Identification of Glioma using Discrete Wavelet Transform (DWT) and Artificial Neural Network (ANN)

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Abstract: Glioma is one of the deadly diseases and suffered by many people in the world. Glioma means brain tumor. In 2016, the World Health Organization (WHO) recorded as many as 6.2 million people of the world suffering gliomas. Based on this fact, it is necessary to examine glioma using a tool that is one of magnetic resonance imaging (MRI), then the results of brain MRI image be analyzed or diagnosed by an expert doctor but sometimes the results of its analysis is still subjective and takes a long time. The image used in this study are the normal brain MRI image and glioma brain MRI image. First steps are image improvement (Adaptive Histogram Equalization), the second step is image segmentation using the Otsu threshold, third step is image extraction using discrete wavelet transform (DWT) with features taken are energy, standard deviation and mean, then classification using ANN (backpropagation) which will be identified into two classes namely normal and glioma. Based on the testing result using the Matlab program, the results of image extraction using the best decomposition levels DWT Haar is 4. Then the results of the best-hidden layers backpropagation ANN classification is 25 then obtained MSE error value = 0,0000999 it indicates that the model used in this study is suitable for identifying gliomas using image data and obtained the best accuracy values of 91.67%, the sensitivity of 100%, and specificity of 85.71%.

1 INTRODUCTION

There are many kinds of brain disease, one of them is a tumor. Many people in the world suffered the disease. Uncontrolled growth of body cells that changes character, shape and kinetic is called a tumor (Lestari, et al., 2017). In this study, we identified the tumor that occurs in glia cells is called glioma (Drevelegas, 2011). Glia cells in the brain are neuron supporting cells that decisive the synaptic contact and protect the ability of neurons signals so the signal connection of neurons and brain properly worked (Purves, et al., 2001). World Health Organization (WHO) recorded that 688,000 people in the United States suffered the primary glioma in 2012 and 6.2 million of the world's population suffered the glioma in 2016 (Anitha & Raja, 2017). Glioma is the fifth disease that causes the death of women cancer patients at age 20-39 years (Sari, et al., 2013). Data cases of glioma in Indonesia haven't reported, so there are just a few data and no records of glioma data. Glioma patients in Indonesia increased in 2013, especially the Gatot Soebroto Army Hospital in Jakarta (Satyanegara, 2010). The test of brain tumors is taken by specialists using CT-Scan or MRI devices which the results will analyze by a doctor, but sometimes the results of doctor's diagnosis are subjective and require a long time. Therefore, a method is needed to help the diagnosis be more objective in a short time.

In this study used brain MRI images data because the results are a clear image and almost 90% used MRI to diagnose the head and spinal cord (Sjahriar & Iwan, 2005). Anitha and Raja obtained the features of brain tumors for identification of brain cells in normal and tumor glia cells in their paper "Segmentation of Glioma Tumors using Convolutional Neural Networks" using morphological operations, there are opening and closing to segmented the features and background in brain images (Anitha & Raja, 2017). Neural networks are used in many problems such as prediction, EEG signal classification, and image classification. Classification of EEG signal used Adaptive Neighborhood Modified Backpropagation

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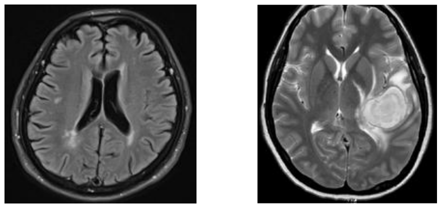
(ANMBP) with EEG signal data in normal and epilepsy patients (Novitasari, 2015). The first study referred by the author of the study is backpropagation neural network implementation for medical image compression which applies backpropagation method for processing medical images with X-ray examination of bones into four classes there are fractured, dislocated, broken and healthy with accuracy values obtained by 90% (Dimililer, 2013). The second study referred is Guijarro et all in discrete wavelet transform for improving greenness image segmentation in agricultural image by extracting the features of agricultural image using DWT texture analysis to obtained value of mean and standard deviation, so image quality is obtained with good results although the image that used is a low-quality image (Guijarro, et al., 2015).

A related study that made by the author based on the previous study is about the identification of glioma using discrete wavelet transform (DWT) and artificial neural network (ANN) to identify and classify brain MRI images into two classes, there are normal brain and glioma. In this study used segmentation process to separate objects and background from brain images. DWT is the technique of low filters and high filters as image processing used to image extraction to obtain the value of energy, mean, and standard deviations, it also to find which the DWT process that obtained the best decomposition level value of glioma texture. The three values used as input to the ANN method with a backpropagation algorithm. In this study used the backpropagation algorithm because the previous research obtained high accuracy values at the process of medical image data. Backpropagation algorithm used to find the proper classification process with the best backpropagation structure.

2 LITERATURE REVIEW

2.1 Glioma

Glioma is a type of disease that occurs in tissues that grow uncontrollably and abnormally in the brain. The brain has an important role in regulating body activity because the brain is the central neuron system. The main cause of gliomas is still unknown. There are several factors that can increase a person's risk of developing a glioma including hereditary factors and side effects of radiotherapy (radiation) procedures. Gliomas that arise from glia cells are called gliomas and this type of brain tumor is most common. This type of glioma is located supratentorially above the tentorium of the brain (Enggariani, 2012). In this study two classes were used: normal and glioma presented in Figure 1. Identification of glioma visually has a different or striking color. The image used in this study results from Magnetic Resonance Imaging (MRI) examination.



A The Brain Normal   B Glioma

Figure 1: Brain MRI image (Anitha & Raja, 2017)

2.2 Discrete Wavelet Transform (DWT)

Wavelet transformation is the transformation of discrete signals into wavelet coefficients obtained by filtering signals using two filters, namely a high pass filter and low pass filter. Mathematical operations that are the main basis of wavelets include (Sutarno, 2010):

1) Translation, example $\psi(x-1)$, $\psi(x-2)$, $\psi(x-b)$
2) Scaling, example $\psi(2x)$, $\psi(4x)$, $\psi\left(\frac{2}{x}\right)$

Based on the two mathematical operations above that combined produce a family of wavelets. Wavelets have many types depending on the functions used, such as Haar, Symlet, Daubechies, Coifflet, and so on. The most commonly used types of wavelets are Haar and Daubechies.

DWT is a transformation that is identical to the hierarchical sub-band system where the logarithmic sub-band is in the frequency domain. DWT decomposes the image of the four sub-bands of frequency, namely the low-pass through low pass filter (LL), the low pass through high filter (LH), the high pass through low pass filter (HL), and the high pass through high pass filter (HH) such as in Figure 2 (Nayak, et al., 2015). The filter on the image is called decomposition.

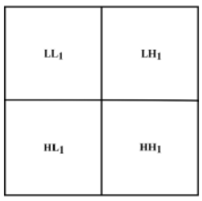


Figure 2: The level 1 wavelet decomposition (Guijarro, et al., 2015)

DWT Haar is used in this study because it is better to represent the characteristics of texture and shape and the computation time needed is less compared to other wavelet methods (Novamizanti & Kurnia, 2015). The analysis of the texture that is used such as energy, average, and standard deviation (Singh, et al., 2015). Energy is used to calculate Euclidean distance which is then used to determine similarity and the inequality of two feature vectors, mean and standard deviation are statistical groups whose purpose is to find out the uniformity and concentration of a data in an image, then the feature vector is used for input artificial neural networks.

2.3 Artificial Neural Network (ANN)

The artificial neural network is one information processing system that is designed by imitating the work of the neuron system in the human brain. ANN consists of two layers, namely the input layer and the output layer which has a different number of networks (neurons), but there are have layers located between the input and output layers called hidden layers (Novitasari, et al., 2016). In this study, the algorithm used is the backpropagation algorithm because based on the previous study obtained high accuracy values and good for classification of image data (Dimililer, 2013). Backpropagation algorithm is a supervised algorithm that trains the network by spreading the output error backward from the output layer to the input layer. The backpropagation training algorithm using the sigmoid activation function is as follows (Siang, 2005):

a. Initialize all weights with small random numbers.
b. If the termination condition has not been met, do step c-j.
c. Each input unit receives a signal and passes it to a hidden unit above it.
d. Calculates all outputs in hidden units which is the sum of input signals that have been given weight and bias.
e. Calculates all network outputs in the output unit.
f. Calculate the error factor of the output unit based on errors in each output unit that serves to correct errors and determine changes in weight to be used.
g. Calculate the error factor of the output unit based on errors in each network unit (node) output, then calculate the change in weight. Next, calculates all changes in weight from the output unit to the hidden unit.

2.4 Measurement of Classification Accuracy

In the classification results using backpropagation algorithm, it is necessary to have a system validation to ensure its accuracy, so that the confusion matrix is used by analyzing the value of sensitivity, specificity, and accuracy (Akobeng, 2006). The confusion matrix structure is presented in Figure 3.

Prediction Value / Actual Value	Negative	Positive
Negative	TN (True Negative)	FP (False Positive)
Positive	FN (False Negative)	TP (True Positive)

Figure 3: Structure Confusion Matrix

Sensitivity is a test to detect the right ill patient is diagnosed with the illness. The method is the TP value divided by the TP value plus the FN value multiplied by 100%. Specificity is a test to detect that a normal patient is diagnosed as normal. The method is the TN value divided by the TN value plus the FP value multiplied by 100%. Accuracy is a test to correctly identify the actual condition of the patient (positive or negative results that are right). The method is to divide the exact number of classification with the total data multiplied bay 100%.

3 RESEARCH METHODS

3.1 Data

In this study, the data used was obtained from the Atlas web. Atlas web is a website that provides information and data in the form of images that are specifically the brain, such as normal brain image data, glioma image data, brain cancer images, etc. (Johnson & Becker, 1995). This study uses data as many as 60 images consisting of the normal brain and tumor images with a comparison of training and testing data that is equal to 80% and 20% and 75% and 25% (Hota, et al., 2013).

3.2 Preprocessing

The first step is the brain image data is converted to grayscale image (gray), then cropping is done, then gray intensity is improved by the adaptive histogram equalization process, then the image is refined using the median filter. This study will be carried out in several main processes is preprocessing, segmentation, extraction, and classification with brain MRI image data. The process is shown in Figure 4.

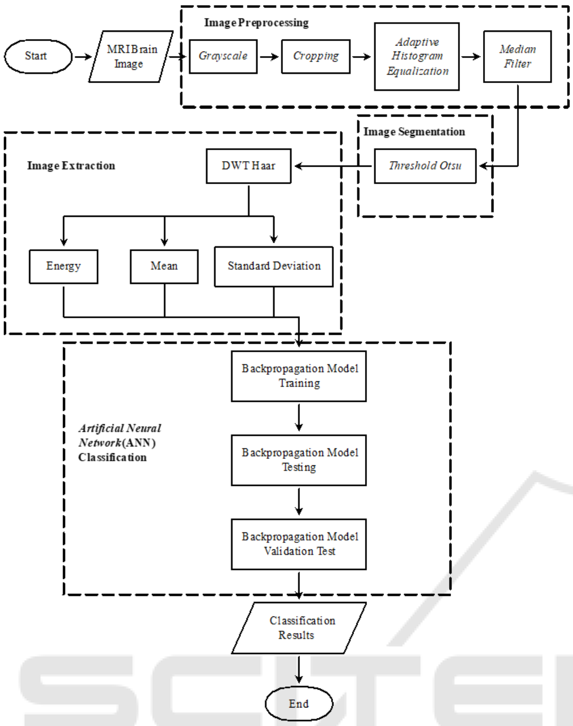


Figure 4: The classification system of glioma image

3.3 Segmentation

Next step, after preprocessing finish is the segmentation process, which is the separation of objects with the background using the Otsu threshold method.

3.4 Extraction

In this process, it functions to take the pattern of normal brain image and glioma pattern using the Discrete Wavelet Transform Haar method then analyzed the pattern texture in the image by calculating the energy, average, and standard deviation values which are then used as input for the classification process ANN backpropagation.

3.5 Classifications

The fourth step is the image classification process. This process uses backpropagation method for data training/testing. The image data used is 60 images consisting of normal brain and glioma. Comparison of training and testing data used is 75%, 25% and 80%, 20%. After classification, the results were tested using a confusion matrix by analyzing the value of sensitivity, specificity, and accuracy. Furthermore, it classified into 2 classes, namely normal or tumor. The structure of the backpropagation model used in this study is in Figure 5.

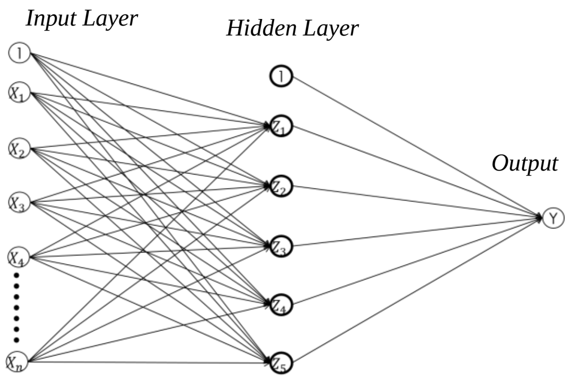


Figure 5: The structure backpropagation of study data (Prasetyo, 2014)

4 RESULTS AND ANALYSIS

The results of the trial of brain image processing and classification using the MatLab program.

4.1 Preprocessing

The results all processing steps use the MatLab presented in Figure 6. Based on the preprocessing results that have been done provide a level of clarity of the glioma object, so the preprocessing results can be applied at the segmentation step.

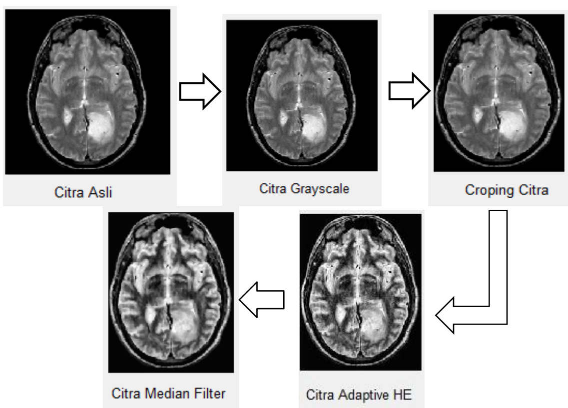


Figure 6: The results of preprocessing brain image

4.2 Segmentation

At this steps, the function in MatLab is used, such as level = graythres (I) so the results are presented in Figure 7. Based on the results of the segmentation obtained the color difference between the object and the background image that the object is at the level of intensity of 0 and 1 pixels, where 0 is the pixel intensity in black and 1 is the color of white pixels.

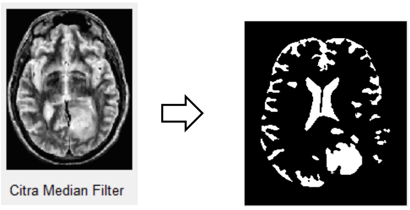


Figure 7: The results of the segmentation otsu threshold brain image

4.3 Extraction

In this study used the image extraction process using Discrete Wavelet Transform Haar method with the decomposition level used is 4 and 5. The results of image extraction are presented in Figures 8 and 9.

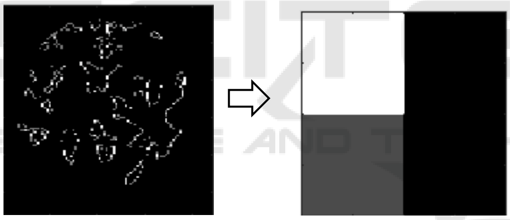


Figure 8: The results of level 4 DWT Haar brain image

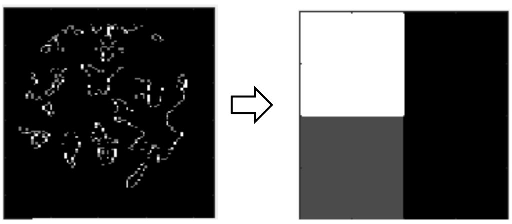


Figure 9: The results of level 5 DWT Haar brain image

At level 4 there are 13 low and high filters and the trial process needs a bit of time to reach the error target. At level 5 there are 16 low and high filters and the trial process takes quite a bit of time to reach the error target. In this feature extraction process obtained vector DWT Haar feature with different decomposition levels, namely level 1-5 which is sized according to the level used. Suppose that the decomposition level used is 3 then got the result of feature vector DWT with size 1 × 30 pixels which will be used as input to the Artificial Neural Network (ANN) Backpropagation.

4.4 Classifications

Backpropagation classification in this study was carried out computationally using Matlab software. Then the training and testing processes are shown in Figure 10.

Backpropagation Parameters						Results of Prediction				
Training Data (%)	Testing Data (%)	Level	Hidden Layer	Epoch	LR	MSE	Accuracy (%)	Sensitivity (%)	Specifity (%)	Correct Prediction
75	25	4	40	485974	0,00088	0,0000999	73,33	100	50	11
		5	70	118951	0,00192	0,0000999	73,33	100	50	11
		4	90	485265	0,00082	0,0000999	80	100	62,5	12
		4	30	574816	0,00082	0,0000999	86,67	100	75	13
		4	20	662616	0,00101	0,0000999	86,67	100	75	13
80	20	5	30	124107	0,00199	0,0000999	66.67	80	57,14	8
		5	35	179364	0,00163	0,0000996	75	100	57,14	9
		5	45	100679	0,00221	0,0000995	75	100	62,5	9
		4	12	307863	0,00299	0,0000999	75	80	71,43	9
		4	25	816877	0,00070	0,0000999	91,67	100	85,71	11

Figure 10: The Results of the Training and Testing Backpropagation

Based on Figure 10 the best results of backpropagation process for glioma identification are 80% training data and 20% testing data using 4 decomposition levels whose results are vectors values of energy, mean, and standard deviations of 1 × 39 lengths for each image, then the best backpropagation structure is 25 nodes of the hidden layer, learning rate equal to 0,00070, and MSE error value is 0.0000999.

Then a comparison is made to check the classification results in the backpropagation model with the results of the actual classification. The result is that there is a normal brain image classified as glioma so the specificity value is 85.71%, the sensitivity value is 100%, and the accuracy value is 91.67%.

5 CONCLUSIONS

Based on the testing result using the Matlab program, the results of image extraction using the best decomposition levels DWT Haar is 4. Then the results of the best-hidden layers backpropagation ANN classification is 25 then obtained MSE error value = 0,0000999 it indicates that the model used in this study is suitable for identifying gliomas using image data and obtained the best accuracy values of 91.67%, the sensitivity of 100%, and specificity of 85.71%.

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