Application of the Support Vector Machine (SVM) Algorithm for the Diagnosis of Diabetic Retinopathy

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ABSTRACT

Diabetic Retinopathy (DR) is a disease that occurs as a result of complications of diabetes mellitus. The earliest sign of Diabetic Retinopathy is the appearance of microaneurysms, which are classified as mild non-proliferative diabetic retinopathy. DR is caused by high levels of sugar in the blood (glucose) resulting from the pancreas' inability to produce insulin. Early and regular examinations can prevent DR. Currently, doctors still use non-mydriatic fundus cameras to take retinal images and manually examine them to diagnose diabetic retinopathy. This process is time-consuming and error-prone. To simplify the process and reduce the workload of medical personnel, a computer system can be used to detect signs of diabetic retinopathy. An application using the SVM algorithm has emerged as a new screening tool for detecting diabetic retinopathy. It helps medical teams and specialist doctors to carry out examinations quickly and automatically, minimizing time and costs and preventing errors in diagnosis results. In this research, MATLAB is used for the application creation process, while GLCM is used for feature extraction and SVM for classification. The benefit of this research is that it helps doctors and medical teams to carry out manual patient diagnoses more accurately and reduces the occurrence of human error.

INTRODUCTION

Sumbawa Regency is one of the regencies in the West Nusa Tenggara Province. In 2019, according to records and reports from community health centers, it was shown that health services for Diabetes Mellitus (DM) sufferers reached 100% of the treatment of 9,459 DM sufferers. And vision loss due to not being detected early and various types of lesions on the retina will appear. The International Diabetes Federation (2020) reveals that 463 million people are diagnosed with diabetes worldwide. It is also estimated that by 2045, the number of people with diabetes will increase to 700 million (Rhys Williams (Chair) et Al., 2019). Diabetic Retinopathy (DR) is a disease caused by complications from diabetes mellitus. High levels of sugar in the blood (glucose) are caused by the pancreas's inability to produce insulin, which can cause retinopathy and blindness (Fitriani et al., 2017). The earliest sign of diabetic retinopathy is microaneurysm, which is categorized as a mild non-proliferative diabetic retinopathy. The cause of microaneurysm (MA) is an abnormal condition of sugar levels in the blood (Mateen et al., 2020).

The damage caused by diabetic retinopathy can be prevented if regular diagnosis is carried out early. Based on the fundus images captured, ophthalmologists will diagnose all patients manually, which is time-consuming and error-prone. Claims that systematic screening for diabetic retinopathy has been identified as a way to save costs as a source of Health care (Valverde et al., 2016). At this time, doctors still use non-mydriatic fundus cameras to capture retinal images. The screening team will diagnose whether the patient has diabetic retinopathy, based on the images obtained from the fundus camera. This process is very tiring and prone to errors in patient examination. Therefore, the presence of a computer system is needed to detect signs of diabetic retinopathy effectively and also help reduce the workload of health workers in the diabetic retinopathy examination process and the Support Vector Machine (SVM) algorithm is a classification model that is widely used today. Supervised learning algorithms that can be used to make regression and classification predictions. The optimal separator to obtain a function (hyperplane) from separate observations has different target variable values (Wang, M. and Chen, 2020).

The application for diagnosing Diabetic Retinopathy using retinal images has emerged as a screening tool to detect diabetic retinopathy. With this application, medical teams and specialist doctors can be helped because examinations are no longer carried out manually. In this way, patients can save time and money and prevent errors in diagnosis results. Based on the problems above, the researchers proposed the research title, namely "Application of the Support Vector Machine (SVM) Algorithm for Diabetic Retinopathy Diagnosis" to facilitate and reduce the workload of...
the medical team and doctors at the eye clinic.

**LITERATURE REVIEW**

The author of this research paper discusses various studies that relate to their own research on identifying diabetic retinopathy through retinal images via deep belief networks. The image processing involves five stages. First, the image is resized to 350x302 by reducing its size in the horizontal and/or vertical direction. Then, grayscale is applied to obtain an image with a gray level. The next stage involves applying a median filter to remove salt and pepper noise commonly found in retinal images. Afterward, contrast stretching is used to enhance image contrast so that the features in the retinal image can be seen clearly. Thresholding is then applied to obtain a binary image with values 0 and 1 (black and white). Lastly, morphological close operations are used to extract the background and optical disk by using morphological close because the object does not include the features to be extracted. After these stages, the deep belief network is used for the classification algorithm, which yields DR, Normal, and Failed results (Rahmah, 2018).

This research focuses on the early detection of Diabetic Retinopathy using Image Processing based on Mathematical Morphology. In the image processing stage, the researcher resizes the image and extracts the green and red channels. The next step involves identifying microaneurysm candidates and determining the presence of disease, using Mathematical Morphology. The results are automatically generated after thresholding, distinguishing between diabetic and normal retinopathy (Heryawan, L., 2017). This research is focused on using image processing techniques to detect Diabetic Retinopathy in the retina of the eye. The process involves multiple steps. Firstly, an image of the retina is captured and then pre-processed. Pre-processing includes grayscale and resize sub-processes. The output of pre-processing is then converted into a binary image using a 3x3 neighborhood calculation and saved in a database. To detect Diabetic Retinopathy, the image of the retina is captured and pre-processed, including grayscale and resize sub-processes. The output of pre-processing is then converted into a binary image using a 3x3 neighborhood calculation. This binary image is classified and its suitability is tested. The results are presented as a percentage of accuracy. Learning Vector Quantization (LVQ) is used for the classification process. For example, the results may show whether patients with Diabetic Retinopathy have been detected with 95% accuracy or whether patients without Diabetic Retinopathy have been detected with 95% accuracy. (Putra et al., 2017).

Diabetic Retinopathy (DR) is an eye disease caused by diabetes that affects the layer of nerves located at the back of the eye. These nerves capture the images that the eye sees and send the information to the brain for translation. DR initially causes blurred vision and can progress to blindness if left untreated. This disease can also lead to swelling of the macula, which is located in the middle part of the retina and is responsible for processing more detailed vision. When this happens, it is known as macular edema, which further worsens the vision of diabetes sufferers (Rahmah, 2018).

Medical images play a crucial role in diagnosing diseases in patients. One of the applications of image processing science is pattern recognition, which involves classifying images into certain categories. Medical image classification is a type of pattern recognition that has been used for over two decades. Medical images like X-rays, mammography photos, and tomography photos are commonly used to determine the health of the lungs, screen for breast cancer, and identify tissue damage or damage to specific organs. This study focuses on medical images of the fundus, which are retinal photographs used to diagnose diabetic retinopathy (Setiawan & Damayanti, 2016).

Image processing refers to the process of enhancing the quality of an image so that it can be easily understood by both humans and computers. This is the primary function of computers. The outcome of this process can be either an image or characteristics that represent the image. The primary objective of image processing is to obtain a high-quality or descriptive image from the original image, thus increasing the amount of information about the image. In this study, grayscale was used as a digital processing technique (Susetyoanigta, 2017) (Saito, 2018).

Support Vector Machine (SVM) is a classification model that is used for both regression and classification prediction. It finds the optimal separator for creating a function (hyperplane) from distinct observations that possess various target variable values. Several studies (Yang & Shami, 2020) (Wang & Chen, 2020). Have proved the effectiveness of SVM in classification. For instance, in the Pima Indian Diabetic Dataset (PiDD), SVM has shown an accuracy of 90.23% which is superior to other classification methods (Hassan et al., 2020) (Prasetyiyan et al., 2019). Mixed Methods involve a combination of quantitative and qualitative approaches. It aims to complement each other, as both approaches have their advantages and disadvantages. By combining the two, researchers can fill the gaps and achieve more accurate results. This method is widely used across various disciplines (Mustaqim, 2016).

**METHOD**

The research conducted in this study employed the Mixed Methods approach, which combines qualitative and quantitative research. Qualitative data collection techniques included direct observation at the Sumbawa Regional Hospital, interviews with doctors and medical teams at the hospital’s eye clinic, as well as a thorough literature review of relevant books, journals, and research conducted by other scholars. The evaluation process involved quantitative methods, specifically the calculation of Accuracy, Sensitivity, and Specificity. The research was carried out in several
stages following:

**Figure 1. Research Flow**

**RESULT**

**System Requirements**

To carry out a research, the researcher requires several types of support. These needs can be divided into three categories: system needs analysis, user needs analysis, and device needs analysis. The following is the order of system requirements that will be developed:

![Diagram](image_url)

**Figure 2. Flow of System Requirements**

The system depicted in the image above starts by taking an input of a fundus image of the eye. The image undergoes preprocessing using a grayscale method. This method involves converting the previously RGB image to gray, which enables it to be extracted or processed further. The next step involves extracting features from the input image using the Gray Level Co-occurrence Matrix (GLCM) with correlation and energy features. The feature extraction results in data classification. The data is compared with the trained data to classify it using the Support Vector Machine algorithm (SVM). After the classification, the final result is determined between DR and No DR.

**Use Case Diagram**

Use cases illustrate the interaction between a system and an actor to determine who has access to specific functions. The following is the use case diagram utilized in this study design:
According to the image provided, it seems that the user can input data or images into the application using a browser. The first step after input is to convert the RGB image into grayscale form. The next step is feature extraction, which utilizes GLCM features to extract the images. The fourth step is classification, which displays the results of classification indicating whether it is DR or No DR. Finally, there is a reset button that lets the user delete the selected image results, grayscale images, feature extraction results, and classification results.

**User Interface**

The researchers utilized the GUI features of the MATLAB application to produce the User Interface results. The application's main display is shown below:

![Main Display](image)

This is the initial display when the application is opened. If it looks like the image above, the application is ready to be used. The following shows the applications that are already in use:

![Display When Used](image)
When the user clicks on the classification button, the application displays the diagnosis results for the image that was input. These results appear in the diagnosis section below the RGB and grayscale images. To reset the application to its original state, the user can simply press the reset button.

**DISCUSSION**

Before moving on to the classification stage with algorithms, we will first explain the methods used in the image processing process. The process involves two steps: converting the original image into a grayscale image and then extracting image features using GLCM features (Tjolleng, 2017):

1. **Grayscale:** In this process, the original image, namely the RGB image, will be converted into a grayscale image.

   ![RGB Image](image1.jpg)

   ![Grayscale Image](image2.jpg)

   It is evident from the image that the retinal image's color change has been converted from an RGB image to a grayscale image.

2. **Feature Extraction:** In this stage, we will describe how the images that will be used for training or testing will be processed. This process involves the extraction of two features from GLCM, which are correlation and energy. The following code represents the feature extraction process that will be applied to the training data.

   ```matlab
   pixel_dist = 1;
   GLCM = graycomatrix(Img_gray, 'Offset', [0 pixel_dist; ...
   -pixel_dist pixel_dist; -pixel_dist 0; -pixel_dist -pixel_dist]);
   stats = graycoprops(GLCM, 'correlation', 'energy');
   Correlation = mean(stats.Correlation);
   Energy = mean(stats.Energy);

   data_latih(k,1) = Correlation;
   data_latih(k,2) = Energy;
   ```

   For the data classification process in this research, the algorithm used is Support Vector Machine (SVM). Once the data is extracted, SVM compares the training values with the extraction values to be tested. Before this, a training target is determined and divided into two classes, namely DR and No DR classes. The coding for this process is as follows:

   ```matlab
   Mdl = fitcsvm(data_latih,target_latih);
   kelas_keluaran = predict(Mdl,data_latih);
   ```

   The image displayed above is the outcome when the application is activated and all of the tools are used, except for the reset tool. At this point, the researcher will test the system by inputting eight images that are classified into two groups: DR and No DR. The SVM algorithm will be used to classify the image by comparing the data that has been trained with the data that will be tested. During this testing stage, it will be determined whether the system created is functioning properly or not. A test evaluation will be conducted by calculating the Accuracy, Sensitivity, and Specificity of the results of the training and testing that have been carried out.
The text above describes the test target and the test results obtained from the system that uses the SVM classification algorithm. After this, the system evaluates the training and test results. If the evaluation results are not satisfactory, you can go back to the previous stage to improve the system's functionality.

3. Evaluation of Training Results

The research results in the table below indicate several classification errors due to poor image quality and similarities in retinal images present in the training data.

Table 3. Training Evaluation Results

<table>
<thead>
<tr>
<th>No.</th>
<th>Index</th>
<th>Values %</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Sensitivity</td>
<td>$\frac{TP}{TP+FN} = \frac{7}{7+2} = 0.78 \times 100 = 78%$</td>
</tr>
<tr>
<td>2</td>
<td>Specificity</td>
<td>$\frac{TN}{TN+FP} = \frac{9}{9+0} = 1 \times 100 = 100%$</td>
</tr>
<tr>
<td>3</td>
<td>Accuracy</td>
<td>$\frac{TP+TN}{TP+FP+FN+TN} = \frac{7+9}{7+2+9+16} = 0.89 \times 100 = 89%$</td>
</tr>
</tbody>
</table>

4. Evaluation of Test Results

Table 4. Training Results

<table>
<thead>
<tr>
<th>No.</th>
<th>Index</th>
<th>Value %</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Sensitivity</td>
<td>$\frac{TP}{TP+FN} = \frac{4}{4+0} = 1 \times 100 = 100%$</td>
</tr>
<tr>
<td>2</td>
<td>Specificity</td>
<td>$\frac{TN}{TN+FP} = \frac{4}{4+0} = 1 \times 100 = 100%$</td>
</tr>
<tr>
<td>3</td>
<td>Accuracy</td>
<td>$\frac{TP+TN}{TP+FP+FN+TN} = \frac{4+4}{4+0+4+8} = 1 \times 100 = 100%$</td>
</tr>
</tbody>
</table>
CONCLUSION

The MATLAB working system creates two folders, namely training data and test data folders. The first step is to perform training by reading all the images with the extension .jpg. These images are then converted from RGB images to grayscale images and are extracted using two features from GLCM: correlation and energy. The images are then divided into two classes, namely the DR class and No DR. The training is performed using the SVM algorithm. After the training, testing is carried out, which is divided into two steps. Firstly, by inputting the entire contents of the test data folder, and secondly, by selecting the images to be tested one by one. The process carried out in testing is almost the same as the process in training; however, one key difference is that an algorithm is used in training, whereas in testing, the training results, which are classified with SVM, are called to match them with the test data. The SVM algorithm can classify diabetic retinopathy using retinal images with a training accuracy of 89% and a testing accuracy of 100%. After testing, the next step is to create an application by utilizing the GUI features in MATLAB. This application can be used for diagnosing diabetic retinopathy.

REFERENCES