Automatic Cataract Detection System based on Support Vector Machine (SVM)

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Abstract

Cataract is one of eye diseases, namely a dense, cloudy area that form in the lens, can cause the blindness. To identify these diseases, most hospital used slit lamp which shows the different structure at the front and inside of the eye. However, this equipment is very expensive for public health center in urban areas. To overcome this problem, the camera installed with artificial intelligence to ensure there is a cataract or not. In this system, feature extraction of Gray Level Co-occurrence Matrix (GLCM) method and identification method of Support Vector Machine (SVM) are being used to distinguish normal eye or the one with cataract. This system makes the process faster and ensured the patient about the diagnosed better. So that they can undergo surgery as soon as possible. The result of this research by using the computer simulation has a good accuracy, namely 82% and 77% respectively for training and testing phases.

Keywords
Cataract; Normal eye; Cataract eye; Gray Level Co-occurrence Matrix (GLCM); Support Vector Machine (SVM)

1. Introduction

Cataract is the main couse of blindness in Indonesia. In 15 provinces, cases of cataracts have percentage rates ranging from 70% to 80% based on the survey was conducted by the Association of Indonesian Ophthalmologists and the Health Research and Development Agency in 2014-2016 (Ihram, Atmaja, & Widjayanto, 2018). Several condition that can cause cataracts are aging process, diabetes, smoking, ect. In those conditions, often people are not aware of cataracts in themselves so that they carry out the activities without feeling any danger to themselves and others. To cure this serious eye disease, surgery is the only solution. However, it is can be done on several condition. Because of the matrix condition for the successful surgery, the information condition the cataract patient's cataract is become important. Therefore, in this research, the patient's cataract condition (level of the blindness) expected to inform which used to determine what kind of cure to be given.

To get information of patient's condition, integration system must be support by an artificial intelligence. Namely, a Neural Network Classifier was used to detect cataracts based on the classification of images in eye pupils. The results are the percentage of accuracy which show the severity of cataracts to inform the patient eyes condition (Lukman Hermawan, 2017). The models was used in this research were Gray Level Co-Occurrence Matrix (GLCM) for extraction and detection of senile cataract stages on eye image and Support Vector Machine (SVM) K-algorithm for the classification.

2. Methods and Literature Reviews

In this study, it is hoped that the system (show in figure 1) can be identified and classify the eyes of cataracts. The first steps in this system are taking the image which carried out by the camera. Then, the image entered into the computer as input in Matlab program. In the process, Matlab will do two important jobs, namely image processing and system identification. In image processing, the incoming image will be extracted into the matrix and then the Gray Level Co-Occurrence Matrix (GLCM) technique taking over for normalization matric texture. The results of the GLCM will be used as input for the inspection process, namely Support Vector Machine (SVM) which is part of the training process. After completing the training process, the testing process will be carried out, and through the GUI interface the test results will be shown to make easier for the public use.

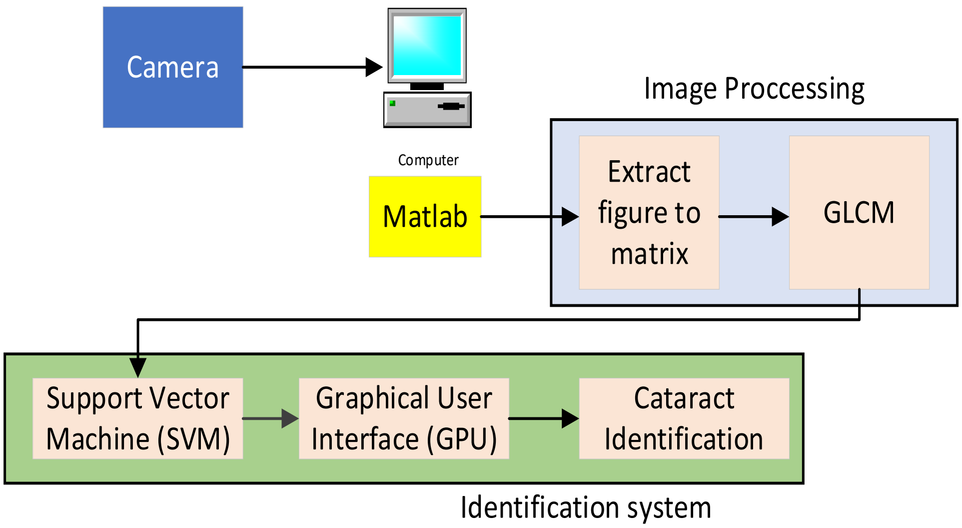

Figure 1. Block diagram of conventional cataract identification system

Gray Level Co-Occurence Matrix (GLCM) which widely used in biomedical application (Arabi, Joshi, & Vamsha Deepa, 2016; Chaudhari & Kulkarni, 2019; Parák & Havlík, 2011; Salem Ghahfarrokhi & Khodadadi, 2020; Vallabhaneni & Rajesh, 2018; Zotin, Hamad, Simonov, & Kurako, 2019), is a method that used to extract features or analyze an image. This matrix contains information about the combination of pixels number that appear in an image which has a certain gray level and a certain pixel value, that makes several angular patterns. These patterns produce properties contained therein regarding energy, comparison, entropy, and homogeneity. The coordinates of the combination on the pixel value have distance and angle (ϴ) where distance is represented in d and angle is represented in degrees. GLCM has an algorithm for creating which is divided into several steps (Davari Dolatabadi, Khadem, & Asl, 2017):

- First, the image changed into a gray level on a scale from scale 1 to the largest scale.
- The result of the gray image is scaled dimensional, which later become the GLCM matrix itself.
- The formation of the matrix is derived from two pairs of pixels in one image that are aligned in the direction of the angular pattern of 0, 45^o, 90^o, and 135^o.
- Review the difference in value for each bit that starts from bit (0,0) to bit (M, N) with the bit that is in position and distance. In bits (M, N) M is the length and N is the width of the matrix.
- Filling the GLCM value can be done by looking graying at the review and neighboring pixels, where the gray value on the review pixel becomes a row and the neighbor pixel becomes a column on the matrix.
- Finally, determine the properties was contained, based on extract features that have been carried out on the GLCM method. There are three types of properties which are contrasted, energy, and homogeneity.

To make prediction, Support Vector Machine (SVM)was used because of its classification ability to distinguish and object and has also been used in several biomedical application (Pandey, 2011; Vieirat, Dias, & Mota, 2003; William, Winda, Satrio, Sofyan, & Solihin, 2019). This technique can be called a semi-eager because the technique requires training process on the data that has been input; and a small portion of the training data will be used again when making predictions. SVM is used to find separator functions or classifiers which can separate two data sets from two different classes optimally as shown in Figure 2. This is because the performance is convincing in predicting the class of new data (Khorshidtalab, Salami, & Hamedi, 2012).

The concept of SVM can be explained simply, which is to find the best hyperplane as a separator of two data classes in the input space. The trick is to measure the margin (the closest data distance between each class and hyperplane.

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For data whose class distribution is not linear, it usually uses the kernel approach as the initial data feature when conducting training. The kernel here is a function that maps data features from low dimensions of new features with higher dimensions. The kernel itself has a way of working which calculates the dot product of 2 vectors in a new dimension space by using the components of 2 vectors in the original / previous dimension space. Kernel has 4 types of functions, namely linear, polynomial, Gaussian, and quadratic functions. The kernel function approach used by the author to classify SVM in the Matlab application is Gaussian. This is because the use of this function has better training accuracy compared to other functions (Thiruvengatanadhan, 2018).

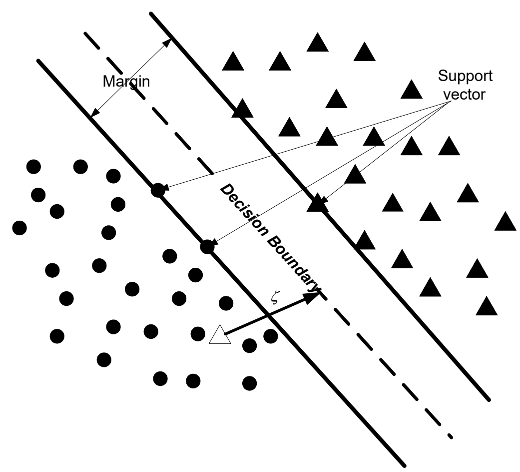

Figure 2. Support Vector Machine Binary Classification

3. Results and Discussion

The eye image which captured by the camera will be digitized through a preprocessing procedure. The preprocessing step is used for spectral flatten the signal and making less susceptible to finite precision effects at a later stage. The preprocessing image is then used as input to the feature extraction steps. Feature extraction is the process of converting the raw image into the feature vector which will be used as input for the classification system. There are two important phases in the proposed system, namely training phases and testing phases. In the training phase, the system is trained to develop an eye based model of the cataract and normal eye as shown in figure 3, respectively, a template for the model pattern stored in the memory. In the testing phase, the input data will match with the model in order to recognize the eye.

All data input, which entered into the computer will be cropped so that the figure only shows the pupil eye area. The cropping process has the aim that in the next process GLCM (Gray Level Co-occurrence Matrix) can recognize the eye better and more accurately. In GLCM, the green part of color level in the cropping images was changed to gray, and the image becomes a matrix 8x8 pixel. The images which have the cataract disease have a high pixel number in the same area; and for normal eyes, the pixel number almost zero due to the black color as shown in figure 4. The next step, GLCM will increase the contrast and reduce the noise of the image as shown in figure 5 which the left side of the cataract eyes and the left for the normal eyes. This process will be helpful in identification system as discussed above the training phase is applied in order of getting the model each of the case, cataract and normal eye respectively. The 30 other data for normal and cataract eye are evaluated. Each of the eyes image is modeled based on GLCM technique into eight by eight GLCM parameters. The training data involve 10 data which consist of five cataract eye and five normal conditions. Therefore, the training data involve 160 parameters for all two kinds of normal and cataract eye. The other brain signal activity, 80 parameters are applied as testing data.

In order to evaluate the effectiveness of the proposed system, the 20 data of each of the cataract and normal eye which a total of 42 data respectively, are performed to train the The SVM-based classification is applied to perform identification of processes using the binary classification method. The SVM based binary classification with the radial basis function (RBF) kernel method with the degree of 13 has been used in this paper. The SVM gives 100%

accuracy for training phased. This means the SVM has perfectly classifies all of the two kind of eye normal and cataract, respectively. Furthermore, the results of analysis with another eye data testing stage produce 72.5% and 82.5% classification rate for normal and cataract eye, respectively. The testing classification rate results have shown that the performance of SVM based pattern matching technique has better performance in term of training and testing accuracy.

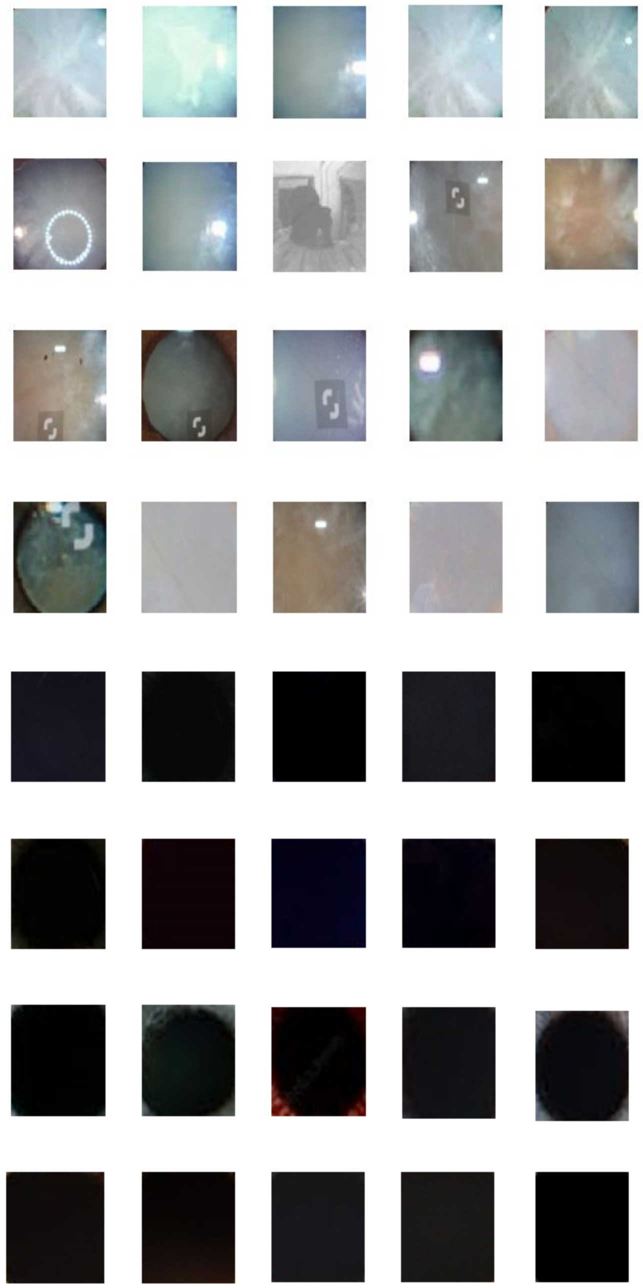

Figure 3. Data training of the cataract (row 1 to 5) and normal eye (row 6 to 10)

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>> GLCMTest
```

0	0	0	0	0	0	0	0
0	27	0	0	0	0	0	0
0	10	216	16	0	0	0	0
0	0	37	8481	613	0	0	0
0	0	0	583	6011	32	0	0
0	0	0	0	12	69	15	2
0	0	0	0	1	4	36	6
0	0	0	0	0	3	4	78

```
>> GLCMTest
```

16256	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0

Figure 4 The example matrix 8x8 of data which (a) upside for cataract eyes (b) downside for normal eyes

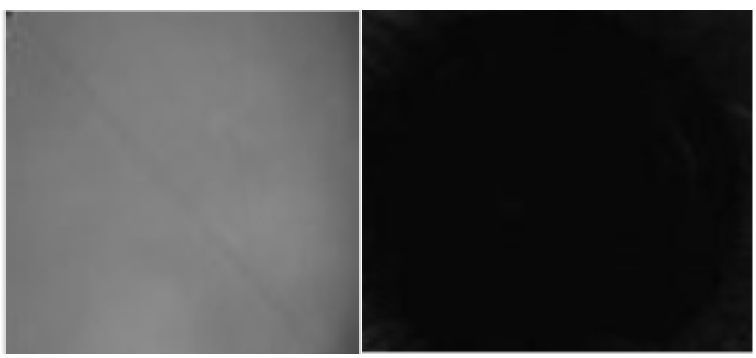

Figure 5. The image had been treated for grayscale, contrast and noise correction. Left side for cataract eye and right side for normal eye.

4. Conclusion

Based on the results of the final project that has been made by the author, the conclusion obtained is the method of image processing using the Gray Level Co-Occurrence Matrix and the Support Vector Machine identification system has succeeded in getting the expected accuracy results when compared with other methods. This system is able to classify or distinguish normal eyes and eyes affected by cataracts. The results can be seen through the accuracy of the training data was 82.6% and the testing data of each eye, which is 72.50% of cataract eye training data and 82.5% of normal eye data. However, from these results the system is still classified as imperfect due to the limitations of the author to retrieve data which results in the processing of data images being less than optimal.

SVM-based cataract recognition system has been proposed and discussed in this paper. This technique is developed based on image processing and intelligent system, the method based on SVM. The accuracy of the SVM based eye image recognition was found good result. It was also clear, from our computer simulation results, that the proposed method requires much less training time than the existing one. These results identify whether normal or cataract based on the eye image is considered. In the future, it is needed to clarify the performance and complexity with increasing number of human eye image to prove its usefulness in real system.

With that in the future work, this system could develop the stand alone embedded system, which consist of special camera, raspberry and LCD. This system work by taking the picture of the eyes using the camera. Picture that captured by the camera then used as input to the system to be identified. The identification result is then displayed at the LCD.

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Leonardo Michael Marcello, final year student from BINUS ASO School of Engineering, Bina Nusantara University, in 2020 majoring in Automotive and Robotics Program, and Currently he is working in Tanggerang. His research mainly on Intelligent system, data base, and embedded system.

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Zener Sukra Lie was born in Jakarta, Indonesia on March,14, 1984. Zener Sukra Lie completed his undergraduate degree in Electrical Engineering from University of Indonesia, Jakarta, Indonesia 2006. In the same year, He joined the graduate program in Electrical Engineering with majoring microelectronics at Bandung Institute of Technology, Bandung, Indonesia. In 2012, He got his doctorate degree on Nuclear Power and Energy Safety Engineering Department from University of Fukui, Fukui, Japan. Currently He is a lecturer in the department of Automotive and Robotics, BINUS ASO School of Engineering (BASE), Bina Nusantara University and the same time he works as a voluntary researcher for M3RC. His research and lecture revolve around Laser-Induced Breakdown Spectroscopy, and Intelligent System.

Winda Astuti received the B.S. Degree in Electrical, Control and Computer engineering from National Institute of Technology, Bandung, Indonesia, in 2000 and the M.S. degree in Electrical and Computer Engineering from International Islamic University Malaysia, Malaysia, in 2008. She is finishing the Ph.D. degree in Mechatronics engineering at International Islamic University Malaysia, Malaysia. Previously, she was a lecturer at Electrical Department at University of Jenderal Soedirman (2007-2009). Currently, she is a full lecturer in the Department of Automotive and Robotics, Binus Aso School of Engineering (BASE), Bina Nusantara University. Her main research interests include control systems theory and applications, intelligent systems, signal and image processing.