IMPLEMENTATION OF GABOR FILTER METHOD AND SUPPORT VECTOR MACHINES IN RECOGNITION AND CLASSIFICATION OF BARK

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ABSTRACT

The tree has a main trunk grows upright, supporting the canopy of tree. Morphology (outer structure) from trunk of each plant is different. Based on a condition of trunk, there are two high level groups, that is a herba plant (soft plant) has a smooth texture and woody plant has a rough texture on skin surface of tree. Texture analysis has a part of important in image processing because the texture analysis was developed with the aim computer can understand, make a dummy, and then processed the texture for can simulated the eyes learned or human vision.

Texture analysis can be obtained with the way of feature extraction an images with any method. Which method used is gabor filter method and support vector machines as a classification method in pattern recognition. Pattern Recognition is a part of computer science, and mapped a data into certain concept can be called a class or a category.

Based on research result, can be concluded this research success applicated gabor filter method and support vector Machines into texture analysis and pattern recognition images of bark with an accuracy 74,1% using the best parameter that scale=1 and orientation=1.

Keyword: Pattern Recognition, Image Processing, Feature Extraction, Gabor Filter, Support Vector Machines.

1 INTRODUCTION

1.1 Background

The tree is also called the "principal" or "Tree" in English, is a woody plant. The tree has a main stem grows upright, prop up the tree canopy. Morphology (outer structure) stem of each plant is different. Such as the rod length is not the same. Some are long and some short. It was influenced by the nature of the genetic and environmental conditions, such as temperature, light, and soil fertility. Thus, plants of the same type will have a different stem lengths due to different environmental conditions [1]. Based on the state of the trunk, there are two groups of higher plants, namely herbaceous plants (plants soft) that has a smooth texture on the skin surface and woody plant that has a rough texture on the surface of the skin. In both these plants there leaves around the stem. In the trunk there is a nodal / book (where meletaknya leaves) and internodus (area in anatara 2 books).

Texture analysis plays an important role on digital image processing for texture analysis was developed with the aim that the computer can understand, model making, as well as the process to be able to mimic the texture of the learning process the human eye or vision. Texture analysis can be obtained by extracting characteristic image with various methods. Some of the methods used in the analysis of texture is Gabor filter method, Run Length method, and the method Matrix Kookurensi. After performing the extraction characteristics of the image, the need for classification of the image. To perform the classification of the image, there are several methods in the classification of the method of k-NN (k-Nearest Neighbour), SVM (support vector machines). In the study [2] analasis texture using Run Length method, with multiples of the rotation angle of 90° image did not obtain a change in the value of image characteristics, and the methods of LDA (Linear Discriminan Analysis) to obtain a classification error of 26.32%, and also on study [3] texture analysis using matrix method Kookurensi at four different angles toward the 0°, 45°, 90°, and 135° not obtain terhadapat change its image characteristic value, and the method of k-NN (k-Nearest Neighbour) against classification obtain the best classification with k = 3, namely 55.557%.

Gabor filter is one of the feature extraction method that is capable of producing images with different characteristic values orientation (direction) different angles, so that the extraction image obtained will be more accurate [4]. Method of Support Vector Machines is one of the classification methods used in pattern recognition (Pattern Recognition). Pattern Recognition is one area in computer science, which maps the data into specific concepts that have been defined previously. This particular concept is called a class or category. In the study [5] using Gabor filter in tracking and face recognition accuracy of 79.31% yield. And research [6] using Support Vector Machine in the human skeleton pose classification accuracy of 90.67% yield.

In this study, by implementing the method of Gabor Filter and Support Vector Machines is expected to produce a more accurate analysis of the texture of the bark, which can recognize the tree as the tree species of herbaceous or woody trees with more accuracy.

1.2 Purpose and Objectives

The objectives to be achieved in this study, namely:

1. In order to recognize and classify the tree bark.
2. In order to determine the accuracy by using Gabor Filter and Support Vector Machines in the recognition and classification of the bark.
3. In order to determine the best parameters used in the method of Gabor Filter.

1.3 Limitation Problem

The boundaries of the problem is:

1. The image taken is the outside (skin) of the tree trunk that has not been peeled.
2. The image is taken should focus on the outside (shell) of the tree trunk.
3. The image is taken from a tree that has a trunk diameter ≥ 10cm.
4. The image used in the training of as many as 15 different species, and each has 5 different image datasets.
5. The process of taking the image of the bark is done with adjustable lighting level that is not dark atupun not too bright.
6. The file used in this application is an image file that has the extension: * .jpg, * .jpeg, * .bmp, * .png, * tif.
7. The image that is used has a resolution of 450 x 600 pixels.
8. The process of extraction using Gabor filter with scale 8 orientation (direction) at a different angle 0°, 30°, 60°, 90°, 120°, 150°, 180°, 210° and 4 different sine wave length that is 1 , 2,3,4.
9. The process of classification using support vector machines with two different classes are group classes woody plants and herbaceous plants.

2 BASIC THEORY

2.1 Computer Vision

Computer Vision is a rapidly growing field devoted to analyze, modify, and high-level image understanding. The goal is to determine what happens in front of the camera and use that understanding to control computers, robotic systems, or to give a new image is more informative than the original camera image. Application areas for computer vision technology including video surveillance, biometrics, automotive, photography, film production, web search, drugs, augmented reality game, a new user interface, and more [7].

2.2 RGB Image

RGB is a color model that consists of red (Red), green (Green), and blue (Blue) are combined and form a wide array of colors. Each primary color has a range of values between 0 smpai 255 [8].

2.3 Grayscale Image

Grayscale is the colors of pixels that are within the range of shades of black and white. Intensity grayscale image data is usually stored as 8 bits or 256 gray color intensity from 0 (black) and 255 (white) [8]. Gray image can be generated from the RGB color image by multiplying the three components of the primary colors red, green, and blue with a coefficient whose number one (a + b + c = 1).

$$Y = a.R + b.G + c.B$$
$$Gray[x,y] = 0.3.R + 0.59.G + 0.11.B \quad (1)$$

2.4 Metode Gabor Filter

Gabor filter method is an object recognition method that aims to bring out the special characteristics of the image that has been dikonvolusi to the kernel. As the filter is used Gabor 2D filter kernel obtained by modulating the 2D sine wave at a frequency and a particular orientation with Gaussian envelope. Basic equation function 2D Gabor filter shown in equation (2), where σ is the standard deviation of the Gaussian envelope dimensions x and y. Lamda (λ) and tetha (θ) is the length and orientation of the 2-D sine wave. The spread of the Gaussian envelope is defined in the form of a sine wave λ. Rotation of the x - y by angle θ generate Gabor filter at orientation θ [9].

$$g(x,y;\lambda,\theta,\psi,\sigma,\gamma) = \exp\left(-\frac{x'^2+\gamma^2y'^2}{2\sigma^2}\right)\cos\left(2\pi\frac{x'}{\lambda}+\psi\right) \quad (2)$$

Where :

$$x' = x\cos\theta + y\sin\theta$$

$$y' = -x\sin\theta + y\cos\theta$$

σ = Standar deviasi *Gaussian envelope*

λ = Panjang gelombang *sinus* pada 2-Dimensi

θ = Derajat Orientasi

γ = Aspek rasio spasial

ψ = *Phase Offset*

Phi (ψ) has a value of between -180 degrees, -90, 0, 90, 180. The value of gamma (γ) of 0.5. Sigma (σ) does not have a value which can be set, but it can be replaced with a bandwidth value (b), namely 1. Wavelength (λ) here has a value> 0. The degree of orientation or tetha (θ) has a value between 0° - 360°. If all Gabor filters with wavelength variation (λ) and the degree of orientation (θ) differ applied to a certain point (x, y), then got a lot of response filter to the point, for example: use four wavelengths and eight orientation, it will generated 32 response filter for each image point will be convoluted with the filter.

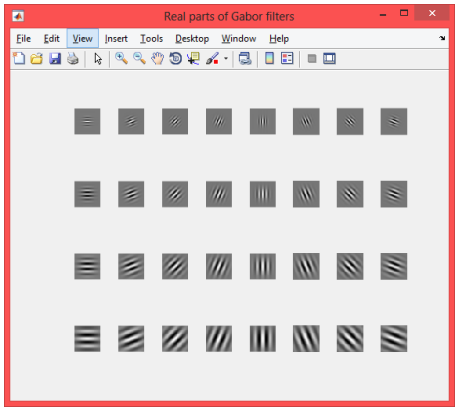


Figure 1 Filter Gabor

2.5 Metode *Support Vector Machines*

Support Vector Machines (SVM) is a classification of types of integrated methods (supervised) because when the training process, required a certain learning targets. SVM is also a working algorithm using nonlinear mappings to change the original training data to a higher dimension. In this case a new dimension, will seek hyperplane to separate linear and nonlinear mapping the right to a dimension that is high enough, the data from the two classes can always be separated by the hyperplane. SVM find this hyperplane using support vector and margin [10].

SVM first appeared in 1992 by Vladimir Vapnik and colleagues Bernhard Boser and Isabelle Guyon. The basis for the SVM has been around since the 1960s (including early work by Vapnik and Alexei Chervonenkis on statistical learning theory).

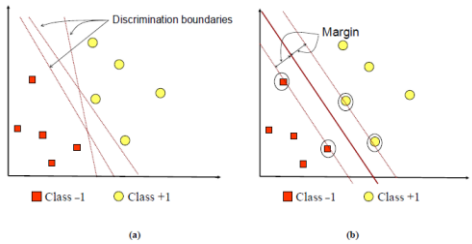


Figure 2 SVM trying to find the best hyperplane which separates the two class -1 and +1

Hyperplane best separator between the two classes can be found by measuring the hyperplane margin and look for maximum points. Margin is the distance between the hyperplane to the nearest pattern of each class. The closest pattern is called a support vector. Solid line in Figure 2-b shows the best hyperplane, which are located right in the middle of the second class, while the red dots and yellow which are in black circle is a support vector. Attempt to find the location of this hyperplane is the core of the learning process on SVM [11].

SVM concepts can be explained simply as an attempt to find the best hyperplane which serves as a separator are two classes in the input space. Figure 2-a shows some patterns that are members of two classes: +1 and -1. Pattern belonging to the class -1 symbolized by the color red (box), while the pattern in the class +1, symbolized by a yellow color (circle). Problem classification can be translated to the business of finding a line (hyperplane) that separates between the two groups. Various alternatives dividing line (discrimination boundaries) shown in Figure 27-a.

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Various alternatives dividing line (discrimination boundaries) are shown in Figure 2 (a). Hyperplane best separator between the two classes can be found by measuring the hyperplane margin and look for maximum points. Margin is the distance between the hyperplane to the nearest pattern of each class. The closest pattern is called a support vector. Solid line in Figure 2 (b) shows the best hyperplane, which is located right in the middle of the second class, while the red dots and yellow which are in black circle is a support vector. Attempt to find the location of this hyperplane is the core of the learning process on SVM. Hyperplane can be defined by the following equation

$$g: w^t + b = 0 \quad (3)$$

The data available notated as $\overrightarrow{x_i} \in \Re^d$ while each label is denoted $y_i \in \{-1, +1\}$ for $i =$

$1, 2, 3, \ldots, l$ where l is the number of data. The second class is assumed to -1 and +1 can be completely separated by a hyperplane dimension d, which is defined

$$\vec{w}.\vec{x} + b = 0 \quad (4)$$

Pattern $\overrightarrow{x_i}$ which includes class -1 (negative samples) can be formulated as a pattern that satisfies inequality,

$$\vec{w}.\overrightarrow{x_i} + b \leq -1 \quad (5)$$

while *pattern* $\overrightarrow{x_i}$ which includes class +1 (positive samples).

$$\vec{w}.\overrightarrow{x_i} + b \leq +1 \quad (6)$$

The largest margin can be found by maximizing the value of the distance between the hyperplane and the closest point, ie $1/\|\vec{w}\|$. It can be formulated as a Quadratic Programming (QP) problem, ie finding the minimum point with regard constraint equation 7 Equation 8.

$$\min_{\vec{w}} \ \tau(w) = \frac{1}{2} \ \|\vec{w}\|^2 \quad (7)$$

$$y_i \ (\overrightarrow{x_i}.\vec{w} + b) - 1 \geq 0 \ , \forall_i \quad (8)$$

This problem can be solved by a variety of computational techniques, including Lagrange Multiplier.

$$L(\vec{w}, b, \alpha) = \frac{1}{2} \ \|\vec{w}\|^2 - \sum_{i=1}^{l} \alpha_i \left(y_i\left((\vec{x}_i.\vec{w} + b) - 1\right)\right)$$

$$i = 1,2,3, \ldots, l \quad (9)$$

α_i is lagrange multiplier, which is zero or positive ($\alpha_i \geq 0$). The optimal value of the equation 9 can be calculated by minimizing L to $\vec{w}$ and b, and maximize L to α_i. With regard to the nature that at the point of optimal gradient L = 0, equation 9 can be modified as a maximization problem that only contains α_i course, as equation 10 below.

Maximize :

$$\sum_{i=1}^{l} \alpha_i - \frac{1}{2}\sum_{i,j=1}^{l} \alpha_i \alpha_j y_i y_j \vec{x}_i \vec{x}_j \quad (10)$$

Subject to :

$$\alpha_i \geq 0 (i = 1,2,3, \ldots, l) \ \ \sum_{i=1}^{l} \alpha_i y_i = 0 \quad (11)$$

From this calculation results obtained α_i the most positive value. Data were correlated with positive α_i is called support vector.

3 ANALYSIS

3.1 System Analysis

This study uses the image feature extraction Gabor Filter and method Support Vector Machines in terms of classification. In this system the analysis phase is devoted in the process of feature extraction and classification of bark, the introduction of the full chart can be seen in figure 3.

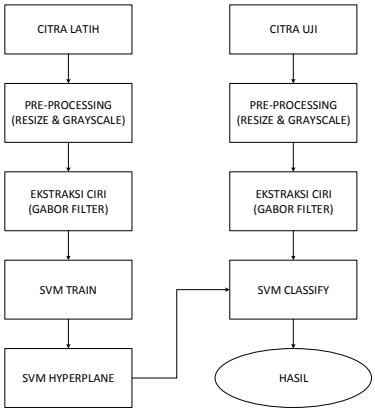


Figure 3 Process Flow System

3.2 Analysis Pre-Processing

Prior to the image feature extraction will be convoluted with Gabor filter, the image must go through the initial processing (pre-processing) advance the same stages, namely: resize ie change the size of the original image to a size of 450 x 600 pixels, and image format conversion (conversion) to grayscale. Grayscale phase is necessary for the process of feature extraction as it only has a single pixel value. The process can not be done if the pixel values of more than one like the original value of an image is RGB.

3.3 Analysis of Gabor Feature Extraction Filters

Extracting characteristic feature is intended to bring out the special characteristics of the image that has been convoluted against Gabor kernel.

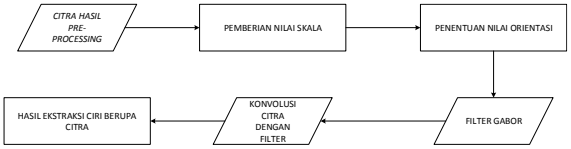


Figure 4 Process Flow of Gabor Feature Extraction

3.4 Analisis Klasifikasi Support Vector Machines

After getting the hallmark of the extraction Gabor filter, then set the classes that will be used by using equations 5 and 6. After specifying the classes that will be used then look for the data which will serve as a support vector with equations 8 and then seek hyperplane with draw some line that separates the two pieces of the class that has been defined by equation 3, and then selected the best hyperplane with distance support vector of each class with a hyperplane has a large margin.

4 IMPLEMENTATION

4.1 Hardware Implementation

The hardware used to implement the system can be seen in Table 1.

Table 1 Hardware Specifications

No.	Hardware	Specification
1.	Processor	Intel i3 2.30 GHz
2	Monitor	Monitor 14" 1366 x 768 (32Bit) (60Hz)
3	VGA	512Mb
4	Memori (RAM)	2GB
5	Keyboard dan Mouse	

4.2 Software Implementation

The software used to build and implement the system can be seen in table 2.

Table 2 Software Specifications

No.	Software	Specification
1.	Operation System	Windows 7, 8, dan 8.1
2	Tools	Matlab R2009 dan selanjutnya
3	Computer Language	Matlab

4.3 System Testing

Scenario testing introduction and classification applications on the tree bark using white box testing and black box. Tests using white box testing focuses on testing that is based on checking the details of the design, using a control structure of the program design is based on a procedural, while the black box testing focuses on functional requirements of software. Scenario testing can be seen in Table 3, which will run on this system.

Table 3 software testing scenarios

Pengunjian	Butir Uji	Jenis Pengujian
Metode *Gabor Filter*	Algoritma Filter Gabor dalam ekstraksi ciri citra dan pengkonvolusian citra.	*White Box*
Metode *Support Vector Machines*	Algoritma *support vector machines* dalam pengklasifikasian citra.	*White Box*
Load Image	Proses pemasukan gambar yang ingin di uji.	*Black Box*
Load Folder Dataset	Proses pemasukan folder dataset yang ingin dilatih	*Black Box*
Proses *Preprocessing*	Proses konversi citra asli ke citra *grayscale* dan pemilihan nilai skala dan orientasi.	*Black Box*
Proses Enroll Dataset	Proses pelatihan citra	*Black Box*
Proses Identifikasi	Proses pendeteksian gambar uji	*Black Box*
Proses *Analysis*	Proses pengecekan keakurasian dari pengujian citra.	*Black Box*

4.4 Performance Testing

Performance testing results based on the speed of time and accuracy in the process of training and testing of data with a total of 75 training dataset fastest and accurate according to Gabor filter parameters, namely the scale and orientation. Can be seen in the graph in Figure 5.

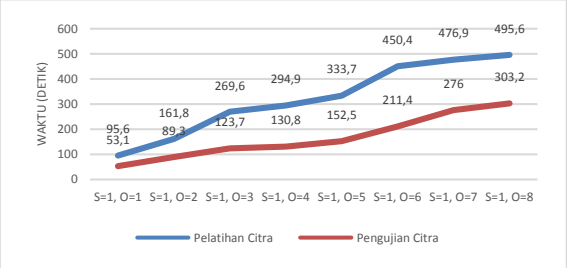


Figure 5 Training time performance graphs and data testing

From the results of performance testing in the figure 5 can be concluded that the practice of testing 75 datasets with Gabor filter parameters ie the smallest scale and orientation, because training can process data quickly than large scale and orientation. And testing is done only until the parameter scale = 1 and orientation = 8. This is due to the influence of the parameters of the Gabor computing time. The greater scale and orientation, the more pixels of the image to

be dikonvolusikan with these parameters. So to get a good performance and efficient use Gabor parameters with scale 1 and orientation 1. Using these parameters can run applications with fast time.

4.5 Accuracy Testing

Results of testing the accuracy of recognition and pengklasifikasin against tree bark can be seen in the following table:

a. Tests based on the images contained in the test folder using Gabor filter parameters are efficient ie scale = 1 and orientation = 1

No	Citra Uji	Hasil Klasifikasi	Hasil Pengujian	Ket
1	alder (1).JPG	Alder	Alder	Berhasil
2	alder (2).JPG	Alder	Alder	Berhasil
3	alder (3).JPG	Alder	Alder	Berhasil
4	banana (1).JPG	Banana	Banana	Berhasil
5	banana (2).JPG	Banana	Banana	Berhasil
6	beech (1).JPG	Beech	Spruce	Gagal
7	beech (2).JPG	Beech	Beech	Berhasil
8	beech (3).JPG	Beech	Beech	Berhasil
9	birch (1).JPG	Birch	Birch	Berhasil
10	birch (2).JPG	Birch	Spruce	Gagal
11	birch (3).JPG	Birch	Birch	Berhasil
12	chestnut (1).JPG	Chestnut	Spruce	Gagal
13	chestnut (2).JPG	Chestnut	Spruce	Gagal
14	chestnut (3).JPG	Chestnut	Chestnut	Berhasil
15	ginkgo_biloba (1).JPG	Ginkgo Biloba	Ginkgo Biloba	Berhasil
16	ginkgo_biloba (2).JPG	Ginkgo Biloba	Ginkgo Biloba	Berhasil
17	ginkgo_biloba (3).JPG	Ginkgo Biloba	Ginkgo Biloba	Berhasil
18	hornbeam (1).JPG	Hornbeam	Hornbeam	Berhasil
19	hornbeam (2).JPG	Hornbeam	Hornbeam	Berhasil
20	hornbeam (3).JPG	Hornbeam	Spruce	Gagal
21	horse_chestnut (1).JPG	Horse Chestnut	Horse Chestnut	Berhasil
22	horse_chestnut (2).JPG	Horse Chestnut	Horse Chestnut	Berhasil
23	horse_chestnut (3).JPG	Horse Chestnut	Spruce	Gagal
24	linden (1).JPG	Linden	Spruce	Gagal
25	linden (2).JPG	Linden	Spruce	Gagal
26	linden (3).JPG	Linden	Linden	Berhasil

27	oak (1).JPG	Oak	Spruce	Gagal
28	oak (2).JPG	Oak	Oak	Berhasil
29	oak (3).JPG	Oak	Beech	Gagal
30	oriental_plane (1).JPG	Oriental Plane	Oriental Plane	Berhasil
31	oriental_plane (2).JPG	Oriental Plane	Oriental Plane	Berhasil
32	oriental_plane (3).JPG	Oriental Plane	Papaya	Gagal
33	papaya (1).JPG	Papaya	Papaya	Berhasil
34	papaya (2).JPG	Papaya	Papaya	Berhasil
35	pine (1).JPG	Pine	Pine	Berhasil
36	pine (2).JPG	Pine	Pine	Berhasil
37	pine (3).JPG	Pine	Spruce	Gagal
38	rimbang (1).JPG	Rimbang	Rimbang	Berhasil
39	rimbang (2).JPG	Rimbang	Rimbang	Berhasil
40	spruce (1).JPG	Spruce	Spruce	Berhasil
41	spruce (2).JPG	Spruce	Spruce	Berhasil
42	spruce (3).JPG	Spruce	Spruce	Berhasil

b. Tests based on input data that is incorrect or not in accordance with the data training.

No.	Citra Uji	Hasil	Keterangan
1	chandraJPG 280 x 340 pixel	Gagal	Dikarenakan pixel gambar tidak sesuai dan juga berbeda objek
2	jagung.JPG 199 x 265 pixel	Gagal	Dikarenakan pixel tidak sesuai walaupun objeknya sesuai
3	original.JPG 400 x 400 pixel	Gagal	Dikarenakan pixel gambar tidak sesuai dan juga berbeda objek
4	osm.PNG 1360 x 768 pixel	Gagal	Dikarenakan pixel gambar tidak sesuai dan juga berbeda objek
5	struktur.JPG 960 x 720 pixel	Gagal	Dikarenakan pixel gambar tidak sesuai dan juga berbeda objek

Based on the accuracy of the test results that have been carried out and resulted in the following data:

Many Data Training : 75
Many Data Testing : 42
Many Data Properly : 30
Many data Wrong : 12

Percentage = Many Data True / Many Data Testing * 100%
= 30/42 * 100%
= 71.4%

So from these data it can be concluded that the percentage of success is performed by the system is 71.4%.

5 CLOSING

5.1 Conclusion

Based on a comparison between the objectives of software development with implementation and testing results, it could be concluded as follows:

1. The application has been successfully implemented in the recognition and classification of the bark, making it easy to identify trees and just kind of image skin only.
2. The results of testing the accuracy of implementation methods Gabor filters and support vector machines in the recognition and classification of bark produces an accuracy of 71.4%.
3. From the test results, system performance is best found on Gabor parameters with scale = 1 and orientation = 1, which resulted in faster processing time than the combined value of other parameters.

5.2 Advice

Apart from the advantages of a software must have shortcomings, and therefore for further development, advice that can be given as follows:

1. To develop applications recognition and classification tree bark in real time.
2. Increase the number of datasets for training around 50.
3. Using the hardware support is more reliable in order to obtain maximum results in using Gabor filters and support vector machines.
4. Application and implementation of this method can be developed in different cases not only bark, but in other fields.
5. For further research may use other methods of feature extraction and classification methods other to get more satisfactory results.

BIBLIOGRAPHY

[1] M. Dra. Irnaningtyas, Biologi untuk SMA/MA Kelas X, Jakarta: Erlangga, 2013.

[2] M. Indriani, "Analisis Tekstur Menggunakan Metode Run Length," Universitas Dipenogoro, Semarang, 2007.

[3] A. J. Arriawati, "Klasifikasi Citra Tekstur Menggunakan k-Nearest Neighbour Berdasarkan Ekstraksi Ciri Metode Matriks Kookurensi," Universitas Diponegoro, Semarang, 2011.

[4] D. E. Kurniawan, "Rancang Bangun Sistem Pengenalan Wajah Menggunakan Filter Gabor," Universitas Dipenogoro, Semarang, 2012.

[5] R. Lim dan R. O. Pantouw.

[6] S. N. Endah dan M. R. Widyanto, "Klasifikasi Pose Skeleton Pada Manusia dengan Support Vector Machines," Universitas Dipenogoro, Semarang, 2012.

[7] Fadlisyah, "Computer Vision dan Pengolahan Citra," Andi, Yogyakarta, 2009.

[8] D. Putra, "Pengolahan Citra," Andi, Yogyakarta, 2010.

[9] J. Domke, "Gabor Filter Visualization," University Of Maryland, Maryland, 2005.

[10] P. P. Widodo, R. T. Handayanto dan Herlawati, Penerapan Data Mining Dengan Matlab, Bandung: Rekayasa Sains, 2013.

[11] A. S. Nugroho, A. B. Witarto dan D. Handoko, "Support Vector Machines - Teori dan Aplikasinya dalam Bioinformatika," IlmuKomputer.Com, 2003. [Online]. Available: asnugroho.net/papers/ikcsvm.pdf. [Diakses 8 Februari 2015].