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# Application Research of Automatic Garbage Sorting Based on TensorFlow and OpenCV

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**Abstract.** Relying on manual garbage classification, the classification efficiency is low, and because of the classification environment is bad, the classification task is heavy, it is very adverse to the health of the classification personnel. With the development of artificial intelligence, artificial intelligence technology has advanced by leaps and bounds. After the concept of deep learning was proposed, the development of artificial intelligence was driven to practical application. And the advantages of deep learning are obvious, which also makes automatic garbage sorting possible. With the development of deep learning, a large number of deep learning network framework structures have gradually emerged, and a group of open source frameworks represented by TensorFlow and Keras have been widely applied. This paper proposes an application research on automatic garbage sorting based on TensorFlow and OpenCV, an open source image library, in order to realize automatic garbage recycling.

## 1. Introduction

In 2019, China's Ministry of Housing and Urban-Rural Development and other departments issued the Notice on the Comprehensive Implementation of Domestic Waste Classification in Cities at and above the Prefectural Level, which required that the work of household waste classification should be started in 2019 and that the system of household waste classification and treatment should be basically completed in cities at and above the prefectural level by 2025. The first step of household waste classification treatment is to classify household waste. However, manual classification is inefficient. In addition, due to the harsh classification environment and heavy classification task, it will have a very adverse impact on the health of classifiers. At the same time, if the amount of garbage is too large, it may not be able to complete its classification, and the rest will be treated as other garbage, which not only causes pollution to the environment, but also wastes recyclable resources. Nowadays, with the rapid development of artificial intelligence, especially convolutional neural network CNN in image processing, it will be possible for intelligent devices to automatically classify garbage through cameras, which can reduce labor, improve classification efficiency, reduce environmental pollution and reduce resource waste.

In this paper, an open source deep learning framework TensorFlow is proposed to obtain the network training model of MSW, and the trained network structure is imported into OpenCV, and the open source image library of OpenCV is used to realize the automatic classification of MSW.



## 2. Technology Introduction

### 2.1. Tensorflow

TensorFlow is a symbolic mathematical system based on data flow programming, which is widely used in programming and realization of various machine learning algorithms. Its predecessor is DistBelief, a neural network algorithm library of Google. The process of machine learning is divided into two steps. The first step is to input a large amount of data collected into the existing model and train it so that the machine can obtain the optimal relationship between variables through repeated operations. The second step is to input new data into the trained machine and predict the output value. After the data is fed to the machine, the machine learns each time according to the new data.

The core components of Distributed TensorFlow include: Distribution Center, Actuator, Core Application, and Bottom Device Layer/Network Layer.

The distribution center cuts subgraphs from the input data flow graph, divides them into action fragments, and starts the executors. When the distribution center processes the data flow graph, it will perform the pre-set operation optimization, including common subexpression elimination, constant folding, etc.

Actuators are responsible for executing graph operations in processes and devices, sending and receiving results from other actuators. Distributed TensorFlow has parameterizers to summarize and update model parameters returned by other actuators. The executor chooses to perform parallel computing and GPU acceleration when scheduling local devices.

Kernel applications are responsible for single graph operations, including mathematical calculations, array operations, control flow, and state management operations. Kernel applications use Eigen for tensor parallel computations, CUDNN libraries for GPU acceleration, and GEMLOWP for low numerical accuracy computations. In addition, users can register additional kernels in the kernel application to improve the performance of basic operations, such as excitation functions and their gradient computations.

### 2.2. CNN Convolutional Neural Network

CNN is a classic deep learning algorithm, which is intended to be explicitly used for image classification. The algorithm first inputs images from the data set, and it takes the input as the activation amount and the output as the activation amount. Therefore, in CNN, the middle layer is not the normal vector like ordinary artificial neural network, but has the spatial dimension of height, width and depth. The algorithm is mainly divided into three layers: convolution layer, maximum pooling layer and full connection layer.

(1) Convolution layer: this layer receives some input, in which case the image will have a specific height, width and depth. It has some filters, which are basically matrices initialized by random numbers. The filter is small in space, but the depth is the same as the channel of the input image. For RGB, the depth of the filter is 3, for gray, the depth of the filter is 1, and so on. The filter convolves on the input quantity. It glides through the image spatially and computes the dot product across the image, and the filter ultimately generates an activation graph for the input image.

(2) Maximum pooling layer: The maximum pooling layer is basically just the lower sampling layer of the activation map. By using the 2\*2 filter and the maximum pooling layer with the step size of 2, the input activation graph is finally reduced to half of the space circle. Another method of pooling is average pooling, in which the maximum value of the submatrix is reserved as the average value of the next layer rather than the maximum value.

(3) Completely connected layer: The completely connected layer takes the volume as the input at the end, which is completely connected to the whole input quantity like a normal neural network. This layer executes the last matrix multiplier to calculate the output.

Convolutional neural network is a multi-layer neural network model composed of several two-dimensional planes, which is different from the traditional neural network. Convolutional Neural Network adds a convolutional layer for feature extraction and a unique invariant lower sampling layer.

The emphasis is on the convolution gradient calculation and the gradient calculation of the lower sampling layer.

### 2.3. *OpenCV*

OpenCV is a BSD-licensed, cross-platform computer vision and machine learning software library that can be used on different operating systems, including Windows, Linux, Android and Mac OS.

OpenCV library using C++ language, including a large number of C functions and some C++ classes, has the advantages of simple code and implementation of colleges. At the same time, it provides a wealth of interfaces, including Python, Matlab, Java and C# programming languages can be directly called, greatly improving its compatibility, can meet a variety of development environments. OpenCV in more than 2500 kinds of optimization algorithm, which includes a comprehensive set of classic and the most advanced computer vision and machine learning algorithms, the algorithm can be used to detect and recognize faces, identify objects, such as tracking a moving object, involves many fields of computer vision, such as information security, medical imaging, product testing, and the camera calibration, etc.

The basic composition of OpenCV function library mainly includes the following aspects:

(1) Core module, which is the Core and basic function, provides basic data structure, dynamic data structure, array operation, basic drawing function, system function interaction and macro functions;

(2) 2D feature framework, including feature detection and description, description extractor interface, description matcher interface, universal description matcher interface, object classification, etc.

(3) CALIB3D module -- camera calibration and 3D reconstruction, including single stereo camera calibration, object position calibration and 3D reconstruction elements;

(4) HighGUI module -- advanced graphical interactive interface, including user exchange, reading and writing operations for videos and books, etc.

(5) IMGProc module -- image processing functions, including linear and non-linear image filtering, geometric transformation of images, drawing functions, topology connection, histogram operation, motion analysis and target tracking, feature detection and target detection, etc.

In addition, there are other commonly used modules, such as Flann for near search, ObjDetect for object detection, VideoIO for video reading and writing interface, ML for machine learning, DNN for deep learning, and CUDA for algorithm acceleration.

## 3. Automatic garbage sorting model

### 3.1. *The establishment of the data set*

The focus of this article is to classify rubbish, the purpose is to identify some of the common garbage, and its corresponding classification to the recycling waste, kitchen waste (wet garbage), hazardous waste and other waste garbage (dry), such as waste paper, plastic, glass, metal, and cloth five categories belong to the recyclable garbage, leftovers, bone, edible orange roots leaves belongs to kitchen waste such as food waste, waste batteries, waste fluorescent tubes, wastewater belongs to hazardous waste silver thermometer, brick and tile ceramic, integral, toilet waste paper and so on are difficult to recycle waste such as belonging to other rubbish.

Since there is no public garbage data set, you need to collect your own image data set manually. The data set is divided into test set, training set and verification set. Labeling tool is used to mark the target location and category of the image to generate an XML file, which is then converted to a TXT file containing the category of garbage, the central coordinates, and the length and width of the minimum enclosing rectangle.

At the same time, due to the small scale of each category, each garbage image is processed, that is, data enhancement, including random rotation of the image, random brightness control of the image, random translation of the image, random scaling of the image and random cutting of the image. In addition, the mean method and normalization method are also implemented. The dataset consists of

four broad categories of objects. The images of the dataset have a white background, and each image is selected in a different orientation and exposure.

### 3.2. *OpenCV image processing*

#### (1) Morphological processing and image invariant moment

Image processing includes the conversion of RGB images to grayscale images, and then binary. This phase removes unnecessary features from the image.

#### (2) Image segmentation

Image segmentation involves separating the object from the background and other objects, using very general image processing methods in this step. The first step is to use Canny algorithm for edge detection. The second step is to use Otsu algorithm threshold to isolation and eliminate noise and background. The third step is gaussian blur to weaken the details and filter the noise. The fourth step is to transform from color image to black and white image and binary image, and use saturated channels to help finding the boundary. The final step is contour detection in the binary image to analyse object separately.

### 3.3. *Deep network architecture design*

A seven-layer deep neural network structure is designed, including two convolution layers, two activation layers, two pooling layers, and one fully connected layer. The image features are extracted and the parameters brought by the original image are reduced. The convolutional layer is used to extract the features of each part of the image. The purpose of the pooling layer is to reduce the number of training parameters and the dimension of the eigenvector output by the convolutional layer. The full connection layer is used to generate a classifier for the number of classes we need.

### 3.4. *Deep network structure training*

After sample processing, 70% of the generated images were taken as the training data sample  $s_{train}$ , and 30% as the training test sample  $s_{text}$ . The category label of training sample is  $T_{train}$ , and the category label of test sample is  $T_{test}$ . The input images of training data samples and training test samples are randomly reduced to  $32 \times 32 \times 3$ . Random reduction can increase the number of data sets and increase the generalization of the model. The data set consisted of 2000  $32 \times 32$  three-channel RGB color images. The image information is normalized for verification. A garbage classifier based on convolutional neural network is established. The classification accuracy is obtained by the ratio of the number of accurate samples to the total number of all samples in the test samples.

### 3.5. *OpenCV call and recognition*

In order to achieve the purpose of online garbage automatic classification and recognition, this paper adopts OpenCV image library and DNN library with it to import the above trained deep network structure, and uses OpenCV to call deep network structure to identify the target object.

Combined with the above analysis, the automatic garbage sorting model based on TensorFlow and OpenCV is as follows:

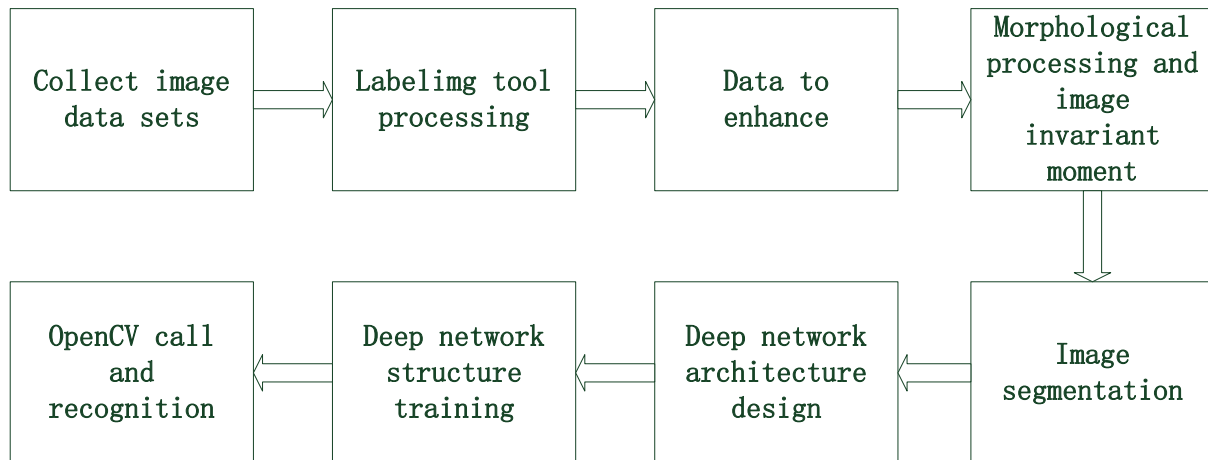


Figure 1. Automatic garbage sorting model

#### 4. Conclusion

Based on the requirements of garbage classification, this paper proposes an automatic garbage classification based on TensorFlow and OpenCV. In this model, the open source deep learning framework TensorFlow is used to obtain the network training model of MSW, and the trained network structure is imported into OpenCV, and the open source image library of OpenCV is used to realize the automatic garbage classification. The realization of automatic garbage classification will reduce labor, improve classification efficiency, reduce environmental pollution and reduce resource waste, which is a good thing for the country and the people.

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