Using K-Means Algorithm and Convolutional Neural Networks to Identify Alzheimer's Disease in Coronal Brain Scans

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Abstract. Accurate diagnosis of Alzheimer's Disease (AD) is of great importance to patient care, especially in the early stage, because it enables patients to take preventive measures before irreversible brain damage occurs. Obviously, if computer-based diagnostic models can make better predictions than doctors, the future of health care will change dramatically from the current system. Based on magnetic resonance imaging (MRI), this paper realizes a classification algorithm to distinguish AD patients from normal people. OASIS Brain Imaging Data Set is an open source online data set, which is a coronal bitmap of the human brain. Canny edge detection algorithm is used to extract image information, and K-Means and convolution neural network (CNN) are used to train the data set. The results show that the recognition accuracy of the training set is 99%, and 26% higher than that of the K-Means algorithm, which can be effectively used in the early diagnosis of Alzheimer's disease.

Keywords: Alzheimer's Disease, Edge Detection, K-Means, Convolution Neural Network

1. Introduction
Alzheimer's Disease (AD) is a progressive brain dysfunction that occurs in the elderly in the form of memory loss and other cognitive impairment, and is a primary dementia syndrome. Brain damage is irreversible, and there is no effective treatment. With the aging of the global population and the deterioration of the environment, the number of Alzheimer's disease patients is also increasing. Mild Cognitive Impairment (MCI) is an intermediate state between normal aging and dementia, and is a cognitive impairment syndrome. Patients with mild cognitive impairment are at high risk for Alzheimer's disease. It is the most effective way to delay the onset of AD if we predict the possibility of conversion from MCI to AD, and then take appropriate treatment and intervention measures for MCI patients who are easy to develop into AD. Therefore, the accurate recognition and classification of MCI medical images is very important for the diagnosis and treatment of AD.

With the arrival of the era of big data, the scale of medical image data is also expanding. Deep learning method shows its advantages. It is data-driven and can automatically acquire useful feature knowledge from data without manual participation, avoiding a large number of prior knowledges. In addition, the open source data set OASIS provides a large number of magnetic resonance scans of the human brain. Therefore, this paper constructs a deep learning network model using TensorFlow to...
train OASIS data sets. Canny edge detection algorithm is used to extract image information, and K-Means algorithm is used to pre-classify images to improve the recognition effect of deep learning network model.

2. Basic Theory

2.1. Edge Detection
Image edge detection can greatly reduce the amount of data, and remove the information that can be considered irrelevant, retaining the important structural attributes of the image. There are many edge detection algorithms, among which Canny operator is the most commonly used edge detection method. The basic idea of Canny edge detection is: Firstly, the image is smoothed by selecting a certain Gauss filter, and then the final edge image is processed by non-extremum suppression technology.

2.2. K-Means Algorithm
K-Means is a clustering algorithm. Its workflow is as follows: randomly select K points as the initial center of mass (the center of mass is the point in the cluster), then assign each point in the data set to a cluster, specifically, find the nearest center of mass for each point, and assign it to the corresponding center of mass. Clusters.

3. Recognition Algorithm
OASIS Open Access Series Imaging Research (OASIS) is a project aimed at making brain magnetic resonance data sets freely available to the scientific community. OASIS provides open access to an important neuroimaging database, as well as image data processed across a wide range of demographic, cognitive and genetic profiles, and can be used in neuroimaging, clinical and cognitive research.

![Figure 1. OASIS Data Set Diagram](image_url)

Longitudinal magnetic resonance imaging data for non-dementia and dementia elderly: This set includes 150 subjects aged 60 to 96 years. Each subject was scanned on two or more visits, at least one year apart, with a total of 373 imaging sessions. For each subject, three or four separate T1-weighted MRI scans were obtained during a single scan. The subjects were right-handed, including men and women. Figure 2 shows a comparison of coronal MR imaging between normal aging and Alzheimer’s disease.
Figure 2. Comparison of MRI images

Figure 3 shows a deep learning network model constructed in this paper for training and recognition of OASIS data sets. K-means algorithm is used in the pixel space of each image, and sklearn.cluster.kmeans() of scikit learns is used to pre-classify all images. K-Means algorithm separates a group of objects into clusters, each of which is located in the nearest cluster center. Since the pixel strength of an image exists in a three-dimensional space defined by its RGB channel value, the points on the image can be aggregated into areas dominating the color. To identify the brain, not the brain, only two clusters were selected. Each pixel is then assigned to the color of its cluster.

Figure 3. Network model

SGD + momentum optimizer is used in training. Because the classification cross-entropy is used as the loss function, it is necessary to vectorize the classification label according to the classification number. During data enhancement, the random rotation range of the image is set to 20 (the whole range is 0-180). The range of image horizontal migration is set to 0.2 (width ratio before and after migration), and the image can be reversed horizontally at random. The specific hyperparameter settings are shown in Table 1.

Table 1. Super Parametric Configuration

| Configurations | Parameters |
|----------------|------------|
| Batch size     | 50         |
| Epoch          | 20         |
| SGDLR          | 0.01       |
| Decay          | 1×10⁻⁶     |
| Momentum       | 0.9        |
4. Analysis of Experimental Results

TensorFlow deep learning framework is used for development and testing, and CUDA is used for parallel acceleration of GPU training process. Other specific configuration parameters are shown in Table 2.

| Configuration | Parameter |
|---------------|-----------|
| GPU           | NVIDIA GeForce GTX 1080Ti 8GB GDDR5X |
| CPU           | Intel(R) Core (TM) i7-8700 CPU@3.2-4.6GHz |
| RAM           | 64GB DDR4 2133MHz |
| OS            | Linux Ubuntu 14.0 |
| IDE           | Anaconda3 |
| Language      | Python 3.5 |
| Framework     | Tensorflow 10.0 |

The network model shown in Figure 3 is used to train the OASIS data set. According to the experimental experience, the training epoch is set to 20. However, in order to prevent over-fitting and save computing time, an early termination training mechanism is introduced. The curve of loss and recognition accuracy with epoch during training and testing is shown in Fig. 4 and Fig. 5. K-Means algorithm is used.

![Figure 4. Recognition Accuracy](image_url)
Figure 5. Loss Curve

The accuracy and loss curves shown above are consistent with epoch. The recognition accuracy reaches the maximum at epoch 5, then remains stable, and finally withdraws from training ahead of time at epoch 14. Fig. 4 shows that the recognition accuracy of training can reach 99%, while the recognition rate of testing can reach nearly 95%, which can effectively identify illness and non-illness.

Figure 6. Accuracy without K-Means

Figure 7. Loss Curve without K-Means
In our model, K-Means algorithm plays an important role. It can pre-process and pre-classify the training set, so that the neural network can better classify. When K-Means algorithm is not used, the process of model training is shown in Figures 6 and 7. The recognition accuracy can only reach about 73%, and the test recognition rate is only 69%. Therefore, the K-Means algorithm has brought about 26% performance improvement for our model.

5. Conclusions
For the early diagnosis of Alzheimer's disease, a method based on deep learning is proposed in this paper. Open source data sets of OASIS brain imaging are used, and data enhancement is used to expand the number of data sets. Canny edge detection algorithm is used to extract edge information, which reduces the amount of data. K-Means algorithm is used to preprocess, and then TensorFlow is used to build a deep neural network for training. The experimental results show that the proposed model can achieve 99% recognition accuracy on the training set and 95% on the test set. Compared with the method without K-Means, it has nearly 26% improvement. This method can almost accurately identify whether the clinical subjects have Alzheimer's disease or whether they are at risk, which is of great significance for the early diagnosis of Alzheimer's disease.

6. References
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