# The Retinal Identification Using Run Length and Naive Bayesian Method

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## ABSTRACT

Retinal is one of human body's part that can be used as personal identification. Retinal have so many blood vessels that formed a unique pattern, every person has different pattern. The way to differentiate between one retinal and others is by differentiate the image of retinal texture. The run length method is a method that can extract the characteristic of image based on texture, the acquired traits are Short Run Emphasis (SRE), Long Run Emphasis (LRE), Grey Level Uniformity (GLU), Run Length Uniformity (RLU), and Run Percentage (RPC). The result of image characteristic extraction based on the texture then will be used as the input value to determine the image classification result based on texture that used naïve bayesian method. Naïve Bayesian method is a simple probabilistic classification method that count the set of probability which sum up the frequency and value combination from dataset that given.

Based on result of the research that has been done, known that retinal image identification can be done using classification based on texture that used run length method to extract the retinal image texture and naïve Bayesian as a method to classified. Based on the testing result that has been done, the obtained accuracy level of the retinal image identification based on texture that used run length method and naïve Bayesian is 100%.

Keywords: Retinal Identification, Run Length, Naive Bayesian Artificial Intelligence.

## 1. INDRODUCTION

Retina is a thin layer of cells located at the back of the eyeball. Retina contains many blood vessels that form a unique pattern such as a fingerprint, therefore retina can be used as a tools of identification. Retinal identification system works by reading someone's eye retina patterns which scanned using a low intensity of infrared light, then the pattern was stored in a computer to be used as a person's identity [1]. Previous research by Md. Amran Siddiqui, to identificate the the eye's retina through four processes, which is the determination of the center detection, segmentation and derivation, extraction, and matching were obtained the accuracy rate of 80% [2]. In a study conducted by Nurul Hikmah, the identification of the eye's retina using HSV and ANFIS was obtained accuracy rate of 65% for MF Trapezoid and 80% for the Gaussian membership function [3].

Based on these case, further research is needed on the identification of the eye's retina to improve the accuracy by using a different method. This study uses Run Length extraction methods for image extraction process and Naive Bayesian methods for classification. Run Length method using the distribution of pixels with the same intensity consecutively in one particular direction as its primitive. The characteristics of the texture image acquired by the Run Length method including the Short Run Emphasis (SRE), Long Run Emphasis (LRE), Grey Level Uniformity (GLU), Run Length Uniformity (RLU), and Run Percentage (RPC). The results of the extraction characteristics of the texture image will be used as an input value to determine the results of image classification based on the texture using Naive Bayesian methods then. In the study that by conducted by Zanobya Nizar, Naive Bayesian methods are used for digital image classification of the palms produce an accuracy rate of 97% [4]. Naive Bayesian method is a simple probabilistic classification method that calculates a set of probabilities by summing the frequency and the combined value of a given dataset.

Based the problems and the solutions that have been described, this study will identify the retina based on the image of the retina by applying Run Length method for the extraction process imagery and Naïve Bayesian method for image classification process, Run Length method and Naïve Bayesian are expected to identify the retina based on the texture and measuring the level of classification accuracy.

### 1.1 Retinal

Eyes are organs that can detect light, simple eye only detects whether light or dark the surrounding environment. In the case of more complex eyes can distinguish shapes and colors. In the human eye, light enters through the pupil and is focused on the retina with the help of a lens. The nerve cells called the light sensitive rod (for

brightness) and cone (for light) that reacts to light. Both of which interact with each other and sending messages to the brain that indicate the brightness, color, contour.

The retina is the innermost layer of the eye that contains photoreceptor cells (rods and cones) and neuronal function transmits shapes we see formed by the lens to the brain via the optic nerve.

Light into the retina passes largely transparent layer of neurons before reaching the rods and cones, the two photoreceptor types that differ in form and function. Retinal Neurons then convey visual information captured by the photoreceptors to the optic nerve and the brain. Each cell bipolar memerima information from multiple rod or cone and every ganglion cells collect the information from several bipolar cells, horizontal and amacrine cells in the retina integrate information. One of the areas of the retina that is the optical disk does not have the receptor as a result this area formed a "blind spot" where the light is not detected [6].

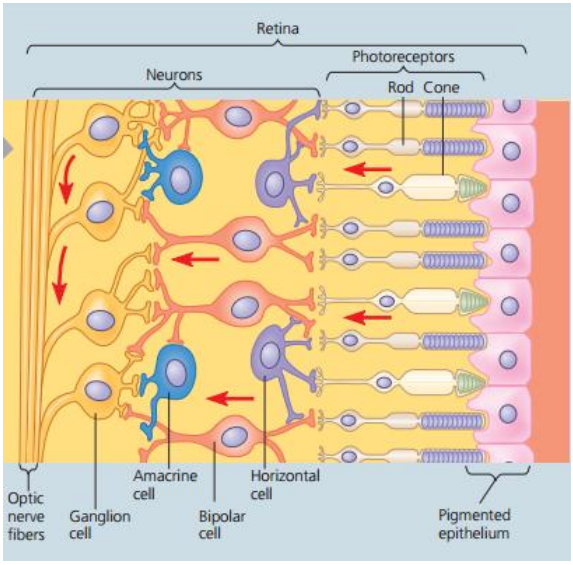



Figure 1 Part of Retinal

### 1.2 Biometric

Biometric is a branch of science by using unique data contained in limbs or human behavior for the purpose of identification. Biometric technology is very useful to prevent identity fraud, because the use of limbs or human behavior as the person's identity. Limb or human behavior that will be used for biometric systems must meet several requirements which are :

a. Universality, that every person has the characteristics.
b. Uniqueness, no similar characteristics.
c. Permanence, that constant characteristics with time.
d. Collectability, characteristics can be measured quantitatively.
e. Performance, accuracy in identifying characteristics.
f. Acceptability, this biometric system is acceptable.
g. Circumvention, the system is not easy to be cheated.

Body parts or behavior that could be used for biometric systems these include Face, Fingerprint, Hand geometry, Keystrokes, Vena hand, Iris eye, retina eyes, Signature, Sound, thermograms, Bau, DNA, gait, and ears. Here is a table of the level of quality of a limb or behavior in biometric systems:

Table 1 Comparision Biometric

| Biometrik | Universality | Uniqueness | Permanence | Collectability | Performance | Acceptability | Circumvention |
|---|---|---|---|---|---|---|---|
| Wajah | High | Low | Medium | High | Low | High | Low |
| Sidik Jari | Medium | High | High | Medium | High | Medium | High |
| Geometri Tangan | Medium | Medium | Medium | High | Medium | Medium | Medium |
| Keystrokes | Low | Low | Low | Medium | Low | Medium | Medium |
| Vena Tangan | Medium | Medium | Medium | Medium | Medium | Medium | High |
| Iris Mata | High | High | High | Medium | High | Low | High |
| Retina Mata | High | High | Medium | Low | High | Low | High |
| Tanda Tangan | Low | Low | Low | High | Low | High | Low |
| Suara | Medium | Low | Low | Medium | Low | High | Low |
| Thermograms | High | High | Low | High | Medium | High | High |
| Bau | High | High | High | Low | Low | Medium | Low |
| DNA | High | High | High | Low | High | Low | Low |
| Gaya Berjalan | Medium | Low | Low | High | Low | High | Medium |
| Telinga | Medium | Medium | High | Medium | Medium | High | Medium |

### 1.3 Image Processing

The image processing is image processing, particularly by using a computer, the image of better quality. Generally, the operating-operation in the image processing applied to the image when:

1. Repair or modify the image needs to be done to improve the quality of appearance or to highlight some aspects of the information contained in the image.
2. The elements in the image need to be grouped, matched, or measured.
3. Some parts of the image must be combined with another image.

Image processing aimed at improving the quality of the image to be easily interpreted by humans or machines (in this case the computer). Image processing techniques to transform the image into another image. Thus, the input is the output image and also the image, but image output has better quality than the input image [7].

### 1.4 Image Processing Operation

The operations were performed in the image processing are manifold. However, in general, the image processing operations can be classified into several types as follows [7]:

1. Image enhancement.
   This type of operation is intended to improve the quality of the image by manipulating the parameters of the image. With this operation, the special features contained in the image is

highlighted. Examples of image enhancement operations include contrast improvement, repair edges of the objects (edge enhancement), sharpening (sharpening), giving false color (pseudocoloring), and screening of noise (noise filtering).

2. Image restoration
   This operation aims to eliminate / minimize defects in the image. Interest restoration of the image is almost the same with image enhancement operations. The difference is, the restoration of the image of an unknown cause image degradation. Examples include image restoration surgery is the removal of ambiguities (deblurring) and removal of noise (noise).
3. Image compression
   This type of surgery is done so that the image can be represented in a more compact form that requires less memory. The important thing to consider in compression is the image that has been compressed must still have great picture quality.
4. Image segmentation
   This type of surgery aims to break an image into multiple segments with a certain criterion. This type of operation is closely related to pattern recognition.
5. Image analysis
   This type of operation is aimed at calculating the amount of the image to produce a quantitative description. Mechanical pengorakan image extracting certain characteristics that help in identification of objects. The segmentation process is sometimes necessary to localize the desired object from its surroundings. Examples include the operation pengorakan image object edge detection (edge detection), extraction limit (boundary), and the representation of the area (region).
6. Image reconstruction
   This type of surgery aims to reshape the image of the object of some projections. Image reconstruction surgery is widely used in the medical field. For example some x-rays with an X-ray is used to reshape the image of organs.
7. Color Model Changing
   Color is perception perceived by the human visual system to the wavelength of light reflected by the object [5]. Each color has a different wavelength. The red color has the highest wavelength, while the color purple has the lowest wavelength. The colors received by the eye is the result of a combination of light at different wavelengths. Research shows that the combination of colors that provide the widest range of colors are red (R), green (G), blue (B).

In the digital image formation color model commonly used are as follows:

a. RGB image
   RGB image commonly referred to as true color image, stored in the image size (m x n) x 3 which defines the color red (red), green (green) and blue (blue) for each pixel. Color at each pixel is determined based on the combination of the colors red, green and blue (RGB). A 24-bit RGB image with red components, green, and blue respectively generally worth 8 bits so that the intensity of the brightness of up to 256 level and the color combinations of less than approximately 16 million colors.
b. Image Grayscale
   Citra with different degrees of gray with RGB image, this image is defined by the value of the degree of color. Generally worth 8 bits so that the intensity of the brightness level up to 256 and 256 variants color combinations. The lowest brightness level that is 0 for black and white worth 255. To convert a color image having RGB to the degree of gray can use the equation :
   $Gray = 0.30 * R + 0.59 * G + 0.11 * B$
   Where :
   R = Red value
   G = Green value
   B = Blue value

**1.5 Texture**

Generally texture refers to the repetition of elements of basic textures are often called primitive or texel (texture element). A texel is composed of several pixels with the rules of periodic position, kuasiperiodik, or random. Definition of texture in this case is the regularity of certain patterns that are formed from the arrangement of pixels in a digital image [5].

To form a texture of at least two conditions must be met, among others:

1 Consists of one or more pixels that form the patterns of primitive (the smallest parts). The forms of these primitive patterns may be the point, straight line, curved line, area and others which are the basic elements of a form.
2 The emergence of primitive patterns repeated at intervals and specific direction so that it can be predicted or discovered characteristics of recurrence, for example of the texture image can be seen from Figure 2.



Figure 2 The Example of Image Texture

An image of an interpretation different texture when viewed at different distances and angles, man looking at the texture based on the description that is random, such as smooth, rough, regular, irregular, and other sebgainya. This is an incorrect description and non-quantitative, so it needed a quantitative description (mathematical) to facilitate analysis [5].

**1.6 Texture Analyze**

Texture analysis is the basis of a wide range of applications, application of texture analysis, among others, remote sensing, medical imaging, identification of quality of a material (wood, leather, textiles and others). In the image analysis, categorized into five main categories: statistical, structural, geometry, basic models and signal processing. Mempertimbangakan statistical approach that internsitas generated by a random two-dimensional field, the method is based on the frequencies of space. Examples of statistical methods is the autocorrelation function, run-length, kookurensi matrix, Fourier transformation, frequency edge. Structural engineering related to the infiltration of the smallest portions of an image. structural method is a model example of a fractal. Methods based on the geometry of the existing geometry on the element of texture. Examples of the base model is a random field. While the signal processing method is a method that is based on the frequency analysis such as Gabor transform and wavelet transform [5].

**1.7 Run Length Method**

Grey level run length matrix commonly abbreviated with GLRLM is one method for extracting texture in order to obtain statistical characteristics or attributes contained in texture to estimate the pixels that have the same degree of gray. Extraction texture with run-length method is done by making a series of value pairs (i, j) in each row of pixels. Keep in mind the purpose of the run-length itself is the number of pixels in sequence in a particular direction which has a degree of gray / value equal intensity. If it is known a run-length matrix with matrix elements q (i, j | θ) where i is the degree of gray at each pixel, j is the value run-length, and θ is the orientation towards a particular shift is expressed in degrees. Orientation is formed by a four-way shift at intervals of $45^0$, which is $0^0$, $45^0$, $90^0$, dan $135^0$.

There are several types of characteristic textures that can be extracted from the matrix run-length [8]. The following variables contained in the extraction of the image by using statistical methods Grey Level Run Length Matrix :

i = Grey value
j = Consecutive pixel (run)
M = Total grays degrees in an image
N = Total consecutive pixel in an image
r(j) = Jumlah piksel berurutan berdasarkan banyak urutannya (run length)
g(i) = Jumlah piksel berurutan berdasarkan nilai derajat keabuannya
s = Jumlah total nilai run yang dihasilkan pada arah tertentu
p(i,j)= himpunan matrik i dan j
n = jumlah baris * jumlah kolom.

Where these variables will be used to find the value of texture attributes as follows:

1. Short Run Emphasis (SRE)

   SRE measuring the distribution of short-run. SRE is very dependent on the amount of short-run and is expected to be great on smooth texture.

$$SRE = \sum_{i=1}^{M}\sum_{j=1}^{N}\frac{p(i,j)/s}{j2} = \sum_{j=1}^{n}\frac{r(j)/s}{j2}$$

2. Long Run Emphasis (LRE)

   LRE measuring the distribution of long run. LRE is very dependent on the number of long run and is expected to be great on a rough texture.

$$LRE = \sum_{i=1}^{M}\sum_{j=1}^{N} j2p(i,j)/s = \sum_{j=1}^{N} r(j)j2/s$$

3. Grey Level Uniformity (GLU)

   GLU measure the degree of gray value equation entire image and is expected to be small if a similar degree of gray values throughout the image.

$$GLU = \sum_{i=1}^{M}(\sum_{J=1}^{N} p(i,j))2/s = \sum_{i=1}^{M}\frac{g(i)2}{s}$$

4. Run Length Uniformity (RLU)

   RLU measure the length of the equation run throughout the image and is expected to be small if the length is similar run throughout the image.

$$RLU = \sum_{j=1}^{N}(\sum_{I=1}^{M} p(i,j))2/s = \sum_{j=1}^{N}\frac{r(j)2}{s}$$

5. Run Percentage (RPC)

   RPC run measure of togetherness and distribution of an image in a certain direction. RPC is worth the most if the length of the run is 1 for all degrees of gray in a certain direction.

$$RPC = \sum_{i=1}^{M}\sum_{j=1}^{N} p(i,j)/n = \sum_{j=1}^{N} r(j)/n$$

### 1.8 Naive Bayesian Method

Naïve Bayesian classification is a simplest method of using the existing opportunities, where it is assumed that every variable X is free (independence) [4]. Because the assumptions are not mutually dependent variable, then obtained :

$$P(X \mid Y = y) = \prod_{i=1}^{q} P(X_i \mid Y = y)$$

There are several steps in the classification using Naive Bayesian method, the following steps:

Training :

1. Calculate the average (mean) of each feature in the training database.

   $\mu = \frac{\sum x_i}{n}$

   Where:
   μ = mean
   n = the number of data
   $\sum x_i$ = total data value
2. Then calculate the variance of the training dataset as on.

   $\sigma^2 = \frac{1}{n-1}\sum_{i=1}^{n}(x]_i - [\mu)^2$

   Where:
   $\sigma^2$= varians
   μ= mean
   $x_i$ = data values
   n = the number of data

Testing :

1. Calculate the probability (Prior) for each class that is by counting the amount of data each class divided by the total number of overall data.
2. Next calculate the probability density. Expressing the relative probability density function. Data with mean μ and standard deviation σ, the probability density function is :

   $\varphi_{\mu\sigma}(x) = \frac{1}{\sqrt{2\pi\sigma^2}} e^{-\frac{(x-\mu)^2}{2\sigma^2}}$

   Where :
   x = data input
   π = 3,14
   σ = standard deviasion
   μ = mean
3. Having obtained the probability density values, then calculate the posterior of each class using the equation.

   $\text{posterior} = \frac{\text{prior x likehood}}{\text{evidence}}$

   Or

   $\text{Posterior} = \frac{P(C_i)x\ P(X1 \ldots\ldots\ldots\ldots Xn|C_i)}{P(X1 \ldots\ldots\ldots\ldots Xn|C_i)}$
4. Having obtained the posterior value of each class, the class corresponding to the input data is the class that has the greatest posterior value.

### 1.9 Testing of Confusion Matrix

Tests conducted on the classification method contained in the accuracy of the classification results. The accuracy of the classification affect the performance of a method of classification. To perform the test accuracy can be used confusion matrix is a matrix of predictions will be compared with the original class of the input data. Each column of the matrix corresponding to the result of the classification and each line in the input. The accuracy of a classification where i = j explain the accuracy of classification in each class [9]. Confusion Matrix The following example can be seen in Table 2.

Table 2 Confusion Matrix

| Class | | Result Clasification | |
|---|---|---|---|
| | | 0 | 1 |
| Target | 0 | 00 | 01 |
| | 1 | 10 | 11 |

The formula used to calculate accuracy:

$$\frac{\text{amount of accuracy}}{\text{total data}} \text{X } 100\% = \text{Accuracy}\%$$

## 2. RESEARCH CONTENT

### 2.1 Problem Analysis

Retina of the eye is a member of the human body that can be used as objects of identification. The image of the retina of the eye can be classified based on the information contained in the image. In previous studies have been done an identification system based on the retina of the eye color characteristic of the image on the retina of the eye and the results of these studies found an accuracy rate of 65% for MF Trapezoid and 80% for the Gaussian membership function [3]. It is necessary to conduct further research to improve the accuracy of the identification system retina of the eye.

Naive Bayesian algorithm is one that can classify images based training provided. Before the classification process, image extraction will be done in advance to obtain the characteristics of the image. The method will be used for the extraction is Run Length, this method is one method for extracting texture in order to obtain statistical characteristics or attributes contained in texture to estimate the pixels that have the same degree of gray.

**2.2 Process Analysis**

Process analysis in this study will describe the existing processes in the retina of the eye in an identification system to classify images based on texture. Here is a process flow system to be built can be seen in figure 3

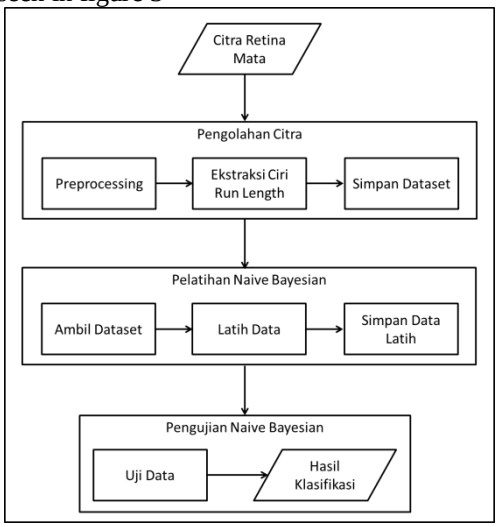



Figure 3 Process Flow System

**2.3 Data Analysis**

The data analysis consisted of analysis of the data input or the input and output of data analysis or output. Sample image data such as retina of the eye that had been prepared in advance.

**2.3.1 Input Analysis**

Input is the image of the retina of the human eye provided on VARIA dataset. The retinal image has a size of 768x584 pixels

**2.3.2 Output Analysis**

Output is the name of the classification results of a retinal image is tested, the data obtained from several processes, namely the image processing, training and testing Naive Bayesian naive Bayesian.

**2.4 Method Analysis**

Analysis method or algorithm on the retina of the eye image identification system is to analyze how naive Bayesian classifying image based on texture. Before you can classify, the input image will go through several stages of image processing and training. After the input image through a few stages later Naive Bayes testing can be performed to classify the image of the retina of the eye.

**2.4.1 Image Preprocessing Analysis**

image processing is done to get a feature extraction contained in the input image. Here is the process undertaken to get a feature extraction :

**2.4.1.1 Process Resize**

Resize is a process of changing the image size, the process is carried out to match the size of each input image. In this study, the image will resize be 32x32 pixels. Sample results are already in resizing the image can be seen in Figure 4.

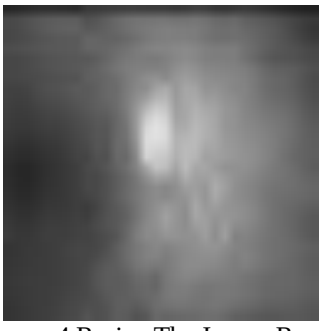


Figure 4 Resize The Image Result

**2.4.1.2 Process Grayscale**

Grayscale is the process of converting an RGB image into a gray level image, this process aims to simplify the previous pixel value RGB image has three values into a single value at each pixel. Converting the information of a color image to gray-scale can also be done by giving weight to each color element [5] with R = 0:30, 0:59 and G = B = 0:11. Thus obtained equation.

Gray = 0.30 * $R$ + 0.59 * $G$ + 0.11 * $B$

Where :

R = red value * 31 / 255

G = green value *31 / 255

B = blue value * 31 / 255

Sample calculation grayscale :

The input image used in the example calculation are the grayscale image 4.

Calculation grayscale pixel (0,0):

R = 40 * 31/255 = 4,86

G = 40 * 31/255 = 4,86

B = 40 * 31/255 = 4,86

Gray = 4,86*0,3 + 4,86*0,59 + 4,86*0,11

Gray = 1,46 + 2,87 + 0,53

Gray = 4,86

Gray = 5

Using the same formula to all the pixels it will get the grayscale matrix that can be seen in figure 5.

| | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 5 | 5 | 5 | 6 | 6 | 6 | 5 | 6 | 6 | 7 | 7 | 7 | 8 | 7 | 7 | 7 | 7 | 7 | 8 | 8 | 7 | 7 | 7 | 7 | 6 | 6 | 6 | 5 | 5 | 4 | 4 |
| 9 | 9 | 10 | 10 | 11 | 11 | 12 | 11 | 10 | 10 | 11 | 13 | 14 | 14 | 14 | 14 | 14 | 14 | 14 | 14 | 12 | 13 | 12 | 12 | 12 | 11 | 10 | 9 | 8 | 7 | 7 |
| 9 | 9 | 10 | 11 | 11 | 11 | 12 | 12 | 12 | 12 | 11 | 13 | 14 | 14 | 15 | 15 | 15 | 15 | 15 | 14 | 13 | 14 | 13 | 12 | 12 | 12 | 11 | 10 | 9 | 8 | 7 |
| 9 | 9 | 10 | 10 | 11 | 11 | 11 | 12 | 12 | 12 | 13 | 13 | 14 | 16 | 15 | 16 | 16 | 16 | 15 | 15 | 14 | 15 | 14 | 13 | 13 | 12 | 11 | 10 | 9 | 8 | 8 |
| 9 | 9 | 10 | 10 | 11 | 11 | 11 | 11 | 12 | 12 | 12 | 13 | 15 | 14 | 14 | 17 | 16 | 17 | 16 | 16 | 16 | 14 | 15 | 15 | 14 | 13 | 12 | 11 | 10 | 10 | 9 |
| 9 | 9 | 10 | 10 | 10 | 11 | 11 | 11 | 12 | 12 | 13 | 14 | 15 | 15 | 15 | 15 | 16 | 17 | 17 | 17 | 17 | 15 | 15 | 15 | 14 | 12 | 11 | 11 | 11 | 10 | 10 | 9 |
| 9 | 9 | 9 | 10 | 10 | 10 | 10 | 11 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 16 | 15 | 18 | 18 | 17 | 17 | 16 | 16 | 15 | 15 | 14 | 13 | 12 | 11 | 10 | 10 | 9 |
| 9 | 9 | 9 | 9 | 10 | 10 | 10 | 11 | 11 | 12 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 18 | 18 | 19 | 18 | 16 | 18 | 16 | 17 | 16 | 14 | 13 | 13 | 12 | 11 | 10 | 9 |
| 8 | 8 | 9 | 9 | 10 | 10 | 10 | 11 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 19 | 20 | 18 | 20 | 19 | 19 | 17 | 18 | 17 | 16 | 15 | 14 | 13 | 12 | 12 | 11 | 9 |
| 8 | 8 | 8 | 9 | 9 | 9 | 10 | 10 | 11 | 12 | 12 | 13 | 15 | 17 | 19 | 21 | 22 | 20 | 20 | 20 | 20 | 19 | 17 | 17 | 16 | 15 | 14 | 13 | 12 | 12 | 11 | 10 |
| 8 | 8 | 8 | 8 | 9 | 9 | 9 | 10 | 11 | 12 | 12 | 13 | 15 | 18 | 22 | 25 | 23 | 20 | 20 | 22 | 21 | 20 | 19 | 18 | 17 | 16 | 14 | 14 | 13 | 12 | 11 | 10 |
| 7 | 7 | 8 | 8 | 8 | 9 | 9 | 10 | 10 | 11 | 12 | 13 | 15 | 17 | 26 | 26 | 24 | 20 | 20 | 22 | 21 | 20 | 19 | 17 | 16 | 16 | 15 | 15 | 13 | 13 | 12 | 11 |
| 7 | 7 | 7 | 7 | 8 | 8 | 9 | 9 | 10 | 11 | 11 | 12 | 14 | 18 | 27 | 28 | 26 | 21 | 23 | 21 | 21 | 20 | 19 | 18 | 17 | 17 | 16 | 15 | 14 | 13 | 13 | 11 |
| 7 | 7 | 6 | 7 | 7 | 7 | 8 | 9 | 9 | 10 | 11 | 12 | 14 | 18 | 27 | 27 | 27 | 22 | 22 | 22 | 23 | 20 | 19 | 18 | 17 | 17 | 16 | 16 | 14 | 13 | 13 | 11 |
| 6 | 6 | 6 | 6 | 7 | 7 | 8 | 8 | 9 | 10 | 11 | 12 | 14 | 18 | 27 | 26 | 26 | 21 | 23 | 22 | 21 | 20 | 19 | 18 | 18 | 17 | 17 | 15 | 14 | 13 | 12 | 11 |
| 6 | 5 | 5 | 6 | 6 | 7 | 7 | 8 | 9 | 10 | 10 | 12 | 14 | 17 | 24 | 26 | 24 | 21 | 22 | 23 | 19 | 19 | 19 | 18 | 18 | 17 | 17 | 15 | 13 | 13 | 12 | 11 |
| 5 | 5 | 5 | 5 | 6 | 6 | 7 | 8 | 9 | 10 | 10 | 12 | 13 | 16 | 20 | 25 | 23 | 20 | 22 | 21 | 20 | 19 | 18 | 18 | 18 | 17 | 16 | 15 | 14 | 13 | 13 | 12 |
| 5 | 5 | 5 | 5 | 6 | 6 | 7 | 7 | 8 | 9 | 9 | 10 | 11 | 13 | 15 | 17 | 20 | 21 | 18 | 21 | 19 | 20 | 20 | 19 | 17 | 16 | 17 | 15 | 14 | 14 | 13 | 13 | 12 |
| 6 | 5 | 5 | 5 | 6 | 7 | 7 | 8 | 8 | 9 | 10 | 11 | 13 | 15 | 16 | 17 | 16 | 18 | 20 | 19 | 19 | 20 | 20 | 19 | 18 | 17 | 15 | 15 | 14 | 14 | 13 | 13 | 12 |
| 6 | 5 | 5 | 6 | 6 | 7 | 7 | 8 | 8 | 9 | 10 | 11 | 13 | 14 | 16 | 17 | 17 | 17 | 18 | 20 | 19 | 20 | 19 | 19 | 18 | 18 | 17 | 16 | 14 | 14 | 14 | 13 | 13 | 11 |
| 6 | 6 | 6 | 6 | 7 | 7 | 7 | 8 | 8 | 9 | 10 | 11 | 13 | 14 | 16 | 18 | 18 | 19 | 17 | 20 | 19 | 19 | 19 | 18 | 18 | 17 | 16 | 15 | 14 | 13 | 13 | 12 | 12 |
| 7 | 6 | 6 | 7 | 7 | 7 | 8 | 8 | 8 | 9 | 10 | 11 | 13 | 14 | 16 | 18 | 19 | 19 | 17 | 19 | 19 | 19 | 18 | 18 | 17 | 16 | 15 | 14 | 13 | 12 | 11 | 11 |
| 7 | 7 | 7 | 7 | 7 | 8 | 8 | 8 | 8 | 9 | 10 | 11 | 13 | 15 | 17 | 18 | 19 | 19 | 17 | 19 | 19 | 18 | 18 | 18 | 17 | 16 | 15 | 14 | 14 | 13 | 11 | 10 |
| 7 | 7 | 7 | 7 | 7 | 8 | 8 | 8 | 8 | 9 | 10 | 11 | 13 | 15 | 17 | 17 | 18 | 17 | 18 | 18 | 19 | 18 | 18 | 17 | 16 | 15 | 15 | 14 | 13 | 12 | 12 | 11 |
| 7 | 7 | 7 | 7 | 8 | 8 | 8 | 8 | 9 | 9 | 10 | 11 | 13 | 15 | 16 | 16 | 18 | 15 | 18 | 18 | 18 | 18 | 17 | 16 | 15 | 15 | 14 | 14 | 13 | 13 | 12 | 12 |
| 7 | 7 | 7 | 7 | 7 | 8 | 8 | 8 | 8 | 9 | 11 | 12 | 13 | 14 | 15 | 17 | 15 | 17 | 17 | 18 | 18 | 17 | 16 | 16 | 15 | 15 | 14 | 13 | 13 | 12 | 12 | 12 |
| 7 | 7 | 7 | 7 | 8 | 8 | 8 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 15 | 14 | 17 | 16 | 16 | 17 | 17 | 16 | 16 | 15 | 14 | 13 | 13 | 13 | 12 | 12 | 12 |
| 7 | 7 | 7 | 7 | 8 | 8 | 8 | 8 | 9 | 9 | 10 | 11 | 12 | 12 | 13 | 14 | 12 | 15 | 16 | 16 | 15 | 16 | 15 | 15 | 15 | 14 | 13 | 13 | 13 | 13 | 12 | 12 |
| 7 | 7 | 7 | 7 | 8 | 8 | 8 | 8 | 9 | 9 | 10 | 11 | 11 | 12 | 13 | 12 | 12 | 15 | 15 | 15 | 15 | 15 | 15 | 14 | 14 | 14 | 13 | 13 | 12 | 12 | 12 | 11 |
| 7 | 7 | 7 | 7 | 7 | 8 | 8 | 8 | 9 | 9 | 10 | 11 | 12 | 13 | 11 | 14 | 15 | 15 | 15 | 14 | 14 | 14 | 14 | 15 | 14 | 13 | 13 | 12 | 12 | 12 | 12 | 11 |
| 7 | 7 | 7 | 7 | 7 | 8 | 8 | 8 | 9 | 10 | 10 | 10 | 11 | 12 | 11 | 12 | 13 | 14 | 14 | 14 | 14 | 14 | 15 | 15 | 14 | 14 | 13 | 12 | 12 | 12 | 12 | 11 | 11 |
| 6 | 7 | 7 | 7 | 7 | 8 | 9 | 9 | 10 | 10 | 11 | 11 | 11 | 10 | 12 | 12 | 12 | 13 | 13 | 13 | 13 | 13 | 13 | 12 | 12 | 11 | 10 | 11 | 11 | 11 | 11 | 10 |

Figure 5 Matrix Grayscale

**2.4.1.3 Run Length Extraction Process**

Run-length is a method for feature extraction, where the value of feature extraction to be obtained

is the value of SRE (short run emphasis), LRE (long run emphasis), GLU (gray level uninformity), RLU (run length uninformity) and RPC (run percentage ). The first step in calculating run length method is to make a run length matrix, the matrix value obtained from the run length grayscale matrix to calculate the degree of gray the same on each line. Orientation is formed by a four-way shift, ie $0^0$, $45^0$, $90^0$ and $135^0$.

For example grayscale matrix in Figure 5 is used to obtain a run length matrix. Here is a run length matrix with a shift towards 00, 450, 900 and 1350 are produced.

Where

i = gray degrees value

j = consecutive pixel (run)

r(j) = The number of pixels in sequence by many order

g(i) = The number of pixels in sequence based on the gray degrees

s = The total number of runs generated value

Table 3 Run Length Matrix $0^0$

| i | r ( j ) | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | G( i|ɵ ) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 | 32 | |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 4 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| 5 | 1 | 3 | 2 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 8 |
| 6 | 6 | 6 | 2 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 16 |
| 7 | 4 | 7 | 4 | 7 | 5 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 28 |
| 8 | 8 | 10 | 5 | 6 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 29 |
| 9 | 19 | 15 | 4 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 39 |
| 10 | 27 | 12 | 4 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 44 |
| 11 | 44 | 7 | 4 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 58 |
| 12 | 31 | 13 | 7 | 1 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 54 |
| 13 | 37 | 16 | 2 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 57 |
| 14 | 39 | 6 | 3 | 1 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 51 |
| 15 | 33 | 9 | 3 | 1 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 48 |
| 16 | 29 | 7 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 39 |
| 17 | 33 | 8 | 2 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 44 |
| 18 | 20 | 9 | 3 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 33 |
| 19 | 17 | 6 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 |
| 20 | 16 | 3 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 20 |
| 21 | 10 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 11 |
| 22 | 7 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 8 |
| 23 | 6 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 6 |
| 24 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3 |
| 25 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 |
| 26 | 2 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 4 |
| 27 | 2 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3 |
| 28 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| 29 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 30 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 31 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| r( j|ɵ ) | 397 | 141 | 52 | 29 | 9 | 2 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 632 |

Table 4 Run Length Matrix $45^0$

| i | r ( j ) | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | G( i|ɵ ) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 | 32 | |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 4 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 |
| 5 | 6 | 3 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 12 |
| 6 | 19 | 1 | 2 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 23 |
| 7 | 27 | 7 | 3 | 2 | 2 | 0 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 44 |
| 8 | 20 | 8 | 0 | 4 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 35 |
| 9 | 33 | 13 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 48 |
| 10 | 43 | 9 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 54 |
| 11 | 49 | 12 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 64 |
| 12 | 47 | 12 | 4 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 65 |
| 13 | 47 | 6 | 5 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 60 |
| 14 | 47 | 11 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 61 |
| 15 | 44 | 8 | 4 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 57 |
| 16 | 32 | 7 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 41 |
| 17 | 34 | 11 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 46 |
| 18 | 25 | 6 | 2 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 35 |
| 19 | 17 | 7 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 |
| 20 | 19 | 2 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 22 |
| 21 | 8 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 10 |
| 22 | 8 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 9 |
| 23 | 6 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 6 |
| 24 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3 |
| 25 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 |
| 26 | 4 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 5 |
| 27 | 3 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 4 |
| 28 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| 29 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 30 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 31 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| r( j|ɵ ) | 546 | 128 | 37 | 12 | 7 | 0 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 734 |

Table 5 Run Length Matrix $90^0$

| i | r ( j ) | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | G( i|ɵ ) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 | 32 | |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 4 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 |
| 5 | 6 | 1 | 1 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 10 |
| 6 | 10 | 7 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 19 |
| 7 | 16 | 3 | 4 | 2 | 0 | 1 | 0 | 0 | 0 | 3 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 30 |
| 8 | 8 | 4 | 4 | 0 | 0 | 1 | 0 | 0 | 0 | 2 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 20 |
| 9 | 5 | 3 | 4 | 1 | 3 | 0 | 2 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 19 |
| 10 | 8 | 5 | 6 | 4 | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 25 |
| 11 | 19 | 4 | 5 | 4 | 2 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 36 |
| 12 | 20 | 7 | 9 | 3 | 2 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 42 |
| 13 | 19 | 7 | 5 | 4 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 37 |
| 14 | 22 | 10 | 5 | 4 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 42 |
| 15 | 22 | 12 | 6 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 42 |
| 16 | 20 | 6 | 4 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 32 |
| 17 | 21 | 9 | 3 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 35 |
| 18 | 11 | 5 | 4 | 2 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 24 |
| 19 | 7 | 5 | 2 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 16 |
| 20 | 7 | 2 | 2 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 13 |
| 21 | 7 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 9 |
| 22 | 4 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 7 |
| 23 | 6 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 6 |
| 24 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3 |
| 25 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 |
| 26 | 4 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 5 |
| 27 | 2 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3 |
| 28 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| 29 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 30 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 31 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| r( j|ɵ ) | 252 | 95 | 67 | 28 | 16 | 6 | 2 | 2 | 2 | 7 | 2 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 480 |

Table 6 Run Length Matrix $135^0$

| i | r ( j ) | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | G( i|ɵ ) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 | 32 | |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 4 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 |
| 5 | 7 | 1 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 12 |
| 6 | 19 | 1 | 1 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 23 |
| 7 | 20 | 10 | 1 | 5 | 4 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 41 |
| 8 | 8 | 8 | 9 | 1 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 28 |
| 9 | 19 | 9 | 2 | 1 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 33 |
| 10 | 24 | 8 | 3 | 0 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 38 |
| 11 | 37 | 12 | 1 | 2 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 54 |
| 12 | 32 | 19 | 6 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 58 |
| 13 | 42 | 13 | 3 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 60 |
| 14 | 40 | 16 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 58 |
| 15 | 43 | 12 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 57 |
| 16 | 37 | 6 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 44 |
| 17 | 32 | 7 | 3 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 43 |
| 18 | 23 | 11 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 36 |
| 19 | 14 | 6 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 23 |
| 20 | 9 | 7 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 17 |
| 21 | 12 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 12 |
| 22 | 8 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 9 |
| 23 | 4 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 5 |
| 24 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3 |
| 25 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 2 |
| 26 | 4 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 5 |
| 27 | 3 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 4 |
| 28 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| 29 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 30 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 31 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| r( j|ɵ ) | 445 | 150 | 43 | 15 | 8 | 3 | 2 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 668 |

After cakcukating the SRE features (Short Run Emphasis), LRE (Long Run Emphasis), GLU (Grey Level Uninformity), RLU(Run Length Uninformity), and RPC (Run Percentage) on run length matrix $0^0$, $45^0$, $90^0$, dan $135^0$, then the result of features value are :

Table 7 Run Length Matrix Features Value

| Feature | Run Length Matrix | | | |
|---|---|---|---|---|
| | $0^0$ | $45^0$ | $90^0$ | $135^0$ |
| SRE | 0.69666 | 0.79458 | 0.59571 | 0.73156 |
| LRE | 3.67089 | 2.66213 | 7.9125 | 3.35329 |
| GLU | 40.61392 | 46.80109 | 29.525 | 42.47305 |
| RLU | 286.58544 | 430.62398 | 162.83333 | 333.35329 |
| RPC | 0.61719 | 0.7168 | 0.46875 | 0.65234 |

### 2.4.2 Naive Bayesian Training Analysis

Naive Bayesian training is done to obtain training data in the form of the mean and variance. The mean and variance of this will be referred for testing. In the training phase the mean and variance sought from every feature on every class training data. The following dataset used for training can be seen in Table 8.

Table 8 Training Data

| Retina | SRE | LRE | GLU | RLU | RPC |
|---|---|---|---|---|---|
| A.1 | 0.70463 | 4.3997 | 39.85326 | 303.34901 | 0.61377 |
| A.2 | 0.68916 | 4.27881 | 38.94517 | 287.53854 | 0.60889 |
| B.1 | 0.66979 | 5.1908 | 40.03463 | 261.16692 | 0.57544 |
| B.2 | 0.64519 | 5.91579 | 41.56174 | 232.42015 | 0.54858 |

Setelah dilakukan proses pelatihan maka didapat hasil data pelatihan yang dapat dilihat pada table 9.

Tabel 9 Hasil Pelatihan

| Retina | Nilai | Fitur | | | | |
|---|---|---|---|---|---|---|
| | | SRE | LRE | GLU | RLU | RPC |
| A | Mean | 0.69690 | 4.33926 | 39.39922 | 295.44378 | 0.61133 |
| | Varian | 0.00012 | 0.00731 | 0.41231 | 124.98548 | 0.00001 |
| B | Mean | 0.65749 | 5.55330 | 40.79819 | 246.79354 | 0.56201 |
| | Varian | 0.00030 | 0.26281 | 1.16603 | 413.18839 | 0.00036 |

### 2.4.3 Naive Bayesian Testing Analysis

Naive Bayesian testing phase is the testing phase of new data on the training data. Examples of imagery to be tested can be seen in Figure 5.

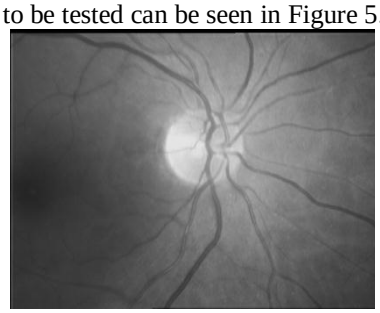


Figure 5 Test Image

The following feature extraction feature value test images can be seen in Table 10.

Table 10 Test Image Feature

| Fitur | Nilai |
|---|---|
| SRE | 0.68916 |
| LRE | 4.27881 |
| GLU | 38.94517 |
| RLU | 287.53854 |
| RPC | 0.60889 |

After the testing process Naive Bayesian posterior retina obtained value class A is greater than B grade retina, then the class which is suitable for the above test images are retina Class A.

## 3. TESTING AND RESULT

Testing method aims to find out the results of the run length method and Naive Bayesian in identifying the retina of the eye. In this study, plan testing is done with a few scenarios. Here's a scenario that will be done :

1. Test the image of the eye's retina that have been used as training data.
2. Test the image of the eye's retina that has not been previously trained and tested the effect of the amount of training data on the level of accuracy.

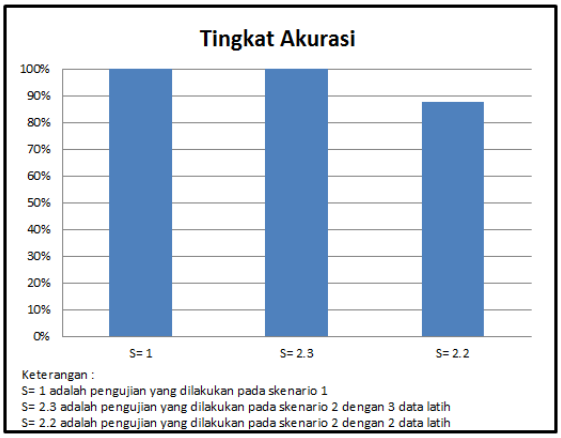



Figure 6 Method Testing Result

Based on the testing that was done method of run length and Naive Bayesian methods can be used to identify the image of the retina of the human eye and is based on the above test concluded that the amount of training data affect the level of accuracy as more training data the greater the resulting degree of accuracy.

## 4. CLOSURE

### 4.1 Conclusion

The results of the research that has been done in the arrangement of this paper as well as referring to the purpose of research, so it can be concluded.

1. Run length method and Naive Bayesian can be used to identify the retina of the eye based on the image.
2. The level of accuracy of the run length method and Naive Bayesian in identifying the retina of the eye based on the image is 100%.

### 4.2 Suggestion

Based on the results of the research that has been reached at this time, there are some suggestions that might be helpful if someone wants to do a similar study, i.e.:

1. The imagery Dataset that is used should have a more diverse class.
2. To obtain a high level of accuracy in classifying the various images, it's better to use a lot of training data.

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