Classification of stroke disease using convolutional neural network

J T Marbun¹, Seniman² and U Andayani³

Department Information Technology, Universitas Sumatera Utara, Indonesia

Email: jodymarbun@gmail.com, seniman@usu.ac.id, ulfi.andayani@usu.ac.id

Abstract— Stroke is a condition that occurs when the blood supply stop flowing to the brain because of a blockage or a broken blood vessel. A symptoms that happen when experiencing stroke, some of them is a dropped consciousness, disrupted vision and paralyzed body. The general examination is being done to get a picture of the brain part that have stroke using Computerized Tomography (CT) Scan. The image produced from CT will be manually checked and need a proper lighting by doctor to get a type of stroke. That is why it needs a method to classify stroke from CT image automatically. A method proposed in this research is Convolutional Neural Network. CT image of the brain is used as the input for image processing. The stage before classification are image processing (Grayscaling, Scaling, Contrast Limited Adaptive Histogram Equalization, then the image being classified with Convolutional Neural Network.

The result then showed that the method significantly conducted was able to be used as a tool to classify stroke disease in order to distinguish the type of stroke from CT image.

1. Introduction

Stroke is a condition that occurs when the blood supply stop flowing to brain because of a blockage or a broken blood vessel. It can happen because there is a plaque in the brain or the patient suffers from hypertension. Stroke can have complications such dementia, afasia and disrupted vision [1]. Stroke can be diagnosed by clinical examination and then followed by Computerized Tomography (CT) Scan by a radiologist. CT Scan will give some image of the brain part that have stroke. In this research, we propose several image processing techniques and Convolutional Neural Network to enhance the image and classify stroke from CT Scan image.

2. Problem Identification

Image that have been produced from CT Scan will be manually checked by a neurologist in order to classify stroke between hemorrhagic and ischaemic which is need a proper lighting to see the image precisely. Therefore, we need a method that can help doctor to classify stroke automatically.

3. Previous Research

Previous research by utilizing CT image had been done to identify stroke from CT image using Contrast Limited Adaptive Histogram Equalization (CLAHE) to raise contrast and Statistical Region Merging to segment the image. They used Statistical Feature Extraction to characterize histogram with 4 parameters such as mean, standard deviation, skewness, and kurtosis. It was concluded that their proposed method can clarify head CT scan image significantly and identify stroke well with the statistical measurement [2].

Another method proposed by Chawla to classify stroke. He used Wiener Filtering to remove noise in image, then using Contra-Later Symmetry to change unsymmetry object become symmetry. For the first level of classification, Histogram Features is used to count the histogram value and for the second
level of classification, they use Wavelet-based features to count the result of histogram value from the first level of classification. The proposed method classify stroke well with accuracy 90% [3].

Next research is to classify brain hemorrhage from CT Scan image with neural network method like Extreme Learning Machine. Grayscale and Scaling method is used to be the image pre-processing before the image being segmented with Threshold to get the object. Then, Extreme Learning machine classify the image well with accuracy 90% [4].

4. Methodology

In this research, there are several steps to classify stroke, namely collecting data of Hemorrhagic and Ischaemic Stroke, Grayscaling to change the RGB image into grey image, Scaling to reduce the pixel of the image, Contrast Limited Adaptive Histogram Equalization (CLAHE) to raise image contrast, Threshold to change image into black and white image, and then using Convolutional Neural Network to classify stroke. General architecture of our proposed method can be shown in Figure 1.

![General Architecture](image.jpg)

**Figure 1. General Architecture**

4.1. Image Acquisition

Head CT Scan data is acquired from https://radiopaedia.org/ [8]. There are 45 digital images that used for Training and Testing Dataset, 10 images of Hemorrhagic Stroke, 10 images of Ischaemic Stroke, 10 images of Normal brain for Training Dataset and 5 images of Hemorrhagic Stroke, 5 images of Ischaemic Stroke and 5 images of Normal brain for Testing dataset in JPG (Joint Photographic Group) format and then will be used for the next step of the proposed method. A sample of head CT Scan image is shown in figure 2.
4.2. Pre-processing

This process consists of three steps, namely Grayscale, Scaling, and CLAHE, which will be clearly explained in the next subsection.

- **Grayscale.** It’s a process to convert RGB image into grayscale image. The conversion from RGB into grayscale can be done using equation (1). Figure 3 (b) shows the result of grayscaling process.

- **Scaling.** It’s a process to reduce the pixel amount of the image that used as input to neural network. So the computation duration can be shortened. In this research we reduce the 250x250 image into 30x30 image. Figure 3 (c) shows the result of scaling.

- **CLAHE.** It’s a process to raise contrast in image, so the stroke object looks clearer. The conversion from RGB into grayscale can be done using equation (1). Figure 3 (d) shows the result of CLAHE process.

4.3. Segmentation

Segmentation is implemented to distinguish the object and the background. We use Thresholding to segmented image. Thresholding will create a binary image. Each pixel in image will be used as input for Convolutional Neural Network to classify stroke. The Threshold value is set to 170, so:

- If the pixel colour $\leq 170$, change the colour to black (0).
- If the pixel colour $\geq 170$, change the colour to white (1). Figure 3(e) shows the result of Thresholding. The binary image obtained from thresholding will be an input for scan line algorithm.

4.4. Classification using Convolutional Neural Network

There are two process of convolutional neural network to classify stroke, namely:

- **Training**
  
  Training process is where CNN being trained with 10 data training of each type classification. In training process, CNN consist of two process (feedforward and backpropagation). Feedforward count all the input neuron from input layer in hidden layer. Weights from Hidden...
Layer will be sent to Output Layer. Backpropagation will trace the error by counting all the weight from Output Layer and then sent it back to Hidden Layer so the neural network obtained a new weights with minimum error. That two process is done for 1 EPOCH.

- **Testing**
  Testing process is where CNN being test with 5 data testing of each type classification and compare the weights from data testing with weights that has been obtained from data training. In testing process, CNN only have feedforward process.

We use Learning Rate = 0.2 , Hidden Node = 30 and maximum EPOCH = 1000 as the parameters in CNN for classifying stroke.

![Graph Result of Parameter Selection](image)

**Figure 4.** Graph Result of Parameter Selection

5. **Development and Testing**

The methods used in classifying stroke are implemented into the system using C# programming language in accordance with the design that has been done. The images of the selected stroke will then be displayed on the left panel as shown in figure 5 below. After that, the "CLAHE" button is used to implement the CLAHE process to image, image which has been done CLAHE will be shown in the center panel of the system. Then use the “Proses” button to implement Threshold to the image, the threshold image will be shown in the center panel and replace the clahe image. After all that process, press the “Uji” button to get the result of the classification, the result will be show in the right panel of the system. Figure 5 and figure 6 will show all of that process.
The value of the testing process will be calculated in neural network to get the most similar value with the value from training process.

6. Result and Evaluation
In this section, we analyze the ability of our proposed method for classifying stroke. The testing result is shown in Table 1. We did 10 test for each image.

Table 1. Result

| No. | Name               | Classification Result | Accuracy |
|-----|--------------------|-----------------------|----------|
|     |                    | True | False |         |
| 1   | Hemoragik1.jpg     | 7    | 3     | 70%     |
| 2   | Hemoragik2.jpg     | 8    | 2     | 80%     |
| 3   | Hemoragik3.jpg     | 10   | 0     | 100%    |
| 4   | Hemoragik4.jpg     | 10   | 0     | 100%    |
| 5   | Hemoragik5.jpg     | 7    | 3     | 70%     |
| 6   | Iskemik1.jpg       | 10   | 0     | 100%    |
| 7   | Iskemik2.jpg       | 9    | 1     | 90%     |
| 8   | Iskemik3.jpg       | 9    | 1     | 90%     |
| 9   | Iskemik4.jpg       | 10   | 0     | 100%    |
| 10  | Iskemik5.jpg       | 0    | 10    | 0%      |
| 11  | Normal1.jpg        | 10   | 0     | 100%    |
| 12  | Normal2.jpg        | 10   | 0     | 100%    |
| 13  | Normal3.jpg        | 10   | 0     | 100%    |
Based on Table 1, from 15 images of testing data, there are 5 testing data detected error while classifying stroke, namely “Iskemik5.jpg”. So, from all the testing result, we can conclude that the obtained accuracy for classifying stroke using convolutional neural network is 90%.

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\text{Percentage of Accuracy} = \frac{14}{15} \times 100\% = 90\%
\]

7. Conclusion
Based on the result for classifying stroke from CT head scan image, convolutional neural network is able to help neurologist to classify stroke. The obtained accuracy also depends on the number of acquired data for training dataset. In this research, our proposed method can give 90% of accuracy for testing 15 images of each type of stroke. The classification result much depends on how much images that being used in training process. More images used in training process, the higher the accuracy.

Future research can be done using other methods for classifying stroke so it can be compare with convolutional neural network. Other Feature Extraction methods also can be used to give specific feature of image to the neural network.

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