Iris image analysis of patient Chronic Renal Failure (CRF) using watershed algorithm

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CLASSIFICATION OF IRIS IMAGE OF PATIENT CHRONIC RENAL FAILUR (CRF) USING WATERSHED ALGORITHM AND SUPPORT VECTOR MACHINE (SVM)

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ABSTRACT

Iridology is an alternative method in studying the condition of human internal organ through the image of iris. Iris chart has been introduced by scientists (Bernard Jensen) long time ago. In this paper we classified the iris image of patients CRF (Chronic Renal Failure) on stage 5 (End Stage of Renal Disease). Sixty one hemodialysis patients and 21 healthy volunteer with normal or nearest normal kidneys participated in this research. Iris image of CRF patients were taken using specific iris camera. Watershed transform technique was used to extract the features of iris image of hemodialysis patients. The ROI (region of interest) of iris image of renal organ is at 5.35-5.95 (252^0 – 268^0) for right eye and at 6.05-6.6 (272^0 - 288^0) for left eye assuming that the circle of iris is divided into 120 points (360^0). The medical records of participants were used to validate the result of this study. The result showed that 87.5% of patients hemodialysis has shown broken tissue on their right iris and 89.3% has shown broken tissue on their left iris. In conclusion, the condition of renal organ of CRF patients mostly showed broken tissue in their iris image. SVM was used to recognize the iris image whether it contains broken tissue that showing kidney disease or not, and the accuracy showed that for learning and testing dataset, best mean of precission is 87.5% and best mean recall is 91.7% given by the percentage split 90 (where the data training was 90% and data testing was 10%).

Keywords : *Iridology, Iris Image Processing, Chronic Renal Failure, Watershed Algorithm, SVM*

1. INTRODUCTION

Iridology has been a pseudo-science for some years in the world-wide [1]. However, some positive results regarding the study of Iridology have also been published [2,3,5,6,7]. There have been numerous researches trying to prove Iridology. Practitioners of iridology believe that Iridology could be the answer for early detection problem for some diseases since iris through eyes have the most connection with the central nervous system of human back bone compared to other organs. Iridology or iris diagnosis can know the condition of inner organs such as pancreas, kidneys, heart and other organs by looking at the iris tissue [2,3,5,6,7]. An Iridology chart has been introduced firstly by dr. Bernard Jensen who taught this alternative medicine method in USA. He claimed that the abnormal condition of the organs can be seen through the iris. Broken tissue in the certain area of iris represents the condition of specific organ in human body. This broken tissue is showed by a pattern or mark or just changing the color of iris [3]. However one of the darwback in mapping

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the iris image is that the mapping system that represents the organs was so close for one area to another. This has a potential for misreading the broken tissue in iris. Due to that, a computerized system with image processing technique would be a great help in detecting the broken tissue in iris.

FIGURE 1. IRIS CHART

Nowadays, since the image processing technique has been developed well, that drawback can be overcome. For example, Lesmana et al., [5] and Wibawa et al., [6] did research about pancreas condition by looking at the iris of patient who have diabetes mellitus by using image processing technique. Result of their study said that iridology can be used as early detection system for the condition of pancreas organ. Sivasankar et al., [7] used Fuzzy C-Means (FCM) as a clustering method after iris image processing technique to detect pulmonary disease. By using wavelet analysis and neural network to process image of iris, Hussein et al [2] showed that there was a relation between broken tissue in iris on specific area with the condition of kidney. Hussein did this research for people with healthy kidney and the people with unhealthy kidney.

Recently the number of patients Chronic Renal Failure (CRF) is increasing every year. According to the annual report of Indonesian Renal Registry, on the year 2012, there were 19.621 new patients of end stage renal disease. While one year before there was about 15.353 patients and in the year 2010, it was recorded 9.649 patients [11, 12, 13]. The increase number of patient diabetes mellitus in Asian especially in Indonesia has been causing the increase of CRF patients. CRF or Chronic Kidney Disease (CKD) is a condition when the kidney has lost the capability to do its function for long period of time [4]. Usually CRF is caused by the other diseases such as diabetes mellitus, hypertension, polycystic kidney disease (an inherited condition where both kidneys are larger than normal due to gradual growth of masses of cysts), systemic lupus erythematosus (a condition of the immune system where the body attacks kidney as if it were foreign tissue), blockages such as kidneys stone or prostate disease, and in few other cases. According to Kidney Disease Outcomes Quality Initiative (K/DOQI) of the National Kidney Foundation (NKF), there are 5 classifications of the stages of CRF based on the value of Glomerular Filtration Rate (GFR) after taking the blood test to get creatinine value. Usually patients of CRF in the early stage did not feel the symptoms even if they feel it, they just think that the symptoms were just the ordinary sickness. This will make the disease going to worst. Based on that background, Iridology has a high potential to be used as an alternative method in developing the early warning system so that the worse condition then can be avoided, besides patients can have better chance to get the proper treatment and avoiding the end stage of renal disease where the kidney already or near loss of all its function.

Chronic Renal Failure (CRF)

Renal or Kidney is one of the vital organs with so many functions. One of them is to absorb the toxic or waste from body and then dumped it out of body by urine. It functions also to stabilize the liquid in body and sugar in blood. According to Kidney Disease Outcomes Quality Initiative (KDOQI) of the National Kidney Foundation (NKF) there are 5 stages of CRF. Table I consist of the stage of CRF based on the GFR (Glomerular Filtration Rate). Value of GFR determined the stage of the kidney disease. The GFR represents how much liquid and waste that passing through from the glomeruli in the kidneys to produce urine in a minute.

TABLE I
GFR CLASSIFICATION OF CRF STAGES

CRF Stage	Description	GFR (ml/min/1.73 m^2)
1	Kidney damage with normal kidney function	≥ 90
2	Kidney damage with mild loss of kidney function	60 – 89
3	Mild to moderate loss of kidney function	30 – 59
4	Moderate to severe loss of kidney function	15 – 29
5	End Stage Renal Disease (ESRD)/ Kidney Failure	< 15

In order to get the GFR value, the creatinine blood test must be done first. Creatinine is one of the waste that kidney should be get it out in urine. For healthy kidneys, value of the serum creatinine should be high in urine and low in the blood. The opposite condition works for the people with unhealthy kidneys. To get GFR, we must estimate value of creatinine. There are several ways to estimate GFR, one of them is MDRD (Modification of Diet in Renal Disease). MDRD technique depends on 4 variables as the parameter such as body mass index, race, gender and age. However, some researchers found that MDRD become

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inaccurate for the people with amputees, frail patients, stroke victims and people with unusual diets or near normal people [8, 9, 10].

The estimated GFR will determine the stage of the CRF. According to table 1, people with GFR less than 15 ml/min/1.73 m^2 is patient ESRD. This means that the patient kidney already loss or near loss its function. There are only 2 options treatment to help them they are kidney transplantation or dialysis. Since the kidney transplantation takes longer time to find the right new kidney and the price is expensive, dialysis is the better option. Dialysis is a medical term to remove the wastes and extra fluid from blood by using peritoneal membrane or pump machine. There are 2 types of dialysis which is Peritoneal Dialysis (PD) and Hemodialysis (HD).

By referencing to those explanation above, this paper presents the pattern of the broken tissues in iris of the CRF patient who have already taken hemodialysis treatment. We hypothesized that broken tissue on the iris of CRF patient would be seemed clearly since CRF patients certainly have problem with the kidney organ. In this study we also analyzed and compared the iris image of normal and near normal kidney organ with the CRF patients. We also hypothesized that normal kidneys will not show any signs of broken tissue in the iris. Watershed technique would be used to extract the broken tissue of iris image and Support Vector Machine (SVM) was developed to classify the iris image based on data of broken tissue of iris automatically.

II. METHOD

In total, 82 people were involved in this study with 61 people were patients of CRF (who have taken hemodialysis treatment) and 21 people were normal and near normal people with the GFR was more than 90 ml/min/1.73 m^2. From 61 patients of CRF in hemodialysis treatment, 36 of them have diabetes mellitus as the cause of CRF (they already have this disease for more than 10 years), 17 of them have Hypertension as the cause of CRF and the rest have different causes like polycystic and other deseases. The youngest patient was 23 years old and the oldest was 79 years old. 50 of them were older than 50 years. These patients usually take hemodialysis treatment twice a week. The duration of their hemodialysis treatment varies from 1 month until 84 month (7 years). Among the participants, male patients was 41 people.

TABLE II
GFR DATA OF PARTICIPANTS
(NORMAL AND NEAR NORMAL)

No	Gender	Age	Creatinine	GFR (MDRD)
1	M	29	0.82	111.08
2	F	30	0.71	96.66
3	M	22	1.01	92.37
4	M	25	0.91	101.51
5	F	35	0.57	120.70
6	M	34	0.75	119.21
7	M	36	1.07	78.20
8	M	26	0.91	100.71
9	M	34	0.76	117.41
10	M	31	0.96	91.36
11	M	29	0.81	112.66
12	M	25	0.96	95.44
13	F	29	0.6	118.19
14	M	27	0.88	103.88
15	F	33	0.79	83.82
16	M	43	0.9	92.10
17	M	34	1.01	84.56
18	F	31	0.67	102.66
19	M	32	0.99	87.61
20	F	24	0.6	122.82
21	F	40	0.7	92.68

The flow work of this study was described in figure 2 below.

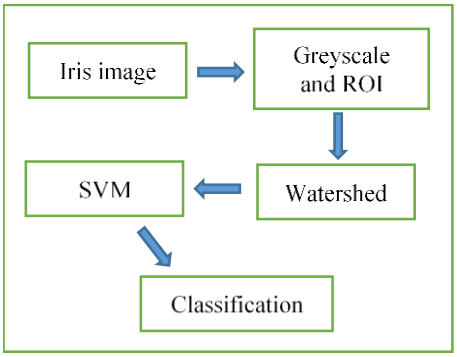

FIGURE 2: FLOW DIAGRAM OF THIS STUDY

The iris image of all participants were taken using Camera Dino-Lite Digital Iris-scope AMH-RUT with two white-light LED illumination built in. The contoured hood on the microscope camera ensures that the camera can be place close to the eye. This camera has a resolution 1.3M pixel for image and frame rate until 30 fps. Iris image for analysis was obtained from the video data resulted from the Dino-Lite camera. The ROI of the kidney organ position in iris chart is at 5.35-5.95 (252^0 – 268^0) for right eye and at 6.05-6.6 (272^0 - 288^0) for left

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eye with the assumption that the circle of iris is divided into 120 points (360^0). The process was started by cropping out the other part of eyes except the iris, the iris image was then divided into 360^0. The centre of iris image was determined through the centre of pupil. The kidneys area is on the third quarter of the circle for right eye and on fourth quarter for the left eye. The ROI is about 18^0 for both eyes and at distance about 0.4 to 0.6 of the iris radius (calculated from the center of iris image).

FIGURE 3: IRIS IMAGE FROM DINO-LITE IRISSCOPE

FIGURE 4: PROCESSING TO GET THE ROI OF THE RIGHT EYE (above) and LEFT EYE (below)

Watershed Method

Segmentation of iris image has an important role in this study. There are 2 types of segmentation of image that are commonly used, they are edge based and region based. Watershed is one of the best tools for segmenting image based on region [20, 21], especially iris image that has thin edge. For producing initial partitioning of the iris image the Sobel's was used to extract the gradient information that was input to gradient magnitude. The gradient magnitude will then be input to the watershed. The gradient magnitude of an image was considered as a topographic surface for the watershed transform. The gradient firstly defines the partial derivative of an image and contains a measurement for the change of gray levels. The gradient values G (x, y) of the initial segmented image in x, y directions as in equation 1 was used to calculate edge strength values.

$$G(x,y) = \sqrt{\left(\partial f / \partial x\right)^2 + \left(\partial f / \partial y\right)^2} \qquad \text{(eq. 1)}$$

Feature of iris and SVM

In this study, there were four features that were extracted from the iris image as the input of SVM, they were:

- Mean of the gradient magnitude image
- Mean of the image result of watershed
- Mean of the watershed binary image
- The size of area of broken tissue

By using 4 neighborhoods pixel and labeling the pixel in binary image we can count the size of broken tissue in ROI. Since there were 4 features for every eye, in total for both eyes (from each participant), there would be 8 features. Firstly, the data set were devided into 3 classes, A, B and C. A class is a group of participants with both iris showing broken tissue for kidney organ. B class is for participants with only one iris (whether right or left) that showing broken tissue for kidney organ. C class is group of participants with no sign of broken tissue in their iris. In this study, SVM with RBF (Radial Basis Function) Kernel with C (cost) and Gamma as the parameters was used. The best value of C and Gamma can be found by using Grid Search algorithm. Grid Search recommended that the best value for C is 16 and Gamma is 100. In order to validate the result of SVM, the data set for training and testing was devided into several format (table 3).

TABLE III. PERCENTAGE SPLIT OF THE DATA

Percentage Split	Data Training (%)	Data Testing (%)
10	10	90
20	20	80
30	30	70
40	40	60
50	50	50
60	60	40
70	70	30
80	80	20
90	90	10

Beside percentage split, k-fold cross validation methods was also used to validate the result. This method will separate the data set into two partitions by using the value of k. The size of partition for testing was determined randomly based on the value of k. The value of k ranged from 1 to 10.

III.RESULT

From 61 images of iris from 61 CRF patients, there were only 56 images that can be used for analysis. Other 5 images cannot be used because of the cataract and eyelids that cover the ROI. From the 56 data images we found that 49 of them (87.5%) showed that in their right iris there were broken tissues in the kidney ROI. 50 of them (89.3%) showed broken tissue in their left iris. Theoritically, right iris represents organs on the right of body organs and left iris represents organs

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in left side. In this study we also found that one patient who has no right kidney for 40 years (the kidney was taken out by surgeon), showed no signs of broken tissue in her right iris. Further research need to be performed to analysis this interested fact. This result was showed in figure 5 below.

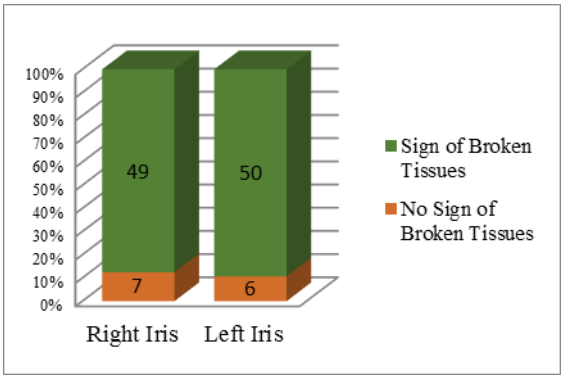

FIGURE 5. NUMBER OF PATIENTS THAT SHOWING BROKEN TISSUE

When we look at both eyes, we found that 45 patients showed broken tissues for both of iris and 11 patients showed only in one iris (whether the right iris or left iris). For SVM with percentage split as we planned using rules on table III, the result showed that best mean precision given by percentage split 90 which is 91.7% and best mean recall also given by percentage split 90 which is 87.5%. This means that by splitting the data into 90% data was used for data training and 10% data was used for data testing, the SVM achieved the highest accucary in detecting the broken tissue of iris. Using SVM with validation methods k-fold Cross Validation with k from 1 to 10 shows that best mean precision given by 4-fold cross validation which was 86.7% and best mean recall also given by 4-fold cross validation which was 87%.

IV. DISCUSSION AND CONCLUSION

It has been years that Iridology has been considered as a Pseudo-Science by many researchers. However, the result of this study, besides among others, proved contrary. This study shows that there is a significant relationship between the broken tissue in iris of CRF patients with the condition of kidneys organ. One of the main scientific explanation for this finding is that eyes are the only organ in human body with the most nerves that connect to the human spinal cord system. Spinal cord system contains most of the nerves system in human body. All things happened in our body, chemically or electronically are recorded by the nerve in the spinal cord, thus the eyes then record it too. By understanding this facts, therefore, iridology can monitor organ that was damaged by a chronical disease like diabetes mellitus, high blood pressure, collesterol or cardiovascular. More over, when comparing this result with the 21 healthy volunteers who did not show any broken tissue in their iris, this finding has emphasized again that iridology has high potential to be used as an alternative method in monitoring human's organ non-invasively. In addition, these findings also showed that iridology has capability to be used as an early warning system for human organ's condition especially for patients with chronical disease.

There is a special case in this experiment that need to be explored more, a patient who has lost the kidney through operation before this experiment, did not show any signs of broken tissue in the related iris. This fact has also given a positive point to iridology, even though the case was only one and we did not know how much time that was needed by the body to erase these broken tissue. We think that some studies for detecting the early condition of CRF patients would also be important in order to obtain a more robust conclusion regarding the iridology, besides avoiding patients to get worse condition. However, it remains unclear among scientists recently that if one organ is getting better, would it also erase/change the broken tissue in iris, if yes, how long does our body take to recover the broken tissue in iris. Contrary, when the condition of organ is getting worse, would the broken tissue in iris be getting bigger or deeper, if yes, how much time for the iris to show some worse broken tissue due to the worse condition of the organs. All of those questions can only be answered by further studies so that people can understand better iridology. From the result above we can conclude that early detection system based on iris image can be developed to monitor the condition of our internal organs by using SVM so that worse condition then can be avoided.

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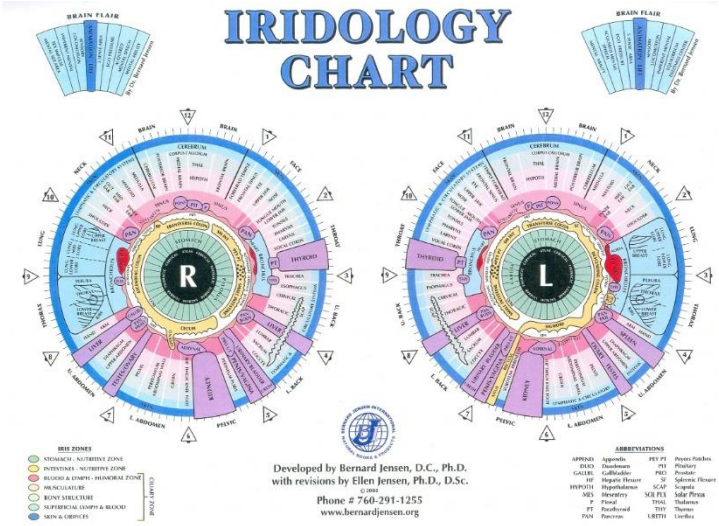

FIGURE 1: CHART IRIDOLOGY

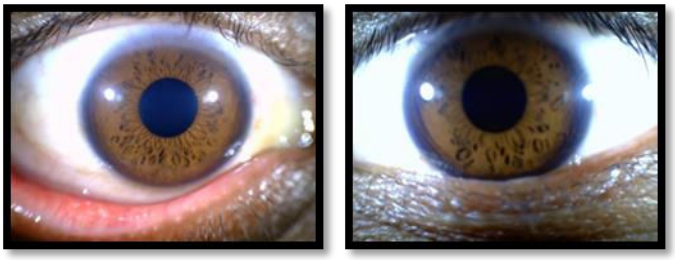

FIGURE 3: IRIS IMAGE FROM DINO-LITE IRISSCOPE
(Left figure is right eye and right figure is left eye)

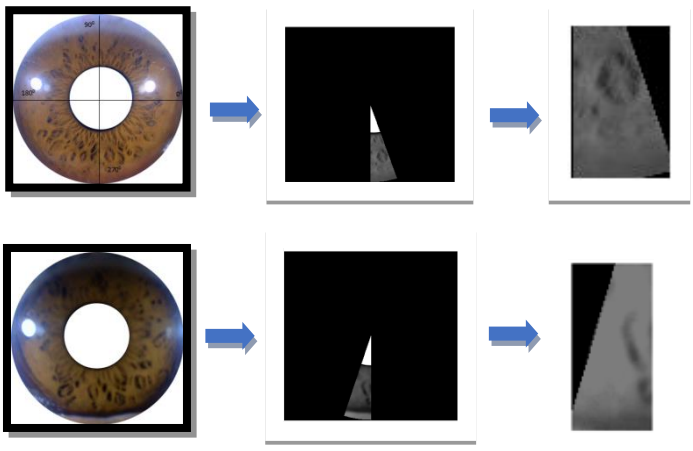

FIGURE 4: PROCESSING TO GET THE ROI OF THE RIGHT EYE (above) and LEFT EYE (below)

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