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INNOVATION OF DIABETES MELLITUS DETECTOR BASED ON IMAGE PROCESSING USING THE IMPROVED PATCH ORDERING ALGORITHM

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Abstract

In 2012, the mortality rate of 1.5 million population of the world is caused by diabetes. Diabetes complications are the third highest cause of death in Indonesia. According to the World Health Organization (WHO), the number of diabetic patients all over the world by the year 2015 as much as 415 million. It is estimated that the number will increase significantly to 642 million by 2040. It gets worse, most people do not know if it had been suffering from diabetes. According to the Ministry of Health of the Republic of Indonesia, two out of three people with diabetes in Indonesia did not know that was had diabetes. In Asia, more than 50 percent of diabetics know have diabetes after experiencing complications in various organs. This causes the access to health care is done in conditions of late. Under these conditions, it would require an innovation for the detection of diabetes wich are easy, effective and efficient. The approach used in the writing of this research is descriptive qualitative based on literature review method. Innovation that given to solve the problem is application for the detection of diabetes with facial image processing technology. Diabetes is detected by the application by analyzing the texture of a human face using MATLAB software. Classification is done by Improved Patch Ordering Algorithm. The conclusions of this research is the application system detection of diabetes consists of: Input face image, applying color correction procedure, block division, feature extraction, the application of Gabor filters, Improved Patch Ordering classification. This application is expected that layman can perform effective and efisien diagnosis early, so that it can immediately take medication when it has been diagnosed with diabetes.

Keywords

Detection, Diabetes Mellitus, Image Processing, Improved Patch Ordering

Introduction

Diabetes mellitus (DM) is a chronic metabolic disorder due to the pancreas does not produce enough insulin or the body can not use the insulin that is produced effectively. Insulin is a hormone that regulates sugar levels in the blood (Kemenkes, 2014). In 2012, the mortality rate of 1.5 million inhabitants of the world are caused by diabetes (World Health Organization, 2016). Diabetes complications are the third highest cause of death

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in Indonesia (Sample Registration System Ministry of Health, 2014). Diabetes mellitus is a disease that is most likely to cause complications such as blindness, kidney failure, amputation of limbs and most deadly ie heart attack and stroke (Sumadewi, 2016).

According to data from the World Health Organization (WHO), the number of diabetic patients worldwide in 2015 as many as 415 million, with the percentage of people with diabetes is 8.5 percent (1 patient out of 11). It is estimated that number will increase to 642 million by 2040 (IDF Atlas, 2015). Indonesia was ranked the 7th largest in the number of diabetics in the world after China, India, USA, Brazil, Russia and Mexico with an estimated 10 million patients and showed increase of 5.7 percent (2007) to 6.9 percent (2013) (WHO, 2014).

An increasing number of people with diabetes is compounded by the delay in the diagnosis of the disease. Delay in diagnosis causes more severe and complications of diabetes. Most people do not know if in fact suffering from diabetes, even two out of three people with diabetes in Indonesia did not know he was suffering from diabetes. In Asia, more than 50 percent of diabetics learned diabetes after experiencing complications in various organs (Hans, 2007). The following table shows the distribution of the number of diabetics diagnosed and undiagnosed in Indonesia:

Table 1. Distribution of diabetics diagnosed and undiagnosed

Conditions	Proportion	Estimated Number
Total Patients	6,9% of 176.689.336 the population aged> 15 years	12.191.564
Diagnosed	30%	3.706.236
Undiagnosed	**69,9%**	**8.485.329**

(Source: Risdekas 2013 Kemenkes RI, 2014)

Delay in diagnosis is due to the difficulty of diagnosis of diabetes and lack of information about diabetes is known by the public. This causes the access to health care is done in conditions of late. Various attempts have been made to detect diseases such as diabetes through blood and urine. The traditional way to diagnose diabetes is through Fasting Plasma Glucose (FPG), which take a small blood sample from each patient. Before the test is done, the patient does not eat for 12 hours. Therefore, the test is considered to be painful, invasive, time consuming, and also bring inconvenience (Shu et al, 2014). Tests were also carried out through the urine in the hospital, but it takes quite a long time and the cost is quite expensive so it is less efficient.

Based on these conditions, it is necessary an innovation to detect diabetes easily, effectively and efficiently. In this study, innovation is given that is a method for detecting diabetes from individual facial features extraction algorithm using texture Improved Patch Ordering. Diabetes is detected in non-invasive facial texture by analyzing human beings and classified. With this application it is expected a layman can do effectively and efisisen diagnosis early on and may soon do the treatment when it has detected diabetes.

Image Processing

Recognition System is divided into two main parts: image processing and recognition techniques. Facial Image Processing is a part of the image processing in the form of a personal identification system that uses the characteristics of a person's face. In

general, the facial image recognition system is divided into two types, namely the feature-based system and the imaged-based system. In the first system to use the features extracted from the image of a face component such as eyes, nose, mouth, etc., then the relationship between these features are modeled geometrically. Whereas the second system uses information from the raw pixel image which is then represented in a particular method.

Image processing section consisting of a facial image capture via scanning, image enhancement, image clipping, filtering, edge detection and feature extraction. The second part consists of artificial intelligence developed by the Genetic Algorithm and there are many approaches or methods for face recognition. Here is a facial image processing system scheme:

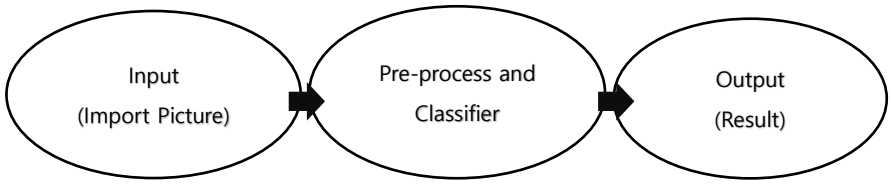

Figure 1. Scheme of facial image processing system
(Source: Rathi et al, 2012)

Working system of facial image processing is illustrated in Figure 2. In this case related to image processing in detecting diabetes starts from the insert face image to be detected. Pre-process is a process prior to the determination of diabetes (classifier) include: correction, block division, extraction and other features. The classification or grouping classification is based on patterns obtained from the algorithm. The following is the work scheme of feature extraction and classification in image processing.

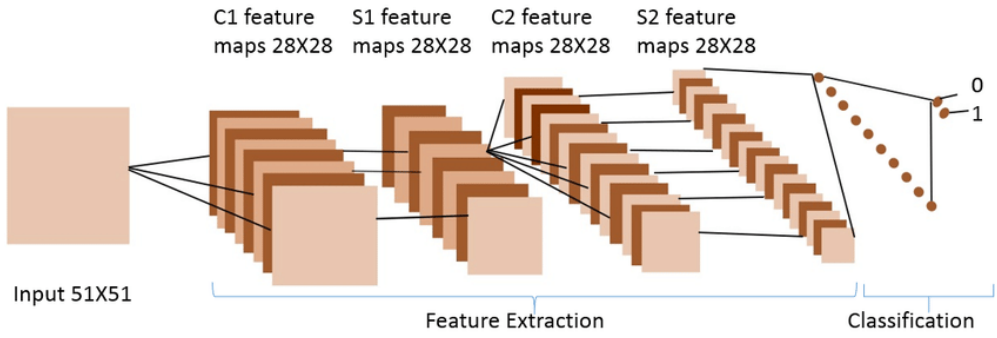

Figure 2. Work scheme of feature extraction and classification in image processing

Gabor Filter

Image Filtering (filtering of the image) is a technique to modify or enhance the image. Filtering is used to filter out images or emphasizing certain features or remove other features. Image processing operations are implemented with filtering include smoothing, sharpening, and improvement. Processing of Texture-like Images is illustrated bellow:

2-D Gabor filter:

$$f\ (x, y, \omega, \theta, \sigma, \sigma) = \frac{1}{2\pi\sigma_x\,\sigma_y}\, exp\left[\frac{-1}{2}\left(\left(\frac{x}{\sigma_x}\right)^2 + \left(\frac{y}{\sigma_y}\right)^2\right) + j\omega(x\ cos\theta + y\ sin\theta)\right]$$

where
σ : the spatial spread
ω : the frequency
θ : the orientation

1-D Gabor filter:

$$f\ (x, \omega, \sigma) = \frac{1}{\sqrt{2\pi\sigma}} \exp(\frac{-x^2}{2\sigma^2} + j\omega x)$$

Gabor Filter is one of the filters that are able to simulate the characteristics of the human visual system in isolating frequencies and specific orientation of the image. Gabor Filters are linear filters are used in the extraction of facial features as the detector characteristics. Gabor Filter feature detectors known as successful because it had the ability to eliminate the variability caused by shifting a little contrast and illumination and image deformation. The following is an example of the application of Gabor Filters that generates Gabor filters using bandwidth, aspect ratio, phase, wavelength and angle as parameters:

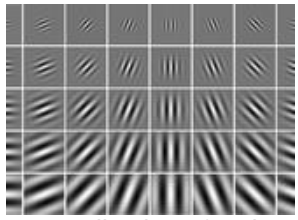

Figure 3. Application of Gabor Filters
(Source: Yang, 2010)

Feature Extraction

Feature extraction is the transformation of original data to a data set with a reduced number of variables, which contains the most discriminatory information. Feature extraction is a visual content retrieval method for image indexing and retrieval. Specially designed device with calibration and developed to take pictures of faces under standard arrangements, to ensure the extraction and analysis of the characteristics that are not biased. Feature extraction is used to indicate a relevant information in solving computational tasks associated with specific applications. There are two types of characteristic texture. First, the size of the texture is a statistic that is calculated from the individual pixels and does not consider the relation of pixels around. The second type are the steps that take into account the relationship around.

Feature extraction procedure resulted in the description of an object in terms of measurable parameters that represent the relevant properties of the object, and can be used for classification by arranging objects to class (Vandenbroucke, Macaire & Postaire, 2003). Image feature extraction is used for segmentation of color and texture features. Texture image using a gray scale by extracting color and all information on the color space. Color is featured in three-dimensional space (RGB) associated with the frequency of red, green and blue of the light spectrum. Feature Extraction transforming the existing features into a lower dimensional space. It perform by creating a subset of new features by combinations of the existing features. That is illustrated with the figure bellow:

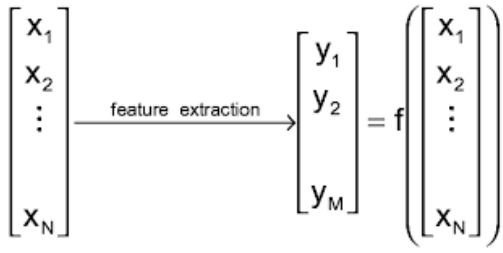

Figure 4. Performances of Features Extraction

Data Classification

Feature Classification is a pattern recognition technique that is used to categorize a huge number of data into different classes. Pattern recognition is the science of making inferences from perceptual data, using tools from statistics, probability, computational geometry, machine learning, signal processing, and algorithm design. Thus, it is of central importance to artificial intelligence and computer vision, and has far-reaching applications in engineering, science, medicine, and business. It is natural that we should seek to design and build machines that can recognize patterns.

From automated speech recognition, fingerprint identification, optical character recognition, DNA sequence identification, and much more, it is clear that reliable, accurate pattern recognition by machine would be immensely useful. Moreover, in solving the indefinite number of problems required to build such systems, we gain deeper understanding and appreciation for pattern recognition systems. For some problems, such as speech and visual recognition, our design efforts may in fact be influenced by knowledge of how these are solved in nature, both in the algorithms we employ and in the design of special-purpose hardware.

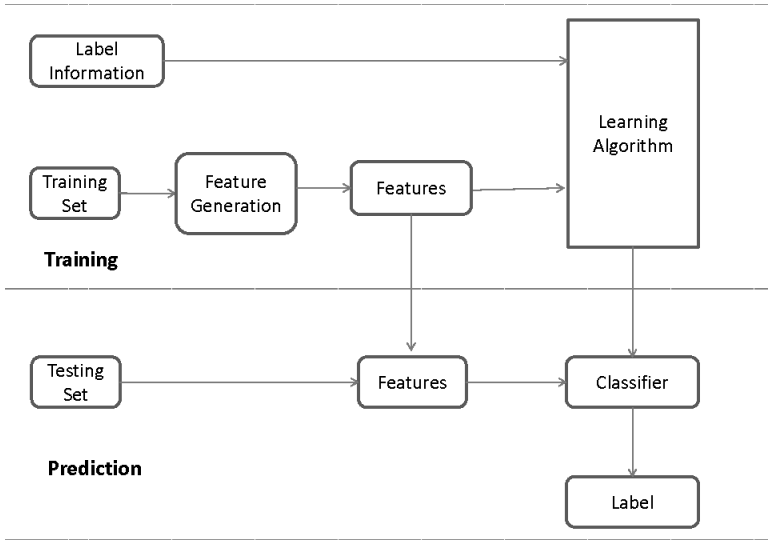

Figure 5. A General Process of Data Classification

A general process of the data classification usually consists of two phases - the training phase and the prediction phase. In the training phase, the data is Analyzed into a set of features based on the feature generation models such as the vector space model for text data. After representing the data through Reviews These extracted features, the learning algorithm will Utilize the label information as well as the Data itself to learn a map function f (or a classifier) from features to labels as:

$$f\ (feautres) \rightarrow labels$$

In the prediction phase, the data is represented by the feature set extracted in the training process, and then the folder function (or the classifier) learned from the training phase will perform on the feature represented the data to predict the labels. Note that the feature set used in the training phase should be the same as that in the prediction phase.

Improved Patch Ordering Algorithm

Nowadays to detect diabetes mellitus, researchers have developed a non-invasive method which is based on the block of the human face. Although some algorithms were also developed for the detection of diabetes mellitus based on the block face, the detection of diabetes continues to be a challenging problem. The first problem is that if the size of the facial image database larger than is needed, then the time to complete the process of SRC longer. Facial Block Color with a Sparse Representation Classifier (SRC) is a very time consuming process.

Another problem is the detection of diabetes using the tongue color, texture and geometry features. Average accuracy using Sequential Forward Selection (SFS) with Support Vector Machines (SVM) amounted to 80.52% at 130 and 296 images healthy tongue diabetes. However, by applying each characteristic individually, the highest average accuracy was only 66.26%. In addressing this problem, an algorithm to detect diabetes mellitus using a non-invasive method which is based on the characteristic texture of the face. Texture characteristic is extracted using Gabor filters and algorithms used to classify is Improved Patch Ordering. The method is based on a combination of the block face.

According to traditional Chinese medicine theory, the health status of the internal organs can be reflected by different regions of the human face (Shu Ting, Bob Zhang and Yuan Yan Tang, 2015). It is the underlying precipitating diabetes detection by the human face and spawned a variety of algorithms. Based Research Shu et al (2015), Improved Algorithm Patch Ordering can classify diabetes mellitus and healthy samples with an accuracy of 99.38%. This method is rated better than other methods.

Detection Procedure

Face image is extracted and analyzed, it was all done based personal computer using MATLAB. There are several steps in detecting a sample. Here is a detection system design flow chart that describes diabetes mellitus step in detecting a sample of image:

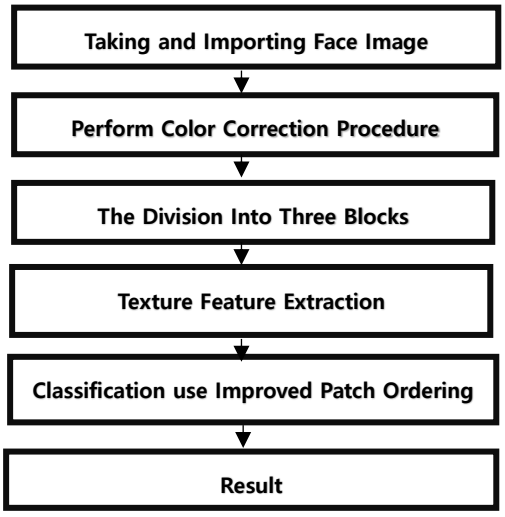

Figure 5. A flow diagram diabetes detection system

1. Input Face Image

The first step is to prepare the picture of a person to be detected in JPG format. Images that have pursued a high resolution so that the extraction and analysis by MATLAB maximum. The image input is an initial stage of the whole process, the input image is an image-reading stage of software testing. The image of the input should be from RGB (Red Green Blue) because the image is converted to grayscale format.

Normalization is a simplification stage pixel values such as the size and intensity of the pixels. Normalization aims for the image to be processed in a characteristic appearance and introduction stage can produce an accurate value, because it will affect the value of feature vector and a big influence in the final process. Stages of normalization used are:

a. Crooping and resizing. Cropping or cutting part aims at eliminating facial image part other than the facial image as the background. Resizing is to change the image size diversified into 128 x 128 pixels size. Aiming for the data to the entire face can be filtered by the Gabor filter that is 128 x 128 pixels.
b. Grayscale. Changing RGB format image into grayscale format aimed at simplifying the pixel intensities.
c. Histogram Equalization (smoothing histogram), aims to sharpen the texture image and gain histogram is evenly distributed.

2. Apply Color Correction Procedures and Block Division

The next step is to apply color correction procedure on a face image. Specially designed device with calibration developed to take pictures of faces under the default settings to ensure the extraction and analysis features that are not biased. Color correction procedure can be called pre-processing or pra-processing, a technique used in image enhancement or image from any cause in order to get the results of the image or picture is much better, making it easier to be processed for specific or others purposes (Arman, 2012).

After it was taken three blocks in the image of the face (A, B and C) to represent a face. In **Figure 6** shows an example of facial images captured and marked with three blocks. Block A is taken on the forehead, block B is taken under the left or right eye and and C located on the nose. Here are pictures of faces that have been marked into three blocks:

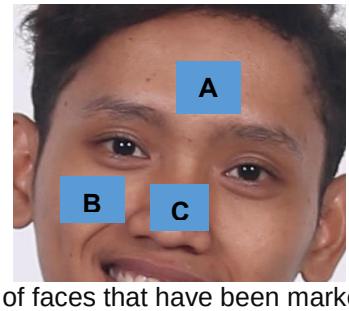

Figure 6. Pictures of faces that have been marked into three blocks

3. Featured Extraction and Applying Gabor Filter

Feature extraction is a hallmark decision stage (value) of the object. In this experiment, the energy feature extraction function to retrieve the value of texture image is shown from the results with Gabor filter convolution that Gabor Response converted into a complex number that is Magnitude Response. Feature extraction function that reads the

average value of a Magnitude Response texture, so that 40 Response magnitudes produced 40 feature vector. Value feature vector is then stored into the database.

Pattern Recognition is the intelligence branch of the emphasis on methods of classifying objects into certain classes to solve specific problems. Examples discussed this time is about the determination of the new face pattern based on the pattern of pre-existing face by using Gabor Filter. Gabor filter is one of the most well-established texture descriptors applied to extract features by analyzing the frequency domain images. This algorithm is actually a linear filter used to detect edges. Representation of Gabor filter is similar to the system of object recognition in humans, so the algorithm is pretty much developed in various fields, such as biometrics.

There are two main processes that do Gabor filter algorithm, which is the process of making an array of Gabor, and then the array will be used in the extraction process/decision vector features from the image file. The difference between the face value of the block texture and healthy diabetes by calculating the average value of the four blocks of texture value of face to represent each block face accordingly. Texture diabetics with healthy people is very different, for example, shown in **Figure 7.** and **Figure 8**. Gabor filter is used for this filter provides a better distinction of various textures.

4. Classification Using Improved Patch Ordering Algorithm

In patch-based denoising techniques, the input noisy image is divided into patches (i.e., blocks). The blocks are then manipulated separately in order to provide an estimate of the true pixel values. In research of Idan et al (2015) propose a method performed Smooth Ordering of the approach using images and color imperfections. Image processing scheme of the study are based on sequence of 1D smoothness of pixels in a given image. The study showed that using carefully designed permutation matrix and 1D simple and intuitive operation such as linear filtering and interpolation, the proposed scheme can be used for image denoising and inpainting.

In order to better facilitate the recovered images, the approach used approach resembles the method of "spin cycle". In the randomized study to build a different permutation matrix K Pk, utilizing each to denoise z pictures using the scheme described above, and average the results. This can be expressed by:

$$y = \frac{1}{K} \sum_{k=1}^{K} \mathrm{P}_k^{-1} H \ \{P, K_Z\}$$

The equation above shows the image processing scheme is proposed. They further explain how we build the matrix reordering P.

Patch Ordering methods have drawbacks, based on research on the detection of between diabetic and healthy. Because the original Ordering Patch is applied to the image gap and coloring, some processes in Patch Ordering for healthy versus diabetes detection can be removed according to the fineness (blur) the image of the face. Because it is applied is Improved Patch Ordering to be applied to the detection of diabetes. Improved Patch Ordering is the development of the patch ordering algorithm where the algorithm is considered easier and more effective.

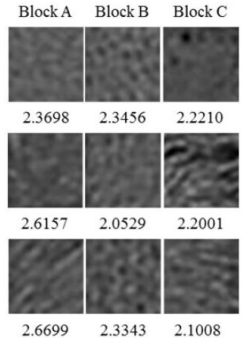

Figure 7. The texture of the diabetics with value
(Source: Shu dkk, 2015)

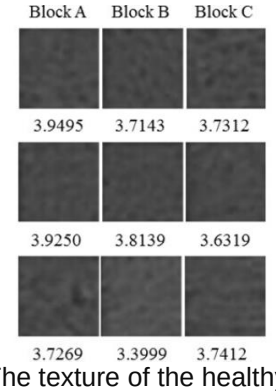

Figure 8. The texture of the healthy with value
(Source: Shu dkk, 2015)

Conclusion

This is a new innovations of method for detecting diabetes (healthy or diseased) which uses facial texture features in individuals who are classified using the Improved Patch Ordering algorithm. Improved Patch Ordering algorithm is an enhancement of the Patch Ordering. Diabetes detection system of work is done by: input face image, applying color correction procedure, block division, feature extraction, Gabor Filter application, classification using Improved Patch Ordering algorithm. With the existence of this detection method is expected to be a new innovation that is effective, efficient and cheap in detecting diabetes. It takes the manufacturing and system testing further to determine the performance of this method, because in this study the system has not been made and tested.

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