Segmentation of Head CT-Scan to Calculate Percentage of Brain Hemorrhage Volume

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Abstract — **Brain hemorrhage is a serious category of head injury that can have a fatal impact on brain function and performance. But sometimes the identification of cerebral hemorrhage can not be known immediately. So far, the identification of cerebral hemorrhage is done through CT Scan image observation that requires special skills. Therefore we need a certain method that can segment the CT Scan image quickly and automated. The goal is to obtain the image segmentation of brain bleeding more quickly and accurately. So patients with cerebral hemorrhage can immediately obtain medical treatment in accordance with the needs. The pre-processing process of CT Scan image starts from the pre-processing phase of the CT Scan image using color filtering, erosion and dilation methods. This stage is done to clarify the cerebral hemorrhage and eliminate the noise contained in the image. Then performed watershed and cropping segmentation to separate the skull bones of the skull with brain tissue. The next step is to improve the image quality using median filtering. Then the image is again segmented using the threshold method to separate the image of cerebral hemorrhage as the observed object. Last performed the calculation of area and volume percentage of bleeding in the brain. From the system test obtained the calculation of brain area has an average error of 1.13%. As for the test calculation of the area of bleeding has an average error of 11.17%.**

Keywords— Watershed Segmentation, Brain Hemorrhage Volume, CT Scan Image

I. INTRODUCTION

CT image segmentation Scan head is one of the important efforts undertaken to determine the health conditions in the human brain. In general, segmentation done manually by experts or radiologists, takes a very long time and often finds the error of segmentation results, because the human error itself. Therefore we need a certain method that can segment the image of the brain quickly and automated. The goal is to obtain the image segmentation of brain bleeding more quickly and accurately. So patients with cerebral hemorrhage can immediately obtain medical treatment in accordance with the needs.

CT Scan is a very useful digital imaging technique, because this technique can provide clear information of the human anatomy. The CT scan scans the nucleus of hydrogen, which is the largest atom in the human body. CT Scan image segmentation becomes the preferred diagnostic method for knowing injuries to the brain, as well as for assessing potential surgical risks or levels of brain treatment. The doctor performs a CT scan to (1) examine the anatomy of the brain, (2) determine precisely the part of the brain that requires special handling. (3) monitor the severity of cerebral hemorrhage, (4) as a guide for surgical planning or other surgical treatments for the human brain.

In this final project, segmentation research on CT brain scan will be done to identify cerebral hemorrhage in humans. Prior to segmentation process, preprocessing should be done first using white filter method, erosion, and dilation. This stage is done to clarify the cerebral hemorrhage and eliminate the noise contained in the image. Then carried out watershed segmentation to separate the skull bones of the skull with the brain tissue. The next step is to improve the image quality using median filtering. Then the image is again segmented using the threshold method to separate the concussion image as the observed object. So that can be known location and position of cerebral hemorrhage that happened to patient. Last performed calculation percentage of bleeding volume in brain. The output of this segmentation process is CT Scan brain bleeding image which can be known volume percentage. The use of this method is expected to help experts in analyzing brain hemorrhage in humans more quickly and accurately. So that the appropriate medical treatment can be done immediately.

II. THEORY SUPPORT

Brain injury is one of many dangers that cause death in humans. Of all the cases of head injuries according to data in the United States last about 49% caused by motorcycle accidents and fall is the second common cause. Head injuries are most commonly found at the age of 15 to 24 years, and twice as large in men as compared to women. The medical process uniquely helps doctors and health professionals to perform special therapies based on the consequences of the patient's pathology condition.

There are many terms used to describe or classify patients with head injuries. In the last year we use the terms "open" and "closed", as well as coup and counter coup. However, the term will be difficult to describe the degree of severity of head injury. The current head injury weights are defined based on the Gaslow coma scale. The terms mil, moderate, and severe head injury are useful in relation to the assessment of parameters for therapy and outcome along the treatment continuum. However, there should be no assumption that mild head injury will result in mild problems or no problems in the patient.

III. METHODOLOGY

In this section, we represent the procedures developed segmentation of head CT Scan. The procedure for head CT Scan segmentation which involves color filtering, erosion, dilation, watershed segmentation, crop, median filtering, threshold. The procedure are graphically described in a schematic diagram shown in Fig. 1.

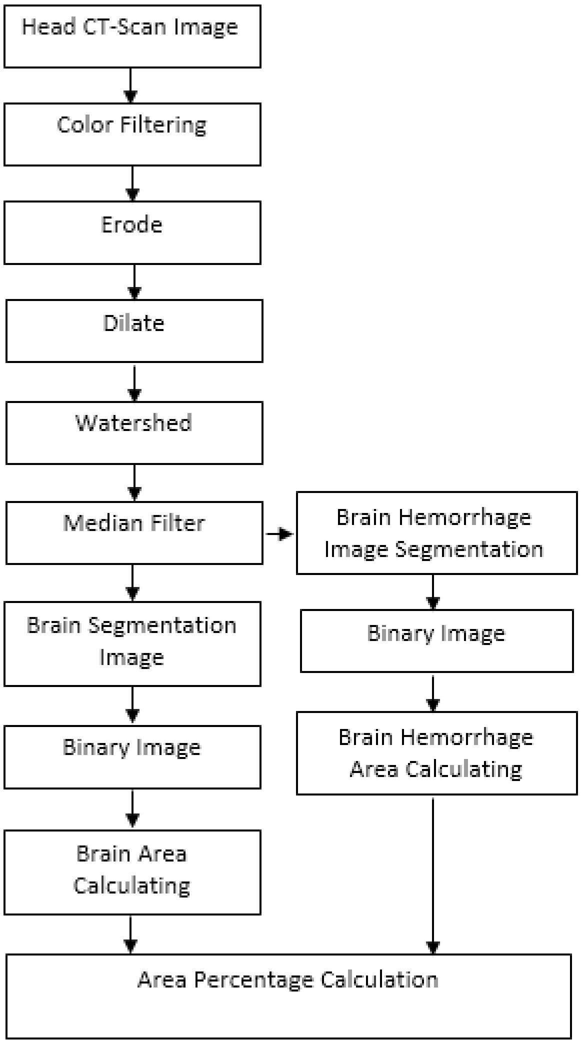


Fig. 1. Schematic diagram of the algorithm

A. Head C- Scan Image

Almost all CT-Scans were performed in axial plane [2]. The axial plane is selected for clearer image results. In this research, we used axial plane head CT-Scan image. Size of input image is 512 x 512 pixels. Fig. 2 represents the head images in axial plane view.

Fig. 2. The head image in axial plane

B. Color Filtering

Color Filtering is an image processing technique used to manipulate an image based on a specific color. The way it works is by comparing the color components of each pixel image with a specific color. If the color corresponds to the specific color of the pixel color component it is left alone. However, if the color does not match the specific color of the pixel color component is changed to the background color, usually a black color. The colors used in Color Filtering can be represented in different color spaces. Fig. 3 represents the result of color filtering.

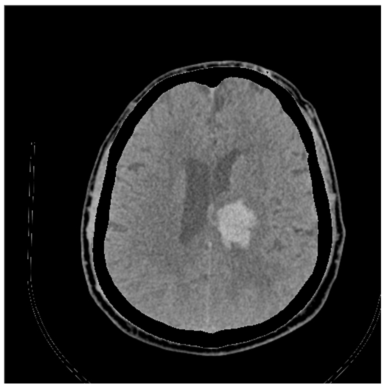


Fig. 3. Result of Color Filtering

C. Erode

Erosion or erosion is one of the image morphology operations that calculates the local minimum value based on the kernel or structuring element area. Image morphology operation is an image processing technique based on the shape or morphology of an image feature. The kernel or structuring element is an mxn-sized matrix that has a central point.

In general, the erosion process performed on an image produces smaller objects and eliminates the object points as part of the background based on the kernel used. Fig. 4 represents the result of erode operations.

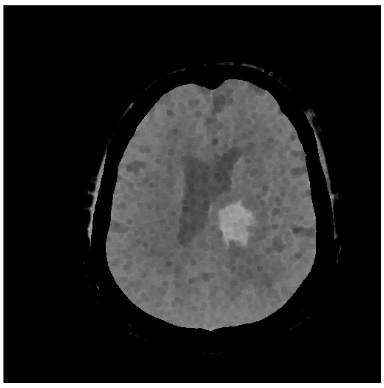


Fig. 4. Result of Erode Operations

D. Dilate

Dilation is the opposite of the erosion process. Dilation or dilation is one of the image morphology operations that calculates the local maximum value based on the kernel or structuring element area. In general, dilation processes performed on an image produce larger objects and merge the object points into parts of the object based on the kernel used. Fig. 5 represents the result of dilate operations.

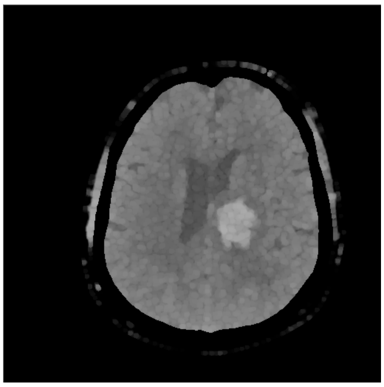


Fig. 5. Result of Dilate Operations

E. Watershed

The concept of Watershed transformation is to assume an image is a three-dimensional form of x and y position with each level of color it possesses. The position of x and y is the basic plane and pixel color level, which in this case is the ash image (gray level) is an altitude with the assumption that the value that is closer to the white color has a higher height.

Assuming the shape of topography, then there are three kinds of points are:

1.The point that is the minimum region

2.The point that is where where if a drop of water is dropped, the water will fall down to a certain minimum

3.The point which is where if water is dropped, the water has the possibility to fall into one of the minimum positions (uncertainly falling to a minimum point, but may fall to a certain minimum point or other minimum point).

Suppose a gray image of level f (x, y) is considered a topographic surface S, where each gray level is considered to be considered terrain elevation, and hill areas correspond to the intended region, as well as valleys or basins showing a minimum . Suppose that every minimum m1 (f) is full of holes and the topographic surface S is depicted vertically into a lake, assumed at a constant velocity. Water will flow and fill the surface. During this filling process, water will come from two or more different minima. Fig. 6 represents the result of watershed segmentation.

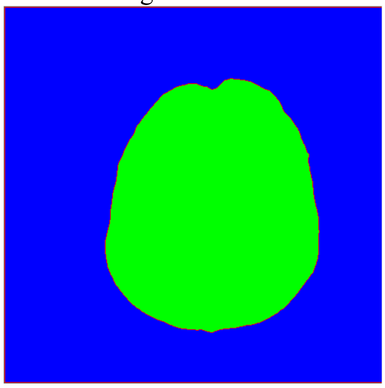


Fig. 6. Result of Watershed Segmentation

F. Crop

Subsequently, image will be crop in segmented area (land area in watershed). The output of this step is brain area (without skull). First find the contours with OpenCV's findContours and create a mask with drawContours. Finally copy the masked original image to the new image, which means only the areas of the contours will be copied. Fig. 7 represents the result of crop operations.

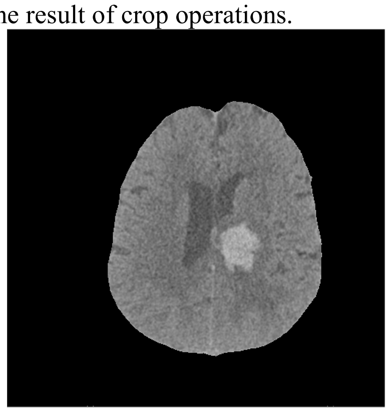


Fig. 7. Result of Crop Operations

G. Median Filtering

Median filtering is a non-linear method used to eliminate noise in the image. It is widely used because it is very effective for removing noise but still retaining edges. The median filter works by moving through pixels to pixels in an image, replacing each value with the median value of neighboring pixels.

Median Filtering is calculated by first sorting all pixel values from window to numerical sequence, and then replacing pixels with pixel middle values. How to find the above median value is:

1. Read the pixel value to be processed along with its neighbor pixels.
2. Sort the pixel values from the smallest to the largest.

3. Select the value in the middle for the new value for pixels (x, y).

Thus, the median filter eliminates very different pixel values with its neighboring pixels. The use of the median filter itself also has a drawback that the processed image will appear slightly blurred or blurred. Fig. 8 represents the result of median filtering.

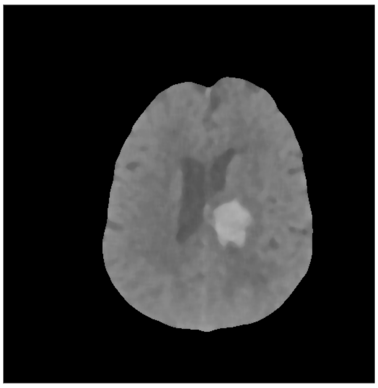
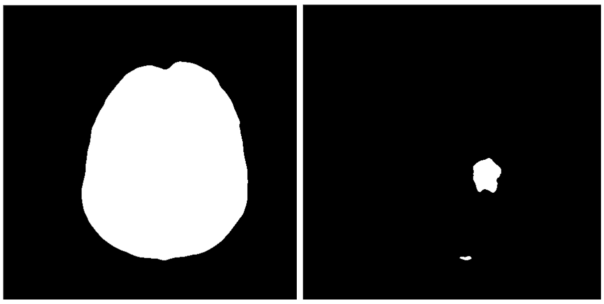


Fig. 8. Result of Median Filtering

F. Threshold Binary

Thresholding is a binary technique used to convert gray images into binary images. Thresholding can be used in the image segmentation process to identify and separate the desired object from the background based on the gray level distribution or image texture. The thresholding process uses a threshold value to change the pixel value of the grayscale image to black or white. Threshold consists of several types, in this research type of threshold used is Threshold Binary.

In the binary threshold, if the pixel value in the image is larger than the threshold value, the pixel value will be replaced by the maxval value, otherwise if the pixel image value is smaller than the threshold then the pixel value will be replaced by 0 (black). Fig. 9 represents the result of threshold binary.



(a) (b)

Fig. 9. Result of Threshold Binary: (a) Brain (b) Brain Hemorrhage

H. Count Pixel of Brain Area & Brain Hemorrage Area

The calculation of the area of the brain begins by searching for pixels that have a gray value not equal to 0 of the global threshold process. The number of pixels is the area of the brain. The calculation of the area of brain hemorrhage begins by looking for pixels that have a gray value not equal to 0 from the threshold region process. The number of pixels is the area of brain hemorrhage. Fig. 10 represents the result of count pixel of brain area and brain hemorrhage area.

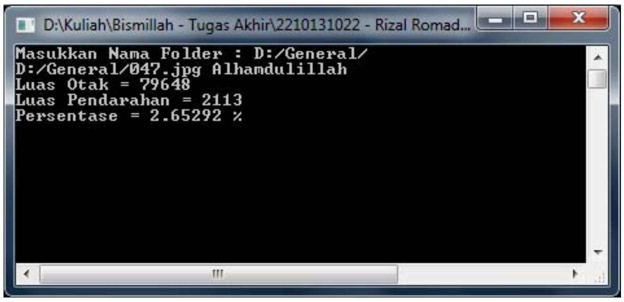


Fig. 10. Result of count pixel of brain area and brain hemorrhage area

I. Calculating Volume and Volume Percentage

At this stage the calculation of the volume of bleeding in the brain. The calculation of the volume of brain hemorrhage begins by finding the extent of bleeding on each CT-Scan layer. In this final project CT-Scan image obtained from the hospital amounted to 200 images with a thickness of 0.5 mm. The following are the steps to calculate the volume of bleeding:

1. Calculate the area of brain hemorrhage from the 1st layer to the nth layer by counting the number of pixels on each layer.
2. Perform calculations to convert pixel values into mm units.
3. Get information about the distance between layers / CT-Scan image slices. This information will be used as high (t) in volume calculation.
4. Illustrate the use of layer and slice distance on CT-Scan

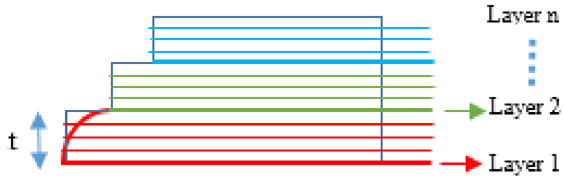


Fig. 11. Counting Bleeding Volume

5. Once we get the width of layer 1 to layer n.
6. Use the volume count formula to get the volume between layers.

$$\text{Volume} = \sum_{i=1}^{n-1} (A_i . t)$$

Information :

V = Volume (mm^3)

A_i = Wide Area (mm^2)

n = Multiple Layers

i = 1, 2, 3, ... n

t = Height (mm)

IV. EXPERIMENTAL RESULT

The proposed algorithm was tested using dataset axial head CT-Scan image from Hospital Haji Surabaya. The experimental steps consist of error value of wide brain segmentation, error value of wide brain hemorrhage segmentation, percentage area calculation. Segmentation and calculation testing were performed on 200 axial head CT-Scan images.

A. Error Value of Wide Brain Segmentation

Table 1. shows some error value calculations in the 28 layer images data. This table shows brain segmentation have average error of 1.13%

Table 1. Error value calculations of brain segmentation

No.	File Name	Wide Brain Reference (mm^2)	Wide brain Experimental (mm^2)	Error (%)
1	070.jpg	19145.76	19355.57	1.10
2	071.jpg	19279.63	19503.21	1.16
3	072.jpg	19417.75	19638.41	1.14
4	073.jpg	19562.21	19790.28	1.17
5	074.jpg	19693.18	19924.42	1.17
6	075.jpg	19826.79	20058.83	1.17
7	076.jpg	19947.44	20186.36	1.20
8	077.jpg	20082.12	20318.92	1.18
9	078.jpg	20201.97	20443.01	1.19
10	079.jpg	20323.94	20562.6	1.17
11	080.jpg	20437.45	20679.28	1.18
12	081.jpg	20549.1	20788.29	1.16
13	082.jpg	20677.16	20892.53	1.04
14	083.jpg	20757.86	20997.04	1.15
15	084.jpg	20870.04	21108.43	1.14
16	085.jpg	20965.82	21210.3	1.17
17	086.jpg	21071.39	21310.57	1.14
18	087.jpg	21163.99	21396.03	1.10
19	088.jpg	21247.07	21484.4	1.12
20	089.jpg	21321.42	21553.46	1.09
21	090.jpg	21396.3	21630.72	1.10
22	091.jpg	21464.56	21698.72	1.09
23	092.jpg	21541.55	21774.39	1.08
24	093.jpg	21593.41	21829.95	1.10
25	094.jpg	21650.83	21886.57	1.09
26	095.jpg	21689.19	21930.49	1.11
27	096.jpg	21732.05	21967.8	1.08
28	097.jpg	21762.48	22004.04	1.11
Average error				1.13

B. Error Value of Wide Brain Hemorrhage Segmentation

Table 2. shows some error value calculations in the 28 layer images data. This table shows brain hemorrhage segmentation have average error of 11.17%

Table 2. Error value calculations of brain hemorrhage segmentation

No.	File Name	Wide Bleeding Reference (mm^2)	Wide Bleeding Experimental (mm^2)	Error (%)
1	070.jpg	0	0	0.00
2	071.jpg	324.64	230.19	29.09
3	072.jpg	267.76	326.5	21.94
4	073.jpg	403.49	383.12	5.05
5	074.jpg	484.45	394.49	18.57
6	075.jpg	571.76	409.57	28.37
7	076.jpg	449	416.98	7.13
8	077.jpg	401.9	462.49	15.08
9	078.jpg	481.28	495.83	3.02
10	079.jpg	523.61	540.54	3.23
11	080.jpg	568.85	558.01	1.91
12	081.jpg	629.71	575.47	8.61
13	082.jpg	622.83	590.81	5.14
14	083.jpg	678.13	609.86	10.07
15	084.jpg	734.75	657.22	10.55
16	085.jpg	842.7	656.7	22.07
17	086.jpg	782.11	659.34	15.70
18	087.jpg	805.39	656.7	18.46
19	088.jpg	749.83	669.13	10.76
20	089.jpg	726.02	694.53	4.34
21	090.jpg	792.96	692.94	12.61
22	091.jpg	721.52	663.57	8.03
23	092.jpg	743.21	660.13	11.18
24	093.jpg	763.59	638.44	16.39
25	094.jpg	702.47	655.64	6.67
26	095.jpg	730.78	677.33	7.31
27	096.jpg	673.89	692.15	2.71
28	097.jpg	723.63	661.19	8.63
Average Error				11.17

C. Percentage Area Calculation

The volume of bleeding is obtained by calculating the area of brain hemorrhage multiplied by the thickness. The thickness of head CT Scan is 0.5 mm. Then to calculation of the percentage of brain hemorrhage volume to the brain volume as a whole. The ratio of brain hemorrhage volume is calculated using the formula:

$$Ratio = \frac{Brain\ Hemorrhage\ Volume}{Brain\ Volume} x\ 100\ \%$$

Table 3. Calculation Percentage Brain Hemorrhage Volume

No.	Id Pasien	Brain Volume (mm^3)	Brain Hemorrhage Volume (mm3)	Ratio (%)
1.	08550000	1526617.25	20737.49	1.36
2.	08590000	1419555.75	38530.26	2.71
3.	09100000	1465322.07	1884.02	1.29
4.	09220000	1477836.97	82173.63	5.56
5.	11440000	1562749.829	2382.91	0.15

V. CONCLUSIONS AND FUTURE WORK

Based on the experimental results, before segmenting the CT Scan head, The process of skull cutting with watershed method still has limitations. Cutting done is still not perfect in some parts, especially in the last slice. Disadvantages in skull bone removal affect the calculation of brain area and bleeding area, so there are still some errors. From the system test obtained the calculation of brain area has an average error of 1.13%. As for the test calculation of the area of bleeding has an average error of 11.17%.

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