Research on the Garbage Classification Problem Based on Convolutional Neural Network

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Abstract. In order to better promote garbage classification, machine learning models are used to discover and solve garbage classification problems. First, the factor analysis is used to conduct field investigation and data analysis on residents' perception of waste classification. Second, convolutional neural network (CNN) is used to classify and recognize garbage images, which is used to assist the judgment of garbage classification. We should put forward some reasonable classification suggestions to better promote the problem of garbage classification.

1. Introduction

Zhuhai is one of the five special economic zones in my country, and it always pays attention to pollution control and other work of ecological environmental protection. On November 27, 2020, the Ministry of Housing and Urban-Rural Development and other departments issued the "Several Opinions on Further Promoting the Classification of Domestic Waste" in the notice that the scientific management of waste classification should be comprehensively strengthened. To reduce the time consumption of garbage error sharing and classification, this paper uses deep learning to identify garbage types. Using the model to fit and predict the output of garbage, and visually demonstrate the effect of publicity and holding of garbage classification.

Ying D[1] et al. proposed a method RSRL, which is based on CNN model, is unbalanced classification of photo aesthetics, which effectively solved the automatic problem of photo aesthetics evaluation in unbalanced classification. He X[2] et al. studied the satisfaction of outpatients in county-level hospitals in the western region of China based on factor analysis. Hu JB[3] et al. used factor analysis to explore the solar radiation situation in Huzhou area, and tested the correlation between solar radiation and extreme values of some meteorological elements. Wu T[4] proposed a waste sorting and recycling system based on artificial intelligence technology. The system can meet the needs of the current waste disposal work from multiple perspectives. Milenkovi M[5] et al. used factor analysis method constitute immense support for decision makers to use the proposed most favorable solution to formulate and implement their plan of development. Kang L[6] et al. the hardness distribution along the thickness direction of 7B50 alloy thick plates was predicted by quench factor analysis method. Ma S[7] et al. used many factors with unknown correlations by using a factor analysis method based on revealed preference (RP) questionnaire data. Francois O[8] et al. proposed to use factor analysis to study evolutionary problems, which solved the problem of neglected sample dates. Marques R[9] et al. proposed a new multi-frequency GR&R method, which correlates variables and factors and applies it to the quality assessment of hardened steel machining holes. Mohammedhasan M[10] et al. proposed to apply convolutional neural networks to the diagnosis of
diabetes, and the established runet-pca model has a diagnostic accuracy rate of 98.44% on the public data set. Hababeh I[11] et al. used CNN to improve image classification in patients with physical and mental disabilities, and effectively improved image prediction in patients with physical and mental disabilities. Xia K J[12] et al. proposed a new multimodal medical image fusion scheme, which took advantage of the features of multi-scale transformation and deep convolutional neural network. Xie C[13] et al. used CNN and supervised discrete hashing for a new method of finger vein authentication. Zhang M[14] proposed an unsupervised deep learning training methods to solve the problem of insufficient data labeling samples. Dario J[15] et al. establish a deep convolutional neural network model to predict the intensity of ground vibration, and effectively estimate ground motion within 15-20 seconds of an earthquake. Wang M H[16] et al. combined discrete wavelet transform with convolutional neural network for the judgment of cable insulation faults.

This article combines field research and model analysis. The first section explains the country and the region's emphasis on garbage classification; in the second section, the data obtained from the field survey were further sorted out and analyzed by using the model. The factor analysis method was used to analyze residents' cognition and willingness of garbage classification, and suggestions were put forward for residents' lack of classification motivation; the third section aims at the problem of insufficient residents' classification knowledge, using the model to classify and recognize images to assist residents in judging the garbage category. To save residents' time and energy as a breakthrough, to achieve the purpose of advancing garbage classification. The fourth section organizes and presents all the research results.

2. Factor Analysis Model

Factor analysis is a data dimensionality reduction technique, first proposed by British psychologist C.E. Spearman, which aims to measure a few latent variables through the measurement of obvious variables. Mainly used in economics, psychology, education, medicine, meteorology, geology, etc. This survey collected a total of 300 offline questionnaires and 150 online questionnaires. After reviewing the questionnaires, there were 442 valid questionnaires, and the questionnaire efficiency was about 98.2%.

The factor analysis steps for the data are as follows:

**Step 1:** Standardize the scoring process on the collected data. The scores corresponding to options A-E are 1-5 points to obtain standardized index variables.

**Step 2:** Calculate the factor load \( a_{ij} \), which is the correlation coefficient between the variable and the common factor, find the eigenvalue and eigenvector, refer to the eigenvalue greater than 1, and initially select 3 factors. The factor loading formula is as follows:

\[
\text{cov}(X_i, F_j) = \text{cov} \left( \sum_{j=1}^{m} a_{ij} F_j + \epsilon_i, F_j \right) \\
= \text{cov} \left( \sum_{j=1}^{m} a_{ij} F_j, F_j \right) + \text{cov}(\epsilon_i, F_j) \\
= a_{ij}
\]  

(1)

**Step 3:** Calculate the factor variance contribution rate \( g_j^2 \). In order to make the factors more interpretable, 6 factors with a cumulative contribution rate of 84.277% are selected as the main factors, and the common degrees of the first 6 factors are all close to 1. Indicates the greater the degree of dependence. The factor variance contribution rate formula is as follows:

\[
g_j^2 = a_{i1}^2 + a_{i2}^2 + a_{i3}^2 + \cdots + a_{im}^2 (j = 1,2,\cdots,m)
\]  

(2)

**Step 4:** Use the maximum variance orthogonal rotation method to obtain the composition matrix after the rotation.

**Step 5:** Calculate the factor scores, get the comprehensive evaluation of each questionnaire, and sort them. Table 1 shows the factor scores. The higher the ranking, the higher the comprehensive score,
indicating the higher the support for the implementation of garbage classification.

| ID  | Factor1 | Factor2 | Factor3 | Factor4 | Factor5 | Factor6 | score  | Rank |
|-----|---------|---------|---------|---------|---------|---------|--------|------|
| 309 | 2.3992  | 1.214   | -1.0911 | 0.9768  | -0.4321 | 0.2245  | 1.124  | 1    |
| 332 | 1.6921  | 1.7975  | -0.3811 | 0.1942  | -0.3486 | 0.1386  | 0.9858 | 2    |
| 268 | 1.9345  | 1.457   | -0.6768 | 0.3743  | -0.0696 | -0.3438 | 0.9341 | 3    |
| 6   | 2.314   | 0.462   | -0.3011 | 0.9255  | -0.7036 | -0.3178 | 0.8201 | 4    |
| 300 | 0.4642  | 2.7497  | 1.4879  | -0.7475 | -1.5646 | 0.7089  | 0.8162 | 5    |
| 305 | 1.6314  | 1.0229  | -1.2647 | 0.9578  | -0.0635 | -0.7199 | 0.7419 | 6    |
| 173 | 1.1345  | 1.2498  | -1.2043 | 0.9086  | -0.2039 | 0.0427  | 0.7365 | 7    |
| 271 | 1.0753  | 1.0292  | -0.8934 | 0.7773  | -0.1945 | 0.5913  | 0.714  | 8    |
| 91  | 1.4442  | 0.134   | 0.1458  | 0.7448  | -0.6864 | 1.8178  | 0.7127 | 9    |
| 312 | 1.9335  | 0.3261  | -0.5501 | 1.6343  | -0.6436 | -0.4315 | 0.7108 | 10   |

Through factor analysis obtained 6 main factors affecting the implementation of garbage classification, respectively are the cultural degree of residents, whether the problem of garbage spread is very serious, whether to support garbage classification, domestic garbage is divided into several categories, satisfaction with the area of garbage disposal, and the usual way of garbage treatment. According to the comprehensive score of the overall questionnaire, it can be seen that only 184 people have a comprehensive score greater than 0, accounting for only 41.6% of the total number of people. Questionnaires with a negative comprehensive score account for nearly 60%. In this field survey, it was found that residents were not very aware of garbage classification and did not realize the importance of garbage classification. In view of this problem, this paper uses the convolutional neural network to classify the garbage images and help the residents correctly judge the garbage category and save residents' energy and time in learning garbage classification.

3. Convolutional Neural Network Model

Deep learning is an effective learning algorithm proposed by Hinton in 2006 to build a multilayer neural network on unsupervised data. The typical deep learning model convolutional neural network has achieved a series of achievements in the field of computer vision, natural language processing and speech recognition, and it is an efficient recognition method. Convolutional Neural Network is an important approach to machine learning. The convolutional neural network selected in this article is a feature extractor composed of convolutional layer and sub-sampling layer added on the basis of ordinary neural network. The idea of local correlation and weight sharing greatly reduces the number of network parameters.

![Figure 1. Schematic diagram of three-layer neural network.](image)
Figure 1 is a schematic diagram of the structure of a three-layer neural network. The convolutional neural network includes three basic layers: a convolutional layer, a pooling layer and a flat layer. Among them, the convolutional layer reduces the size of the picture, the pooling layer reduces the network scale and parameters, and the flat layer "flatten" the data.

Garbage classification is a very important environmental protection issue in contemporary. The investigation found that due to the wide variety of garbage, people often cannot correctly determine which type of garbage they throw out. If it can be recognized intelligently, it can help people to classify and reduce the rate of misclassification. This article takes pictures of vegetable leaves, cartons, batteries, and chopsticks as identification objects, and trains through the establishment of a convolutional neural network model to realize automatic identification of garbage pictures and assist people in distinguishing various types of garbage.

The sample selection in this article comes from the dataset of Hejing.com, which consists of 14,802 txt files (including tags) and jpg files. This paper extracted four common household waste from the dataset, totaling 1453 samples. The data is processed first, and 1453 txt files (including tags) and jpg files are processed into an npz file containing tags and pictures. Figure 2 shows 10 pictures randomly selected from four labels.

In the first convolutional layer used in this article, set 32 filters of size is 3×3 with a step size of 1, add a pooling layer called Max Pooling, Then perform the first downsampling, take the maximum value in the pool size of 2×2. In order to avoid over-fitting, a pruning layer is established, set the pruning rate to 0.5; the second convolutional layer and the third convolutional layer are set 64 and 128 filters respectively, and other parameters remained. Then build a flat layer and a pruning layer, set the pruning rate to 0.25; finally, a hidden layer and an output layer are built, and the model training period is set to 30. Table 2 is the model summary of the convolutional neural network. There are 33,652,804 parameters in the entire model, and all of them are used for the training of this model.

| Layer (type)                           | output shape       | Param |
|----------------------------------------|--------------------|-------|
| conv2d (conv2D)                        | (None,128,128,32)  | 896   |
| dropout (Dropout)                      | (None, 128,128,32) | 0     |
| max_pooling2d (MaxPooling2D)           | (None,64, 64, 32)  | 0     |
| conv2d_1 (conv2D)                      | (None,64,64,64)    | 18496 |
| dropout_1 (Dropout)                    | (None, 64,64,64)   | 0     |
| max_pooling2d_1 (MaxPooling2D)         | (None, 32,32,64)   | 0     |
| conv2d_2 (conv2D)                      | (None, 32,32,128)  | 73856 |
| dropout_2 (Dropout)                    | (None, 32, 32,128)| 0     |
| max_pooling2d_2 (MaxPooling2D)         | (None, 16,16,128)  | 0     |
| flatten (Flatten)                      | (None, 32768)      | 0     |

Figure 2. Display of randomly selected junk pictures.

Table 2. Summary of CNN model
dropout_3 (Dropout) (None, 32768) 0
dense (Dense) (None, 1024) 33555456
dropout_4(Dropout) (None, 1024) 0
dense_1 (Dense) (None, 4) 4100

Figure 3 shows the accuracy process of the train set and test set of the experimental model. As the number of training increases, the accuracy of the model continues to increase, and eventually stabilizes. Finally, the accuracy of the evaluation model is 85.32%.

Figure 3. Accuracy of training set and test set.

According to the completion of the questionnaire, a large part of the reason for the difficulty in advancing garbage classification is that it takes a lot of time and energy. The model established at this time can assist people to classify garbage, reduce time and energy spent on classification and identification.

4. Conclusion
In this paper, CNN (convolutional neural network) model is used to classify garbage images, and the final accuracy is 85.32%. This model is used to assist people with garbage classification, reducing the time and energy needed for the classification and identification, so as to achieve the purpose of promoting garbage classification.

With the promotion and advance of garbage classification, it is believed that public support for garbage classification will increase. Later, the research on garbage classification problem should be more on the optimization of each link, such as the planning of garbage transportation routes, various types of garbage recycling frequency, screening of garbage with correct classification and so on.

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