x. The difference is the depth of the network. The more feature maps are obtained with more deeper backbone network. However, the calculation of the deeper network are more complicated [16]. In this paper, YOLOv5s with the minimum pre-training structure is selected on the premise of meeting the accuracy requirements, and the model size is only 13.7M. Our network structure is shown in Fig. 3. Where in, the sub-figures Fig. 3(b)-(f) explain the important components in network structure.

C. Cloud Service Module Design

The cloud module is designed and developed based on Alibaba Cloud. The model updates the classified data to the MySQL database in the cloud server through remote access to realize data update and storage. The server is always running, waiting for receiving the data sent by the model through the Internet and storing the data to the MySQL database, while waiting for calling from the client. The client calls the data in the database through the JavaScript(JS) writing interface, and stops calling the data in the cloud server after the model runs. The flow chart is shown in Fig. 4.

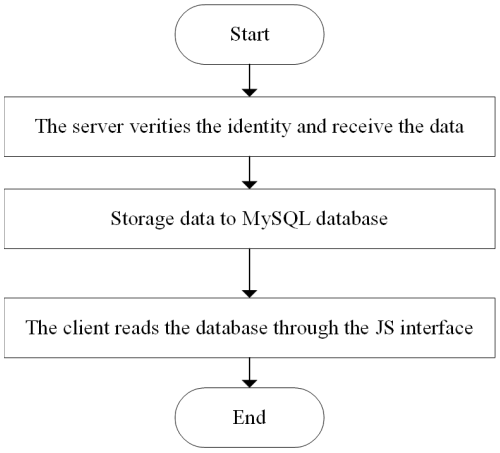


Fig. 4. Cloud server module flow.

III. Results & Discussion

A. Experimental Environment

The system is Ubuntu 16.04 with PyTorch(1.8.0), and the CPU is Intel E5-2660v4@2.00 GHz with 64G memory, and GPU is RTX 1080Ti with CUDA(10.1).

B. Datasets

We collect a garbage image dataset with five categories, which are batteries, orange peel, waste paper, paper cups and bottles, an example is shown in Fig. 1. And, the datasets are randomly divided into 642 pictures in training set and 40 pictures in validation set.

C. Training Process

The number of epochs time is 500. The training loss curves are shown in Figs. 5 and 6. The validation loss function curves is shown in Fig. 7. As shown in Figs. 5-6, with the increase of the number of epochs, the loss curve gradually stabilizes, which indicates that the model training effect is better.

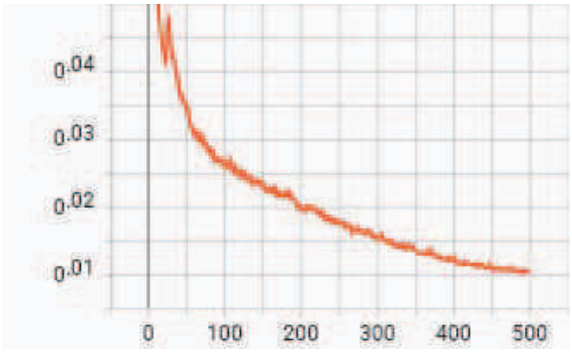


Fig. 5. Training loss curve for box.

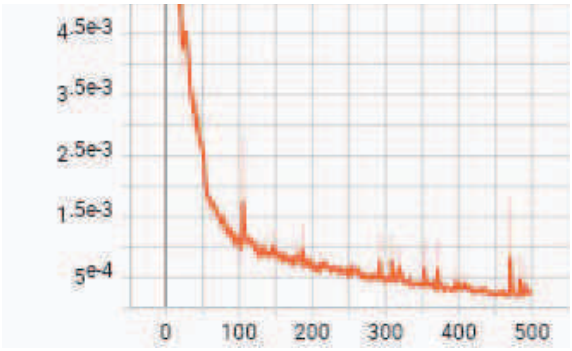


Fig. 6. Training loss curve for cls.

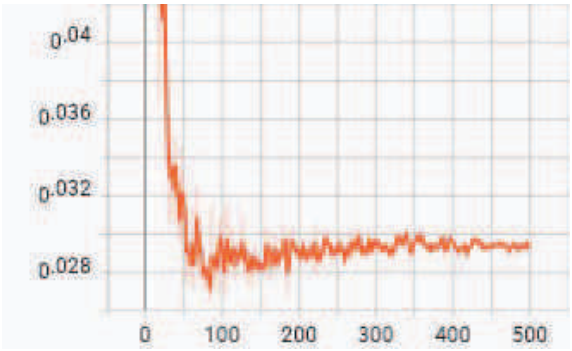


Fig. 7. Validation loss curve for box.

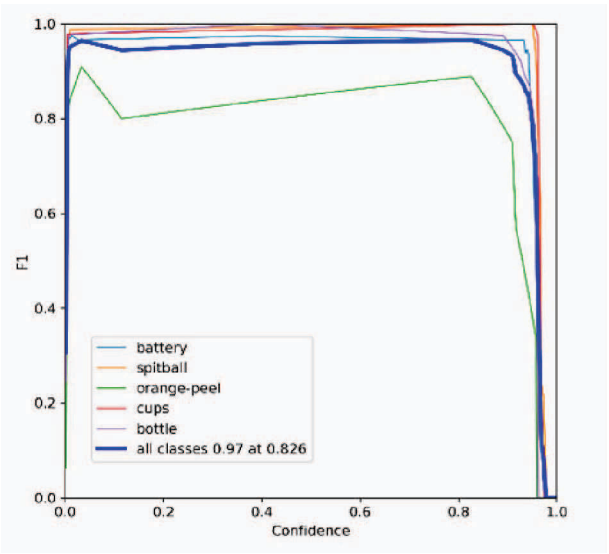


Fig. 8. F1 graph of our model.

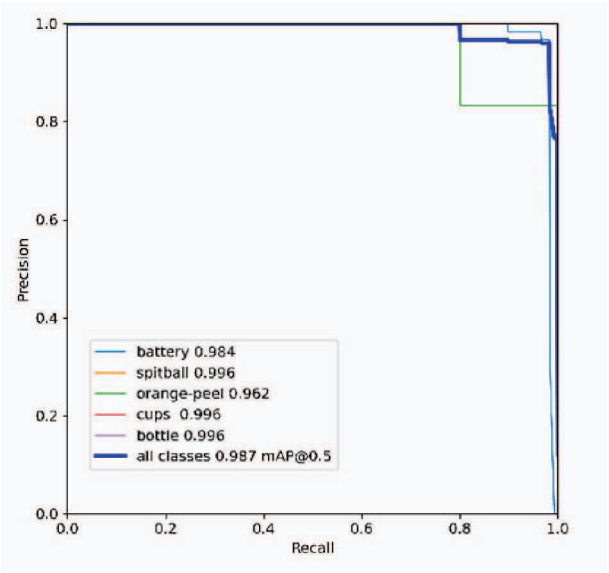


Fig. 9. PR graph of our model.

D. Model Measurement

In this training, YOLOv5s pre-training weight training was used to obtain the F1 and PR curves of integrated Precision and Recall(PR) evaluation indexes, as shown in Figs. 8 and 9. It can be seen that among the five kinds of garbage, the orange peel has the worst F1 and PR evaluation, while the paper cups has the best F1 and PR evaluation. Furthermore, the expression and recognition ability of the model for a specific class can be improved by adding sample data of a certain class.

Table I. is the evaluation data of each index after model training, which is obtained after rounding and rounding the data with keeping it to two decimal places. It can be seen that the mAP (IoU[0.5]), mAP (IoU [0.5: 0.95]), Recall and Precision of the garbage classification model reach 99.59%, 64.70%, 100% and 99.86%, respectively.

TABLE I
MODEL EVALUATION

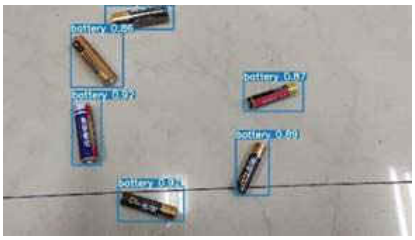
Evaluation Indicator	Model
mAP (IoU[0.5])/%	99.59
mAP (IoU[0.5:0.95]) /%	64.70
Recall/%	100
Precision/%	99.86

E. Experiment Effect

The test pictures of batteries, orange peel, waste paper, paper cups and bottles are shown in Fig. 10.

As shown in Fig. 10(a). It can be seen that GC-YOLOv5 can successfully classify and identify batteries of different brands, sizes and colors.

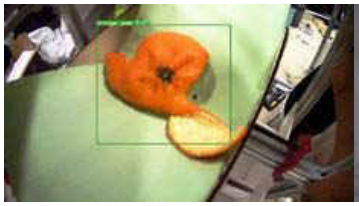
For bottles garbage, GC-YOLOv5 can successfully identify bottles in real and virtual scenes, and the detection results are



(a) Battery

(b) Bottles in real scene

(c) Bottles in virtual scene



(d) Orange peel in a complex scene

(e) Orange peel in a simple scene

(f) All kinds of garbage in real scene

Fig. 10. Experimental renderings.

shown in Figs. 10(b) and (c).

GC-YOLOv5 can also realize the accurate recognition of orange peel under multi-illumination and complex background. The detection results are shown in Figs. 10(d) and (e).

As shown in Fig. 10(f). GC-YOLOv5 can also accurately identify the types of garbage when many kinds of garbage are imported. Even in the camera environment with distorted angle, the model can successfully distinguish each category.

IV. Conclusion

This paper implements a garbage classification model based on deep learning. A garbage classification model based on YOLOv5 object detection network named GC-YOLOv5 is designed. First, according to the common daily garbage category, five typical kinds of garbage were selected, data cleaned, labeled, and constructed a garbage dataset. Further, the GC-YOLOv5 was built and trained on our datasets.

The experimental results show that the average accuracy of mAP was more than 99%. Recall and Precision were close to 100%. In the real scene, the model is deployed, and the test results show that this garbage classification model can accurately identify all kinds of garbage types, and achieve high detection accuracy, the accuracy rate can reach more than 80%. In addition, the model uploads data to Alibaba cloud server in real time through the Internet to realize cloud storage of data, and the data of garbage detection and classification can be viewed online in real time by accessing the cloud through multi-terminal devices. The model has been tested for many times, and its accuracy and real-time performance can meet the requirements. This garbage classification model has certain scientific and engineering significance to the current garbage classification work.

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