Automated Midline Setting for Brain Image Analysis to Detect Intracerebral Hemorrhage

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Abstract. One crucial step in detecting intra-cerebral hemorrhage automatically is to develop a midline setting that will divide the brain structure into 2 parts: the right hemisphere and the left hemisphere. This is useful for the process of detecting bleeding in the brain. By comparing the right hemisphere and the left hemisphere, bleeding detection can be done quickly and automatically on the application system. In this study, we proposed a method that was developed based on the pixel scan algorithm and the determination of the center of weight of the segmented part of the brain. The midline was set as the longest line possible drawn from edges of the brain skull. The result was then compared to manual reading by conducting user agreement surveys to radiology experts. The result shows that more than 75% of the cases experts strongly agree and agree with the midline setting automatically set by the algorithm, but 65% of them were dissatisfied and suggested improvement of the algorithm.

1. Introduction
A critical step in detecting intra-cerebral hemorrhage automatically is to develop a midline setting that will divide the brain structure into 2 parts: the right hemisphere and the left hemisphere. This is useful for the process of detecting bleeding in the brain, wherein this way, we can utilize the symmetrical properties of the right and left hemispheres in detecting the part of the brain that is bleeding [1, 8]. The healthy part of the brain will have the same Hounsfield unit (HU) value or be in a particular range, compared to the part that has bleeding will experience a decrease in the value of HU on the CT scan image [2].

By comparing the right hemisphere and the left hemisphere, bleeding detection can be done quickly and automatically on the application system [3]. The midline method proposed should be able to provide a strict boundary between the 2 parts of the brain that allows comparison between the 2 parts of the brain [4,5]. In this study, we proposed a method that was developed based on the pixel scan algorithm and the determination of the center of weight of the segmentation of the brain against the background.
Figure 1. The appearance of hemorrhage on a CT scan image

2. Material and methods
The process of automated midline setting can be divided into 3 essential steps: pixel scan, the center of weight calculation, and midline setting from the maximum length between edges across the center of weight.

The pixel scan process is needed to get the next borderline of the brain skull. This information later will be used as well to detect the center of the weight of the image. The pixel scan process was done for 4 neighborhood directions: east, west, south, and north.

The threshold process first applied to get the binary image, followed by morphological operation (closing and opening) to clean up the brain image [6]. This way, we can execute the pixel scan in 4 different directions, as illustrated in figure 3. Finally, the midline was set up by observing the longest path between edges from the scanning result.

Figure 2. Preprocessing to set the center of weight (a) thresholding (b) cleaning after the morphological operation and (c) pixel scan.

3. Results and discussion
This method has been tested on CT scan data sets that have been collected previously, and the results have been validated by experts as the golden standard. The results of developing midline on brain images can be seen in the following figure, where for cases where there are artifacts such as head movement [7], this midline method can still be used properly, as shown in figure 3.
Figure 3. Result of automated midline setting for (a) normal and (b) artifact.

The automated results then validated by radiologists as a golden standard. There are 4 statements for the user agreement survey and 4 statements for a user satisfaction survey. These statements are made to take a measure of the user agreement and user satisfaction for the midline setting that automatically developed. Table 1 and figure 2 present the design and its result of the user agreement and user satisfaction survey (for only 15 out of 20 samples).

Table 1. User agreement level survey.

| Level of Agreement | Level of Satisfaction | Score |
|--------------------|-----------------------|-------|
| Strongly Disagree  | Very Dissatisfied     | 1     |
| Disagree           | Dissatisfied          | 2     |
| Agree              | Satisfied             | 3     |
| Strongly Agree     | Very Satisfied        | 4     |

Table 2. Result of user agreement level survey (15 out of 20 examples).

| No | Brain Images | Level of agreement | Level of satisfaction |
|----|--------------|--------------------|-----------------------|
| 1  | ![Brain Image](image1.png) | Strongly Agree (4) | Satisfied (3) |
|   |   | Agree (3) | Dissatisfied (2) |
|---|---|-----------|------------------|
| 2 |   |           |                  |
| 3 |   | Strongly Agree (4) | Satisfied (3)   |
| 4 |   | Agree (3) | Dissatisfied (2) |
| 5 |   | Strongly Agree (4) | Satisfied (3)   |
| 6 |   | Strongly Disagree (1) | Strongly Dissatisfied (1) |
| 7 |   | Disagree (2) | Dissatisfied (2) |
| 8 |   | Disagree (2) | Dissatisfied (2) |
Table 3 shows a summary of the user agreement and user satisfaction from 20 datasets. The result shows that more than 75% of the cases experts strongly agree and agree with the midline setting automatically set by the algorithm, but 65% of them were dissatisfied suggested improvement of the algorithm.
Table 3. Scores in user agreement level and user satisfaction survey.

| Level of Agreement | Number of cases | Level of Satisfaction | Number of cases |
|--------------------|-----------------|-----------------------|-----------------|
| Strongly Agree     | 6 (30%)         | Very Satisfied        | 0 (0%)          |
| Agree              | 9 (45%)         | Satisfied             | 7 (35%)         |
| Disagree           | 5 (25%)         | Dissatisfied          | 11 (55%)        |
| Strongly Disagree  | 0 (0%)          | Very Dissatisfied     | 2 (10%)         |

4. Conclusion
The automated midline setting algorithm works properly and can provide a solution to set the midline for hemorrhage automatically. From experts validation, this algorithm has more than 75% agreement but demanding improvement, especially for the dataset with the artifact and or dataset with abnormalities appearance.

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