Application of Diagram Image Classification Based on PCBMER

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Abstract. Nowadays, in order to express data more clearly and accurately, data visualization has become a wave of the times. In this context, due to the different types and quantities of data stored in computer systems, different forms of data visualization can be seen in web pages, demonstration slides and papers. However, in many cases, we can't directly obtain the underlying data, so the classification of chart images becomes very important. Only with the classification technology of chart images can we understand it more intuitively and deal with it more concretely, such as generating new charts according to the extracted data. Using depth learning technology to classify chart images is now a very popular way. In the field of image classification, convolution neural network (CNN) is the most widely used technology in depth learning, not only because of its high accuracy, but also because it encapsulates the process of feature extraction. At the same time, using the software architecture of PCBMER framework to design application programs can maintain high stability of the system. From the experimental results, this new technology is feasible, and the architecture can be further optimized to make the results more accurate.

Keywords: Component; chart classification; Convolution neural network; PCBMER architecture; Deep learning.

1. Introduction

With the development of information technology in the field of visualization, we have mastered many methods that can visualize data. Among them, charts have become an important tool to visually express and analyze these data. [1] People use charts for various purposes. We can see the use of charts in the fields of finance, education, scientific research, media, etc. Chart can be divided into two different types: dynamic chart and static chart. [2]

For static charts, we can use manual extraction. But now the amount of chart data we use is increasing exponentially, and the use of manpower has become unrealistic. Therefore, we need computers to automatically classify charts and extract data in some way.

In the past research and practice, people have put forward some researches and experiments on chart classification. For example, ReVision, a commonly used tool, is good at image classification, but its accuracy is relatively low and it is not sensitive enough to some chart types. There are also some papers, their feature extraction systems have more grades, which improves its accuracy, but this will lead to
their cost function is relatively large, thus their processing time is relatively long, which is not suitable for application systems [3].

The main contributions of this paper are as follows: 1. Breaking through the limitations of KNN and support vector product algorithms in previous chart image classification, the convolution neural network method is used instead; 2. Propose an application framework of chart image classification using PCBMER architecture.

The organization of this paper is as follows: The second section will introduce the relevant work on this issue; The third section will introduce the specific working modules of the PCBMER software framework we provide; The fourth section will introduce the experiments and preliminary results.

2. Related Work

2.1. PCBMER Architecture
Patent Cooperation Treaty is a hierarchical architecture, which consists of six layers, namely presentation layer, controller layer, bean layer, intermediary layer, entity layer and resource layer. The Patent Cooperation Treaty coordinates with each other through these six layers, and ensures the efficiency and stability of communication between users and the system according to the characteristics of MER work of the Patent Cooperation Treaty. [4]

2.2. Image classification
Giannakopoulos et al. previously performed classifier comparisons. In the experiment, they extracted several typical image types from a large number of scientific publications as data bases, and used proximity algorithm (KNN), depth confidence network (DBN) and support vector machine (SVM) for classification comparison. The result of their experiments is that the classification effect of DBN algorithm is better than KNN and SVM, which proves the excellent properties of neural network in image classification. [5]

Weihua Huang et al. have also used machine learning methods to classify images before. Their job is to extract feature vectors of images from the general shapes of graphics. Their work mainly uses the improved Diversity Density algorithm. The results of their experiments ensure that most charts have good classification accuracy, but there are some problems in the classification of line charts. [6]

Gary Tam et al. made image classification, and they used the decision tree method to classify images in their papers. Their main work mainly focuses on facial expression recognition. [7] After their experiments, they successfully explained why image recognition is not effective in traditional machine learning models.

Zhou Wei et al. tried to apply image recognition technology to information interaction in industrial design. [8] He adopted a more reasonable information interaction system, which can successfully carry out information interaction. However, the interactive system designed by his work still has room for improvement, and there are still some problems in the recognition of industrial products with some characteristics in image recognition technology.

The main work of this paper is based on PCBMER architecture, so as to solve the problem of recognition and classification of different types of chart images. The difference between the work done in this paper and the previous related work is that it ensures the encapsulation of data by using the one-way communication of PCBMER architecture, so that it can be used as a client for users. The specific working method of software work: the image is uploaded from the client layer to the application system, processed by PCBMER architecture in the application system, and finally the data and charts needed by the user are returned.

3. Working Methods
This section will introduce our proposed chart classification and data extraction, as well as the model of new chart generation. Its main idea is to realize each function through hierarchical division of labor based on PCBMER architecture, thus ensuring the stability of the system running on most devices.
3.1. Specific Application of Architecture in Chart Image Problem

In Figure 1: Six layers in the application can communicate with the server through the Internet. The six layers run different functions: obtaining images, identifying the categories of chart images, storing charts, extracting data from charts, generating charts and updating databases. We can set up a separate server for each of the six layers to run, thus ensuring the stable operation of the program.

![Pipeline diagram](image1.png)

**Fig.1** Pipeline diagram: the specific flow of the customer's use program. The image is classified and extracted in the application program, and finally a new chart is generated.

![Chart recognition system based on PCBMER architecture](image2.png)

**Fig.2** A chart recognition system based on PCBMER architecture is proposed. We get the chart image from the client, and the application program specifies different layers to operate according to specific functions, so as to ensure that the output of each layer can make the program work normally.

In Figure 2: the user sends the picture to the application program through the device that can transmit the picture at the client layer, and the presentation layer of the application program starts to work after receiving the picture. When classifying images, we extract data in the data extraction part after preprocessing the chart images. Finally, according to the user's requirements, output a chart image with intact framework.

Through PCBMER architecture, the application encapsulates the processing process of chart image. Save in Excel format in the data file of the final output chart image, and save the output new chart image in png format. Customers can download data files and new chart images directly from the application. Excel's output format can ensure that users can use it more conveniently without learning additional programming languages.
3.2. Chart Image Data set

In this article, the data we use are obtained by searching for corresponding picture keywords from Baidu pictures, 360 pictures, Bing pictures, etc. and downloading through batch downloaders. However, in this process, we will get some wrong results. We have excluded some unusable chart images through manual search and filtering algorithms.

Excluded chart image types include:
① Hand-drawn charts;
② Displaying incomplete chart images;
③ charts that do not belong to this classification;
④ chart images with low resolution;
⑤ mixing various types of chart images;
⑥ Chart images without data;
⑦ Not a chart image;
⑧ Chart images that cannot be used for other reasons;

Table 1. Number of charts collected after excluding unavailable charts

| Chart Type                  | Test Set | Training set |
|----------------------------|----------|--------------|
| Histogram                  | 110      | 437          |
| Bar chart                  | 107      | 427          |
| Line chart                 | 108      | 433          |
| Column chart               | 72       | 289          |
| Scatter plot               | 77       | 310          |
| Pie chart                  | 105      | 420          |
| Map                        | 68       | 267          |
| Thermodynamic diagram      | 81       | 325          |
| Rectangular tree graph     | 69       | 274          |
| wordcloud                  | 108      | 434          |
| Radar chart                | 74       | 295          |
| Funnel diagram             | 71       | 284          |
| Waterfall chart            | 64       | 256          |
| Mulberry diagram           | 43       | 172          |
| Sum                        | 1157     | 4623         |

Fig.3 Examples of chart types collected in the image data set

From the data in Table 1, we control the ratio of test set to training set to be 1: 4. Figure 3 shows an image example of each chart image category after we filtered, totaling 4623.

3.3. Chart Image Classification module

In the field of traditional methods, the classification of chart images can adopt proximity algorithm (KNN), support vector machine (SVM), decision tree [7] and other methods.

In this paper, we will use CNN to classify images in the control layer. CNN extracts encapsulation features and forms a completed neural network framework by virtue of the local perception and weight sharing characteristics of convolution layer. CNN structure greatly improves the accuracy of our classification of chart images.
In the past research literature, several convolutional neural network models have been proposed: LeNet1, AlexNet, GoogleNet … When we receive new images, we update the data in the server in the resource layer, thus expanding the image database in our training set and improving the accuracy of model prediction. [9]

Now, we have many new models: VGGNet [10], Resnet [11], DenseNet [12] and so on. These new models have better accuracy and robustness, and we can also use these models in classification. Attention mechanism was originally applied to natural language processing, but now it has achieved quite good results in the field of image recognition, with high accuracy and speed. [13]

During the experiment, we found that the accuracy of traditional models is different, and the time consumption is different. On the whole, using GoogleNet to recognize chart images has the best performance.

3.4. Image Data Extraction Module
At the mediator level, we successfully extracted the data of the chart image, and then we need to generate the Excel file of the data at the entity level.

For the problem of data extraction, the biggest difficulty lies in identifying the region where the text is located. Because when we successfully recognize the area where the text is located, we can recognize it according to Optical Character Recognition Software (OCR).

We need to provide a specific method of extracting data according to the types of chart images we classify. We can use CNN in this part to identify the area where the text is located by training CNN. Therefore, when we successfully recognize the text, we can generate the data into an Excel file according to the established format, thus outputting the file.

3.5. A New Chart Image Generation Module
After we get the data of chart images at the mediator level, we can generate new chart images according to the needs of users. By default, we use the standard image form 224 $\times$ 224 $\times$ 3 (representing 224 pixel height, 224 pixel width and RGB three colors), and the image format is png, thus giving users a new visual experience.

It should be noted in this module that when the new chart type required by the user cannot meet the data provided by the existing chart, the system should pop up a data missing warning.

4. Experimental Process and Results
In this section, we will focus on the chart image classification module. Users upload images in the client layer, and applications accept the uploaded images in the presentation layer, and classify chart images in the control layer.

In order to make the size of the image within the range of CNN model processing, we need to edit and other image operations on the images uploaded by users. By using the image normalization of Python image library, we adjust the size to 224 $\times$ 224 $\times$ 3 (width $\times$ height $\times$ color) and convert the image format to PNG, then we can recognize it more accurately.

We used the collected image database (4,623 in total) to carry out the experiment. We used the image database to evaluate three network models: LeNet1, AlexNet and GoogLeNet. The accuracy data of the evaluation are as follows:

**Table 2. Comparison of Accuracy of Diagram Image Classification of Different Models**

| Model       | Accuracy (%) |
|-------------|--------------|
| LeNet-1     | 43.0         |
| AlexNet     | 81.8         |
| GoogLeNet   | 84.3         |
From Table 2, we find that the accuracy of chart image classification in GoogLeNet and AlexNet is much higher than that in LeNet-1. On the premise of similar accuracy, GoogLeNet has fewer parameters and occupies less memory space than AlexNet. When training the model, LeNet-1 takes the shortest time, only less than one minute, while AlexNet and GoogLeNet take more time, about 50 minutes and 40 minutes respectively.

In the training process, we use the gradient descent solution method and set the iterative learning rate to 0.001.

Because we want to apply this algorithm to our PCBMER architecture, we can think that the experimental results are reasonable.

5. Summary and Prospect

In this paper, a new architecture is proposed, which can be used to solve many problems of chart images. This architecture is based on QUBMER model and uses many methods of deep learning to operate chart images.

The main advantage of the model proposed in this paper is to ensure the mutual independence and unidirectional communication between the layers of applications, thus ensuring the stability of the application operation, and ensuring the availability of chart classification, data extraction and image generation. The method proposed in this paper is extensible, which is completely suitable for using more suitable algorithms to replace some of the contents in the future, has more freedom of modification, and keeps pace with the times.

The deficiency of this paper is that there are few data sets in the collection of graphic classification database, and we need more data sets to ensure that the model we study is more accurate.

In future work, we will try to train more data at the resource level. At the same time, we intend to try to adopt more robust algorithms and models to better improve our functions. Finally, we need to complete the work of data extraction and image generation, so as to better verify the feasibility of our proposed architecture.

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