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Effectiveness of VGG19 in deep learning for brain tumor detection

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ABSTRACT

Image processing in the diagnosis of disease is one of the jobs that is currently developing in the world of health. Diagnosis is carried out by utilizing the role of image processing to provide a level of accuracy in diagnosis results and provide efficiency to medical personnel. This research aims to develop a brain tumor object detection process using a deep learning (DL) approach to magnetic resonance images (MRI) images. This development was carried out to optimize the brain tumor diagnosis process by playing the role of the image extraction process. This research dataset was sourced from the M. Djamil Padang Provincial General Hospital with a total of 3370 MRI images. The results of this work report show that DL performance is capable of carrying out the detection process automatically with an accuracy level of 97,83%. The results of the development of the extraction process can work effectively in ensuring brain tumor objects are precise and accurate. Overall, this research can make a major contribution to maximizing the diagnosis process and assisting medical personnel in the early treatment of brain tumor patients.

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1. INTRODUCTION

The diagnosis process using medical images is a job that is currently developing, especially for medical personnel and researchers [1]. Medical images are a form of technological development in the world of health which plays an important role in the diagnosis process [2]. The role of medical images has also been able to provide improvements and efficiency for medical personnel in carrying out the diagnosis process [3]. As a form of the role of medical images used in the diagnosis process, it can be seen based on magnetic resonance images (MRI) images. MRI images can depict organ objects such as bones and tissue cells in the human body [4].

MRI images can also be used to diagnose tumors that occur in the brain [5]. However, quite a few of these works provide optimal results [6]. This is caused by the tumor object having a shape and texture that resembles cells in the brain [7]. Brain tumors are diseases that are difficult to detect [8]. This disease can occur in brain cells so it is the main cause of increasing death rates throughout the world [9]. With this, MRI images are a hope for increasing the life expectancy of brain tumor patients [10].

Improving MIRI images in the process of diagnosing brain tumors can be done by adopting the performance of digital image processing (DIP). DIP is a scientific concept that is capable of manipulating a digital image [11]. DIP plays an important role in assisting medical performance in the disease diagnosis process [12]. The results of DIP performance can improve the quality of MRI image results, making the identification process easier [13]. This performance results from several developments that have been made, such as the automatic detection of MRI images in the detection of brain tumors [14]. Furthermore, previous research has reported that the brain tumor classification process using an artificial neural network (ANN) can be adopted based on the results of MRI images [15]. Previous research also explained that the development of DIP in the process of detecting and classifying brain tumor types was able to provide maximum results [16]. Other research has also contributed to the brain tumor classification process using an Artificial Neural Network based on the development of an MRI image segmentation process using Fuzzy C-Means and the Bounding Box method [17]. Similar research also reports the performance results of DIP which can utilize the deep learning (DL) learning process in the process of diagnosing brain tumors [18].

DL is a learning concept by adopts human thinking [19]. DL is also known as a technique in machine learning (ML) that can complete work like humans [20]. The implementation of DL in the brain tumor diagnosis process has also provided measurement results of 96% precision, 91.78% F1-score, and 96% accuracy. The application of DL is also capable of carrying out a classification process in determining the type of brain tumor with a valid accuracy value of 98.90% [21]. Other research also explains that DL in the process of diagnosing brain tumors can provide maximum performance results [22].

Based on reports from previous research, DL development can still be carried out to provide better diagnostic results [23]. DL development in this research will focus on the performance of segmentation techniques in automatic detection systems to increase learning accuracy [24]. The development of DL can be seen in the performance of gallstone image object segmentation presenting an accuracy rate of 91% [25]. The same study has also reported that gallstone objects can be detected well based on the average precision, recall, and deviation ratio values of 94.56%, 96.56%, and 98.92% respectively [26]. The segmentation process has also been combined with several other methods as a form of development for needs in identification problems [27]–[29].

Based on this, the development of DL will be the aim of this research to provide innovation in the brain tumor detection process. This novelty is presented in the development of DL in the segmentation process adopted in a detection model. The development of DL will also be expected to provide maximum results based on the learning process carried out to diagnose brain tumors. The importance of developing DL in this study is updating DL performance in the detection process. This research will also provide considerable potential for the development of medical images which play an important role in decision making. Overall, this research contributes to the development of DIP in the detection process and has a positive impact on medical personnel in early treatment of brain tumors.

2. METHOD

The process of detecting brain tumors in MRI images is carried out by developing DL in image extraction. DL development is carried out in several stages, namely preprocessing, classification process, and image extraction. All these stages will present output results that will be tested to measure the level of detection accuracy. The stages of DL development can be described in the research framework for detecting brain tumors which is presented in Figure 1.

Figure 1 is a research framework for the development of DL in the brain tumor detection process. The detection process presents systematic stages to produce optimal output. The output results presented will be able to be measured to test the performance of DL in the brain tumor detection system. The results of measurements and testing as well as the resulting detection model will be a form of novelty in the process of identifying brain tumors.

2.1. Convolutional neural network (CNN)

CNN or ConvNet is a layer, or layers consisting of many neurons and is optimized by carrying out a learning process [27]. CNN works by extracting low-level features [28]. The deeper the raw input is in the CNN layer, the higher the level of features that will be extracted [29]. Basically, CNN has three types of layers, namely convolutional layers, pooling layers, and full connection layers [30]. This layer will be able to work systematically in carrying out the learning process in the network [31].

2.2. Visual geometry group network (VGG19)

VGG19 is a CNN architectural model used to carry out image processing [32]. VGG19 is an architectural model that has the most layers with 19 main layers [33]. The VGG19 layer has the shape of a filter or kernel whose size is like 3x3 [34]. Apart from that, VGG19 also has other layers such as 5 MaxPool layers and 1 SoftMax layer [35]. An overview of the VGG19 model can be seen in Figure 2 [36].

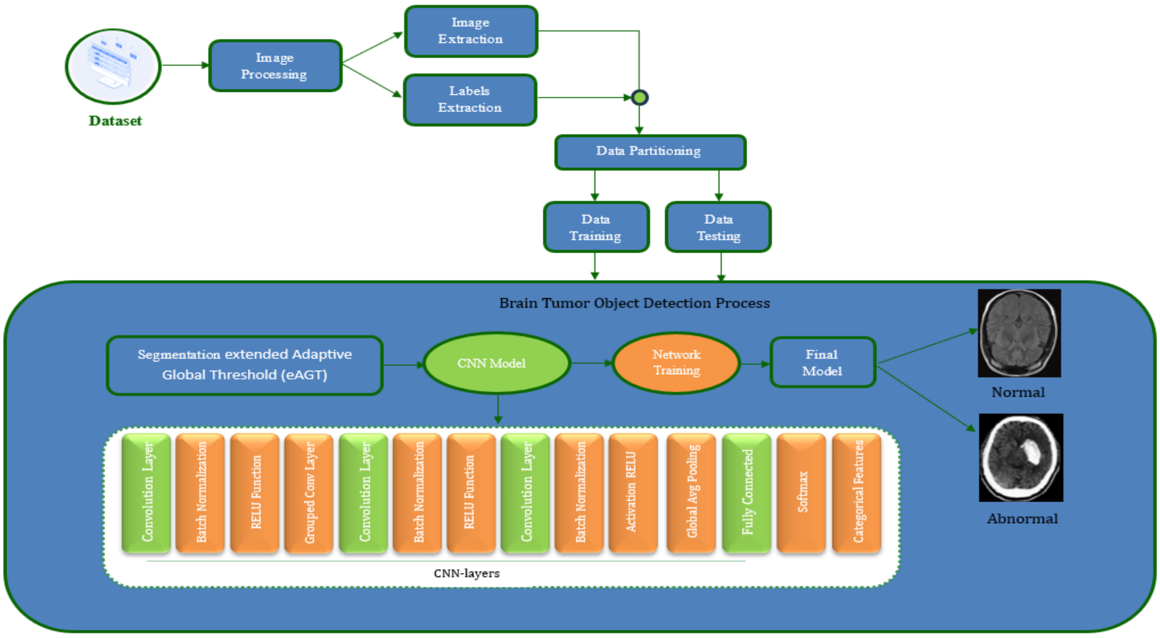


Figure 1. Research framework

Figure 2. VGG19 model overview

Figure 2 is a representation of the VGG19 model in the DL learning process. The DL learning algorithm with VGG19 consists of a convolution layer and three fully connected layers. There are 41 layers including the Max pool, fully connected layer, Relu layer, Dropout layer, and Softmax layer. Similar to Vgg16, the input layer has a size of 224×224×3. Meanwhile, the last layer contains the classification layer.

2.3. Neural style transfer

The deep learning style transfer method is neural style transfer (NST). NST was first introduced in 2017 playing a CNN show [37]. The performance of the NST algorithm can be adopted in the CNN method to extract features from images [38].

3. RESULTS AND DISCUSSION

Brain tumor detection using a deep learning approach begins by carrying out a segmentation process on the MRI image. The research dataset comes from the results of examinations of patients at the M. Djamil Padang Provincial general hospital. The research dataset is 3,370 divided into 1,650 normal, 1,650 abnormal, and 70 testing data. The dataset can be presented in Figure 3.

Figure 3 is a MRI image from an examination of a patient with a brain tumor. The detection process begins with preprocessing which aims to make improvements to the input image. The detection process continues by adopting a segmentation process which plays a role in separating tumor objects. The segmentation results will be the start of the extraction process to identify the characteristics of the tumor object through the performance of VGG19 in modeling the CNN architecture. Based on this, this research presents a new detection and identification model for DL performance.

3.1. Preprocessing

The process of detecting brain tumor objects in MRI images begins with image preprocessing. This preprocessing involves several techniques such as croping and improving image quality with enhancement techniques. The following preprocessing image results are presented in Figure 4.

The preprocessing results presented in Figure 4 are part of the process of detecting brain tumor objects in MRI images. Sub-Figure 4(a) is the image form used in the input process. Sub-Figure 4(b) depicts the cropping results in the preprocessing process. Sub-Figure 4(c) is the result of the image enhancement process using enhancement techniques. Overall, the image preprocessing results provide quite good image improvements in overcoming the noise problem in the previous input image. The preprocessing image output will also continue with the tumor object detection process.

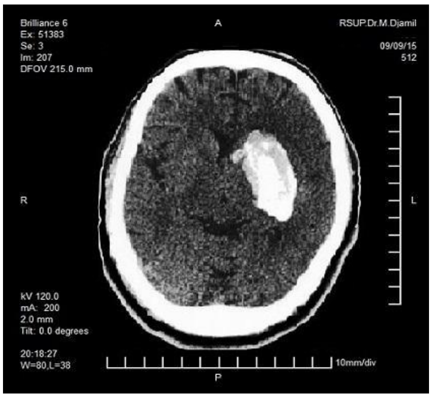
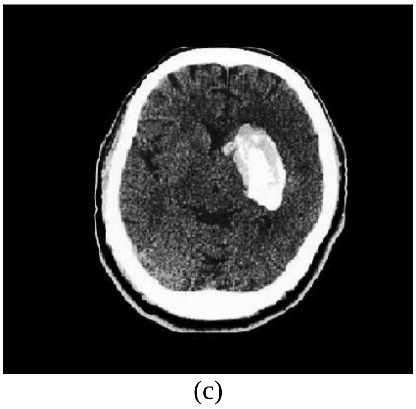


Figure 3. MRI image dataset

(a)

(b)



(c)

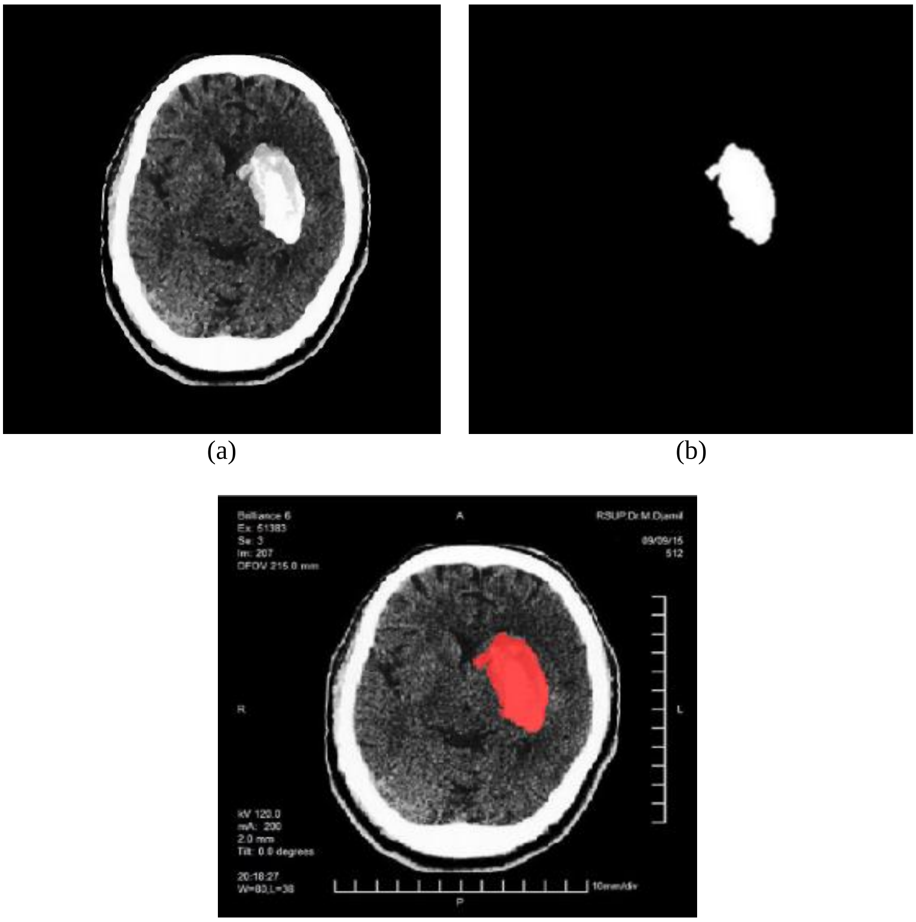
Figure 4. Image preprocessing results in the process of detecting brain tumor objects; (a) input image results, (b) image cropping results, and (c) image enhancement results

3.2. Brain tumor object detection process

The process of detecting brain tumor objects using segmentation techniques involves the extended adaptive global threshold (eAGT) function and morphological operations. The eAGT function can be used to approach threshold values to provide appropriate threshold values for segmenting brain tumor image objects. The output results of the segmentation image can be presented in Figure 5.

Figure 5 is the output segmentation image with the performance of the eAGT function in determining the optimal threshold value. This function also has a significant influence on the performance of morphological operations in separating image objects. Based on the image output, the tumor object looks quite clear. This is based on Sub-Figure 5(a) which is the result of image processing in the object detection process. Sub-Figure 5(b) also illustrates the results of the tumor object segmentation process. Sub-Figure 5(c) is a final depiction of the segmentation process used in the detection process. The results of the segmentation process will be continued in the learning process using the DL approach. The DL model is designed by adopting the performance of the CNN method. The model undergoes a training and testing process to measure the performance of the detection process. The CNN learning output results can be presented in Figure 6.

The graph of CNN learning results presented in Figure 6 is a testing process for detecting tumor objects in MRI images. Based on test results, the CNN learning accuracy level is 97,83%. These results can be explained again as presented in Table 1. Table 1 shows the results of CNN learning. Based on this table, it can be seen that the best level of accuracy is found in Epoch-15. These results can also prove that the proposed detection model using the CNN method which acts as a testing process provides quite optimal detection results. The detection results will be able to provide accuracy of the detection object.



(a) (b)

(c)

Figure 5. Brain tumor object detection results (a) image preprocessing results, (b) segmented tumor object, and (c) segmentation process results

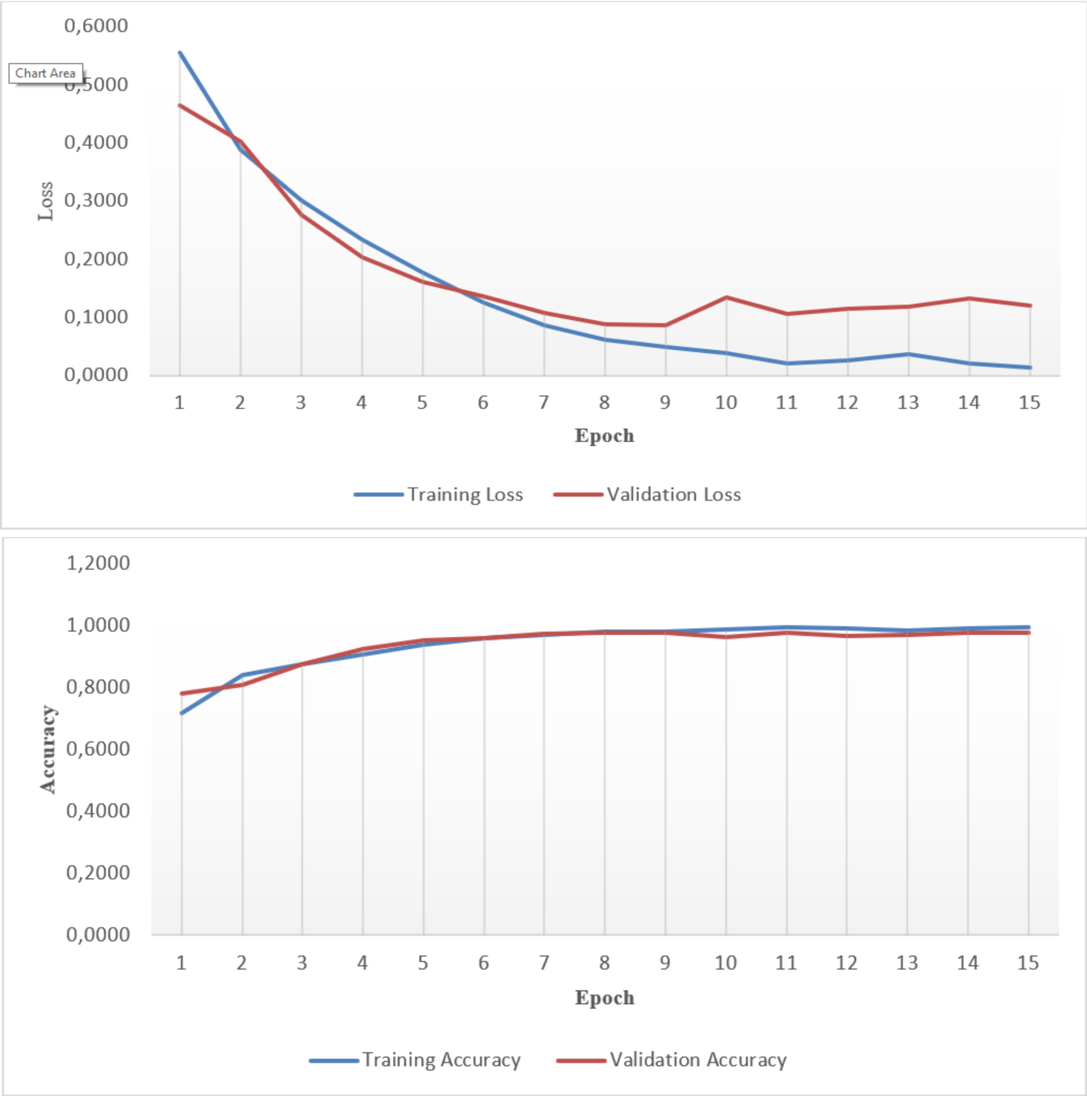


Figure 6. Graph of CNN learning results in tumor object detection

Table 1. CNN learning results

Epoch	Training loss	Validation loss	Training accuracy	Validation accuracy
1	0,5549	0,4644	0,7188	0,7800
2	0,3888	0,4020	0,8400	0,8100
3	0,3011	0,2769	0,8779	0,8750
4	0,2345	0,2037	0,9071	0,9267
5	0,1782	0,1616	0,9388	0,9533
6	0,1266	0,1359	0,9592	0,9600
7	0,0862	0,1086	0,9721	0,9733
8	0,0618	0,0879	0,9829	0,9767
9	0,0498	0,0866	0,9812	0,9800
10	0,0381	0,1348	0,9904	0,9633
11	0,0214	0,1072	0,9958	0,9767
12	0,0261	0,1153	0,9921	0,9683
13	0,0380	0,1186	0,9854	0,9717
14	0,0204	0,1327	0,9933	0,9783
15	0,0144	0,1214	0,9954	0,9783

Based on the tests that have been carried out, it can be seen that the development of DL in the brain tumor detection process provides quite maximum results. The development of DL has provided a novel detection process presented in a detection model. The development of DL presented in the detection model also plays an important role in this study to provide considerable potential for the development of DL in carrying out detection. Overall, it can be said that the development of DL in the detection process has had a significant impact on the medical side in the early treatment of tumor diseases.

4. CONCLUSION

The development of DL in the brain tumor detection process is quite promising work in image processing. Based on the tests carried out, it can be concluded that the detection model developed for DL performance has been proven to be successful in detecting objects quite well with an accuracy of 97,83%. These results were obtained regarding the effectiveness of the segmentation process combined with eAGT and morphological operations. Not only that, DL performance has also been quite effective in carrying out learning in the detection process. Overall, this research can provide efficiency in detecting tumor objects by presenting a precise and accurate detection model and can also be used as an alternative in dealing with several other problems in the detection process.

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