PRIMARY RESEARCH

Detection of melanoma cancer using gray level co-occurance matrix and artificial neural network methods

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Abstract

Image feature extraction is a step of object extraction information in an image to recognize or distinguish it from other objects. The method used for feature extraction is the Gray Level Co-Occurance Matrix (GLCM). This research is related to features calculation from the melanoma cancer and non-melanoma images using GLCM based on variations of gray level, which are 4, 8, 16, 32, and 64, and angles of GLCM orientation consisting of 4 and 8-way. The used features are angular second moment, contrast, correlation, entropy, inverse moment, and variance. Then, the feature values are used as input parameters to classify melanoma cancer by utilizing an artificial neural network (ANN). This experiment is conducted by using 45 datasets of images from www.skinvision.com. Generally, all of the experiment types' results accurately predict melanoma and non-melanoma classification by ANN more than 93%. By inputting six parameters from GLCM feature extraction using (1) 4th degree of gray level and 4-way orientation angles and (2) 16th-degree gray level and 8-way orientation angles, we can obtain the accuracy of ANN classification by 100%.

I. INTRODUCTION

Skin is the outer part of the body which has various functions such as protection from the things that may be hazardous, sense of touch, covering the body, temperature controller and the other. Skin faces environment directly that causes skin to easily get diseases or infections. Skin area which gets infection is called lesion. This is clinical sign of diseases such as smallpox, herpes or melanoma cancer [1, 2].

Melanoma cancer is one of the various cancers which are categorized as harmful so that it can cause death. Based on Worl Health Organization (WHO) data there are 132.000 melanoma cases every year in the world. This number keeps increasing because of the thinning of ozone layer. Melanoma appears on normal skin and firstly, it is a mole or the other part of the skin that changes with the characteristics called ABCDE parameter, such as assymetry, border irregularity, color variation, diameter and evolving [3, 4].

Texture is an intuitive concept describing smoothness, roughness, and orderliness on the area or region or surface.

In processing digital image, texture is defined as a spatial distribution of greyish level in pixel set that is side by side. Feature extraction is a step to extract characteristics or information from the object in the image. The information can be used to distinguish between one object and another. One of the methods used to analyze texture feature is a gray level co-occurance matrix method usually used in several fields such as face texture test, quality of ceramics, distinguishing kind of leaves and the others [5].

One of the methods used to analyze image is a GLCM. Haralick introduces the use of probability by using gray level co-occurance matrix method in order to extract various texture features [6]. Variables that are focused on gray level, orientation angle to determine direction of the pixel, and distance used to determine distance of the pixel. The result of characteristic/information extraction from GLCM is used as an input in object classification. This step is applied by using ANN.

The previous research, [2] Segmentation and classification of skin melanoma cancer using GLCM feature extraction

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method and joining two classification methods which are SVM and KNN. Research is a used dataset of 726 images from 5 classes of kind of skin. Moreover GLCM feature used consists of four parameters such as mean, deviation standard, skewness, and variance. The research shows the accuracy used SVM is about 46.71%, with K-NN 34%, while joining two methods SVM and K-NN is 61%. Research of [7] to detect and classify melanoma and non-melanoma used GLCM feature extraction method and ANN classification method. The dataset used 50 images, 30 for melanoma and 20 for non-melanoma. This study used contrast, correlation, homogeneity, energy, mean, skewness, and kurtosis as the feature. The result of the feature will be used as an input for ANN method. The accuracy of this research is 90%.

Generally, GLCM for feature extraction used gray level of 8. The greater number of gray level can increase quality of the extraction result and give information texture which is more accurate, however it takes a long time [6, 8].

This research analyzes the accuracy of detection of melanoma cancer using ANN with various neurons on one

hidden layer. The inputs from 6 GLCM features based on the difference value of gray level are 4, 8, 16, 32, and 64. Each level used orientation angle of 4 directions (0, 90, 180, 270 degree) and 8 directions (0, 45, 90, 135, 180, 225, 270, 320 degree).

II.   MATERIALS AND METHODS

A.   Melanoma

Melanoma is a skin cancer which is from pigmented cells (melanocytes). It is one of the dangerous types of cancer that can cause death. The causes or indications of melanoma cancer are moles that change and become big, this can be seen in Figure 1, the growth of little pigmented skin which can grow on sun-exposed skin. Melanoma case usually starts with the growth of a pigmented mole. The difference of characteristics of melanoma and non-melanoma can be seen in the Table 1 as follows [3].

According to the medical world [3], there is are the difference of characteristics between melanoma and non-melanoma. This can be seen on in Table 1 as follows:

(a) with hair   (b) without hair

Fig. 1. Melanoma cancer

TABLE 1

THE DIFFERENCE OF CHARACTERISTIC

No	Characteristics	Melanoma	Non-Melanoma
1.	Symetry in shape	$\times$	$\checkmark$
2.	Have flat border	$\times$	$\checkmark$
3.	Have more than one colour	$\checkmark$	$\times$
4.	Have bigger size more than 6 mm	$\checkmark$	$\times$
5.	Evolving	$\checkmark$	$\times$

B.   Preprocessing

Preprocessing means process of increasing image quality so it can fulfil criteria to be used as research data. In this research there are 6 steps in preprocessing.

1)   Resize: Changing size of source image in order to accelerate the counting process of co-ocurance matrix. The smaller size of the image, the faster is the counting process.

This research shows, the first image is 500×500px and it is resized into 300×300px.

2)   Median filtering: Median filter basis which is used to minimalize sound of roaring in the image. Melanoma cancer is type of cancer that grows on the skin so it cannot slip away from noise that inhibits detection of cancer object. In brief Median filtering was done by building a sliding win-

dow 3x3 as long as image order where middle point of window was replaced with median value from nine elements of the windows.

3) Conversion of RGB to grayscale: Was done in order to know the intensity of the spread of gray level in image and the GLCM method which used probability of gray level in counting co-occurance matrix. The similarity (1) this is similarity between conversions of RGB to grayscale with a_r, a_g, a_b is intensity value of red, green, and blue on source coloured image.

$$Grayscale = (a_r + a_g + a_b)/3 \qquad (1)$$

4) Conversion of grayscale to binary: The back ground and foreground of the image can be seen by using binary image. The second similarity (2) is used to convert grayscale to binary [8].

$$f_B(i,j) = \{ \begin{array}{l} 0, f_g(i,j) \ \leq \ T \\ 1, others \end{array} \qquad (2)$$

In this case, $f_g(i,j)$ is grayscale image $f_B(i,j)$ is binary image, and *T* is specification value threshold. This research is implemented by MatLab function.
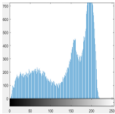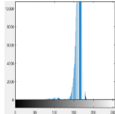
5) AND operation: Is logic operation of AND between grayscale image and binary image as the result 4. The aim is to make an object change into grayscale which is more clear and separated with the background.

6) Histogram: Used to know the separation of intensity values of pixel from an image or part of an image [9] to make strong analysis.

The results of preprocessing stage are resize, median filtering, grayscale, binary, operation of AND between grayscale and binary, and histogram that can be seen in Table 2, as follows.

TABLE 2
THE RESULT OF PREPROCESSING STAGE

Preprosessing	Melanoma	Non-Melanoma
Origin imagel		
Resized image		
Median filtering		
Grayscale (Gs)		
Binary (Bi)		
Gs AND Bi		
Histogram (Complement)		

C. Gray level Co-Occurance Matrix

Image classification based on texture analysis usually needs extraction of characteristic stage which consists of three kinds such as statistic, spactal, and structural [10]. GLCM includes statistic method that the calculation used distribution of gray level. Co-occurance means mutual events, total of events of pixel value side by side with the other pixel value in distance (d) and orientation angle (θ). Distance was declared as pixel and direction of orientation angle is degree [5], for example: angle of 135º value $\Delta_x = -1$ and value $\Delta_y = -1$ or make a diagonal direction to the left. The 3rd formula is the equation used to calculate probability of co-occurancce matrix.

$$P(i,j|\Delta x, \Delta y) = WQ(i,j|\Delta x, \Delta y)$$

$$W$$

$$\frac{1}{(M - \Delta x)(N - \Delta y)} \qquad (3)$$

$$Q(i,j|\Delta x, \Delta y) = \sum_{N-\Delta y}^{n=1} \sum_{M-\Delta x}^{m=1} A$$

$$= \begin{cases} 1 \, if \, a(m,n == i-1) and \\ \square \, (a(m+\Delta y, n+\Delta x) == j-1) \\ \square \quad \square \\ 0 \quad elsewhere \end{cases}$$

$$or \, A = \begin{cases} if \, a(m,n == j-1) and \\ 1(a(m+\Delta y, n+\Delta x) == i-1) \\ 0 \quad elsewhere \end{cases}$$

1)   The gray level: Is the intensity value of gray limit in the image which shown image matrix size. On the Figure 2, 0-3 gray intensity shows 4 gray level matrix so it can be seen matrix work are 4x4 in order (b). Generally, the range of pixel intensity value in the image starts from 0 to 255. If it is work area 255×255, the process in counting co-occurance matrix will takes longer time. Therefore, it needs to be classified into 5 gray level variations: 4, 8, 16, 32, and 64.

0	0	1
3	3	1
0	3	3
2	3	2
1	1	1

	0	1	2	3
0	(0,0)	(0,1)	(0,2)	(0,3)
1	(1,0)	(1,1)	(1,2)	(1,3)
2	(2,0)	(2,1)	(2,2)	(2,3)
3	(3,0)	(3,1)	(3,2)	(3,3)

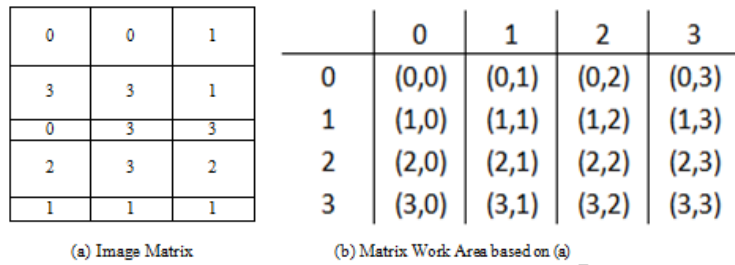(a) Image Matrix   (b) Matrix Work Area based on (a)

Fig. 2. Melanoma cancer

Then, image matrix should be get transformation by determining coefficient of divider for all of the intensity values in order to get matrix that is appropriate with gray level size. The coefficient is the highest value in the matrix divided by value of gray level variation chosen.

2)   Orientation angle direction of GLCM: Is a variable which is used to determine probability direction $P(\theta)$ in order to find neighbourhood pixel. Orientation angle direction that is usually used is 4 directions with 90º interval, but it can be developed as 8 direction with 45º interval, it means θ = 0º, 45º, 90º, 135º, 180º, 255º, 270º, and 315º [6]. Figure 3 describes Orientation angle direction of GLCM.
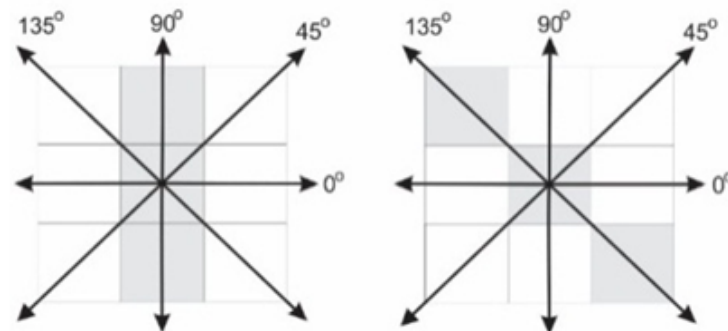

Fig. 3. Orientation angle direction of GLCM 90 and 135 degree

3) *Distance:* Is defined as the differences of two pixel positions (i_1, j_1) and (i_2, j_2).

Gray level, orientation angle, and distance are the main parameter to count probability of co-occurance matrix with the Equation 3. After the co-occurance matrix was obtained then transpose matrix operation should be done in order to make symmetric matrix. The next is the process of normalization matrix.

GLCM features used are as follows [5, 11].

4) *Angular second moment:* is the image homogenity size.

$$ASM = \sum_{i=0}^{G-1} \sum_{j=0}^{G-1} \{P(i,j)\}^2 \qquad (4)$$

5) *Contrast:* is the measurement of the existence of gray limit pixel variation.

$$CON = \sum_{n=0}^{G-1} n^2 \{\sum_{i-1}^{G} \sum_{j=1}^{G} P(i,j)\}|i-j| = n \qquad (5)$$

6) *Correlation:* is the measurement of dependence of linear between gray limit values in the image.

$$COR = \sum_{i=0}^{G-1} \sum_{j=0}^{G-1} \frac{\{i \times j\} \times p(i,j) - \{\mu_i \times \mu_j\}}{\sigma_i \times \sigma_j} \qquad (6)$$

7) *Inverse different moment:* Was used to measure homogeneity. This value is very sensitive towards value of the main diagonal. It has high value when the pixel value as the same as others.

$$IDM = \sum_{i=0}^{G-1} \sum_{j=0}^{G-1} \frac{1}{1 + (i+j)^2} P(i,j) \qquad (7)$$

8) *Entropy:* Shows the measurement of irregularity of gray limit in the image. Entropy value is high for the image with transition of gray spread evenly and it is low if image structure is irregular and various.

$$ENT = -\sum_{i=0}^{G-1} \sum_{j=0}^{G-1} P(i,j) \times logP(i,j) \qquad (8)$$

9) *Variance:* Shows various elements of matrix. Image with the small gray level will have small variance.

$$VAR = \sum_{i=0}^{G-1} \sum_{j=0}^{G-1} (i \times \mu)^2 P(i,j) \qquad (9)$$

D. ANN

ANN is one of the artificial intelligences that was designed to imitate human brain works. It was inspired by brain cells. In biology, a nerve cell (neuron) only has one nucleus to process information. The information is accepted by dendrite; beside there is axon as the output for the result of information process. This result is an input for the other neuron where dendrite receives the input from the output axon through synapse. Information sent between neurons is stimulation through synapse and dendrite. Information that dendrite got will be accumulated and transferred through the other axon. This information will be received by the other neurons if it fulfils the threshold [12]. Information as the input is transferred to the neuron with a certain weight. Then, it is processed by certain function that will be accumulated values in each incoming input and weight. Furthermore, the adding result is compared with certain threshold through activation function in every neuron. If the input passes the certain threshold, the neuron will be activated. When the neuron is active, the neuron transfers weight as the output to all the neurons connected. In ANN, neuron is collected in the layers. Neuron in a layer will be connected with the previous or the next layer. Information put into neural network transfers from one layer to the other. It starts from input layer to output layer through hidden layer [12]. The illustration of ANN work can be seen in Figure 4 and Figure 5.
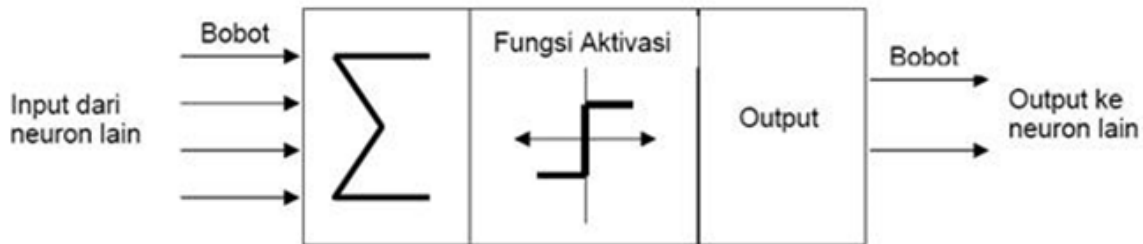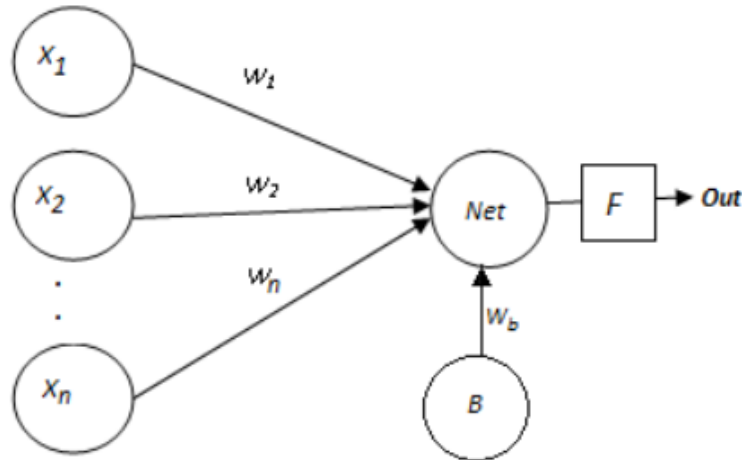

Fig. 4. Mechanism of ANN process

Fig. 5. Architecture of ANN with bias

A neuron will process n input (*X1*, *X2*, *X3*,...*Xn*) in which each of them has weight *W1*, *W2*, *W3*,...*Wn*, the same as in the Equation 10.

$$Net = \sum_{i=1}^{n} X_i W_i \qquad (10)$$

Activation function *F* is activated so it becomes an output for the network. Bias is the adding neuron with node that has 1 in value. The influence of bias to neuron is shown bias weight (W_b). if the neural network is equipped with bias, computation process in neuron the same as the Equation 11.

$$Net = W_b + \sum_{i=1}^{n} X_i W_i \qquad (11)$$

ANN area is not regardless of training technique. The aim of training techniques is to get the best weight in each connection. The techniques used in this research is Back Propagation Throught Time (BPTT). There are two computation steps in each iteration such as forward pass and backward pass. In each iteration there are revisions for values and weight on hidden node, output and bias that is in the network [12].

1) Fordward pass: The calculation for output node and error got towards its value target. The Equation 12 is the equation in order to count the input value and bias with activation function of sigmoid.

$$Out_h = \frac{1}{1 + e^{-Net_h}} \qquad (12)$$

The calculation of the signal of the output from hidden layer in order to get output layer used the Equation 12.

$$Net_o = W_c + \sum_{i=1}^{n} X_i W_i \qquad (13)$$

Count the result of the Equation 13 with the activation function in hidden with the output layer in the Equation 14.

$$Net_o = Net_o \qquad (14)$$

The next is comparing output of network with the target. Calculate *E* error with the Equation 15.

$$E = |target - Out_o \qquad (15)$$

Calculate quadratic error function with the Equation 16.

$$E_{total} = \frac{\sum E^2}{n} \qquad (16)$$

2) Backward pass: Weighty process that depends on the result of the error got from forward pass. In order to do weighty there should be partial derivative calculations from the error towards weight. The calculation of partial derivative is to know that how much change has been done to the weight towards total of error. The Equation 17 is used to calculate partial derivative.

$$\frac{\partial E_{total}}{\partial W} \qquad (17)$$

Then, if the chain rule based on structure of network is applied, the Equation 17 changes into the Equation 18.

$$\frac{\partial E_{total}}{\partial W} = \frac{\partial Out}{\partial Net} * \frac{\partial Net}{\partial W} \qquad (18)$$

Calculate each of the partial derivative. Each of the partial derivative can be seen in the Equations 19, 20, 21, 21, 22.

$$\frac{\partial E_{total}}{\partial W} = \frac{2}{n}(target - Out) \qquad (19)$$

Function of linear activation is in the hidden activation with the output layer. So, partial derivative is the same as the Equation 20.

$$\frac{\partial Out}{\partial Net} = 1 \qquad (20)$$

However, if the partial derivative is with the sigmoid activation function, equation that will be used is the Equation 21.

$$\frac{\partial Out}{\partial Net} = Out(1 - Out) \qquad (21)$$

This is equation of partial derivative *N* function to *W*.

$$\frac{\partial Out}{\partial W} Out_h \qquad (22)$$

If it is combined, it becomes the Equation 23.

$$\frac{\partial E_{total}}{\partial W} = \frac{2}{n}(target - Out) * 1 * Out_h \qquad (23)$$

The next is weighty process for W with the Equation 24.

$$W^+ = W - (\eta * \frac{\partial E_{total}}{\partial W}) \qquad (24)$$

III. RESEARCH METHOD

This research is focused on knowing the influence of various values of gray level on orientation angle and distance within extraction of texture feature of GLCM in order to detect Melanoma cancer or it is not to ANN. The flow research process can be seen in the Figure 6.
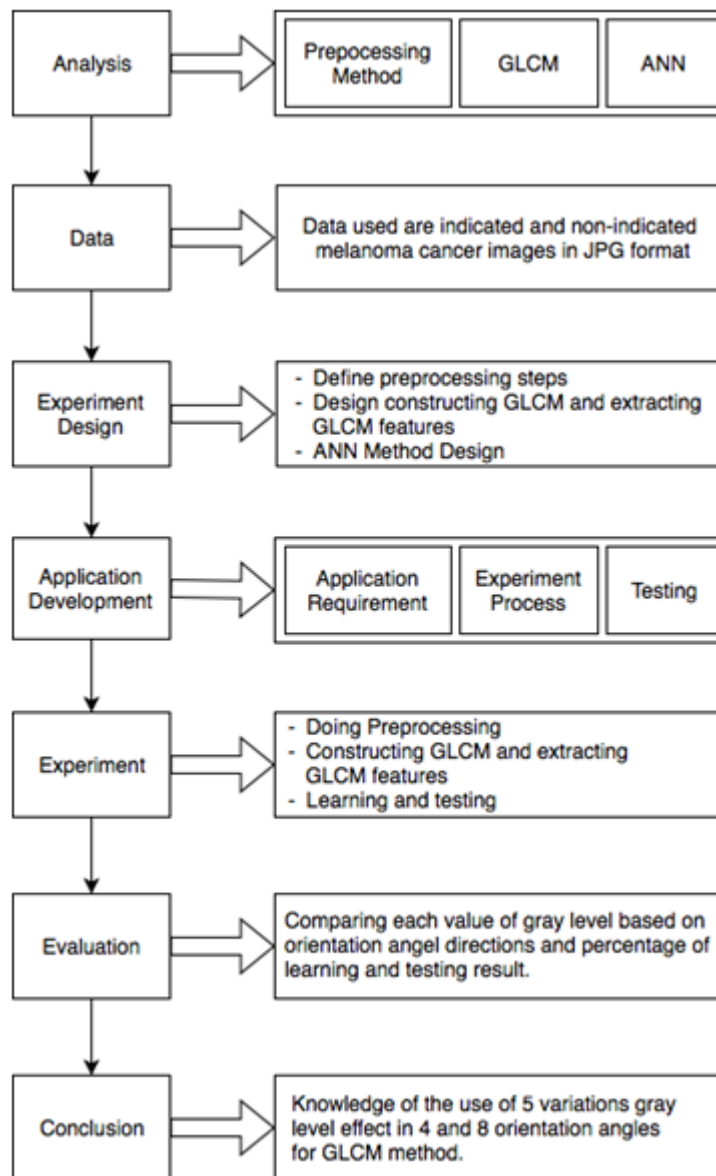

Fig. 6. Research methodology

IV.   RESEARCH DATA

Research data used is image sample from www.skinvision com. It is medical data from the people that indicated melanoma cancer or not. Each of the images has label or ground truth that is appropriate with the example in the Table 3, as follows.

TABLE 3
GROUNDTRUTH OF RESEARCH DATA

Normal	Dyplastic	Melanoma
Low Risk	Medium Risk	Dangerous

There are 3 images categories that hasve a label; image normal or low risk, dysplastic image or medium risk, and melanoma image or dangerous. This research used 14 images normal or low risk categorized as non-melanoma cancer and 31 dyplastic or medium categorized as melanoma. So the experiment used 45 images.

V.   RESULTS AND DISCUSSION

Five processing steps shown in the Table 2 is the input for calculation of features in GLCM. The next is Experimentation of GLCM shown in Table 4. This step produced ASM, contrast, correlation, entropy, IDM, and Variance for each image.

TABLE 4
SPECIFICATION OF THE ESTABLISHMENT OF CO-OCCURANCE MATRIX

Types of Image	Gray Level (g)	Angle (θ) 4 Directions	Angle (θ) 8 Directions	Distance (d)
Melanoma	4, 8,	0°, 45°,	$0^o = 180^o$	
or	16,	90°, 135°	$45^o = 225^o$	1
Non-Melanoma	32, 64		$90^o = 270^o$	
			$135^o = 315^o$	

According to calculation of 6 parameter of co-occurance martrix it can be concluded as follows:

3)   ASM feature: The value decreases only in the melanoma image and it has difference in the 4 and 8 level except the other. It is not influenced by orientation angle. The higher the gray level, the smaller the ASM value. It is because in the co-occurance matrix, the neighbourhood of the pixel gives a big opportunity to have various values of pixel intensity. So, it does not make heterogeneous.

4)   Contrast feature: Is influenced by gray level in 4, 8, and 16. Moreover, orientation angle influences contrast value on the melanoma or non-melanoma. Contrast is the measurement of variation of gray level so the higher the value of gray level, the higher is the contrast feature.

5)   Entropy feature: Is influenced by gray level, orientation angle only influences melanoma image and only in gray levels 4, 8, and 16. Therefore, entropy presents measurement of irregularity of pixel intensity. Entropy has a high value if the gray level value is increasing.

6)   Correlation feature: Is influenced by gray level only in levels 4 and 64 on melanoma image. The correlation in the other level has the same value. Gray level did not influence non-melanoma image and orientation angle did not influence correlation whether in the melanoma image or non-melanoma.

7)   IDM feature: Is influenced by gray level only in levels 4 and 64 on melanoma image while the other level has the same value. Gray level did not influence IDM of non-melanoma image. In addition, orientation angle did not influence IDM whether in the melanoma image or non-melanoma.

8)   Variance feature: Is influenced by gray level whether in melanoma or non-melanoma but it is not influenced by orientation angle 4 or 8 directions. It is because the difference of value of gray level shows many variations of pixel value.

According to the result of the training and testing to value of texture feature of GLCM in the ANN method, the training process used 30 images that consist of 21 melanoma image data and 9 non-melanoma data. While the testing used 15 data that consist of 10 melanoma images and 5 non-melanoma images. The result of detection of accuracy towards category of melanoma or non-melanoma, used WEKA help. It can be seen in the Tables 5, 6.

Additionally, in this research there are histograms for each 45 images that were used. The result showns that histogram for melanoma image has more than one peaks normal distribution curve (multi modal) whereas non-melanoma image only has one peak.
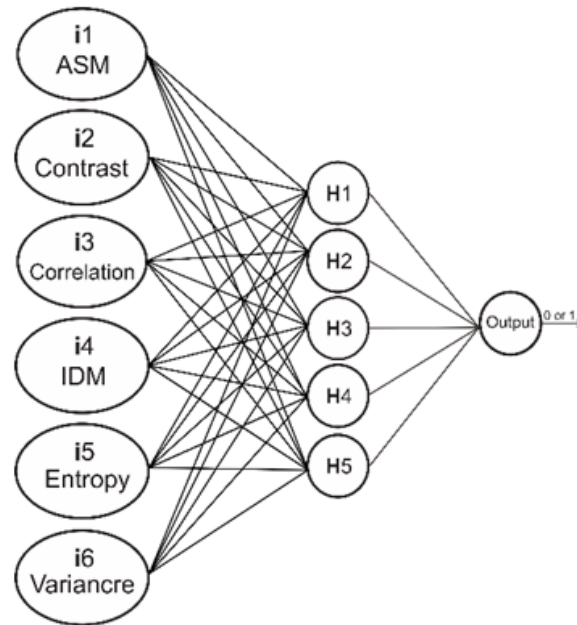
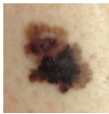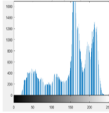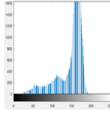Fig. 7. ANN by 6 inputs, 5 neurons in hiden layer and 1 output
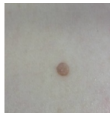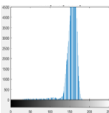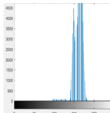
TABLE 5
PARAMETER FOR WEKA

Variable	Value
Neuron in one hidden layer	1, 2, 3, 4, 5
Learning rate	0.8
Momentum	0.7
Training time	300
Attributes	ASM, Contrast, Entropy, Correlation, IDM, Varian, Class
Data Training	Melanoma : 21,
	Non-melanoma : 9
Data Testing	Melanoma : 10
	Non-melanoma : 5

TABLE 6
PARAMETER FOR WEKA

Direction of Orientation Angle (θ)	Gray level (g)	Average Time (s)	Accuracy (%)
4	4	0.48	100%
	8	0.86	97.32%
	16	2.19	97.32%
	32	7.37	95.58%
	64	27.46	93.3%
8	4	0.68	93.3%
	8	1.73	93.3%
	16	3.98	100%
	32	13.76	94.64%
	64	51.81	95.96%

TABLE 7
MELANOMA AND NON MELANOMA HISTOGRAM

MELANOMA-1	MELANOMA-2

NON-MELANOMA-1	NON-MELANOMA-2

VI.   CONCLUSION

Combination of GLCM and ANN can be detected with excellent melanoma and non-melanoma cancer classification. Based on 6 parameters of GLCM, The ANN results are (1) 93%–100% accuracy using 4, 8 orientation angle and 1 to 5 neurons in one hidden layer.

(2) 100% accuracy can be achieved generally by (a) 4 gray level and 4 orientation angle, each 1-5 neurons, (b) 16 or 64 gray levels and 8 orientation angle, each 1-5 neurons in one hidden layer.

VII.   SUGGESTIONS

The next research is suggested to:

● Find the alternative preprocession method to make the image clean from the noise. In this case, noise is very influential in detecting objects in the image.

● Add characteristics of feature extraction, so it can give much information that is obtsianed from the image. It also adds parameter of input ANN.

● Increased image that will be tested.

● The spatial distance of the co-occurance matrix can be done by more than one.

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