Estimating Aspect Score for Stroke from Brain CT Images Based-on Deep-Learning

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Abstract. Stroke is a very dangerous disease and CT image is a good way to quickly diagnose the disease. Aspect Score is a tool to measure the severity of the stroke but it has a problem of the scoring variability among experts. This study proposed an objective and automated aspect score diagnosis algorithm based on image processing and deep-learning technologies.

Keywords: Stroke, Aspect Score, Deep-Learning, Segmentation, Brain CT

1 Introduction

Stroke is a brain damage caused by the blockage or rupture of a blood vessel supplying blood to the brain, resulting in physical disability. It has been reported by the World Health Organization and other leading stroke experts that stroke claims 6.2 million lives each year [1] [2]. Previously, it was mainly recognized as an elderly disease. However, it has become common to people in their 30s and 40s and it is perceived as a dangerous and extensively occurring disease. There are two types of strokes: one type is an ischemic stroke, which occurs because the blood vessel supplying oxygen to the brain is clogged, and the other type is a hemorrhagic stroke, which is caused by the rupture of the blood vessel going to the brain. The latter accounts for approximately 80% of occurrences and the main cause of them is thrombi, clots of blood, that clog the blood vessels that supply oxygen and nutrients to the brain.

A variety of tests have been developed for diagnosing stroke. Among them, the computed tomography (CT) can diagnose a stroke in a relatively short time. CT is considered as an appropriate test method because a quick response is essential for treating the stroke. In the case of a hemorrhagic stroke, cerebral hemorrhage is immediately found from CT so CT is a useful tool to determine a hemorrhagic stroke before the application of clotbuster (a drug used to dissolve thrombi and unclog the blood vessel). Moreover, CT is important to monitor the progress of cerebral hemorrhage after applying clotbuster.

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In 2000, Barber et al[3] introduced the Alberta Stroke Program Early CT Score. ASPECTS Score divides the MCA(Middle Cerebral Artery) territory into 10 predefined anatomic areas and grades the presence of early infarct signs by parenchymal hypodensity on NCCT.

The aspect score has been proven to be a powerful predictor for diagnosing the status of a stroke patient. However, the determination of early signs of ischemia and their translation into the ASPECTS have a considerable interrater variability, which is, among other factors, influenced by rater experience[4]. The scoring variability negatively affects the decision-making process for the clinical results of a patient, which is a disadvantage of the system.

The objective of this study was to establish a guideline to estimate a standardized aspect score by consulting with neurosurgeons and radiologist. Moreover, the study aimed to propose an automated aspect score calculation algorithm by utilizing the deep learning technology based on the developed guideline.

2 Methods & Result

The dataset used in the algorithm was brain CT images of 131 stroke patients who had aspect scores calculated by the judgment of medical experts. Six images were used per patient; three images of the Ganglionic level and three images of Supra Ganglionic level. In order to estimate an aspect score of each patient, positive and negative was determined for seven areas of the Ganglionic level and three areas of Supra Ganglionic level. The accuracy of the algorithm was determined by comparing ground-truth values prepared by medical professionals and values calculated by the algorism for ten legions (positive or negative).

The algorithm can be roughly divided into three steps to calculate the aspect score based on the CT images of the stroke patients. The first step is the pre-processing step and it is for standardizing the image-set. The second step is the segmentation step and it is to separate ten lesions in the CT image. The third step is the deep-learning based judgment step. It calculates the aspect score based on the brain CT images of patients by establishing the neural network that learns positive/negative images for each lesion. The flowchart of the algorithm containing each step is the same as the following Fig. 1.
This study explained each step of the entire algorithm, evaluated the result of the test S/W in the deep learning based diagnosis of lesions step, and verified the whole algorithm.

2.1 Pre-Processing

The pre-processing step ensures more accurate results in the segmentation and deep learning steps by standardizing the image-set. The pre-processing step includes the phase of finding the position of the skull in a brain CT image based on image processing, the alignment phase (i.e., rotation degree and center point), and the horizontal invert phase according to Lesion-side.

The image that has undergone the pre-processing step is standardized to be an image aligned at the center of an image with having the left brain as Lesion and the center vertical line as the brain's symmetry line.

2.2 Segmentation

The segmentation step is a step to separate a brain CT image into ten areas for estimating the aspect score. It extracts seven areas from Ganglionic level and three areas from Supra Ganglionic level.
Ganglionic and Supra Ganglionic level images have feature points that are always present. Each lesion was segmented by using the skull extracted Ellipse and corresponding feature points based on the image processing technology. The following Fig.2 describes the segmentation standards and red points indicate the feature points used in each level. The results of segmentation, obtained through programming, are being optimized for appropriate threshold values and weights by consulting with neurosurgeons and radiologists.

![Fig. 2. Ganglionic Level Segmentation (A), Supra Ganglionic Level Segmentation (B)](image)

2.3 Deep Learning based diagnosis of lesions

Each lesion image is cropped from the whole image according to the segmentation results. Afterward, the map learning is conducted by using the neural network prepared for each lesion with including the positive/negative information a cropped image. Each Neural Network uses CNN and consists of six hidden layers and two dropout layers to prevent overfitting. ReLU is used as an activation function.

The following results show the test results regarding the M4 lesion of Supra Ganglionic level. It was developed as a prototype for predicting the accuracy of the neural network of each lesion.

![Fig. 3. M4 Lesion Neural Network Structure](image)

Three hundreds of cropped images for M4 Lesion were used for training and 75 images were used for testing accuracy. The results showed that the accuracy was 70.9%, and the lack of dataset and poor segmentation accuracy were the main
problems. It is planned to improve the neural network structure and enhance the accuracy of dataset additionally.

3 Conclusion

This study proposed an algorithm that could automatically calculate the aspect score, an objective index to judge the status of stroke patients. It is at an early stage of the research and the study aimed to confirm the necessity of the study and the possibility of development through developing a prototype S/W.

The initial test accuracy was 70.9%. It was believed that the deep learning based diagnosis of lesions for strokes could provide meaningful results when a certain level of segmentation accuracy for each lesion and sufficient data for stroke patients were secured, considering the lack of data (131) and the unoptimized neural network structure.

It is expected that the automated aspect score estimation program for stroke disease can be used as a reliable index that can prevent the problem associated with the scoring variability among experts and facilitate the patient’s treatment decision in the point of medical care, considering that stroke patients requiring prompt treatment.

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