IMPLEMENTATION OF IMAGE TEXTURE ANALYSIS USING NEIGHBORHOOD GREY TONE DIFFERENT MATRIX METHOD

By

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A project dissertation submitted to the
Electrical & Electronics Engineering Programme
Universiti Teknologi PETRONAS
in partial fulfilment of the requirement for the
Bachelor of Engineering (Hons)
(Electrical & Electronics Engineering)

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CERTIFICATION OF APPROVAL

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Approved:

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Project Supervisor

UNIVERSITI TEKNOLOGI PETRONAS
TRONOH, PERAK

June 2006

CERTIFICATION OF ORIGINALITY

This is to certify that I am responsible for the work submitted in this project, that the original work is my own except as specified in the references and acknowledgements, and that the original work contained herein have not been undertaken or done by unspecified sources or persons.

Norhidayah binti Jamaludin

ACKNOWLEDGEMENT

Firstly, I would like to grant my gratitude to God for giving me the strength and enlighten every step that I had taken in order for me to complete this project and for making it possible in the first place.

I also would like to express my appreciation especially to my supervisor, Ms. Azrina bt. Aziz for guiding me throughout the whole project. She had done a great job as my supervisor and she is supportive during the whole time needed to complete the whole case study. Despite the packed schedule that she has to endure, she still spares some time and energy to lead me all the way.

My gratitude also goes towards all lecturers and technicians who were willing to help me in every way that they can in the area of their specialty. The helps and knowledge that they offer were very valuable in completing this project.

Finally yet importantly, this gratitude goes towards all my colleagues, friends, and any individuals who were directly or indirectly involve in assisting me throughout the whole project.

ABSTRACT

Texture has found in wide application in image processing and it is commonly agreed that texture analysis plays a fundamental role in classifying objects or images. Two approaches have evolved over the years for texture analysis, which are called statistical and structural analysis. In recent studies, the texture classification and discrimination usually approached by using statistical analysis. Therefore, this project is carried out to distinguish the application of statistical analysis especially in the approach of Neighborhood Grey Tone Different Matrix (NGDTM) in image classification. This project presents the NGTDM approach of image texture analysis by using MATLAB. Thus, three types of texture selected, which consist of thirty images respectively, are analyzed using the algorithm of first and second order statistic developed in MATLAB. First order statistic extracts the statistical parameters from the image and second order statistic specifically NGTDM emphasizes on the intensities of neighboring pixels. The first and second order characteristics of each image are varying to each other, which are lead to the classification of texture. As a result, each of the input images is successfully classified regarding to its type of texture. Future work on image classification can be conducted for the use of application, such as medical image processing and remote sensing community.

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CHAPTER 1
INTRODUCTION

Texture is the term used to characterize the surface of a given object or phenomenon and it is definitely one of the main features in image processing and pattern recognition [1]. It is commonly agreed that texture analysis plays a fundamental role in classifying objects and outlining the significant regions of a given grey level image. Therefore, this chapter outlined the background study of image texture analysis together with the objectives and the scope of the project.

1.1 Background of study

The word texture originally referred to the appearance of a woven fabric, but a general definition is the arrangement or characteristic of the constituent elements of anything, especially as regards surface appearance or fictile qualities. Another definition described texture is an attribute representing the spatial arrangement of the gray levels of the pixels in region [3]. Texture can be seen in images ranging from multispectral remote sensed data to microscopic images. Texture can be classified in term of deterministic and stochastic manner. In deterministic manner, texture is describes as a being generated by one or more basic local pattern that are repeated in a periodic manner over some image region. The examples of deterministic type of images are line arrays, checkerboards and hexagonal tiling. On the other hand, images like the one identified in an aerial photograph of the earth does not seem to possess an isolatable basic pattern or a dominant repetition frequency and instead, they possess some stochastic structure. Figure 1.1 shows the image of checkerboard, which possesses deterministic type of texture while Figure 1.2 shows the image of computer graphic, as an example of stochastic texture.

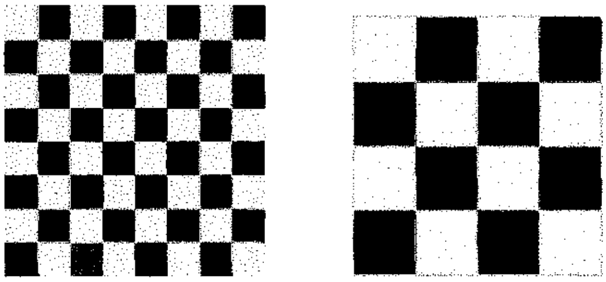

Figure 1.1: Checkerboard images [4]

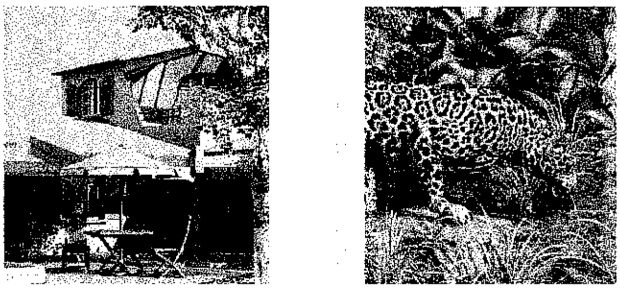

Figure 1.2: Computer graphic images [5]

Since there are two types of texture, therefore it should be expected that two different approaches would have evolved over the years for the image texture analysis. The two approaches indeed crystallized over the years are called statistical and structural approach. Statistical approach defines texture in term of local-grey level statistics, which are constant, or slowly varying over a textured region. Different textures can be discriminated by comparing the statistics computed over different sub-regions. While, the other approach, which are called structural, is assumes that the texture pattern is composed of a spatial arrangement of texture primitive. Both of the method analyzes the stochastic and deterministic texture respectively. Statistical and structural methods are complementary. While statistical features measure grey value variations in image neighborhood, structural features explicitly characterize properties of texture primitives, such as their size and shape. Therefore, structural methods are more appropriate for computing the coarseness of an image and for deciding if an image with that coarseness really is textured. Statistical texture analysis methods can then be used to classify or segment the detected textured region [6].

This project outlines the significance of statistical approach in the analysis and classification of the images. This method is chosen in this project because it describes texture which are more random (stochastic) in nature and concerned with relations in space and distribution of grey levels compare to the structural method. In some application, most of the image is considered as stochastic, for examples, aerial images, which are obtained from aircraft or satellite platform, and microscopic images of cell cultures or tissue sample. Therefore, a statistical approach is more appropriate to use in analyzing and classifying an image rather than structural approach. Furthermore, it is more practical and easier to perform the texture analysis using statistical method rather than structural, since structural approach is based on variations in density and arrangement of material. Another advantage of statistical approach is they are generally good for micro textures compare to the structural techniques [7], which lead to the accuracy of the analysis.

1.2 Problem Statement

Texture has found wide applications in image processing and it is commonly agreed that texture analysis plays fundamental role in classifying objects and images [6]. In recent studies, the texture classification and discrimination is usually approached by using some statistical methods for extracting the characteristic parameters. Therefore, this project is carried out to distinguish the application of statistical approach in image classification. Statistical approach extracts a set of parameters from a given image and it consists of first and second order statistic, which focuses on Neighborhood Grey Tone Different Matrix approach. There are some advantages of using statistical approach, which are, statistical approach defined stochastic (random) texture and it is generally good in micro textures.

This project presents the statistical approach of image texture analysis by using MATLAB. Images from different texture are analyzed using first and second order algorithm developed in MATLAB. It is necessary to analyze and classify different types of texture before implementing the algorithm to other application such as medical image processing.

1.3 Objectives and scope of study

1.3.1 Objectives

This project aims to achieve the following objectives:

1.3.1.1 To be able to develop the algorithms for first and second order statistic, specifically Neighborhood Grey Tone Matrix (NGTDM) using MATLAB.

1.3.1.2 To be able to verify the first and second order statistic algorithms developed in MATLAB.

1.3.1.3 To be able to analyze different types of texture using the algorithm developed.

1.3.1.4 To be able to classify the image characteristic regarding to its type of texture.

1.3.1.5 To be able to perform statistical approach of image texture analysis in MATLAB

1.3.2 Scope of study

This project is focuses on two parts, which are algorithm development as well as image analysis and classification.

The development of the algorithm involved two parts; developing an algorithm for first order statistic and second order statistic (NGTDM). Both algorithm is developed and simulated in MATLAB.

Then, it is follows by image analysis and classification of the sample images. In this project, there are three types of texture selected, which are called Brodatz, Aerials and Computer Graphic [5]. Each of the texture consists of thirty images respectively; each of the images will be analyzed using the first and second order algorithm developed in MATLAB. Based on this result, each sample images will be classified regarding to its type of texture.

The implementation of image texture analysis is shown in the Figure 1.3.

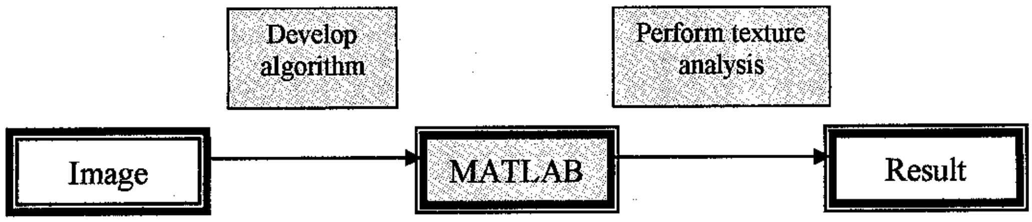

Figure 1.3: Flow of the project

Figure 1.3 shows the flow of the project where the sample images will be fed into MATLAB software and these images will be analyzed using the statistical algorithm that has been designed in MATLAB file editor. The parameters obtained from this analysis will be used as input features for the classification of the image. The result will displayed in MATLAB command window and with the use of Microsoft Excel, the result for each sample images will be tabulated in graphical representation.

CHAPTER 2
LITERATURE REVIEW

The most formal definition to characterize texture has been given in the introduction. One definition characterizes textures as visual images, which possess some stochastic structure. The other definition described a texture as being generated by one or more basic local patterns that are repeated in periodic manner over some image region [1]. As a result of this dichotomy, two different approaches would have evolved over the years for the image texture analysis. The two approaches are called statistical and structural and they analyze the stochastic or repetitive structure of texture, respectively. Therefore, this chapter will discuss on the basic concept of two approaches applied in image texture analysis.

2.1 Structural Approaches

Pure structural models of texture are based on the view that textures are made up of a set of primitive which are appear in regular and repetitive arrangement. It then described the texture as a combination of such primitives according to different placement rules [8]. The choices of which primitive to be chosen and the probability of the chosen primitive being placed at particular location can be strong or weak function of primitive location in the texture. However, this approach has faced some difficulties especially in identifying the primitive in the texture unless the texture is artificial and not too complex [3]. Practically, texture will have much more complex primitives and they will not be precisely reproducible from one texel to the next, therefore, this method is considered to be more complicated and it involves arrangement. Therefore, structural approach is not yet widely used. Carlucci, who defined texture language for polygon recognition, suggests a texture model using primitives of line segment, open polygons and closed polygon, gives an early example of structural approach [9].

2.2 Statistical Approaches

The statistical approach defines texture in term of local grey level statistic, which extracts a set of parameters from a specified image. The parameters obtained are then used as the input features for classification of the image. Statistical approaches can be divided into four groups, which are; visual perception, co-occurrence, linear transform and finally model fractal based methods.

2.2.1 Visual Perception Based Method

Visual perception approach is based on the second order statistic of the image. It relates with the intensities of neighboring pixels and their spatial relationship [10]. The approach used to emphasize the properties is Neighborhood Grey Tone Different Matrix, which defines five-texture measures, which are coarseness, busyness, contrast, complexity and texture strength.

2.2.2 Co-occurrence Based

The occurrence matrix represents the joint probability distribution of pairs of grey level intensities. From this matrix texture features may determined. There are two approaches is used which are Spatial Grey Level Different Matrix (SLGDM) and Grey Level Different Statistic.

2.2.3 Linear transform Based Methods

By using this method, the texture primitives are extracted in the transform domain instead of the spatial domain. The Fourier Transform is the obvious choice; a spectrum, which is concentrated near the origin at low frequencies, represents a coarse texture whereas one, which is predominantly at higher frequencies, is a fine or busy texture [10].

2.2.4 Model Fractal Based Methods.

Fractal image is categorized as an image whose geometry has a structure, which is invariant over certain finite magnifications. The most significant parameter in fractal geometry is the fractal dimension, which is a non-integer number [10].

2.3 First Order Statistic

First order statistic are conceptually simple, thus it possibly will provides some imprecise value in texture information. However, the first order statistic is used to pre processing step of the image before applying the Second order statistic specifically Neighborhood Grey Tone Different Matrix. The properties that are frequently used are mean, variance, coarseness, skew as well as kurtosis. Each of these properties is obtained from histogram of the image.

However, texture measures using the histogram only do not take the neighborhood relations between pixels into consideration. Therefore, second order statistics need to be used.

Let b are random variable representing the pixel intensity $0 \le b \le L-1$, where L is the number of distinct grey level; and let $P(b)$ be the corresponding histogram of the image, that defined such that if $N(b)$ is the number of pixels of intensity b in the image and M is the total number of pixel in the image [10].

Thus, the corresponding histogram of the image is described as:

$$P(b) = N(b) / M$$

The first four moments defined as;

2.3.1 Mean $$m = \sum_{b=0}^{L-1} bP(b) \qquad [2.1]$$

The mean indicates the average grey level of the image. Grey level refers to the pixel intensity within the range of 0 to 255.

2.3.2 Variance $$\sigma^2 = \sum_{b=0}^{L-1} (b-m)^2 P(b) \qquad [2.2]$$

The variance gives the average of the square of the distance of each data point from the mean. A texture with a small variance represents one in which the image tends to be relatively smooth.

2.3.3 Coarseness $$= 1 - \frac{1}{1+\sigma^2} \qquad [2.3]$$

A measure of the coarseness of a texture may be defined in terms of the variance. Small value of coarseness indicates the texture, which is tend to be relatively smooth.

2.3.4 Skew $$\text{skew} = \frac{1}{\sigma^3} \sum_{b=0}^{L-1} (b-m)^3 P(b) \qquad [2.4]$$

Skewness is a measure of the asymmetry of the probability distribution of a real - valued random variable. This property is obtained from the histogram.

2.3.5 Kurtosis $$\text{Kur} = \frac{1}{\sigma^4} \sum_{b=0}^{L-1} (b-m)^4 P(b) \qquad [2.5]$$

Kurtosis is a measure of the peaked ness or sharpness of the surface.

Other first order statistics are:

2.3.6 Energy $$\text{eng} = \sum_{b=0}^{L-1} \left[P(b)^2\right] \qquad [2.6]$$

Energy refers to probability of occurrence grey level in the image. It depends on the histogram of the image. Large values of energy correspond to homogenous regions.

2.3.7 Entropy $$etp = \sum_{b=0}^{L-1} P(b) \log\left[P(b)\right] \qquad [2.7]$$

Entropy indicates measure of randomness or disorder of a system. Large values of entropy imply more uniform distribution of grey levels.

2.3.8 Median

$$med = k \text{ when } \sum_{b=0}^{k-1} P(b) = \sum_{b=k}^{L-1} P(b) = \frac{1}{2} \qquad [2.8]$$

The median is one of several indices of central tendency that statisticians use to indicate the point on the scale of measures where the population is centered. It gives the value of the middle grey level.

2.3.9 Mode

$$mod = k \text{ when } P(k) \geq P(b) \text{ for } 0 \leq b \leq L-1 \qquad [2.9]$$

The mode is the most frequently occurring grey level in a distribution and is used as a measure of central tendency.

2.4 Second Order Statistic: Neighborhood Grey Tone Difference Matrix (NGTDM)

Visual perception is in general based on the second order statistic of the image. Human vision tends to classify textures in terms of properties like coarseness, contrast, roughness and directionality. These are related to the intensities of neighboring pixels difference matrix to emphasize these properties. Using this approach, a number of texture measures can be defined [10].

If i be the grey level at (x,y) then the average grey level over a neighborhood centered at (x,y) is :

$$A_j = A(x,y) = \frac{1}{W-1} \sum_{m=-d}^{d} \sum_{n=-d}^{d} (x+m, y+n) \qquad (m,n) \neq (0,0) \qquad [2.10]$$

Where d denotes the neighborhood size and $W = (2d+1)^2$

The i^{th} element in the NGTDM is

$$s(i) = \begin{cases} \sum |i - A_i| & \text{for } \; i \in S_i \; \text{ if } \; S_i \neq 0 \\ 0 & \text{otherwise} \end{cases} \qquad [2.11]$$

Where $\{Si\}$ is the set of all pixels having grey levels i within the computation window.

Five texture features may now be defined as:

2.1.2.1 Coarseness

$$coas = \left[\varepsilon + \sum_{i=0}^{L-1} P_i s(i) \right] \qquad [2.12]$$

A high value of coarseness corresponds to a fine texture. ε is a small number used to prevent '*coas*' from becoming infinite.

2.1.2.2 Contrast

$$cont = \left[\frac{1}{N_g(N_g - 1)} \sum_{i=0}^{L-1} \sum_{j=0}^{L-1} P_i P_j (i-j)^2 \right] \left[\frac{1}{n^2} \sum_{i=0}^{L-1} s(i) \right] \qquad [2.13]$$

A high value indicates large variations in intensity locally.

2.1.2.3 Busyness

$$busy = \left[\sum_{i=0}^{L-1} P_i s(i) \right] \left[\sum_{i=0}^{L-1} \sum_{j=0}^{L-1} \left| iP_i - jP_i \right| \right]^{-1} \quad P_i \neq 0, P_j \neq 0 \qquad [2.14]$$

A high value indicates rapid changes in texture.

2.1.2.4 Complexity

$$comp = \sum_{i=0}^{L-1} \sum_{j=0}^{L-1} \frac{|i-j| (P_i s(i) + P_j s(j))}{n^2 (P_i + P_j)} \qquad [2.15]$$

Complexity is a measure of the information content of the texture.

2.1.2.5 Texture strength

$$txts = \left[\sum_{i=0}^{L-1} \sum_{j=0}^{L-1} (P_i + P_j)(i-j)^2 \right] \left[\varepsilon + \sum_{i=0}^{L-1} P_i s(i) \right]^{-1} \qquad [2.16]$$

A strong texture corresponds to one where the texels are clearly identifiable.

CHAPTER 3
METHODOLOGY AND PROJECT WORK

In this chapter, the procedure taken to implement this project will be described which involved the design procedure; tools identification as well as problem encountered during implements this project.

3.1 Design stage

There are few steps of systematic approach applied in implementing this project, which is represented by Figure 3.1.

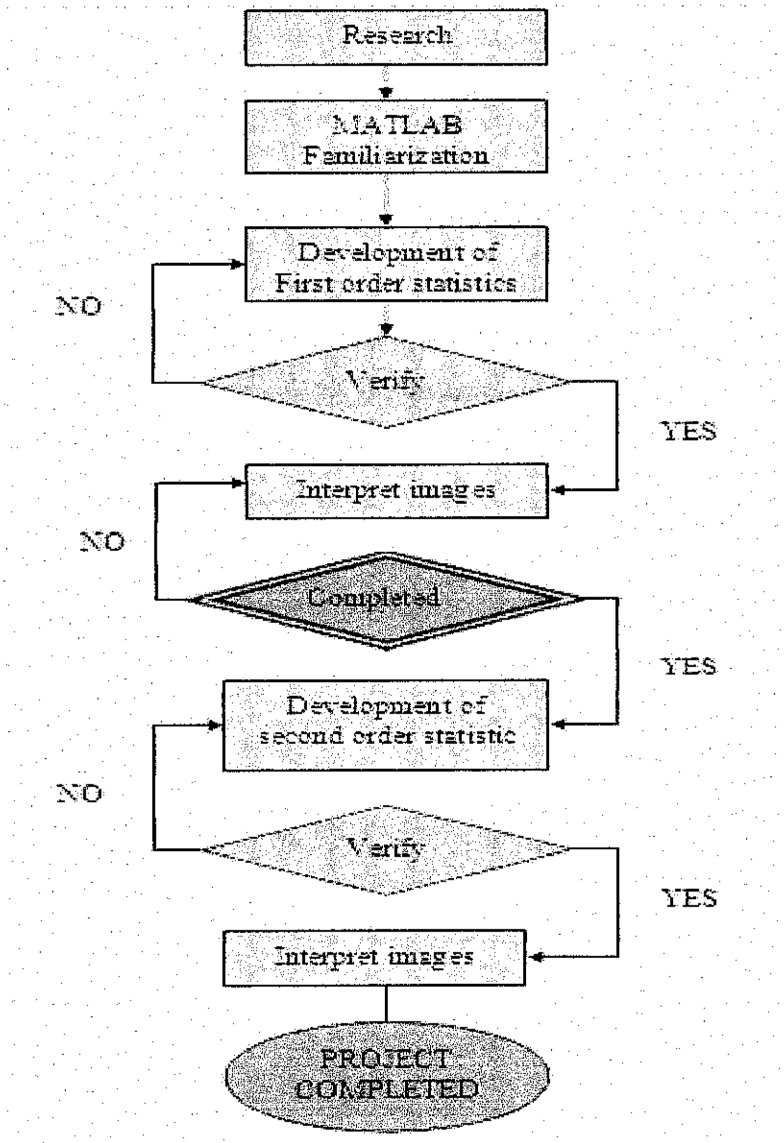

Figure 3.1: Design stage of image texture analysis

3.1.1 Research

Research is the initial and main stage of the project development process. At this stage, firm understanding and planning on the project is considered. Thus, this stage aids the author to predetermine the problem, objectives, scope of study, tools, and development flow as well as problem analysis throughout the project execution.

3.1.1.1 Images selection

In order to distinguish the statistical approach in image classification, there are three types of texture selected in this project, which are Brodatz, Aerials and Computer Graphic. Each of the texture presents thirty images respectively. All of the images are obtained with permission from http://sipi.usc.edu/database/ and other related website. The description for every image used is attached in Appendix B.

3.1.2 Tools identification

The required tools for this project are identified at this stage. The software that is important for this project is MATLAB and Microsoft Excel. MATLAB is used as port output of the algorithm while Microsoft Excel is used to represent the data in graphical representation. Statistical approach of image texture analysis will be presented in MATLAB; therefore, it is necessary for the author to be familiar with MATLAB features.

Functions used in MATLAB are:

3.2.2.1 imread

Imread is MATLAB function that used to read the input images in graphics file. This function is used in this project to read the input image.

3.2.2.2 imshow

Imshow is another MATLAB function used in this project in order to display the input image.

3.2.2.3 imhist

Imhist displays a histogram for the intensity image, *I* whose number of bins is specified by the image type. It used in determining the first order characteristic.

3.1.3 Development of algorithm

After conducting researches and identifies the tools used in this project, it is required to develop the first and second algorithm in MATLAB. Description on development of first and second order algorithm will be discussed in next section.

3.1.3.1 First order statistic

First order statistic is necessary pre-processing step before applying the second order statistic. It emphasizes on pixel distributions of the grey levels image via histogram equalization. The features extracted from first order statistic are the mean, variance, coarseness, skew ness, kurtosis, energy, entropy, median and mode. Each of the features represented by different equation respectively as stated in Chapter 2.

First order algorithm developed in MATLAB is created based on their equation.

The first order algorithm developed in MATLAB is attached in Appendix A1.

3.1.3.2 Second order statistic

Neighborhood Gray Tone Different Matrix (NGTDM) is selected to be the second order statistic used in this project. It concentrates on relationship of neighboring pixels within the images. Using this approach, five texture measures can be defined which are, coarseness, contrast, busyness, complexity and texture strength. Each of the elements in second order statistic represented by equations stated in Chapter 2. Similar to first order statistic, the second order algorithm is created in MATLAB based on their equation.

The first order algorithm developed in MATLAB is attached in Appendix A2.

3.1.4 Verification of algorithm

After both algorithms are developed, it is necessary to verify these algorithms using a sample array. The verification of the algorithm is done to ensure that the algorithm is correct before any images can be analyzed.

3.1.4.1 First order statistic

The algorithm of first order statistic can be verified by calculating the first order characteristic of the sample array. The result is then compared to the simulation result, which has been computed by MATLAB.

The calculation is done based on the equation specified in Chapter 2.

In this case, the sample array specified is I = [1 2 3 4 5].

The MATLAB code for verification of first order statistic is attached in Appendix A3.

3.1.4.2 Second order statistic

Verification is done by running sample array extracted from [10] and comparing the result implemented by MATLAB with the result specified in [10].

The sample array specified is,

I = [0 0 2 2 0 0 ; 0 0 2 2 0 0 ; 0 0 2 2 0 0 ; 0 0 2 2 0 0 ; 0 0 2 2 0 0 ; 0 0 2 2 0 0]

The MATLAB code for verification of first order statistic is attached in Appendix A4

3.1.5 Image Interpretation

As mentioned before, there are three types of texture used in this project. Each of them represents 30 images. Each of the images will be analyzed using the first and second order algorithm developed in MATLAB. First and second order characteristics of each image are computed by MATLAB and the result is then recorded in Microsoft Excel according to its type of texture. Each types of texture will produce a set of range for every statistical properties stated before. By using this range, the image is classified according to its types of texture.

The MATLAB code for image classification is attached in Appendix A1 and Appendix A2.

CHAPTER 4
RESULTS

This chapter indicates the result of the project work done by the author. The project work involved the development of the algorithm in MATLAB and analyzing the statistical characteristic of three types of image texture.

4.1 Project Work 1: Verification of Algorithm

Refer to the previous report, it is stated that the author has completed the task on developing first and second order statistic algorithm in MATLAB.

The verification of the algorithm is done to ensure that the algorithm is correct before any images can be analyzed.

4.1.1 Verification of First Order Statistic (FOS)

Verification of first order statistic is done by calculating first order characteristic of the sample array and compare with the result computed by MATLAB.

The sample array of the first order statistic is I = [1 2 3 4 5].

Result:

FOS	MATLAB Simulation	Calculation	Error (%)
Mean	45	45	0
Variance	26940	26940	0
Coarseness	1.0000	1.0000	0
Skew	-0.2586	-0.2586	0
Kurtosis	0.0670	0.0670	0
Energy	9.0000	9.0000	0
Entropy	1.4314	1.4314	0

Table 4.1: Verification of first order statistic

Calculation method:

Input array: y = [1 2 3 4 5]

[a c] = size(y)

a = 1; c = 5;

M = a*c = 5

N = sum(y) = 1+2+3+4+5 = 15

P = N/M = 15/5 = 3

1. Find mean $m = \sum_{b=0}^{L-1} bP(b) = 3[1 + 2 + 3 + 4 + 5] = 3(15) = \mathbf{45}$

2. Find variance $\sigma^2 = \sum_{b=0}^{L-1} (b-m)^2 P(b) = 8830(3) = \mathbf{26490}$

3. Find coarseness $coas = 1 - \frac{1}{1+\sigma^2} = 1 - 0.00003775 = \mathbf{1.000}$

4. Find skew ness $skew = \frac{1}{\sigma^3} \sum_{b=0}^{L-1} (b-m)^3 P(b) = \frac{-371700(3)}{\left(\sqrt{26490}\right)^3} = \mathbf{-0.2586}$

5. Find kurtosis $kur = \frac{1}{\sigma^4} \sum_{b=0}^{L-1} (b-m)^4 P(b) = \frac{15664354(3)}{\left(\sqrt{26490}\right)^4} = \mathbf{0.067}$

6. Find energy $eng = \sum_{b=0}^{L-1} \left[P(b)^2\right] = 3^2 = \mathbf{9}$

7. Find entropy $etp = \sum_{b=0}^{L-1} P(b) \log\left[P(b)\right] = 3(0.47712) = \mathbf{1.4314}$

4.1.2 Verification of Second Order Statistic(SOS)

Verification is done by running sample array extracted from [10] and comparing the result implemented by MATLAB with the result specified in [10].

The sample array specified is

I=[0 0 2 2 0 0;0 0 2 2 0 0;0 0 2 2 0 0;0 0 2 2 0 0;0 0 2 2 0 0;0 0 2 2 0 0]

The result of the simulation is tabulated in the table below :

SOS	Actual Result	MATLAB	Error (%)
Coarseness	0.16667	0.1666	0.04
Contrast	0.75000	0.7481	0.25
Busyness	1.50000	1.5120	0.8
Complexity	1.50000	1.4570	2.87
Texture strength	0.66670	0.666	0.10

Table 4.2: Verification of second order statistic

4.2 Project Work 2: Performing image texture analysis

In performing image texture analysis, there are three types of texture is selected namely Brodatz, Computer Graphic and Aerial. Each of the texture group consists of 30 images respectively. Each of the image represent different stochastic characteristic, which could be described using the first and second order algorithm developed in MATLAB. There are two stages involved in performing image texture analysis, first is determining the first order characteristic and secondly, determining the second order characteristic for every image in each type of texture .

4.2.1 First order statistic

The description and the image of three different textures are attached in Appendix B.

The result for analyzing first order characteristic of 30 images from each type of texture is shown in the Appendix C.

Table 4.3 Average value of first order statistic for three different textures.

FOS	Brodatz	Aerials	Computer Graphic
Mean	144.2922	151.7689	119.7328
Variance	3351.8250	919.1143	3707.5890
Coarseness	0.9985	0.9984	0.9996
Skew	-0.6307	-0.0856	0.0984
Kurtosis	4.8715	2.8405	2.3660
Energy	0.0161	0.0125	0.0067
Entropy	-2.0152	-1.9924	-2.2602
Median	148.3667	152.3333	115.2667
Mode	151.0333	153.4333	134.9000

The first order characteristic for three type of texture, is displayed below :

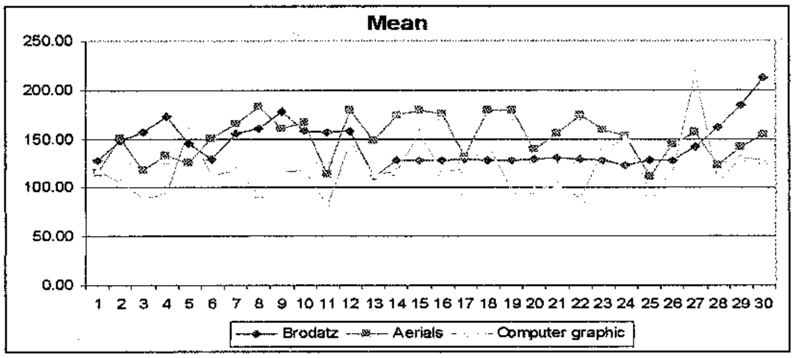

Figure 4.1: Mean

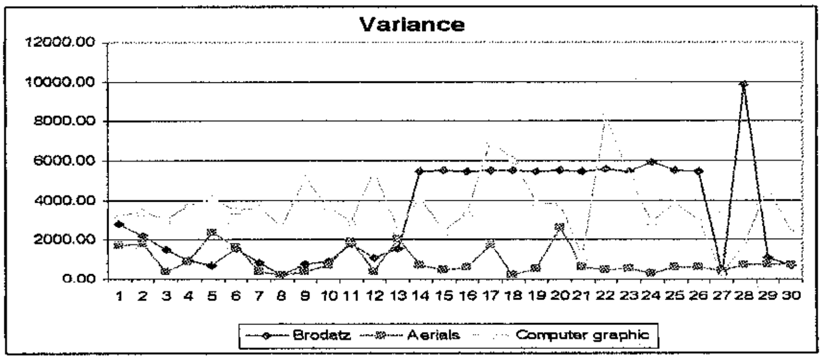

Figure 4.2: Variance

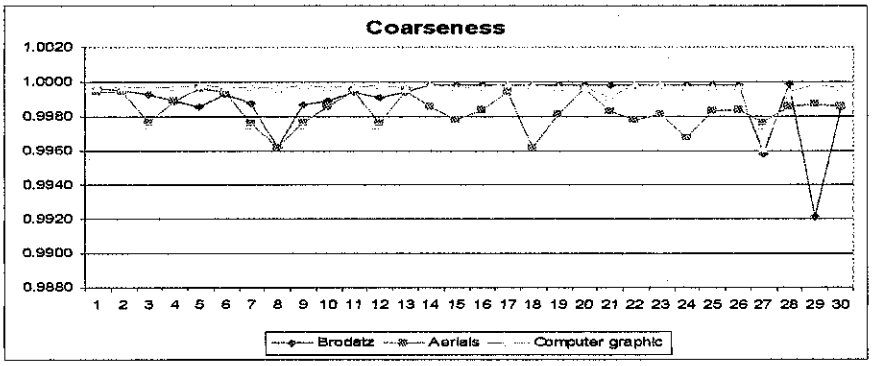

Figure 4.3: Coarseness

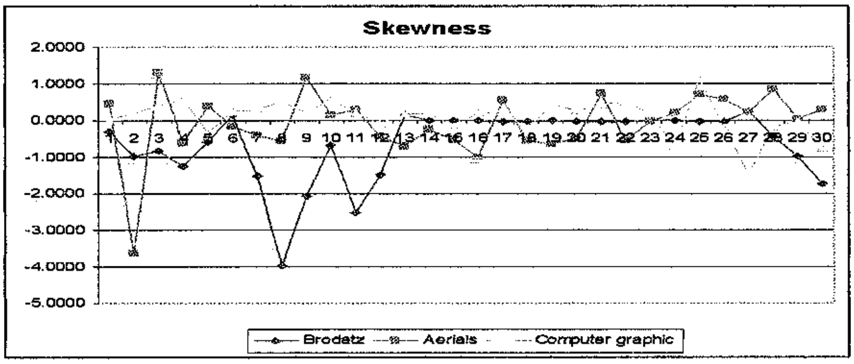

Figure 4.4: Skewness

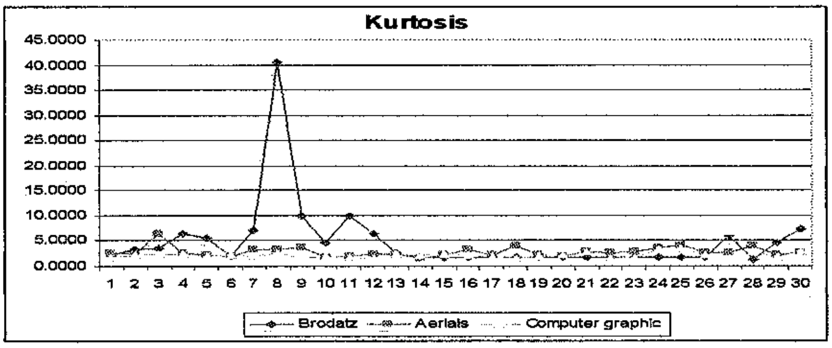

Figure 4.5 : Kurtosis

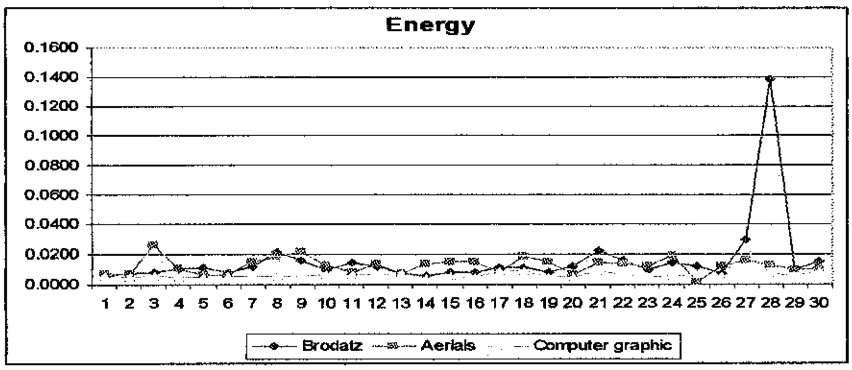

Figure 4.6 : Energy

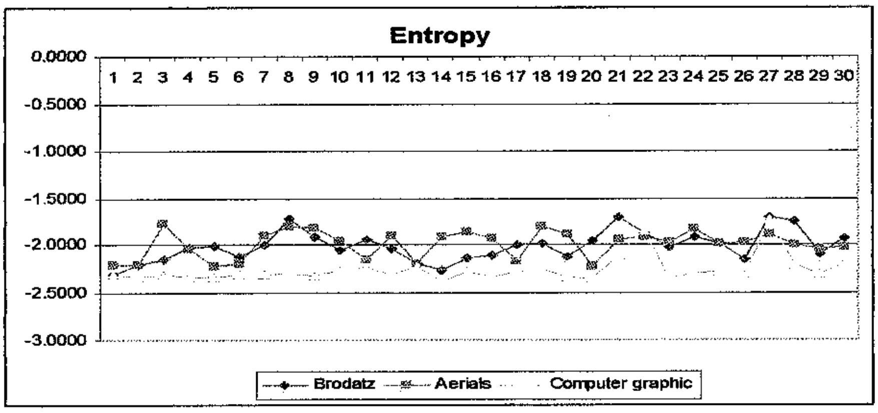

Figure 4.7 : Entropy

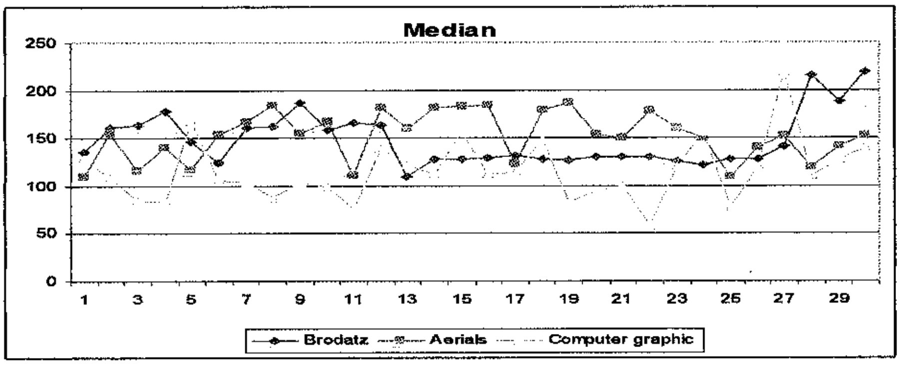

Figure 4.8 : Median

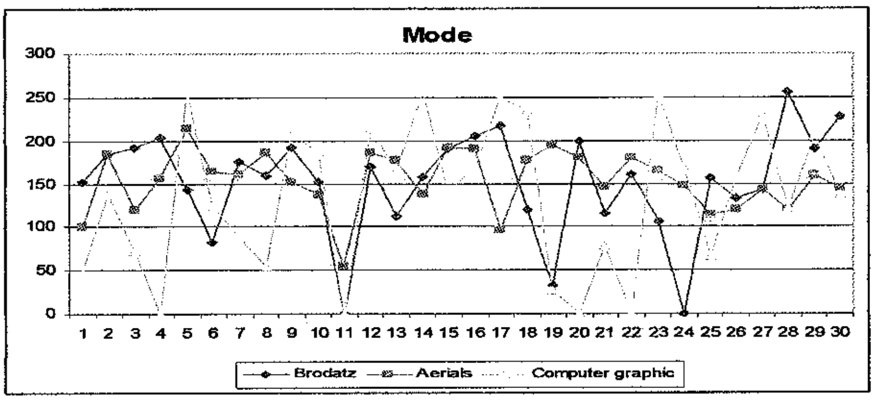

Figure 4.9 : Mode

4.2.2. Second Order Statistic (SOS)

The result for analyzing the second order statistic for each type of texture is attached in Appendix D.

Table 4.4 shows the average value of second order statistic for three types of texture selected.

Table 4.4 Average value of second order characteristic for three different textures.

SOS	Brodatz	Aerials	Computer Graphic
Coarseness	8.7169E-06	9.5740E-06	2.0596E-05
Contrast	8.8200E-05	9.8267E-06	1.5310E-05
Busyness	1.6407	0.9491	0.7077
Complexity	0.0698	0.0054	0.0034
Texture strength	3.5221	3.6421	5.3877

The second order characteristic for three type of texture, is displayed below

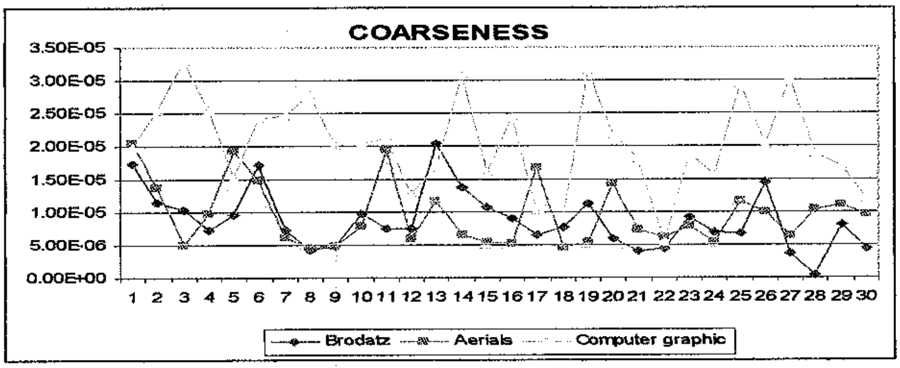

Figure 4.10 : Coarseness

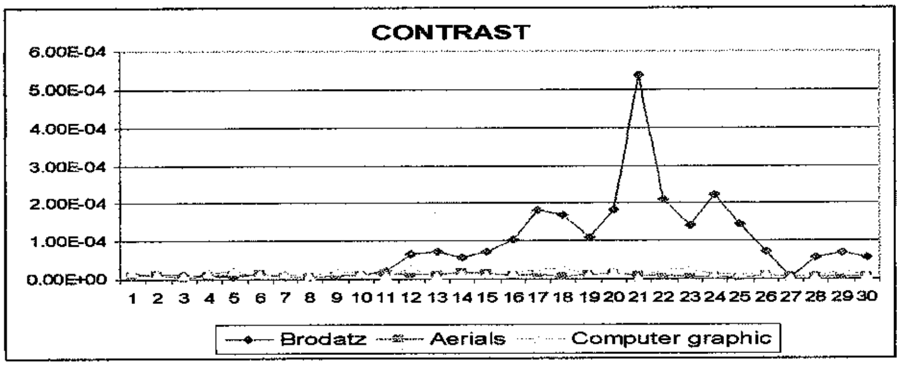

Figure 4.11 : Contrast

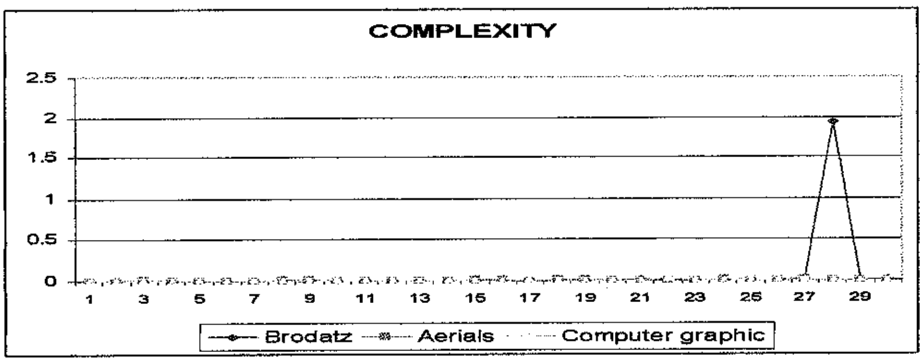

Figure 4.12 : Complexity

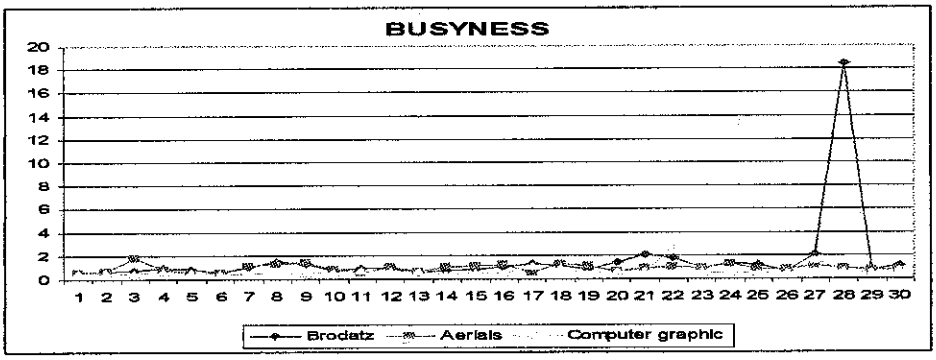

Figure 4.13 : Busyness

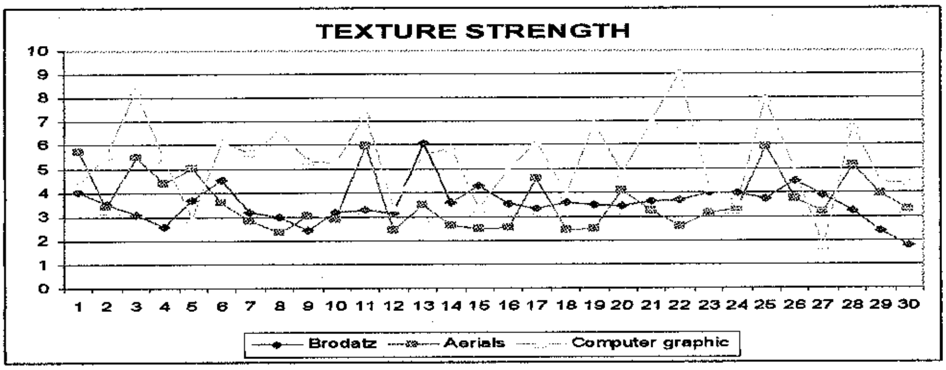

Figure 4.14 : Texture strength

4.3 Image classification

After performing first and second order statistic, all the image is successfully classified according to their type of texture. Each of the texture represents different range value for every element in first and second order statistic.

Table 4.5 summarizes the range value of first order elements for the three types of texture. The image is classified based on their range of value for each element in first order statistic.

Table 4.5: Range values for first order elements

FOS	Brodatz	Aerials	Computer Graphic
Mean	110 – 213	111 – 184	81.1 – 216.2
Variance	235 – 9870	259 – 2616	254.5 – 8320
Coarseness	0.992 – 0.9999	0.996 – 0.9996	0.996 – 0.9999
Skew	-3.98 – 0.256	-3.624 – 1.316	-1.47 – 1.14
Kurtosis	1.43 – 41	1.64 – 6.52	1.55 – 6.91
Energy	0.0055 – 0.14	0.0012 – 0.027	0.0042 – 0.024
Entropy	-2.31 – (-1.69)	-2.232 – (-1.772)	-2.3825 – (-1.73)
Median	109 – 220	109 – 188	57 - 220
Mode	0 – 255	55 - 216	0 - 255

The range value for second order elements are described in Table 4.6.

Table 4.6: Range values for second order elements.

SOS	Brodatz	Aerials	Computer Graphic
Coarseness	3.7E-7 - 2.06E-5	4.5E-6 - 2.04E-5	5.3E-6 - 3.29E-5
Contrast	2.70E-6 - 5.37E-4	3.24E-6 - 1.98E-5	4.13E-6 - 2.97E-5
Busyness	0.55 - 18.52	0.54 - 1.8133	0.42 - 2.55
Complexity	0.00087 - 1.938	0.0009 - 0.019	0.00042 - 0.0452
Texture strength	1.77 - 6.07	2.33 - 5.97	1.7225 - 9.074

The MATLAB simulation result for Brodatz, Aerial and Computer graphic is attached in Appendix E.

CHAPTER 5

DATA ANALYSIS AND DISCUSSION

This chapter discusses on the result attached in Chapter 5. It involves data analysis and as well, as image interpretation.

5.1 Verification of algorithm

In order to perform image texture analysis, it is required to develop first and second order algorithm in MATLAB. Thus, to ensure the accuracy, the algorithm developed should be verified before it can be used in analyzing the images.

5.1.1 First Order Statistic

Table 4.1 represents the result on verification of first order statistic. The sample array specified is I = [1 2 3 4 5]. From the result in Table 4.1, the calculation value is similar as the simulation result in the MATLAB. This is proof that the first order algorithm developed by the author is correct. There is 0% error in the first order statistic, which is probably gives accurate data for analysis.

5.1.2 Second order Statistic

Table 4.2 shows the comparison between actual result and MATLAB simulation result when the sample array, *I* is fed into the algorithm developed in MATLAB. As a result, the MATLAB simulation result is slightly different compared to actual result, which leads to the error. Highest error found in determining contrast, busyness and complexity. However, the error value obtained is quite small, thus the MATLAB code is acceptable to use in analyzing an image.

5.2 Performing image texture analysis

In performing image texture analysis, there are three types of texture is selected namely Brodatz, Aerial and Computer Graphic. Each of the texture group consists of 30 images respectively. Each of the images is analyzed based on first and second order statistic and the result is tabulated in Table 4.3 and Table 4.4 respectively.

5.2.1 First Order Statistic

First order statistic is used as pre processing step before applying second order statistic. It contains several element, which are mean, variance, coarseness, skew ness, kurtosis, energy, entropy, median and mode.

Table 4.3 described the average value of first order characteristic for three types of texture used in this project, which are Brodatz, Aerials and Computer Graphic. Each of the texture gives different value to each other. The highest mean is represented by aerials image. Aerial images tend to gives the highest average grey level of the image compared to other texture. It is also tend to be the most relatively smooth since the value of variance is smaller than the other two textures. The image with the highest coarseness is represented by Computer graphic texture.

Figure 4.1 shows the value of mean for three different type of texture. Mean is defined as the distribution of average grey level of the image. Refer to Figure 4.1, the value of mean for each texture is varied to each other. The value of mean for Brodatz image approximately range from 110 to 220. Highest distribution of average grey level for Brodatz image is found in image 30. For Aerials image, the value of mean is ranging approximately range from 111 to 184. For computer graphic image, the value of mean is approximately range from 80 to 217.

The variance gives the average of the square of the distance of each data point from the mean. This feature is significant in texture description. Small value of variance indicates the fine or smooth texture. Refer to Figure 4.2, the lowest value of variance found in image 27 for Brodatz, image 18 for Aerial and image 27 for computer graphic.

A measure of the coarseness of the texture maybe defined in term of variance. High values of coarseness correspond to fine texture. Figure 4.3 indicates the value of coarseness for three type of texture.

Figure 4.4 indicates the value of skew ness. Skewness is a measure of symmetry, or more precisely, the lack of symmetry. A distribution, or data set, is symmetric if it looks the same to the left and right of the center point. . Negative values for the skewness indicates a distribution that are skewed left (asymmetric tail extending towards more negative) and positive values for the skewness indicate data that are skewed right (asymmetric tail extending towards more positive)

Kurtosis is based on the size of a distribution's tails. Distributions with relatively large tails (positive) are called "leptokurtic"; those with small tails (negative) are called "platykurtic." A distribution with the same kurtosis as the normal distribution is called "mesokurtic." Figure 4.5 shows the distribution of kurtosis for Brodatz, Aerial and computer graphic.

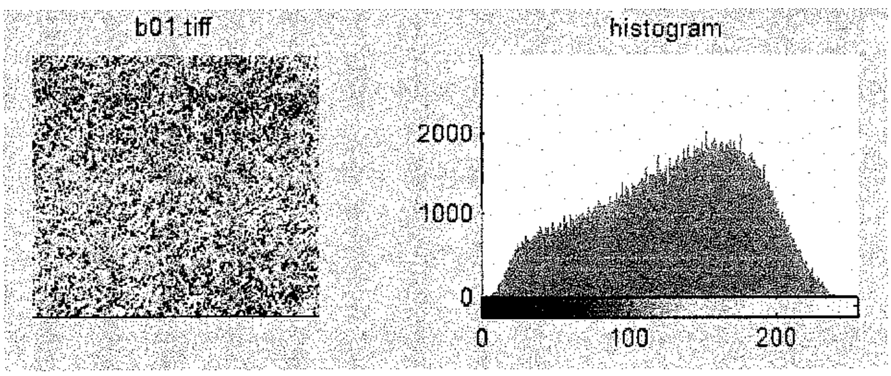

Figure 5.1 Shape of histogram for Brodatz image (B01)

Figure 5.1 shows the illustration of histogram for Brodatz image (B01). From the histogram, it can be seen that the asymmetric tail of the histogram extending towards more negative, therefore, the value for skewness for B01 is –0.3070. On the other hand, the value of kurtosis for the specified image is 2.2190. The positive value of kurtosis represents the leptokurtic shape of the histogram.

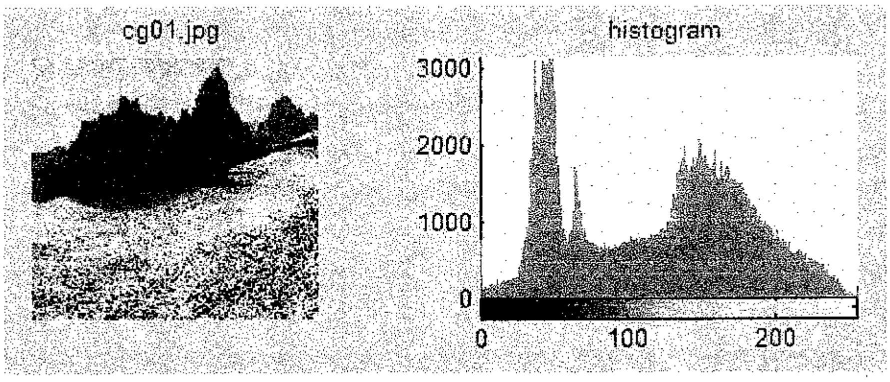

Figure 5.2 Shape of the histogram for Computer Graphic image (CG01)

Figure 5.2 indicates the shape of histogram for computer graphic image (CG01). The shape of the histogram shows that the asymmetric tail extending towards more positive, therefore the value of skew ness obtained is positive which is 0.0299. Since the histogram shows distribution with relatively big tails, therefore the value is kurtosis is 1.7925.

5.2.2 Second Order Statistic

Table 4.4 indicated the average value of second order statistic for three type of texture. Refer to the table, it can be seen that each texture gives different characteristic. Computer graphic image have the highest value of coarseness, which correspond to a fine texture. Brodatz texture gives the highest value in contrast, busyness and complexity while, computer graphic image represent the most identifiable texels.

Second order statistic specifically Neighborhood Gray Tone Different Matrix consists of five texture properties namely, coarseness, contrast, busyness, complexity and texture strength. Figure 4.10 to Figure 4.15 described the value of corresponding second order properties for the three types of texture.

Coarseness is the most fundamental property of texture and in narrow sense, it is used to imply image. In a coarse texture, the primitive or basic patterns making up the texture are large. As a result, such texture tends to possess a high degree of local uniformity in intensity, even over a large area.

Perceptually, an image is said to have high level of contrast if areas of different intensity levels are clearly visible. Thus, high contrast means that the intensity different between neighboring region is large. In addition, the spatial frequency of the changes in intensity will affect the contrast of an image.

A busy texture is one in which there are rapid changes of intensity from one pixel to its neighbor; that is the spatial frequency of intensity change is very high. High value of busyness indicates rapid changes in texture.

Complexity refers to the visual information content of a texture. A texture is considered complex if the information content is high. This occurs when there are many patches or primitives present in the texture and more so when the primitives have different average intensities.

The term texture strength is a difficult concept to define concisely. However, a texture is generally referred to as strong when the primitives that comprise it are easily definable and clearly visible. Such textures generally tend to look attractive, as they present a high degree of visual feel.

5.3 Image classification

The three types of texture which represent 30 image respectively is classified according to their statistical characteristic which consist of first and second order statistic.

5.3.1 First Order Statistic

Table 4.5 summarizes the range value of first order characteristic for the three-selected texture. Each of the texture contributes to different range value. For example refer to Table 4.5, it can be seen that Computer Graphic image covers wide range for mean compare to Brodatz and Aerials. For variance, Aerial images is said to be the most relatively smooth with small range of variance compare to Brodatz and Computer Graphic.

The image is then classified to its type of texture using the information tabulated in Table 4.5.

5.3.2 Second Order Statistic

Table 4.6 describes the range values of second order characteristic of three-selected texture. Similar to first order statistic, the information outlined in Table 4.6 is used in classifying the image according to its type of texture.

The MATLAB code for image classification is attached in Appendix A.

CHAPTER 6
CONCLUSION

6.1 Summary

As conclusion, the statistical characteristic of three types of textures, which are Brodatz, Aerials and Computer graphic, have been successfully determined using the algorithm developed in MATLAB. The first and second order algorithm developed in MATLAB not only can analyze statistical characteristic of the image but also can classify the image regarding to its type of texture. The outcome of this project verified that statistical approach specifically Neighborhood Grey Tone Different Matrix (NGTDM) could be used in classification and discrimination of texture.

6.2 Further recommendation

The statistical properties of every image obtained from this work are varied to each other. Hence, it is worth to consider more samples of texture or image to be run in order to ensure the accuracy of this approach before applying it to other possible application such as medical image processing and remote sensing.

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APPENDIX A
MATLAB CODE

```
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%FIRST ORDER↙
STATISTIC%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
% load image file
[filename,pathname] = uigetfile('*.tiff','load tiff file');
x = [filename];
I = imread(x);

% display
disp('Performing first order statistic')
disp(filename)

% read the image
% show the image in figure
subplot(2,2,1), imshow(I), title(filename);

% define the image in the histogram
% intensity of the image can be determine from the histogram
% N is the number of pixel for each intensities

subplot(2,2,2),imhist(I), title('histogram') ;
N = imhist(I);

%identify the size of the image
%determine the total pixel(M) of the image J

[a c] = size(I)
M = a*c

% set the range of the intensity
% 0 is black and 255 is white
% b represent pixel intensity
% P is corresponding to the histogram

b =(0:255);
P= N/M ;

%*************************FIRST ORDER STATISTICS**********************************

%determine the mean of the texture
%the mean gives the average grey level of the image

m = sum(b*P);
Mean = m


%determine the variance of the image
%variance = significance in texture description , small variance = relatively smooth


v = sum(((b - m).^2)*P);
Variance = v
```

```
%determined the coarseness of the image

c = 1 - (1/(1+v));
Coarseness = c


%determine the skewness of the image
%skewness measure of the symmetry of the histogram

s = (1/v^(3/2)).* sum(((b - m).^3)*P);
Skewness = s


%determine kurtosis of the image
%kurtosis indicates the flatness of the histogram

k = (1/(v^2)).*sum(((b-m).^4)*P);
Kurtosis = k

%determine energy.
%Large values of energy correspond to homogeneous regions

eng = sum(P.^2);
Energy = eng

%entropy
%Large values of entropy imply more uniform distribution of grey level

y=find(P>0);
etp=sum(P(y).*log10(P(y)));
Entropy = etp

%Median
%The median gives the value of the middle grey level

total = 0;
x=0;
while (total<=0.5)
    x=x+1;
    total = total+P(x);
end
Median = x - 1

%mode
%Mode gives the most frequently occuring grey level

d=max(P);
Mode = find(P>=d)-1


%enhancement
```

```
if (m>=110 && m<=213 && v>=235 & v<=9870 && c>=0.992 && c<=0.9999 && s>=-3.98 &↙
s<=0.256 & k>=1.43 & k<=41 & eng>=0.0052 & eng<=0.14 & etp>=-2.35 & etp<=-1.69 &↙
Median>=109 & Median<=220)
    I ='Brodatz texture'
else if (m>=111 & m<=184 & v>=259 & v<=2616 & c>=0.999 & c<=0.9996 & s>=-3.624 &↙
s<=1.316 & k>=1.64 & k<=6.52 & eng>=0.0012 & eng<=0.027 & etp>=-2.232 & etp<=-1.772↙
& Median>=109 & Median<=188)
    I = ('Aerials texture')
else
    I='CG texture'

    end
end




%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
```

```
%------------------------------------------------------------------
% APPENDIX A2 : SECOND ORDER STATISTIC (NGTDM)
% PREPARED BY : NORHIDAYAH JAMALUDIN
%------------------------------------------------------------------

% load image file
[filename,pathname] = uigetfile('*.tiff','load tiff file');
x = [filename];
I = imread(x);

% display
disp('Performing second order statistic')
disp(filename)

% show the image in figure
imshow(I), title(filename);

[a b] = size(I);          % determine size of array
S = zeros(1,512);         % initial value of S within range (1,512)
P = zeros(1,512);         % initial value of P within range (1,512)
for x=2:(b-1)             % range of matrix x from 2 to 511
    for y=2:(a-1)         % range of matrix y
       M = (b-2)*(a-2);                                                  %↙
size of matrix [x,y]
       k = sum(sum(double(I(x-1:x+1,y-1:y+1)))- (double(I(x,y))));       %↙
entry in the NGTDM
       S(double(I(x,y))+1) = abs(double(I(x,y)) - k/8) + S(double(I(x,y))+1);   %↙
determine s(i)
       P(double(I(x,y))+1) = 1/M + P(double(I(x,y))+1);                 %↙
determine p(i)

    end;
end;

% Coarseness

d= 1;                     %neighborhood size
Q=P.*S;                   %determine prob.occurence of grey tone value
sumQ = sum(Q);            %summation of Q
coas = 1/(0.001+sumQ);    %define computational measure for coarseness
Coarseness = coas

MM = zeros(1,512);         % condition to determine N
for i = 1:512
    if P(i)== 0
        MM(i)=0;
    else
        MM(i)=1;
    end;
end;

N = sum(MM);      %total no of diff.gray level present in image
```

```
n = ((a-1)-2)^2;

% contrast

cc = (1/(n^2)).*sum(S);     %to determine the value of contrast
dd = (1/(N.*(N-1)));
ee = 0;
for i=1:512;
    for j=1:512;
  ee=P(i).*P(j).*((i-j)^2)+ee;
    end;
end;

Contrast = dd.*ee.*cc

% busyness

ff=0;
for i =1:512;
    for j = 1:512;
        ff=abs(((i-1).*P(i))-((j-1).*P(j)))+ff;
    end;
end;

gg = 1 / ff;

Busyness = (sumQ)*gg

%Complexity

hh=0;
for i = 1:512;
    for j = 1:512;
        hh = (abs(i-j)).*((((P(i).*S(i))+(P(j).*S(j)))/ (n^2).*((P(i)+P(j))))+hh;
    end;
end;

Complexity = hh

% texture strenght

jj = 0;
for i = 1:512;
    for j = 1:512;
    jj = ((P(i)+P(j)).*(((i-1)-(j-1))^2)) + jj;
    end;
end;
kk = 1/(0.001+sum(S));
Texturestrength = jj.*kk

%enhancement
```

```
if (Coarseness>=3.7e-07 & Coarseness<=2.06e-5 & Contrast>=2.70e-6 & Contrast<=5.37e-↙
4 & Busyness>=0.55 & Busyness<=18.52 & Complexity>=0.0007 & Complexity<=1.94 &↙
Texturestrength>=1.77 & Texturestrength<=6.07)
    I='Brodatz texture'
else if (Coarseness>=4.5e-06 & Coarseness<=2.04e-5 & Contrast>=3.24e-6 &↙
Contrast<=1.98e-5 & Busyness>=0.54 & Busyness<=1.8133 & Complexity>=0.0009 &↙
Complexity <=0.019 & Texturestrength>=2.33 & Texturestrength<=5.97)
    I='Aerials image'
else
    I='Computer Graphic texture'


end

end
```

```
%-----------------------------------------------------------------
% APPENDIX A3 : VERIFICATION OF FIRST ORDER STATISTIC
% PREPARED BY : NORHIDAYAH BINTI JAMALUDIN
%-----------------------------------------------------------------

disp('Verification of first order statistic')
y = [1 2 3 4 5]
[a c]=size(y)
M = a*c
b=y;
N=sum(y);
P = N/M;

%**************************FIRST ORDER STATISTICS**********************

%determine the mean of the texture

m = sum(b*p);
Mean = m

%determine the variance of the image

v = sum(((b - m).^2)*p);
Variance = v

%determined the coarseness of the image

c = 1 - 1/(1+v);
Coarseness = c


%determine the skewness of the image

s = (1/v^(3/2))* sum(((b - m).^3)*p);
Skewness = s

%determine kurtosis of the image

k = (1/v^2)*sum(((b-m).^4)*p);
Kurtosis = k

%Energy

eng = sum(p.^2);
Energy = eng

%entropy

y=find(p>0);
etp=sum(p(y).*log10(p(y)));
Entropy = etp
```

```
%Median

somme = 0;
x=0;
while (somme<=0.5)
    x=x+1;
    somme = somme+p(x);
end
Median = x - 1

%mode
d=max(p);
Mode = find(p>=d)-1
```

```
%----------------------------------------------------------------
% APPENDIX A4 : VERIFICATION OF SECOND ORDER STATISTIC (NGTDM)
% PREPARED BY : NORHIDAYAH BINTI JAMALUDIN
%----------------------------------------------------------------

I = [0 0 2 2 0 0 ; 0 0 2 2 0 0 ; 0 0 2 2 0 0 ; 0 0 2 2 0 0 ; 0 0 2 2 0 0 ; 0 0 2 2 0↙
0] % sample array
[a b] = size(I)                                          % determine size of array
S = zeros(1,6);
P = zeros(1,6);
for x=2:(b-1)             % range of matrix x from 2 to 511
    for y=2:(a-1)         % range of matrix y
       M = (b-2)*(a-2);                                      %size of matrix [x,y]
       k = sum(sum(I(x-1:x+1,y-1:y+1)))- I(x,y);             %entry in the NGTDM
       S(I(x,y)+1) = abs(double(I(x,y)) - k/8) + S(I(x,y)+1) %determine s(i)
       P(I(x,y)+1) = 1/M + P(I(x,y)+1)                       %determine p(i)

    end;
end;

% Coarseness

d= 1;                     %neighborhood size
Q=P.*S;                   %determine prob.occurence of grey tone value
sumQ = sum(Q);            %summation of Q
coas = 1/(0.001+sumQ);    %define computational measure for coarseness
Coarseness = coas

MM = zeros(1,6);         % condition to determine N
for i = 1:6
    if P(i)== 0
        MM(i)=0;
    else
        MM(i)=1;
    end;
end;

N = sum(MM);        %total no of diff.gray level present in image
n = ((a-1)-2)^2;

% contrast

cc = (1/(n^2))*sum(S);     %to determine the value of contrast
dd = (1/(N*(N-1)));
ee = 0;
for i=1:6;
    for j=1:6;
  ee=P(i).*P(j).*((i-j))^2+ee;
    end;
end;

Contrast = dd*ee*cc
```

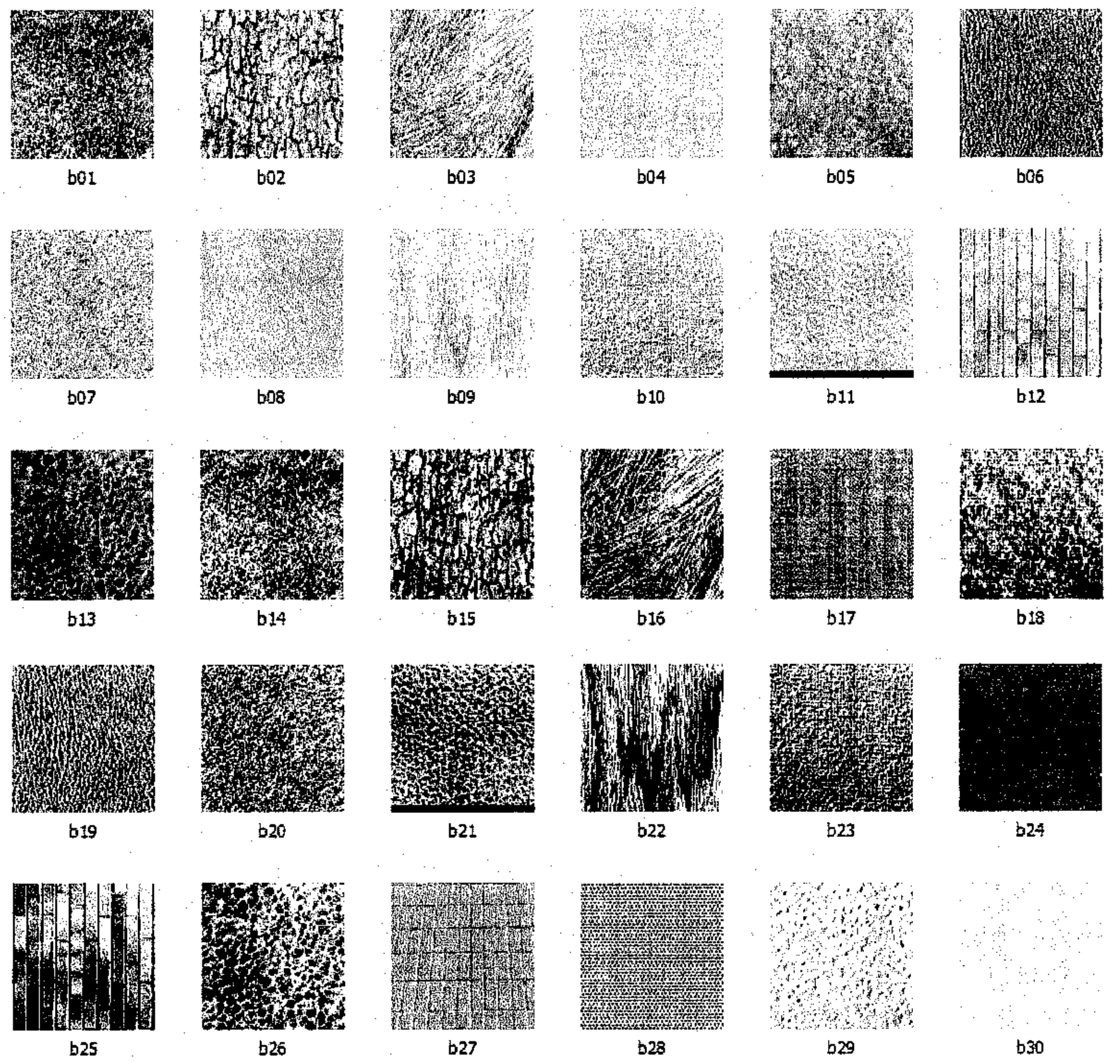
```
% busyness

ff=0;
for i =1:6;
    for j = 1:6;
        ff=abs(((i-1).*P(i))-((j-1).*P(j)))+ff;
    end;
end;

gg = 1 / ff;

Busyness = (sumQ)*gg

%Complexity

hh=0;
for i = 1:6;
    for j = 1:6;
        hh = (abs(i-j)).*((((P(i).*S(i))+(P(j).*S(j)))/ (n^2).*((P(i)+P(j))))+hh;
    end;
end;

Complexity = hh

% texture strength

jj = 0;
for i = 1:6;
    for j = 1:6;
        jj = ((P(i)+P(j)).*((i-j).*(i-j))) + jj;
    end;
end;
kk =(0.001+sum(S));
Texturestrength = jj/kk
```

APPENDIX B
IMAGES DESCRIPTION

APPENDIX B
IMAGE DESCRIPTION

Appendix B1: Brodatz

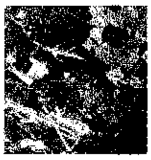
The entire image is taken with permission from *http://sipi.usc.edu/database/*



Filename	Description	File Format	Size
B01	Grass	*tiff	512x512
B02	Bark	*tiff	512x512
B03	Straw	*tiff	512x512
B04	Herringbone wave	*tiff	512x512
B05	Woolen cloth	*tiff	512x512
B06	Pressed calf leather	*tiff	512x512
B07	Beach sand	*tiff	512x512
B08	Water	*tiff	512x512
B09	Wood grain	*tiff	512x512
B10	Raffia	*tiff	512x512
B11	Pigskin	*tiff	512x512
B12	Brick wall	*tiff	512x512
B13	Plastic bubbles	*tiff	512x512
B14	Grass	*tiff	512x512
B15	Bark	*tiff	512x512
B16	Straw	*tiff	512x512
B17	Herringbone wave	*tiff	512x512
B18	Woolen cloth	*tiff	512x512
B19	Pressed calf leather	*tiff	512x512
B20	Beach sand	*tiff	512x512
B21	Water	*tiff	512x512
B22	Wood grain	*tiff	512x512
B23	Raffia	*tiff	512x512
B24	Pigskin	*tiff	512x512
B25	Brick wall	*tiff	512x512
B26	Plastic bubbles	*tiff	512x512
B27	Mosaic #1	*tiff	512x512
B28	Mosaic #2	*tiff	512x512
B29	Mosaic #3	*tiff	512x512
B30	Mosaic #4	*tiff	512x512

Appendix B2: Aerial

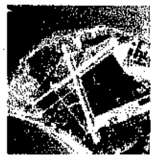
The entire image is taken with permission from *http://sipi.usc.edu/database/*

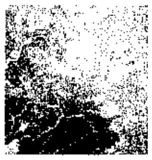

a01


a02

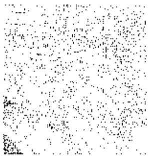

a03


a04


a05


a06


a07


a08


a09


a10


a11

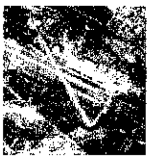

a12

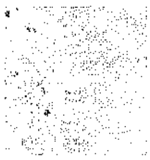

a13


a14


a15


a16


a17


a18


a19


a20


a21

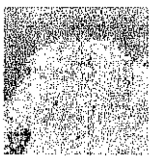

a22

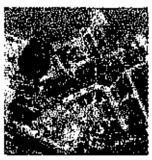

a23


a24


a25


a26


a27


a28


a29


a30

Filename	Description	File Format	Size
A01	San Diego (Miramar NAS)	*tiff	512x512
A02	San Diego	*tiff	512x512
A03	San Francisco(Golden Gate)	*tiff	512x512
A04	Oakland	*tiff	512x512
A05	San Diego (North Island NAS)	*tiff	512x512
A06	Woodland Hills, Ca.	*tiff	512x512
A07	Foster City, Ca.	*tiff	512x512
A08	San Diego	*tiff	512x512
A09	San Diego (Point Loma)	*tiff	512x512
A10	San Diego (Shelter Island)	*tiff	512x512
A11	Earth from space	*tiff	512x512
A12	San Diego (Downtown)	*tiff	512x512
A13	San Diego	*tiff	512x512
A14	San Diego	*tiff	512x512
A15	San Diego	*tiff	512x512
A16	Richmond, Ca.	*tiff	512x512
A17	San Diego (Miramar NAS)	*tiff	512x512
A18	San Francisco (Bay Bridge)	*tiff	512x512
A19	Oakland	*tiff	512x512
A20	San Diego	*tiff	512x512
A21	San Francisco	*tiff	512x512
A22	Richmond and San Rafael	*tiff	512x512
A23	Stockton	*tiff	512x512
A24	San Francisco and Oakland	*tiff	512x512
A25	Stockton	*tiff	512x512
A26	Shreveport	*tiff	512x512
A27	San Francisco	*tiff	512x512
A28	San Francisco	*tiff	512x512
A29	San Francisco	*tiff	512x512
A30	Stockton	*tiff	512x512

Appendix B3: Computer Graphic

The entire image is taken with permission from *http://artworks.avalonweb.net/gallery/*


cg01


cg02

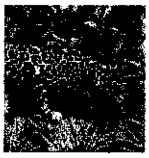

cg03


cg04


cg05

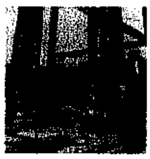

cg06


cg07


cg08

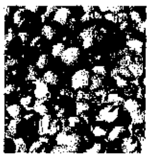

cg09


cg10


cg11


cg12


cg13


cg14


cg15


cg16


cg17


cg18


cg19


cg20


cg21

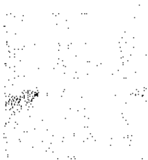

cg22


cg23


cg24


cg25


cg26


cg27


cg28


cg29


cg30

Filename	Description	File Format	Size
cg01	Abandoned city	*jpeg	512x512
cg02	Accident	*jpeg	512x512
cg03	Ash fondle	*jpeg	512x512
cg04	Bath of Juturna	*jpeg	512x512
cg05	Beautiful sunset	*jpeg	512x512
cg06	Below zero	*jpeg	512x512
cg07	Bon appetite	*jpeg	512x512
cg08	Bright bay	*jpeg	512x512
cg09	Cornet	*jpeg	512x512
cg10	Crystallia Sliders	*jpeg	512x512
cg11	Court yard	*jpeg	512x512
cg12	Street	*jpeg	512x512
cg13	Deep green	*jpeg	512x512
cg14	Dry season	*jpeg	512x512
cg15	Ducati	*jpeg	512x512
cg16	Interior studio	*jpeg	512x512
cg17	Leopard	*jpeg	512x512
cg18	Mediterranean	*jpeg	512x512
cg19	Memories	*jpeg	512x512
cg20	Morning on the bay	*jpeg	512x512
cg21	Mountain cottage	*jpeg	512x512
cg22	Multicores	*jpeg	512x512
cg23	Muuuh	*jpeg	512x512
cg24	Pond	*jpeg	512x512
cg25	RO	*jpeg	512x512
cg26	Rays of glory	*jpeg	512x512
cg27	Rochas	*jpeg	512x512
cg28	Serengeti	*jpeg	512x512
cg29	Undervue	*jpeg	512x512
cg30	Wind on the hill	*jpeg	512x512

APPENDIX C
FIRST ORDER STATISTIC

Appendix C: First Order Statistic

Appendix C1: Brodatz

IMAGE		FIRST	FOUR	MOMENT			OTHER	FOS		
No	Size	Mean	Variance	Coarseness	Skew	Kurtosis	Energy	Entropy	Median	Mode
1	512 x 512	128.67	2804.00	0.9996	-0.3070	2.2190	0.0053	-2.3090	135	152
2	512 x 512	148.67	2208.00	0.9995	-0.9651	3.2330	0.0074	-2.2051	161	184
3	512 x 512	156.77	1508.00	0.9993	-0.8175	3.4694	0.0079	-2.1520	164	192
4	512 x 512	173.57	940.63	0.9989	-1.2400	6.3651	0.0107	-2.0279	178	204
5	512 x 512	145.66	718.98	0.9986	-0.5750	5.6054	0.0110	-2.0211	146	144
6	512 x 512	128.87	1534.00	0.9993	0.1549	2.0204	0.0078	-2.1320	125	83
7	512 x 512	155.70	809.58	0.9988	-1.5134	7.2020	0.0122	-2.0037	161	176
8	512 x 512	161.41	258.86	0.9962	-3.9732	40.6608	0.0220	-1.7147	162	160
9	512 x 512	178.60	760.33	0.9987	-2.0578	9.9864	0.0159	-1.9134	187	192
10	512 x 512	158.03	908.89	0.9989	-0.6657	4.7095	0.0095	-2.0530	159	152
11	512 x 512	157.58	1784.30	0.9994	-2.5270	10.0567	0.0143	-1.9375	166	0
12	512 x 512	158.18	1051.80	0.9991	-1.4908	6.3208	0.0117	-2.0467	164	170
13	512 x 512	111.38	1546.80	0.9994	0.1418	2.5830	0.0070	-2.1962	110	112
14	512 x 512	127.81	5463.20	0.9998	-0.0048	1.7926	0.0056	-2.2644	128	158
15	512 x 512	127.63	5495.50	0.9998	-0.0050	1.7973	0.0078	-2.1470	128	190
16	512 x 512	127.66	5482.50	0.9998	-0.0053	1.7924	0.0082	-2.1147	129	206
17	512 x 512	129.98	5543.60	0.9998	-0.0354	1.7938	0.0109	-1.9932	132	217
18	512 x 512	127.77	5511.80	0.9998	-0.0153	1.7899	0.0112	-1.9892	128	120
19	512 x 512	127.85	5450.10	0.9998	0.0006	1.7981	0.0079	-2.1207	127	33
20	512 x 512	129.40	5527.80	0.9998	-0.0372	1.7898	0.0124	-1.9596	130	199
21	512 x 512	130.08	5467.50	0.9998	-0.0444	1.8031	0.0221	-1.7017	131	115
22	512 x 512	128.90	5569.10	0.9998	-0.0194	1.7882	0.0161	-1.8750	131	161
23	512 x 512	127.81	5463.10	0.9998	-4.8190E-05	1.8019	0.0096	-2.0330	126	106
24	512 x 512	122.71	5922.10	0.9998	-0.0123	1.7775	0.0146	-1.9098	122	0
25	512 x 512	128.12	5504.40	0.9998	-0.0197	1.7908	0.0121	-1.9809	128	156
26	512 x 512	128.18	5477.00	0.9998	-0.0227	1.7911	0.0072	-2.1588	128	133
27	512 x 512	141.97	236.01	0.9958	0.2555	5.8906	0.0296	-1.7106	142	144
28	512 x 512	162.38	9867.80	0.9999	-0.4286	1.4366	0.1388	-1.7503	215	255
29	512 x 512	184.61	1092.80	0.9921	-0.9728	4.5946	0.0097	-2.1030	189	190
30	512 x 512	212.82	646.28	0.9985	-1.7171	7.2548	0.0150	-1.9312	219	227

Appendix C: First Order Statistic

Appendix C2: Aerial

IMAGE		FIRST FOUR MOMENT					OTHER FOS			
No	Size	Mean	Variance	Coarseness	Skew	Kurtosis	Energy	Entropy	Median	Mode
1	512 x 512	115.3449	1699.9	0.9994	0.4548	2.7553	0.0071	-2.208	110	101
2	512 x 512	150.8738	1799.4	0.9994	-3.623	2.3989	0.0066	-2.2142	155	184
3	512 x 512	117.8217	430.4416	0.9977	1.3156	6.516	0.0263	-1.7727	116	120
4	512 x 512	133.3738	881.5418	0.9989	-0.6145	2.5775	0.0105	-2.0448	140	156
5	512 x 512	125.9169	2377.8	0.9996	0.405	2.2437	0.0066	-2.231	117	215
6	512 x 512	150.3559	1689.8	0.9994	-0.1571	2.0608	0.0067	-2.197	154	164
7	512 x 512	166.4329	409.5339	0.9976	-0.4009	3.2628	0.015	-1.9079	167	161
8	512 x 512	183.6457	259.4701	0.9962	-0.5459	3.3576	0.0181	-1.8086	185	186
9	512 x 512	161.3564	437.7648	0.9977	1.1678	3.6701	0.0213	-1.8131	155	152
10	512 x 512	166.5935	715.177	0.9986	0.1554	1.7636	0.0125	-1.9585	167	137
11	512 x 512	114.6489	1877.7	0.9995	0.2987	2.071	0.0078	-2.1539	111	55
12	512 x 512	180.1378	414.8029	0.9976	-0.4152	2.4729	0.0138	-1.9011	182	186
13	512 x 512	148.627	1990.4	0.9995	-0.6963	2.481	0.0074	-2.1941	160	177
14	512 x 512	174.5868	737.8039	0.9986	-0.2519	1.6496	0.0136	-1.9105	182	137
15	512 x 512	179.4462	454.3743	0.9978	-0.5201	2.1499	0.0154	-1.8551	184	192
16	512 x 512	176.4888	614.5237	0.9984	-0.9931	3.3222	0.0156	-1.9278	185	190
17	512 x 512	132.4828	1720.9	0.9994	0.5464	2.253	0.0077	-2.1623	123	96
18	512 x 512	180.2412	259.9171	0.9962	-0.5335	3.9483	0.0185	-1.804	180	178
19	512 x 512	179.7145	525.942	0.9981	-0.6411	2.2588	0.0149	-1.8926	187	195
20	512 x 512	138.948	2615.9	0.9996	-0.4839	1.945	0.0065	-2.2312	154	180
21	512 x 512	156.2185	588.1118	0.9983	0.716	2.9479	0.0143	-1.9434	150	147
22	512 x 512	174.2573	457.4511	0.9978	-0.5525	2.6359	0.0139	-1.9124	178	180
23	512 x 512	159.2339	530.6256	0.9981	-0.0326	2.7751	0.0122	-1.9735	160	165
24	512 x 512	153.1385	314.5343	0.9968	0.2113	3.4879	0.0192	-1.834	150	148
25	512 x 512	111.909	576.5831	0.9983	0.6846	4.1569	0.00126	-1.9806	110	114
26	512 x 512	144.6376	612.6372	0.9984	0.5697	2.6512	0.012	-1.9769	141	119
27	512 x 512	157.2889	428.3985	0.9977	0.1989	2.6719	0.0161	-1.8919	153	144
28	512 x 512	122.8241	722.0885	0.9986	0.8587	3.8907	0.013	-2.0001	119	119
29	512 x 512	141.63	739.2124	0.9987	0.0234	2.106	0.0098	-2.0448	142	160
30	512 x 512	154.893	690.6942	0.9986	0.2881	2.7335	0.0107	-2.025	153	145

Appendix C: First Order Statistic

Appendix C3: Computer Graphic

IMAGE		FIRST	FOUR	MOMENT		OTHER	FOS			
No	Size	Mean	Variance	Coarseness	Skew	Kurtosis	Energy	Entropy	Median	Mode
1	512 x 512	118.1154	3188.9	0.9997	0.0299	1.7925	0.0059	-2.3029	129	49
2	512 x 512	105.9319	3425.9	0.9997	0.2167	2.13	0.0051	-2.335	108	137
3	512 x 512	89.2515	3024.4	0.9997	0.3872	2.4325	0.0054	-2.3071	84	72
4	512 x 512	94.4363	3767.6	0.9997	0.563	2.4297	0.0051	-2.3407	83	0
5	512 x 512	157.9308	4106.4	0.9998	-0.3479	1.9241	0.0049	-2.3414	168	255
6	512 x 512	113.4433	3485.9	0.9997	0.2555	2.158	0.0055	-2.3076	106	124
7	512 x 512	118.1125	3609.4	0.9997	0.3135	1.9425	0.0056	-2.3097	104	88
8	512 x 512	93.6787	2691.8	0.9996	0.5161	2.7404	0.0056	-2.3028	87	55
9	512 x 512	116.2245	5109.1	0.9998	0.2179	1.6499	0.0058	-2.3198	103	207
10	512 x 512	118.5245	3674	0.9997	0.5833	2.0588	0.0066	-2.2643	99	187
11	512 x 512	81.2447	2920.6	0.9997	0.2254	1.7621	0.0065	-2.2402	75	0
12	512 x 512	146.0386	5498.3	0.9998	-0.091	1.5564	0.0062	-2.3087	139	214
13	512 x 512	114.6461	2480.9	0.9996	0.1817	2.3905	0.0074	-2.2272	122	166
14	512 x 512	116.2946	4153.9	0.9998	0.1895	2.1638	0.0043	-2.3824	112	255
15	512 x 512	156.326	2428.9	0.9996	-0.1599	2.4898	0.006	-2.282	156	142
16	512 x 512	117.4129	3404.2	0.9997	0.2115	2.144	0.0049	-2.3444	112	169
17	512 x 512	119.6963	7052.5	0.9999	0.2414	1.7405	0.0088	-2.2865	115	250
18	512 x 512	145.8466	6087.8	0.9998	-0.2039	1.5375	0.0086	-2.2531	149	235
19	512 x 512	96.9573	3927.1	0.9997	0.4208	1.9704	0.005	-2.3337	82	27
20	512 x 512	98.2111	3809.8	0.9997	0.2805	2.1259	0.0048	-2.3482	95	0
21	512 x 512	103.5888	1120.9	0.9991	0.4176	2.8647	0.0086	-2.1164	100	78
22	512 x 512	88.7528	8319.5	0.9999	0.5054	1.6413	0.00645	-1.843	58	0
23	512 x 512	137.7887	5198.6	0.9998	0.1737	1.7004	0.005	-2.3498	121	252
24	512 x 512	151.1337	2907.1	0.9997	-0.6954	3.3612	0.006	-2.2933	156	170
25	512 x 512	95.7109	3845.5	0.9997	1.1308	3.549	0.0063	-2.2807	77	67
26	512 x 512	115.7522	2975.8	0.9997	-0.1758	2.2189	0.0053	-2.3205	121	156
27	512 x 512	216.1798	254.5578	0.9961	-1.4653	6.9079	0.023	-1.7377	219	229
28	512 x 512	106.0007	1762.7	0.9994	-0.1784	2.8121	0.0074	-2.2119	111	121
29	512 x 512	130.3005	4607.2	0.9998	-0.022	1.8147	0.0057	-2.3122	127	205
30	512 x 512	128.4537	2388.4	0.9996	-0.7689	2.9705	0.0085	-2.2018	140	137

APPENDIX D
SECOND ORDER STATISTIC

Appendix D: Second Order Statistic

Appendix D1: Brodatz

IMAGE		SECOND ORDER STATISTIC				
No	Size	Coarseness	Contrast	Busyness	Complexity	Texture Strength
1	512 x 512	1.74E-05	1.43E-05	0.593	0.000887	4.0212
2	512 x 512	1.14E-05	1.31E-05	0.7075	0.0019	3.5211
3	512 x 512	1.03E-05	1.15E-05	0.7393	0.0021	3.1052
4	512 x 512	7.28E-06	8.99E-06	0.9034	0.0038	2.5884
5	512 x 512	9.60E-06	5.69E-06	0.8258	0.0031	3.6886
6	512 x 512	1.72E-05	1.52E-05	0.5844	0.0011	4.5479
7	512 x 512	7.21E-06	4.90E-06	1.0013	0.0047	3.177
8	512 x 512	4.24E-06	6.14E-06	1.5431	0.0131	2.985
9	512 x 512	4.74E-06	9.14E-06	1.287	0.0093	2.4478
10	512 x 512	9.82E-06	1.18E-05	0.768	0.0024	3.1772
11	512 x 512	7.49E-06	2.06E-05	0.9499	0.0045	3.2781
12	512 x 512	7.55E-06	6.60E-05	0.9522	0.0045	3.1198
13	512 x 512	2.05E-05	7.28E-05	0.5637	0.00094	6.0689
14	512 x 512	1.37E-05	5.58E-05	0.7119	0.0012	3.5702
15	512 x 512	1.06E-05	7.13E-05	0.8368	0.0022	4.2794
16	512 x 512	8.90E-06	1.05E-04	0.9992	0.0027	3.5104
17	512 x 512	6.44E-06	1.84E-04	1.2998	0.0048	3.3567
18	512 x 512	7.59E-06	1.71E-04	1.1516	0.0041	3.5635
19	512 x 512	1.12E-05	1.10E-04	0.8582	0.002	3.4777
20	512 x 512	6.01E-06	1.82E-04	1.3875	0.0059	3.4554
21	512 x 512	3.92E-06	5.36E-04	2.0371	0.0148	3.6412
22	512 x 512	4.47E-06	2.09E-04	1.8216	0.0111	3.6841
23	512 x 512	9.19E-06	1.42E-04	0.9579	0.0028	3.9593
24	512 x 512	6.79E-06	2.22E-04	1.3002	0.0054	3.9555
25	512 x 512	6.71E-06	1.46E-04	1.27	0.0054	3.7522
26	512 x 512	1.46E-05	7.08E-05	0.6493	0.0013	4.4558
27	512 x 512	3.66E-06	2.76E-06	2.0398	0.0267	3.8786
28	512 x 512	3.71E-07	5.73E-05	18.5139	1.9378	3.2466
29	512 x 512	8.09E-06	6.83E-05	0.7882	0.0032	2.379
30	512 x 512	4.39E-06	5.67E-05	1.179	0.0087	1.7714

Appendix D: Second Order Statistic

Appendix D2: Aerial

IMAGE		SECOND ORDER STATISTIC				
No	Size	Coarseness	Contrast	Busyness	Complexity	Texture Strength
1	512 x 512	2.0383E-05	8.3101E-06	0.5585	0.001	5.6974
2	512 x 512	1.3680E-05	1.1605E-05	0.6138	0.0013	3.3966
3	512 x 512	5.0664E-06	3.2433E-06	1.8133	0.0187	5.4699
4	512 x 512	9.7919E-06	8.1386E-06	0.8780	0.0033	4.3611
5	512 x 512	1.9241E-05	1.1707E-05	0.5455	0.001	5.0453
6	512 x 512	1.4907E-05	1.4146E-05	0.5708	0.0012	3.5990
7	512 x 512	6.0692E-06	6.5967E-06	1.0934	0.0068	2.8489
8	512 x 512	4.5444E-06	7.8040E-06	1.2927	0.0098	2.3374
9	512 x 512	4.7228E-06	8.5626E-06	1.4329	0.0139	3.0387
10	512 x 512	7.7596E-06	1.3979E-05	0.8887	0.0044	2.8812
11	512 x 512	1.9477E-05	1.4472E-05	0.5793	0.0012	5.9691
12	512 x 512	5.9862E-06	1.1853E-05	1.0294	0.0056	2.4426
13	512 x 512	1.1741E-05	1.2092E-05	0.6970	0.0019	3.4971
14	512 x 512	6.4422E-06	1.9762E-05	0.9947	0.0053	2.6264
15	512 x 512	5.4392E-06	1.6304E-05	1.1220	0.0069	2.4648
16	512 x 512	5.1498E-06	9.8123E-06	1.2120	0.0092	2.5594
17	512 x 512	1.6926E-05	1.1385E-05	0.5780	0.0013	4.5779
18	512 x 512	4.5699E-06	5.9446E-06	1.3090	0.0101	2.4260
19	512 x 512	5.3954E-06	1.3755E-05	1.1336	0.0075	2.4633
20	512 x 512	1.4293E-05	1.5873E-05	0.6271	0.0014	4.0668
21	512 x 512	7.3404E-06	8.7591E-06	0.9873	0.0058	3.2513
22	512 x 512	6.0325E-06	8.8063E-06	1.0533	0.0059	2.6089
23	512 x 512	7.8563E-06	7.3648E-06	0.9085	0.004	3.1121
24	512 x 512	5.4136E-06	4.8059E-06	1.3094	0.0109	3.3433
25	512 x 512	1.1712E-05	3.8547E-06	0.8729	0.0033	5.8969
26	512 x 512	9.8801E-06	8.1902E-06	0.8104	0.0031	3.7457
27	512 x 512	6.3935E-06	6.6798E-06	1.1014	0.0073	3.1659
28	512 x 512	1.0276E-05	5.4675E-06	0.9178	0.0044	5.1382
29	512 x 512	1.1162E-05	7.7615E-06	0.7481	0.0023	3.9545
30	512 x 512	9.5570E-06	7.7670E-06	0.7931	0.0029	3.2772

Appendix D: Second Order Statistic

Appendix D2: Computer Graphic

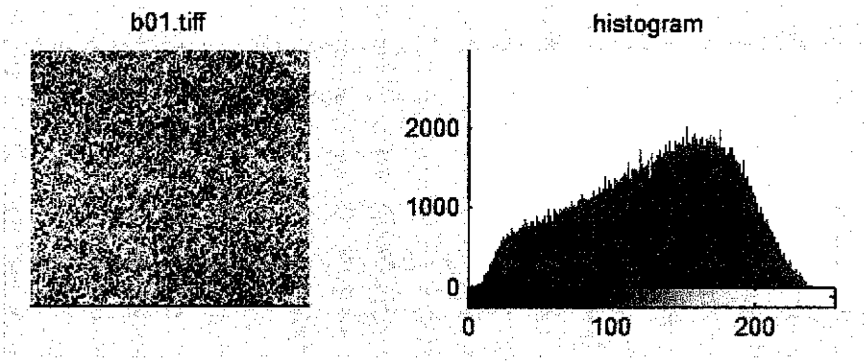
IMAGE		SECOND ORDER STATISTIC				
No	Size	Coarseness	Contrast	Busyness	Complexity	Texture Strength
1	512 x 512	1.9850E-05	1.8258E-05	0.5915	9.4470E-04	4.3271
2	512 x 512	2.5420E-05	1.3628E-05	0.5319	6.3976E-04	5.5834
3	512 x 512	3.2847E-05	8.9500E-06	0.4821	5.1239E-04	8.2876
4	512 x 512	2.5571E-05	1.6754E-05	0.6523	6.7570E-04	5.4249
5	512 x 512	1.5340E-05	2.2954E-05	0.5505	9.6336E-04	2.9566
6	512 x 512	2.4283E-05	1.2159E-05	0.4861	7.3258E-04	6.1018
7	512 x 512	2.4688E-05	1.3161E-05	0.4829	7.4812E-04	5.6915
8	512 x 512	2.7835E-05	9.7629E-06	0.5557	6.3457E-04	6.5505
9	512 x 512	2.0275E-05	2.0783E-05	0.5974	1.1000E-03	5.3316
10	512 x 512	2.0408E-05	1.4501E-05	0.5786	1.2000E-03	5.2469
11	512 x 512	2.1151E-05	1.0287E-05	0.7575	1.4000E-03	7.3091
12	512 x 512	1.2744E-05	2.9688E-05	0.6895	1.9000E-03	3.3987
13	512 x 512	1.6887E-05	9.4602E-06	0.6747	1.7000E-03	5.5830
14	512 x 512	3.0741E-05	1.5019E-05	0.4233	4.2990E-04	5.8696
15	512 x 512	1.6034E-05	1.1584E-05	0.5355	1.1000E-03	3.3553
16	512 x 512	2.4502E-05	1.4184E-05	0.5044	5.9856E-04	4.9738
17	512 x 512	1.0112E-05	2.5471E-05	1.0938	8.1000E-03	6.1152
18	512 x 512	9.1843E-06	2.9120E-05	0.9206	4.7000E-03	3.9103
19	512 x 512	3.1617E-05	1.3481E-05	0.4821	4.9443E-04	6.9266
20	512 x 512	2.1827E-05	1.8848E-05	0.6959	8.3960E-04	4.7665
21	512 x 512	1.8250E-05	4.1317E-06	0.6548	1.4000E-03	7.0058
22	512 x 512	5.3762E-06	2.4818E-05	2.5442	4.5200E-02	9.0736
23	512 x 512	1.8963E-05	2.3883E-05	0.5242	9.8207E-04	4.1593
24	512 x 512	1.5749E-05	1.3540E-05	0.5481	1.1000E-03	3.5729
25	512 x 512	2.9478E-05	1.1575E-05	0.5061	7.6053E-04	7.9493
26	512 x 512	2.0280E-05	1.2673E-05	0.5699	8.3709E-04	4.8512
27	512 x 512	3.0373E-05	4.1350E-06	1.6119	1.8700E-02	1.7225
28	512 x 512	1.8919E-05	5.5653E-06	0.6214	1.4000E-03	6.8102
29	512 x 512	1.7071E-05	2.0546E-05	0.5871	1.2000E-03	4.4210
30	512 x 512	1.2089E-05	1.0388E-05	0.7772	2.4000E-03	4.3543

APPENDIX E
MATLAB SIMULATION RESULT

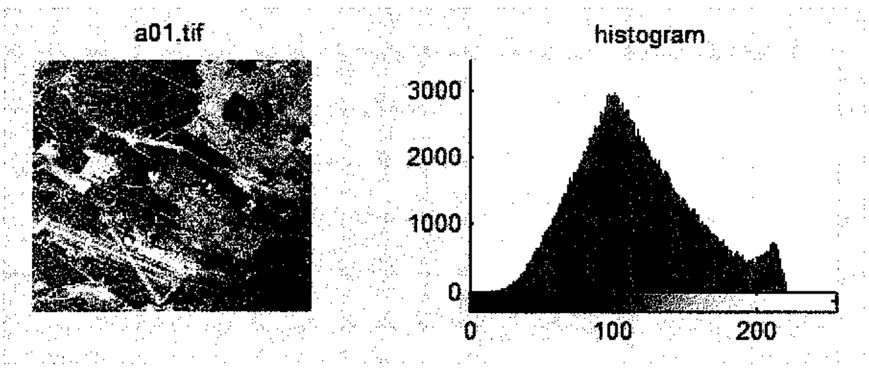
Appendix E: MATLAB simulation result

Appendix E1: First Order Statistic

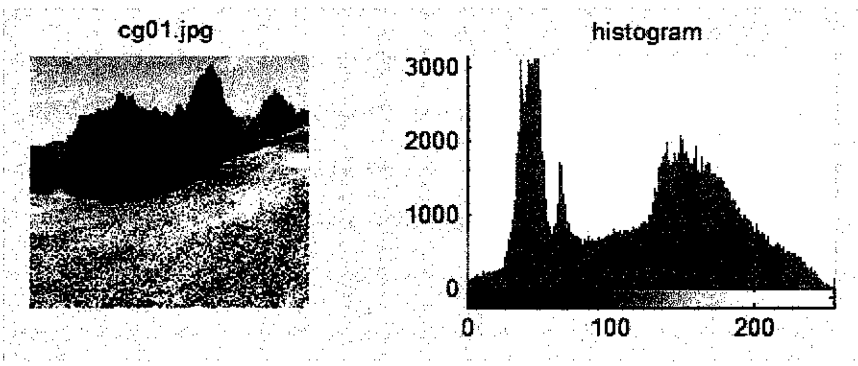
Brodatz



Aerial



Computer Graphic



```
Performing first order statistic
b01.tiff

a =

   512


c =

   512


M =

      262144


Mean =

  128.6726


Variance =

  2.8039e+003


Coarseness =

    0.9996


Skewness =

   -0.3070


Kurtosis =

    2.2189


Energy =

    0.0053


Entropy =

   -2.3090


Median =

   135
```

```
Mode =

   152


I =

Brodatz texture

>>
```

```
Performing second order statistic
b02.tiff

Coarseness =

  1.1407e-005


Contrast =

  1.3083e-005


Busyness =

    0.7075


Complexity =

    0.0019


Texturestrength =

    3.5211


I =

Brodatz texture

>>
```

APPENDIX F
GANTT CHART

FINAL YEAR PROJECT

Name : Norhidayah binti Jamaludin **ID : 3083**

No.	Detail/ Week	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1	Project Work Continue		■	■											
	-Develop second order Statistic														
2	Submission of Progress Report 1			●											
3	Project Work Continue				■	■	■	■							
	-Verification of algorithm -Analyzing images														
4	Submission of Progress Report 2								●						
5	Project work continue								■	■	■	■			
	-Image interpretation														
6	Submission of Dissertation Final Draft												●		
7	Oral Presentation													●	
8	Submission of Project Dissertation														●

● Suggested milestone

■ Process