BAB IV
HASIL DAN PEMBAHASAN

4.1 Pembahasan

4.1.1 Analisis Data

Setelah data didapatkan, maka selanjutnya menguraikan bagaimana cara pengolahan data tersebut. Tahapan analisis dimaksudkan untuk melakukan analisis terhadap data-data yang telah diperoleh yang selanjutnya akan dilakukan proses ekstraksi fitur citra songket menggunakan *Grey Level Co-Occurrence Matrix* (GLCM) dan kemudian melakukan proses klasifikasi dengan *Support Vector Machine* (SVM). Adapun beberapa tahapan dalam mengelola data yang diperoleh antara lain adalah sebagai berikut :

1. Menyediakan citra jenis songket Batu Bara berjenis *grayscale* dengan ukuran 512 × 512 piksel sebagai data untuk pengujian.
2. Menerapkan metode *Grey Level Co-Occurrence Matrix* (GLCM) untuk melakukan ekstraksi fitur.
3. Menerapkan metode *Support Vector Machine* (SVM) untuk mengklasifikasikan jenis motif songket Batu Bara berdasarkan tekstur.

4.1.2 Representasi Data

Data yang digunakan berupa citra *grayscale* dengan ukuran 512 × 512 piksel yang akan dilakukan proses klasifikasi jenis motif songket Batu Bara berdasarkan tekstur dengan metode *Grey Level Co-Pccurence Matrix* (GLCM) dan *Support Vector Machine* (SVM), tetapi untuk melakukan pengujian *sample* pada metode *Grey Level Co-Pccurence Matrix* (GLCM) penulis menggunakan citra motif songket Batu Bara berjenis *grayscale* dengan ukuran 4 × 4 piksel, sedangkan pada metode *Support Vector Machine* (SVM) penulis melakukan pengujian *sample* sesuai dengan sistem yang dibuat.

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

Gambar 4. 1 *Sample* citra motif songket Batu Bara berukuran 4 × 4 piksel

Sample citra di atas merupakan citra motif songket Batu Bara jenis pucuk betikam yang memiliki nilai disetiap piksel, citra tersebut berjenis *grayscale* yang telah melalui *preprocessing* dengan ukuran 4 × 4 piksel yang memiliki 4 derajat keabuan dengan rentang 0 - 3. *Sample* citra tersebut terdiri dari 4 baris dan 4 kolom yang akan digunakan untuk melakukan proses klasifikasi jenis motif songket Batu Bara berdasarkan tekstur dengan menerapkan metode *Grey Level Co-Pccurence Matrix* (GLCM). Sedangkan dalam penerapakan metode *Support Vector Machine* (SVM) menggunakan *sample* sesuai dengan sistem yang dibuat.

4.1.3 Hasil Analisis Data

Pada proses implementasi penggunaan metode *Grey Level Co-Occurence Matrix (*GLCM) dalam melakukan proses ekstraksi fitur citra motif songket Batu Bara penulis menggunakan *sample* citra motif songket Batu Bara berjenis *grayscale* dengan ukuran 4 × 4 piksel. Sedangkan pada proses implementasi penggunaan metode *Support Vector Machine* (SVM) dalam melakukan proses klasifikasi motif songket Batu Bara, penulis menggunakan *sample* sesuai dengan sistem yang dibuat.

4.1.3.1 Analisis Data dengan *Gray Level Co-Occurance Matrix* (GLCM)

Piksel $4 \times 4,\ d = 1,\ \theta = 0^{\circ}$ Matrix Kookurensi:

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

i/j	0	1	2	3
0	2	1	1	
1	1	1	0	
2	0	0	0	
3	1	3	0	

GLCM Simetris:

$$\begin{bmatrix} 2 & 1 & 1 & 0 \\ 1 & 1 & 0 & 3 \\ 0 & 0 & 0 & 1 \\ 1 & 3 & 0 & 0 \end{bmatrix} + \begin{bmatrix} 2 & 1 & 0 & 1 \\ 1 & 1 & 0 & 3 \\ 1 & 0 & 0 & 0 \\ 0 & 3 & 1 & 0 \end{bmatrix} = \begin{bmatrix} 4 & 2 & 1 & 1 \\ 2 & 2 & 0 & 6 \\ 1 & 0 & 0 & 1 \\ 1 & 6 & 1 & 0 \end{bmatrix} = 28$$

Normalisasi Matrix:

$$\begin{bmatrix} {}^{4}/_{28} & {}^{2}/_{28} & {}^{1}/_{28} & {}^{1}/_{28} \\ {}^{2}/_{28} & {}^{2}/_{28} & {}^{0}/_{28} & {}^{6}/_{28} \\ {}^{1}/_{28} & {}^{0}/_{28} & {}^{0}/_{28} & {}^{1}/_{28} \\ {}^{1}/_{28} & {}^{6}/_{28} & {}^{1}/_{28} & {}^{0}/_{28} \end{bmatrix}$$

Hasil Normalisasi Matrix:

${}^{4}/_{28}$	${}^{2}/_{28}$	${}^{1}/_{28}$	${}^{1}/_{28}$
${}^{2}/_{28}$	${}^{2}/_{28}$	${}^{0}/_{28}$	${}^{6}/_{28}$
${}^{1}/_{28}$	${}^{0}/_{28}$	${}^{0}/_{28}$	${}^{1}/_{28}$
${}^{1}/_{28}$	${}^{6}/_{28}$	${}^{1}/_{28}$	${}^{0}/_{28}$

Contrast:

$$Con = \sum_{i}\sum_{j}(i-j)^2 p(i,j)$$

$Con(0,0) = (0-0)^2 \times ({}^{4}/_{28})$

$= (0)^2 \times ({}^{4}/_{28})$

$= 0$

$Con(0,1) = (0-1)^2 \times ({}^{2}/_{28})$

$= (-1)^2 \times ({}^{2}/_{28})$

$= {}^{2}/_{28}$

$= 0.071$

$Con(0,2) = (0-2)^2 \times (1/28)$
$= (-2)^2 \times (1/28)$
$= 4/28$
$= 0.142$

$Con(0,3) = (0-3)^2 \times (1/28)$
$= (-3)^2 \times (1/28)$
$= 9/28$
$= 0.321$

$Con(1,0) = (1-0)^2 \times (2/28)$
$= (1)^2 \times (2/28)$
$= 2/28$
$= 0.071$

$Con(1,1) = (1-1)^2 \times (2/28)$
$= (0)^2 \times (2/28)$
$= 0/28$
$= 0$

$Con(1,2) = (1-2)^2 \times (0/28)$
$= (-1)^2 \times (0/28)$
$= 0/28$
$= 0$

$Con(1,3) = (1-3)^2 \times (6/28)$
$= (-2)^2 \times (6/28)$
$= 24/28$
$= 0.857$

$Con(2,0) = (2-0)^2 \times (1/28)$
$= (2)^2 \times (1/28)$
$= 4/28$
$= 0.142$

$Con(2,1) = (2-1)^2 \times (0/28)$
$= (1)^2 \times (0/28)$
$= 0/28$
$= 0$

$Con(2,2) = (2-2)^2 \times (0/28)$
$= (0)^2 \times (0/28)$
$= 0/28$
$= 0$

$Con(2,3) = (2-3)^2 \times (1/28)$
$= (-1)^2 \times (1/28)$
$= 1/28$
$= 0.035$

$Con(3,0) = (3-0)^2 \times (1/28)$
$= (3)^2 \times (1/28)$
$= 9/28$
$= 0.321$

$Con(3,1) = (3-1)^2 \times (6/28)$
$= (2)^2 \times (6/28)$
$= 24/28$
$= 0.857$

$Con(3,2) = (3-2)^2 \times (1/28)$
$= (1)^2 \times (1/28)$
$= 1/28$
$= 0.035$

$Con(3,3) = (3-3)^2 \times (0/28)$
$= (0)^2 \times (0/28)$
$= 0/28$
$= 0$

$Con(Total) = 0 + 0.071 + 0.142 + 0.071 + 0.321 + 0 + 0 + 0.857 + 0.142 + 0 + 0 + 0.035 + 0.321 + 0.857 + 0.035 + 0$
$= 2.817$

Correlation:

$$Cor = \sum_i \sum_j \frac{(i-\mu i)(j-\mu j)p_{(i,j)}}{\sigma i \, \sigma j}$$

Dimana:

$$\mu i = \sum_i \sum_j i p_{(i,j)}$$

$$\mu j = \sum_i \sum_j j p_{(i,j)}$$

$$\sigma i = \sqrt{\sum_i \sum_j (i-\mu i)^2 p_{(i,j)}}$$

$$\sigma j = \sqrt{\sum_i \sum_j (j-\mu j)^2 p_{(i,j)}}$$

$\mu i = ((0\times4) + (0\times2) + (0\times1) + (0\times1) + (1\times2) + (1\times2) + (1\times0) + (1\times6) + (2\times1) + (2\times0) + (2\times0) + (2\times1) + (3\times1) + (3\times6) + (3\times1) + (3\times0)) / 28$

$\mu i = \frac{38}{28}$

$\mu i = 1.357$

$\mu j = ((0\times4) + (1\times2) + (2\times1) + (3\times1) + (0\times2) + (1\times2) + (2\times0) + (3\times6) + (0\times1) + (1\times0) + (2\times0) + (3\times1) + (0\times1) + (1\times6) + (2\times1) + (3\times0)) / 23$

$$\mu j = \frac{38}{28}$$

$$\mu j = 1.357$$

$$\sigma i(0,0) = \left(0 - \frac{38}{28}\right)^2 \times \frac{4}{28}$$
$$= \frac{1444}{784} \times \frac{4}{28}$$
$$= \frac{5776}{21952}$$
$$= 0.263$$

$$\sigma i(0,1) = \left(0 - \frac{38}{28}\right)^2 \times \frac{2}{28}$$
$$= \frac{1444}{784} \times \frac{2}{28}$$
$$= \frac{2888}{21952}$$
$$= 0.131$$

$$\sigma i(0,2) = \left(0 - \frac{38}{28}\right)^2 \times \frac{1}{28}$$
$$= \frac{1444}{784} \times \frac{1}{28}$$
$$= \frac{1444}{21952}$$
$$= 0.065$$

$$\sigma i(0,3) = \left(0 - \frac{38}{28}\right)^2 \times \frac{1}{28}$$
$$= \frac{1444}{784} \times \frac{1}{28}$$
$$= \frac{1444}{21952}$$
$$= 0.065$$

$$\sigma i(1,0) = \left(1 - \frac{38}{28}\right)^2 \times \frac{2}{28}$$
$$= \frac{100}{784} \times \frac{2}{28}$$
$$= \frac{200}{21952}$$
$$= 0.009$$

$$\sigma i(1,1) = \left(1 - \frac{38}{28}\right)^2 \times \frac{2}{28}$$
$$= \frac{100}{784} \times \frac{2}{28}$$
$$= \frac{200}{21952}$$
$$= 0.009$$

$$\sigma i(1,2) = \left(1 - \frac{38}{28}\right)^2 \times \frac{0}{28}$$
$$= \frac{100}{784} \times \frac{0}{28}$$
$$= \frac{0}{21952}$$
$$= 0$$

$$\sigma i(1,3) = \left(1 - \frac{38}{28}\right)^2 \times \frac{6}{28}$$
$$= \frac{100}{784} \times \frac{6}{28}$$
$$= \frac{600}{21952}$$
$$= 0.027$$

$$\sigma i(2,0) = \left(2 - \frac{38}{28}\right)^2 \times \frac{1}{28}$$

$$\sigma i(2,1) = \left(2 - \frac{38}{28}\right)^2 \times \frac{0}{28}$$

$$= \frac{324}{784} \times \frac{1}{28}$$
$$= \frac{324}{21952}$$
$$= 0.014$$

$$\sigma i(2,2) = \left(2 - \frac{38}{28}\right)^2 \times \frac{0}{28}$$
$$= \frac{324}{784} \times \frac{0}{28}$$
$$= \frac{0}{21952}$$
$$= 0$$

$$\sigma i(2,3) = \left(2 - \frac{38}{28}\right)^2 \times \frac{1}{28}$$
$$= \frac{324}{784} \times \frac{1}{28}$$
$$= \frac{324}{21952}$$
$$= 0.014$$

$$\sigma i(3,0) = \left(3 - \frac{38}{28}\right)^2 \times \frac{1}{28}$$
$$= \frac{2116}{784} \times \frac{1}{28}$$
$$= \frac{2116}{21952}$$
$$= 0.096$$

$$\sigma i(3,1) = \left(3 - \frac{38}{28}\right)^2 \times \frac{6}{28}$$
$$= \frac{2116}{784} \times \frac{6}{28}$$
$$= \frac{12696}{21952}$$
$$= 0.57$$

$$\sigma i(3,2) = \left(3 - \frac{38}{28}\right)^2 \times \frac{1}{28}$$
$$= \frac{2116}{784} \times \frac{1}{28}$$
$$= \frac{2116}{21952}$$
$$= 0.096$$

$$\sigma i(3,3) = \left(3 - \frac{38}{28}\right)^2 \times \frac{0}{28}$$
$$= \frac{2116}{784} \times \frac{0}{28}$$
$$= \frac{0}{21952}$$
$$= 0$$

$$\sigma i(Total) = \sqrt{(0.263 + 0.131 + 0.065 + 0.065 + 0.009 + 0.009 + 0 + 0.027 + 0.014 + 0 + 0 + 0.014 + 0.096 + 0.57 + 0.096 + 0)}$$
$$= 1.165$$

$$\sigma j(0,0) = \left(0 - \frac{38}{28}\right)^2 \times \frac{4}{28}$$
$$= \frac{1444}{784} \times \frac{4}{28}$$

$$\sigma j(0,1) = \left(1 - \frac{38}{28}\right)^2 \times \frac{2}{28}$$
$$= \frac{100}{784} \times \frac{2}{28}$$

$$= \frac{5776}{21952}$$

$$= 0.263$$

$$\sigma j(0,2) = \left(2 - \frac{38}{28}\right)^2 \times \frac{1}{28}$$

$$= \frac{324}{784} \times \frac{1}{28}$$

$$= \frac{324}{21952}$$

$$= 0.014$$

$$\sigma j(1,0) = \left(0 - \frac{38}{28}\right)^2 \times \frac{2}{28}$$

$$= \frac{1444}{784} \times \frac{2}{28}$$

$$= \frac{2888}{21952}$$

$$= 0.131$$

$$\sigma j(1,2) = \left(2 - \frac{38}{28}\right)^2 \times \frac{0}{28}$$

$$= \frac{324}{784} \times \frac{0}{28}$$

$$= \frac{0}{21952}$$

$$= 0$$

$$\sigma j(2,0) = \left(0 - \frac{38}{28}\right)^2 \times \frac{1}{28}$$

$$= \frac{1444}{784} \times \frac{1}{28}$$

$$= \frac{1444}{21952}$$

$$= 0.065$$

$$\sigma j(2,2) = \left(2 - \frac{38}{28}\right)^2 \times \frac{0}{28}$$

$$= \frac{324}{784} \times \frac{0}{28}$$

$$= \frac{200}{21952}$$

$$= 0.009$$

$$\sigma j(0,3) = \left(3 - \frac{38}{28}\right)^2 \times \frac{1}{28}$$

$$= \frac{2116}{784} \times \frac{1}{28}$$

$$= \frac{2116}{21952}$$

$$= 0.096$$

$$\sigma j(1,1) = \left(1 - \frac{38}{28}\right)^2 \times \frac{2}{28}$$

$$= \frac{100}{784} \times \frac{2}{28}$$

$$= \frac{200}{21952}$$

$$= 0.009$$

$$\sigma j(1,3) = \left(3 - \frac{38}{28}\right)^2 \times \frac{6}{28}$$

$$= \frac{2116}{784} \times \frac{6}{28}$$

$$= \frac{12696}{21952}$$

$$= 0.57$$

$$\sigma j(2,1) = \left(1 - \frac{38}{28}\right)^2 \times \frac{0}{28}$$

$$= \frac{100}{784} \times \frac{0}{28}$$

$$= \frac{0}{21952}$$

$$= 0$$

$$\sigma j(2,3) = \left(3 - \frac{38}{28}\right)^2 \times \frac{1}{28}$$

$$= \frac{2116}{784} \times \frac{1}{28}$$

$$= \frac{0}{21952}$$
$$= 0$$

$$\sigma j(3,0) = \left(0 - \frac{38}{28}\right)^2 \times \frac{1}{28}$$
$$= \frac{1444}{784} \times \frac{1}{28}$$
$$= \frac{1444}{21952}$$
$$= 0.065$$

$$\sigma j(3,1) = \left(1 - \frac{38}{28}\right)^2 \times \frac{6}{28}$$
$$= \frac{100}{784} \times \frac{6}{28}$$
$$= \frac{600}{21952}$$
$$= 0.027$$

$$\sigma j(3,2) = \left(2 - \frac{38}{28}\right)^2 \times \frac{1}{28}$$
$$= \frac{324}{784} \times \frac{1}{28}$$
$$= \frac{324}{21952}$$
$$= 0.014$$

$$\sigma j(3,3) = \left(3 - \frac{38}{28}\right)^2 \times \frac{0}{28}$$
$$= \frac{2116}{784} \times \frac{0}{28}$$
$$= \frac{0}{21952}$$
$$= 0$$

$$\sigma j(Total) = \sqrt{(0.263 + 0.009 + 0.014 + 0.096 + 0.131 + 0.009 + 0 + 0.57 + 0.065 + 0 + 0 + 0.096 + 0.065 + 0.027 + 0.014 + 0)}$$
$$= 1.165$$

$$Cor(0.0) = \frac{(0 - 1.35)(0 - 1.35)(\frac{4}{28})}{(1.165)(1.165)}$$
$$= \frac{(-1.35)(-1.35)(0.14)}{1.357}$$
$$= \frac{0.255}{1.357}$$

$$Cor(0.1) = \frac{(0 - 1.35)(1 - 1.35)(\frac{2}{28})}{(1.165)(1.165)}$$
$$= \frac{(-1.35)(-0.35)(0.071)}{(1.165)(1.165)}$$
$$= \frac{0.033}{1.357}$$

$$Cor(0.2) = \frac{(0 - 1.35)(2 - 1.35)(\frac{1}{28})}{(1.165)(1.165)}$$
$$= \frac{(-1.35)(0.65)(0.035)}{1.357}$$

$$Cor(0.3) = \frac{(0 - 1.35)(3 - 1.35)(\frac{1}{28})}{(1.165)(1.165)}$$
$$= \frac{(-1.35)(1,65)(0.035)}{(1.165)(1.165)}$$

$$= \frac{-0.030}{1.357} \qquad = \frac{-0.77}{1.357}$$

$$Cor(1.0) = \frac{(1-1.35)(0-1.35)(\frac{2}{28})}{(1.165)(1.165)} \qquad Cor(1.1) = \frac{(1-1.35)(1-1.35)(\frac{2}{28})}{(1.165)(1.165)}$$

$$= \frac{(-0.35)(-1.35)(0.071)}{(1.165)(1.165)} \qquad = \frac{(-1.35)(-1.35)(0.071)}{(1.165)(1.165)}$$

$$= \frac{0.033}{1.357} \qquad = \frac{0.129}{1.357}$$

$$Cor(1.2) = \frac{(1-1.35)(2-1.35)(\frac{0}{28})}{(1.165)(1.165)} \qquad Cor(1.3) = \frac{(1-1.35)(3-1.35)(\frac{6}{28})}{(1.165)(1.165)}$$

$$= \frac{(-0.35)(0.65)(0)}{1.357} \qquad = \frac{(-0.35)(1.65)(0.21)}{(1.165)(1.165)}$$

$$= \frac{0}{1.357} \qquad = \frac{-0{,}121}{1.357}$$

$$Cor(2.0) = \frac{(2-1.35)(0-1.35)(\frac{1}{28})}{(1.165)(1.165)} \qquad Cor(2.1) = \frac{(2-1.35)(1-1.35)(\frac{0}{28})}{(1.165)(1.165)}$$

$$= \frac{(0.65)(-1.35)(0.035)}{1.357} \qquad = \frac{(0.65)(-0.35)(0)}{(1.165)(1.165)}$$

$$= \frac{-0{,}030}{1.357} \qquad = \frac{0}{1.357}$$

$$Cor(2.2) = \frac{(2-1.35)(2-1.35)(\frac{0}{28})}{(1.165)(1.165)} \qquad Cor(2.3) = \frac{(2-1.35)(3-1.35)(\frac{1}{28})}{(1.165)(1.165)}$$

$$= \frac{(0.65)(0.65)(0)}{1.357} \qquad = \frac{(0.65)(1.65)(0.035)}{(1.165)(1.165)}$$

$$= \frac{0}{1.357} \qquad = \frac{0.037}{1.357}$$

$$Cor(3.0) = \frac{(3-1.35)(0-1.35)(\frac{1}{28})}{(1.165)(1.165)} \qquad Cor(3.1) = \frac{(3-1.35)(1-1.35)(\frac{6}{28})}{(1.165)(1.165)}$$

$$= \frac{(1.65)(-1.35)(0.035)}{1.357} \qquad = \frac{(1.65)(-0.35)(0.21)}{(1.165)(1.165)}$$

$$= \frac{-0{,}077}{1.357} \qquad = \frac{-0{,}121}{1.357}$$

$$Cor(3.2) = \frac{(3-1.35)(2-1.35)(\frac{1}{28})}{(1.165)(1.165)} \qquad Cor(3.3) = \frac{(3-1.35)(3-1.35)(\frac{0}{28})}{(1.165)(1.165)}$$

$$= \frac{(1.65)(0.65)(0.035)}{1.357} \qquad = \frac{(1.65)(1.65)(0)}{(1.165)(1.165)}$$

$$= \frac{0.037}{1.357} \qquad = \frac{0}{1.357}$$

$Cor(Total) =$ (0.255 + 0.033 + (-0.030) + (-0.77) + 0.033 + 0.129 + 0 + (-0,121) + (-0,030) + 0 + 0 + 0.037 + (-0,077) + (-0,121) + 0.037 + 0) / (28/1.357)

$$= \frac{0.915}{20.633}$$

$$= 0.044$$

Homogenety:

$$Hom = \sum_i \sum_j \frac{p(i,j)}{1+|i-j|}$$

$$Hom(0,0) = \frac{{}^{4}/_{28}}{1+|0-0|} \qquad Hom(0,1) = \frac{{}^{2}/_{28}}{1+|0-1|}$$

$$= \frac{4}{28(1+|0-0|)} \qquad = \frac{2}{28(1+|0-1|)}$$

$$= \frac{4}{28} \qquad = \frac{2}{56}$$

$$= 0.142 \qquad = 0.035$$

$$Hom(0,2) = \frac{{}^{1}/_{28}}{1+|0-2|} \qquad Hom(0,3) = \frac{{}^{1}/_{28}}{1+|0-3|}$$

$$= \frac{1}{28(1+|0-2|)} \qquad = \frac{1}{28(1+|0-3|)}$$

$$= \frac{1}{84} \qquad = \frac{1}{112}$$

$$= 0.011 \qquad = 0.08$$

$$Hom(1,0) = \frac{{}^{2}/_{28}}{1+|1-0|} \qquad Hom(1,1) = \frac{{}^{2}/_{28}}{1+|1-1|}$$

$$= \frac{2}{28(1+|1-0|)} \qquad = \frac{2}{28(1+|1-1|)}$$

$$= \frac{2}{56} \qquad = \frac{2}{28}$$

$$= 0.035$$

$$Hom(1,2) = \frac{0/28}{1+|1-2|}$$

$$= \frac{0}{28(1+|1-2|)}$$

$$= \frac{0}{56}$$

$$= 0$$

$$Hom(2,0) = \frac{1/28}{1+|2-0|}$$

$$= \frac{1}{28(1+|2-0|)}$$

$$= \frac{1}{84}$$

$$= 0.11$$

$$Hom(2,2) = \frac{0/28}{1+|2-2|}$$

$$= \frac{0}{28(1+|2-2|)}$$

$$= \frac{0}{28}$$

$$= 0$$

$$Hom(3,0) = \frac{1/28}{1+|3-0|}$$

$$= \frac{1}{28(1+|3-0|)}$$

$$= \frac{1}{112}$$

$$= 0.008$$

$$Hom(3,2) = \frac{1/28}{1+|3-2|}$$

$$= \frac{1}{28(1+|3-2|)}$$

$$= \frac{1}{56}$$

$$= 0.017$$

$$= 0.071$$

$$Hom(1,3) = \frac{6/28}{1+|1-3|}$$

$$= \frac{6}{28(1+|1-3|)}$$

$$= \frac{6}{84}$$

$$= 0.071$$

$$Hom(2,1) = \frac{0/28}{1+|2-1|}$$

$$= \frac{0}{28(1+|2-1|)}$$

$$= \frac{0}{56}$$

$$= 0$$

$$Hom(2,3) = \frac{1/28}{1+|2-3|}$$

$$= \frac{1}{28(1+|2-3|)}$$

$$= \frac{1}{56}$$

$$= 0.017$$

$$Hom(3,1) = \frac{6/28}{1+|3-1|}$$

$$= \frac{6}{28(1+|3-1|)}$$

$$= \frac{6}{84}$$

$$= 0.071$$

$$Hom(3,3) = \frac{0/28}{1+|3-3|}$$

$$= \frac{0}{28(1+|3-3|)}$$

$$= \frac{0}{28}$$

$$= 0$$

$$Hom(Total) = 0.142 + 0.035 + 0.011 + 0.08 + 0.035 + 0.071 + 0 +$$
$$0.071 + 0.11 + 0 + 0 + 0.017 + 0.008 + 0.071 + 0.017 + 0$$

$= 0{,}668$

Energy:

$$Eng = \sum_i \sum_j p(i,j)^2$$

$$Eng = (\frac{4}{28})^2 + (\frac{2}{28})^2 + (\frac{1}{28})^2 + (\frac{1}{28})^2 + (\frac{2}{28})^2 + (\frac{2}{28})^2 + (\frac{0}{28})^2 + (\frac{6}{28})^2 + (\frac{1}{28})^2 + (\frac{0}{28})^2 + (\frac{0}{28})^2 + (\frac{1}{28})^2 + (\frac{1}{28})^2 + (\frac{6}{28})^2 + (\frac{1}{28})^2 + (\frac{0}{28})^2$$

$$Eng = \frac{4^2 + 2^2 + 1^2 + 1^2 + 2^2 + 2^2 + 0^2 + 6^2 + 1^2 + 0^2 + 0^2 + 1^2 + 1^2 + 6^2 + 1^2 + 0^2}{28^2}$$

$$Eng = \frac{106}{784}$$

$$= 0.1352$$

Piksel $4 \times 4,\ d = 1, \theta = 45^{\circ}$ Matrix Kookurensi:

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

i/j	0	1	2	3
0	1	0	2	0
1	0	1	0	1
0	0	0	1	2
1	1	0	0	3

GLCM Simetris:

$$\begin{bmatrix} 0 & 1 & 0 & 2 \\ 1 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \\ 1 & 1 & 0 & 0 \end{bmatrix} + \begin{bmatrix} 0 & 1 & 0 & 1 \\ 1 & 0 & 0 & 1 \\ 0 & 1 & 0 & 0 \\ 2 & 0 & 1 & 0 \end{bmatrix} = \begin{bmatrix} 0 & 2 & 0 & 3 \\ 2 & 0 & 1 & 1 \\ 0 & 1 & 0 & 1 \\ 3 & 1 & 1 & 0 \end{bmatrix} = 16$$

Normalisasi Matrix:

$$\begin{bmatrix} {}^{0}/_{16} & {}^{2}/_{16} & {}^{0}/_{16} & {}^{3}/_{16} \\ {}^{2}/_{16} & {}^{0}/_{16} & {}^{1}/_{16} & {}^{1}/_{16} \\ {}^{0}/_{16} & {}^{1}/_{16} & {}^{0}/_{16} & {}^{1}/_{16} \\ {}^{3}/_{16} & {}^{1}/_{16} & {}^{1}/_{16} & {}^{0}/_{16} \end{bmatrix}$$

Hasil Normalisasi Matrix:

${}^{0}/_{16}$	${}^{2}/_{16}$	${}^{0}/_{16}$	${}^{3}/_{16}$
${}^{2}/_{16}$	${}^{0}/_{16}$	${}^{1}/_{16}$	${}^{1}/_{16}$
${}^{0}/_{16}$	${}^{1}/_{16}$	${}^{0}/_{16}$	${}^{1}/_{16}$
${}^{3}/_{16}$	${}^{1}/_{16}$	${}^{1}/_{16}$	${}^{0}/_{16}$

Contrast:

$$Con = \sum_{i}\sum_{j}(i-j)^2 p(i,j)$$

$Con(0,0) = (0-0)^2 \times ({}^{0}/_{16})$
$= (0)^2 \times ({}^{0}/_{16})$
$= 0$

$Con(0,1) = (0-1)^2 \times ({}^{2}/_{16})$
$= (-1)^2 \times ({}^{2}/_{16})$
$= {}^{2}/_{16}$
$= 0.125$

$Con(0,2) = (0-2)^2 \times ({}^{0}/_{16})$
$= (-2)^2 \times ({}^{0}/_{16})$
$= {}^{0}/_{16}$
$= 0$

$Con(0,3) = (0-3)^2 \times ({}^{3}/_{16})$
$= (-3)^2 \times ({}^{3}/_{16})$
$= {}^{27}/_{16}$
$= 1.687$

$Con(1,0) = (1-0)^2 \times ({}^{2}/_{16})$
$= (1)^2 \times ({}^{2}/_{16})$
$= {}^{2}/_{16}$

$Con(1,1) = (1-1)^2 \times ({}^{0}/_{16})$
$= (0)^2 \times ({}^{0}/_{16})$
$= {}^{0}/_{16}$

$= 0.125$

$Con(1,2) = (1-2)^2 \times (1/16)$

$= (-1)^2 \times (1/16)$

$= 1/16$

$= 0\ .062$

$Con(2,0) = (2-0)^2 \times (0/16)$

$= (2)^2 \times (0/16)$

$= 0/16$

$= 0$

$Con(2,2) = (2-2)^2 \times (0/16)$

$= (0)^2 \times (0/16)$

$= 0/16$

$= 0$

$Con(3,0) = (3-0)^2 \times (3/16)$

$= (3)^2 \times (3/16)$

$= 27/16$

1.687

$Con(3,2) = (3-2)^2 \times (1/16)$

$= (1)^2 \times (1/16)$

$= 1/16$

$= 0.062$

$= 0$

$Con(1,3) = (1-3)^2 \times (1/16)$

$= (-2)^2 \times (1/16)$

$= 4/16$

$= 0.857$

$Con(2,1) = (2-1)^2 \times (1/16)$

$= (1)^2 \times (1/16)$

$= 1/16$

$= 0.062$

$Con(2,3) = (2-3)^2 \times (1/16)$

$= (-1)^2 \times (1/16)$

$= 1/16$

$= 0.062$

$Con(3,1) = (3-1)^2 \times (1/16)$

$= (2)^2 \times (1/16)$

$= 4/16$

$= 0.25$

$Con(3,3) = (3-3)^2 \times (0/16)$

$= (0)^2 \times (0/16)$

$= 0/16$

$= 0$

$Con(Total) = 0 + 0.125 + 0 + 1.687 + 0.125 + 0 + 0\ .062 + 0.857 + 0 + 0.062 + 0 + 0.062 + 1.687 + 0.25 + 0.062 + 0$

$= 4.979$

Correlation:

$$Cor = \sum_i \sum_j \frac{(i-\mu i)(j-\mu j)p_{(i,j)}}{\sigma i\ \sigma j}$$

Dimana:

$$\mu i = \sum_i \sum_j i p_{(i,j)}$$

$$\mu j = \sum_i \sum_j j p_{(i,j)}$$

$$\sigma i = \sqrt{\sum_i \sum_j (i-\mu i)^2 p_{(i,j)}}$$

$$\sigma j = \sqrt{\sum_i \sum_j (j-\mu j)^2 p_{(i,j)}}$$

$$\mu i = \big((0\times 0)+(0\times 2)+(0\times 0)+(0\times 3)+(1\times 2)+(1\times 0)+(1\times 1)+ (1\times 1)+(2\times 0)+(2\times 1)+(2\times 0)+(2\times 1)+(3\times 3)+(3\times 1)+ (3\times 1)+(3\times 0)\big)\ /\ 16$$

$$\mu i = \frac{23}{16}$$

$$\mu i = 1.437$$

$$\mu j = \big((0\times 0)+(1\times 2)+(2\times 0)+(3\times 3)+(0\times 2)+(1\times 0)+(2\times 1)+ (3\times 1)+(0\times 0)+(1\times 1)+(2\times 0)+(3\times 1)+(0\times 3)+(1\times 1)+ (2\times 1)+(3\times 0)\big)\ /\ 16$$

$$\mu j = \frac{23}{16}$$

$$\mu j = 1.437$$

$$\sigma i(0,0) = \left(0-\frac{23}{16}\right)^2 \times \frac{0}{16}$$
$$= \frac{529}{256} \times \frac{0}{16}$$
$$= \frac{0}{4096}$$
$$= 0$$

$$\sigma i(0,1) = \left(0-\frac{23}{16}\right)^2 \times \frac{2}{16}$$
$$= \frac{529}{256} \times \frac{2}{16}$$
$$= \frac{1058}{4096}$$
$$= 0.25$$

$$\sigma i(0,2) = \left(0 - \frac{23}{16}\right)^2 \times \frac{0}{16}$$
$$= \frac{529}{256} \times \frac{0}{16}$$
$$= \frac{0}{4096}$$
$$= 0$$

$$\sigma i(0,3) = \left(0 - \frac{23}{16}\right)^2 \times \frac{3}{16}$$
$$= \frac{529}{256} \times \frac{3}{16}$$
$$= \frac{1587}{4096}$$
$$= 0.38$$

$$\sigma i(1,0) = \left(1 - \frac{23}{16}\right)^2 \times \frac{2}{16}$$
$$= \frac{49}{256} \times \frac{2}{16}$$
$$= \frac{98}{4096}$$
$$= 0.023$$

$$\sigma i(1,1) = \left(1 - \frac{23}{16}\right)^2 \times \frac{0}{16}$$
$$= \frac{49}{256} \times \frac{0}{16}$$
$$= \frac{0}{4096}$$
$$= 0$$

$$\sigma i(1,2) = \left(1 - \frac{23}{16}\right)^2 \times \frac{1}{16}$$
$$= \frac{49}{256} \times \frac{1}{16}$$
$$= \frac{49}{4096}$$
$$= 0.011$$

$$\sigma i(1,3) = \left(1 - \frac{23}{16}\right)^2 \times \frac{1}{16}$$
$$= \frac{49}{256} \times \frac{1}{16}$$
$$= \frac{49}{4096}$$
$$= 0.011$$

$$\sigma i(2,0) = \left(2 - \frac{23}{16}\right)^2 \times \frac{0}{16}$$
$$= \frac{81}{256} \times \frac{0}{16}$$
$$= \frac{0}{4096}$$
$$= 0$$

$$\sigma i(2,1) = \left(2 - \frac{23}{16}\right)^2 \times \frac{1}{16}$$
$$= \frac{81}{256} \times \frac{1}{16}$$
$$= \frac{81}{4096}$$
$$= 0.019$$

$$\sigma i(2,2) = \left(2 - \frac{23}{16}\right)^2 \times \frac{0}{16}$$
$$= \frac{81}{256} \times \frac{0}{16}$$
$$= \frac{0}{4096}$$
$$= 0$$

$$\sigma i(2,3) = \left(2 - \frac{23}{16}\right)^2 \times \frac{1}{16}$$
$$= \frac{81}{256} \times \frac{1}{16}$$
$$= \frac{81}{4096}$$
$$= 0.019$$

$$\sigma i(3,0) = \left(3 - \frac{23}{16}\right)^2 \times \frac{3}{16}$$
$$= \frac{625}{256} \times \frac{3}{16}$$
$$= \frac{1875}{4096}$$
$$= 0.45$$

$$\sigma i(3,1) = \left(3 - \frac{23}{16}\right)^2 \times \frac{1}{16}$$
$$= \frac{625}{256} \times \frac{1}{16}$$
$$= \frac{625}{4096}$$
$$= 0.152$$

$$\sigma i(3,2) = \left(3 - \frac{23}{16}\right)^2 \times \frac{1}{16}$$
$$= \frac{625}{256} \times \frac{1}{16}$$
$$= \frac{625}{4096}$$
$$= 0.152$$

$$\sigma i(3,3) = \left(3 - \frac{23}{16}\right)^2 \times \frac{0}{16}$$
$$= \frac{625}{256} \times \frac{0}{16}$$
$$= \frac{0}{4096}$$
$$= 0$$

$$\sigma i(Total) = \sqrt{(0 + 0.25 + 0 + 0.38 + 0.023 + 0 + 0.011 + 0.011 + 0 + 0.019 + 0.019 + 0.45 + 0.152 + 0.152 + 0)}$$
$$= 1.21$$

$$\sigma j(0,0) = \left(0 - \frac{23}{16}\right)^2 \times \frac{0}{16}$$
$$= \frac{529}{256} \times \frac{0}{16}$$
$$= \frac{0}{4096}$$
$$= 0$$

$$\sigma j(0,1) = \left(1 - \frac{23}{16}\right)^2 \times \frac{2}{16}$$
$$= \frac{49}{256} \times \frac{2}{16}$$
$$= \frac{98}{4096}$$
$$= 0.023$$

$$\sigma j(0,2) = \left(2 - \frac{23}{16}\right)^2 \times \frac{0}{16}$$
$$= \frac{81}{256} \times \frac{0}{16}$$
$$= \frac{0}{4096}$$
$$= 0$$

$$\sigma j(0,3) = \left(3 - \frac{23}{16}\right)^2 \times \frac{3}{16}$$
$$= \frac{625}{256} \times \frac{3}{16}$$
$$= \frac{1875}{4096}$$
$$= 0.45$$

$$\sigma j(1,0) = \left(0 - \frac{23}{16}\right)^2 \times \frac{2}{16}$$
$$= \frac{529}{256} \times \frac{2}{16}$$
$$= \frac{1058}{4096}$$
$$= 0.25$$

$$\sigma j(1,1) = \left(1 - \frac{23}{16}\right)^2 \times \frac{0}{16}$$
$$= \frac{49}{256} \times \frac{0}{16}$$
$$= \frac{0}{4096}$$
$$= 0$$

$$\sigma j(1,2) = \left(2 - \frac{23}{16}\right)^2 \times \frac{1}{16}$$
$$= \frac{81}{256} \times \frac{1}{16}$$
$$= \frac{81}{4096}$$
$$= 0.019$$

$$\sigma j(1,3) = \left(3 - \frac{23}{16}\right)^2 \times \frac{1}{16}$$
$$= \frac{625}{256} \times \frac{1}{16}$$
$$= \frac{625}{4096}$$
$$= 0.152$$

$$\sigma j(2,0) = \left(0 - \frac{23}{16}\right)^2 \times \frac{0}{16}$$
$$= \frac{529}{256} \times \frac{0}{16}$$
$$= \frac{0}{4096}$$
$$= 0$$

$$\sigma j(2,1) = \left(1 - \frac{23}{16}\right)^2 \times \frac{1}{16}$$
$$= \frac{49}{256} \times \frac{1}{16}$$
$$= \frac{49}{4096}$$
$$= 0.011$$

$$\sigma j(2,2) = \left(2 - \frac{23}{16}\right)^2 \times \frac{0}{16}$$
$$= \frac{81}{256} \times \frac{0}{16}$$
$$= \frac{0}{4096}$$
$$= 0$$

$$\sigma j(2,3) = \left(3 - \frac{23}{16}\right)^2 \times \frac{1}{16}$$
$$= \frac{625}{784} \times \frac{1}{16}$$
$$= \frac{625}{4096}$$
$$= 0.152$$

$$\sigma j(3,0) = \left(0 - \frac{23}{16}\right)^2 \times \frac{3}{16}$$
$$= \frac{529}{256} \times \frac{3}{16}$$
$$= \frac{1587}{4096}$$
$$= 0.38$$

$$\sigma j(3,1) = \left(1 - \frac{23}{16}\right)^2 \times \frac{1}{16}$$
$$= \frac{49}{256} \times \frac{1}{16}$$
$$= \frac{49}{4096}$$
$$= 0.011$$

$$\sigma j(3,2) = \left(2 - \frac{23}{16}\right)^2 \times \frac{1}{16} \qquad \sigma j(3,3) = \left(3 - \frac{23}{16}\right)^2 \times \frac{0}{16}$$

$$= \frac{81}{256} \times \frac{1}{16} \qquad = \frac{625}{256} \times \frac{0}{16}$$

$$= \frac{81}{4096} \qquad = \frac{0}{4096}$$

$$= 0.019 \qquad = 0$$

$$\sigma j(Total) = \sqrt{(0 + 0.023 + 0 + 0.45 + 0.25 + 0 + 0.019 + 0.152 + 0 + 0.011 + 0 + 0.152 + 0.38 + 0.011 + 0.019 + 0)}$$

$$= 1.21$$

$$Cor(0.0) = \frac{(0 - 1.43)(0 - 1.43)(\frac{0}{16})}{(1.21)(1.21)} \qquad Cor(0.1) = \frac{(0 - 1.43)(1 - 1.43)(\frac{2}{16})}{(1.21)(1.21)}$$

$$= \frac{(-1.43)(-1.43)(0)}{(1.21)(1.21)} \qquad = \frac{(-1.43)(-0.43)(0.125)}{(1.21)(1.21)}$$

$$= \frac{0}{1.464} \qquad = \frac{0.076}{1.464}$$

$$Cor(0.2) = \frac{(0 - 1.43)(2 - 1.43)(\frac{0}{16})}{(1.21)(1.21)} \qquad Cor(0.3) = \frac{(0 - 1.43)(3 - 1.43)(\frac{3}{16})}{(1.21)(1.21)}$$

$$= \frac{(-1.43)(0.57)(0)}{(1.21)(1.21)} \qquad = \frac{(-1.43)(1{,}57)(0.187)}{(1.21)(1.21)}$$

$$= \frac{0}{1.464} \qquad = \frac{-0.419}{1.464}$$

$$Cor(1.0) = \frac{(1 - 1.43)(0 - 1.35)(\frac{2}{16})}{(1.21)(1.21)} \qquad Cor(1.1) = \frac{(1 - 1.43)(1 - 1.43)(\frac{0}{16})}{(1.21)(1.21)}$$

$$= \frac{(-0.43)(-1.43)(0.125)}{(1.21)(1.21)} \qquad = \frac{(-0.43)(-0.43)(0)}{(1.21)(1.21)}$$

$$= \frac{0.076}{1.464} \qquad = \frac{0}{1.464}$$

$$Cor(1.2) = \frac{(1 - 1.43)(2 - 1.43)(\frac{1}{16})}{(1.21)(1.21)} \qquad Cor(1.3) = \frac{(1 - 1.43)(3 - 1.43)(\frac{1}{16})}{(1.21)(1.21)}$$

$$= \frac{(-0.43)(0.57)(0.062)}{(1.21)(1.21)} \qquad = \frac{(-0.43)(1.57)(0.062)}{(1.21)(1.21)}$$

$$= \frac{-0{,}015}{1.464} \qquad = \frac{-0{,}041}{1.464}$$

$$Cor(2.0) = \frac{(2-1.43)(0-1.43)(\frac{0}{16})}{(1.21)(1.21)} \qquad Cor(2.1) = \frac{(2-1.43)(1-1.43)(\frac{1}{16})}{(1.21)(1.21)}$$

$$= \frac{(0.57)(-1.43)(0)}{(1.21)(1.21)} \qquad = \frac{(0.57)(-0.43)(0.062)}{(1.21)(1.21)}$$

$$= \frac{0}{1.464} \qquad = \frac{-0{,}015}{1.464}$$

$$Cor(2.2) = \frac{(2-1.43)(2-1.43)(\frac{0}{16})}{(1.21)(1.21)} \qquad Cor(2.3) = \frac{(2-1.43)(3-1.43)(\frac{1}{16})}{(1.21)(1.21)}$$

$$= \frac{(0.57)(0.57)(0)}{(1.21)(1.21)} \qquad = \frac{(0.57)(1.57)(0.062)}{(1.21)(1.21)}$$

$$= \frac{0}{1.464} \qquad = \frac{0.055}{1.464}$$

$$Cor(3.0) = \frac{(3-1.43)(0-1.43)(\frac{3}{16})}{(1.21)(1.21)} \qquad Cor(3.1) = \frac{(3-1.43)(1-1.43)(\frac{1}{16})}{(1.21)(1.21)}$$

$$= \frac{(1.57)(-1.43)(0.187)}{(1.21)(1.21)} \qquad = \frac{(1.57)(-0.43)(0.062)}{(1.21)(1.21)}$$

$$= \frac{-0.419}{1.464} \qquad = \frac{-0.041}{1.464}$$

$$Cor(3.2) = \frac{(3-1.43)(2-1.43)(\frac{1}{16})}{(1.21)(1.21)} \qquad Cor(3.3) = \frac{(3-1.43)(3-1.43)(\frac{0}{16})}{(1.21)(1.21)}$$

$$= \frac{(1.57)(0.57)(0.062)}{(1.21)(1.21)} \qquad = \frac{(1.57)(1.57)(0)}{(1.21)(1.21)}$$

$$= \frac{0.055}{1.464} \qquad = \frac{0}{1.464}$$

$Cor(Total)$ = (0 + 0.076 + 0 + (-0.419) + 0.076 + 0 + (-0.015) + (-0.041) + 0 + (-0.015) + 0 + 0.055 + (-0,419) +(-0.041) + 0.055 + 0) / (16/1.464)

$$= \frac{-0{,}688}{10{,}928}$$

$$= -0{,}0629$$

Homogenety:

$$Hom = \sum_i \sum_j \frac{p(i,j)}{1 + |i - j|}$$

$$Hom(0,0) = \frac{{}^{0}/_{16}}{1+|0-0|} = \frac{0}{16(1+|0-0|)} = \frac{0}{16} = 0$$

$$Hom(0,1) = \frac{{}^{2}/_{16}}{1+|0-1|} = \frac{2}{16(1+|0-1|)} = \frac{2}{16} = 0.125$$

$$Hom(0,2) = \frac{{}^{0}/_{16}}{1+|0-2|} = \frac{1}{16(1+|0-2|)} = \frac{0}{48} = 0$$

$$Hom(0,3) = \frac{{}^{3}/_{16}}{1+|0-3|} = \frac{3}{16(1+|0-3|)} = \frac{3}{64} = 0.046$$

$$Hom(1,0) = \frac{{}^{2}/_{16}}{1+|1-0|} = \frac{2}{16(1+|1-0|)} = \frac{2}{32} = 0.062$$

$$Hom(1,1) = \frac{{}^{0}/_{16}}{1+|1-1|} = \frac{0}{16(1+|1-1|)} = \frac{0}{16} = 0$$

$$Hom(1,2) = \frac{{}^{1}/_{16}}{1+|1-2|} = \frac{1}{16(1+|1-2|)} = \frac{1}{32} = 0.031$$

$$Hom(1,3) = \frac{{}^{1}/_{16}}{1+|1-3|} = \frac{1}{16(1+|1-3|)} = \frac{1}{48} = 0.020$$

$$Hom(2,0) = \frac{0/16}{1+|2-0|} = \frac{0}{16(1+|2-0|)} = \frac{0}{48} = 0$$

$$Hom(2,1) = \frac{1/16}{1+|2-1|} = \frac{1}{16(1+|2-1|)} = \frac{1}{32} = 0.031$$

$$Hom(2,2) = \frac{0/16}{1+|2-2|} = \frac{0}{16(1+|2-2|)} = \frac{0}{16} = 0$$

$$Hom(2,3) = \frac{1/16}{1+|2-3|} = \frac{1}{16(1+|2-3|)} = \frac{1}{32} = 0.031$$

$$Hom(3,0) = \frac{3/16}{1+|3-0|} = \frac{3}{16(1+|3-0|)} = \frac{3}{64} = 0.046$$

$$Hom(3,1) = \frac{1/16}{1+|3-1|} = \frac{1}{16(1+|3-1|)} = \frac{1}{48} = 0.020$$

$$Hom(3,2) = \frac{1/16}{1+|3-2|} = \frac{1}{16(1+|3-2|)} = \frac{1}{48} = 0.020$$

$$Hom(3,3) = \frac{0/16}{1+|3-3|} = \frac{0}{16(1+|3-3|)} = \frac{0}{16} = 0$$

$$Hom(Total) = 0 + 0.125 + 0 + 0.046 + 0.062 + 0 + 0 + 0.031 + 0 + 0.031 + 0.046 + 0.020 + 0.020 + 0 + 0.017 + 0 = 0.398$$

Energy:

$$Eng = \sum_i \sum_j p(i,j)^2$$

$$Eng = (\frac{0}{16})^2 + (\frac{2}{16})^2 + (\frac{0}{16})^2 + (\frac{3}{16})^2 + (\frac{2}{16})^2 + (\frac{0}{16})^2 + (\frac{1}{16})^2 + (\frac{1}{16})^2 + (\frac{0}{16})^2 + (\frac{1}{16})^2 + (\frac{0}{16})^2 + (\frac{1}{16})^2 + (\frac{3}{16})^2 + (\frac{1}{16})^2 + (\frac{1}{16})^2 + (\frac{0}{16})^2$$

$$Eng = \frac{0^2 + 2^2 + 0^2 + 3^2 + 2^2 + 0^2 + 1^2 + 1^2 + 0^2 + 1^2 + 0^2 + 1^2 + 3^2 + 1^2 + 1^2 + 0^2}{16^2}$$

$$Eng = \frac{32}{256}$$

$$= 0.125$$

Piksel 4×4, $d = 1, \theta = 90^{\circ}$ Matrix Kookurensi:

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

i/j	0	1	2	3
0	1	1	2	1
1	2	0	0	1
2	0	2	0	0
3	1	0	0	2

GLCM Simetris:

$$\begin{bmatrix} 1 & 1 & 2 & 1 \\ 2 & 0 & 0 & 1 \\ 0 & 2 & 0 & 0 \\ 1 & 0 & 0 & 1 \end{bmatrix} + \begin{bmatrix} 1 & 2 & 0 & 1 \\ 1 & 0 & 2 & 0 \\ 2 & 0 & 0 & 0 \\ 1 & 1 & 0 & 1 \end{bmatrix} = \begin{bmatrix} 2 & 3 & 2 & 2 \\ 3 & 0 & 2 & 1 \\ 2 & 2 & 0 & 0 \\ 2 & 1 & 0 & 2 \end{bmatrix} = 24$$

Normalisasi Matrix:

Hasil Normalisasi Matrix:

$^2/_{24}$	$^3/_{24}$	$^2/_{24}$	$^2/_{24}$
$^3/_{24}$	$^0/_{24}$	$^2/_{24}$	$^1/_{24}$
$^2/_{24}$	$^2/_{24}$	$^0/_{24}$	$^0/_{24}$

$$\begin{bmatrix} {}^{2}/_{24} & {}^{3}/_{24} & {}^{2}/_{24} & {}^{2}/_{24} \\ {}^{3}/_{24} & {}^{0}/_{24} & {}^{2}/_{24} & {}^{1}/_{24} \\ {}^{2}/_{24} & {}^{2}/_{24} & {}^{0}/_{24} & {}^{0}/_{24} \\ {}^{2}/_{24} & {}^{1}/_{24} & {}^{0}/_{24} & {}^{2}/_{24} \end{bmatrix}$$

${}^{2}/_{24}$	${}^{1}/_{24}$	${}^{0}/_{24}$	${}^{2}/_{24}$

Contrast:

$$Con = \sum_{i}\sum_{j}(i-j)^2 p(i,j)$$

$Con(0,0) = (0-0)^2 \times ({}^{2}/_{24})$
$= (0)^2 \times ({}^{2}/_{24})$
$= 0$

$Con(0,1) = (0-1)^2 \times ({}^{3}/_{24})$
$= (-1)^2 \times ({}^{3}/_{24})$
$= {}^{3}/_{24}$
$= 0.125$

$Con(0,2) = (0-2)^2 \times ({}^{2}/_{24})$
$= (-2)^2 \times ({}^{2}/_{24})$
$= {}^{8}/_{24}$
$= 0.33$

$Con(0,3) = (0-3)^2 \times ({}^{2}/_{24})$
$= (-3)^2 \times ({}^{2}/_{24})$
$= {}^{18}/_{24}$
$= 0.75$

$Con(1,0) = (1-0)^2 \times ({}^{3}/_{24})$
$= (1)^2 \times ({}^{3}/_{24})$
$= {}^{3}/_{24}$
$= 0.125$

$Con(1,1) = (1-1)^2 \times ({}^{0}/_{24})$
$= (0)^2 \times ({}^{0}/_{24})$
$= {}^{0}/_{24}$
$= 0$

$Con(1,2) = (1-2)^2 \times ({}^{2}/_{24})$
$= (-1)^2 \times ({}^{2}/_{24})$
$= {}^{2}/_{24}$
$= 0\ .083$

$Con(1,3) = (1-3)^2 \times ({}^{1}/_{24})$
$= (-2)^2 \times ({}^{1}/_{24})$
$= {}^{4}/_{24}$
$= 0.166$

$Con(2,0) = (2-0)^2 \times ({}^{2}/_{24})$
$= (2)^2 \times ({}^{2}/_{24})$

$Con(2,1) = (2-1)^2 \times ({}^{2}/_{24})$
$= (1)^2 \times ({}^{2}/_{24})$

$= {}^{8}/_{24}$ $= {}^{2}/_{24}$

$= 0.33$ $= 0.083$

$Con(2,2) = (2-2)^2 \times ({}^{0}/_{24})$ $Con(2,3) = (2-3)^2 \times ({}^{0}/_{24})$

$= (0)^2 \times ({}^{0}/_{24})$ $= (-1)^2 \times ({}^{0}/_{24})$

$= {}^{0}/_{24}$ $= {}^{0}/_{24}$

$= 0$ $= 0$

$Con(3,0) = (3-0)^2 \times ({}^{2}/_{24})$ $Con(3,1) = (3-1)^2 \times ({}^{1}/_{24})$

$= (3)^2 \times ({}^{2}/_{24})$ $= (2)^2 \times ({}^{1}/_{24})$

$= {}^{18}/_{24}$ $= {}^{4}/_{24}$

$= 0.75$ $= 0.166$

$Con(3,2) = (3-2)^2 \times ({}^{0}/_{24})$ $Con(3,3) = (3-3)^2 \times ({}^{2}/_{24})$

$= (1)^2 \times ({}^{0}/_{24})$ $= (0)^2 \times ({}^{2}/_{24})$

$= {}^{0}/_{24}$ $= {}^{0}/_{24}$

$= 0$ $= 0$

$$Con(Total) = 0 + 0.125 + 0.33 + 0.75 + 0.125 + 0 + 0.083 + 0.166 + 0.33 + 0.083 + 0 + 0 + 0.75 + 0.166 + 0 + 0$$
$$= 2.908$$

Correlation:

$$Cor = \sum_i \sum_j \frac{(i-\mu i)(j-\mu j)p_{(i,j)}}{\sigma i \, \sigma j}$$

Dimana:

$$\mu i = \sum_i \sum_j i p_{(i,j)}$$

$$\mu j = \sum_i \sum_j j p_{(i,j)}$$

$$\sigma i = \sqrt{\sum_i \sum_j (i-\mu i)^2 p_{(i,j)}}$$

$$\sigma j = \sqrt{\sum_i \sum_j (j - \mu j)^2 p_{(i,j)}}$$

$$\mu i = \big((0 \times 2) + (0 \times 3) + (0 \times 2) + (0 \times 2) + (1 \times 3) + (1 \times 0) + (1 \times 2) + (1 \times 1) + (2 \times 2) + (2 \times 2) + (2 \times 0) + (2 \times 0) + (3 \times 2) + (3 \times 1) + (3 \times 0) + (3 \times 2)\big) \,/\, 24$$

$$\mu i = \frac{29}{24}$$

$$\mu i = 1.208$$

$$\mu j = \big((0 \times 2) + (1 \times 3) + (2 \times 2) + (3 \times 2) + (0 \times 3) + (1 \times 0) + (2 \times 2) + (3 \times 1) + (0 \times 2) + (1 \times 2) + (2 \times 0) + (3 \times 0) + (0 \times 2) + (1 \times 1) + (2 \times 0) + (3 \times 2)\big) \,/\, 24$$

$$\mu j = \frac{29}{24}$$

$$\mu j = 1.208 \; done$$

$$\sigma i(0,0) = \left(0 - \frac{29}{24}\right)^2 \times \frac{2}{24} = \frac{841}{576} \times \frac{2}{24} = \frac{1682}{13824} = 0.121$$

$$\sigma i(0,1) = \left(0 - \frac{29}{24}\right)^2 \times \frac{3}{24} = \frac{841}{576} \times \frac{3}{24} = \frac{2523}{13824} = 0.182$$

$$\sigma i(0,2) = \left(0 - \frac{29}{24}\right)^2 \times \frac{2}{24} = \frac{841}{576} \times \frac{2}{24} = \frac{1682}{13824} = 0.121$$

$$\sigma i(0,3) = \left(0 - \frac{29}{24}\right)^2 \times \frac{2}{24} = \frac{841}{576} \times \frac{2}{24} = \frac{1682}{13824} = 0.121$$

$$\sigma i(1,0) = \left(1 - \frac{29}{24}\right)^2 \times \frac{3}{24}$$

$$\sigma i(1,1) = \left(1 - \frac{29}{24}\right)^2 \times \frac{0}{24}$$

$$= \frac{25}{576} \times \frac{3}{24}$$
$$= \frac{75}{13824}$$
$$= 0.005$$

$$= \frac{25}{576} \times \frac{0}{24}$$
$$= \frac{0}{13824}$$
$$= 0$$

$$\sigma i(1,2) = \left(1 - \frac{29}{24}\right)^2 \times \frac{2}{24}$$
$$= \frac{25}{576} \times \frac{2}{24}$$
$$= \frac{50}{13824}$$
$$= 0.003$$

$$\sigma i(1,3) = \left(1 - \frac{29}{24}\right)^2 \times \frac{1}{24}$$
$$= \frac{25}{576} \times \frac{1}{24}$$
$$= \frac{25}{13824}$$
$$= 0.001$$

$$\sigma i(2,0) = \left(2 - \frac{29}{24}\right)^2 \times \frac{2}{24}$$
$$= \frac{361}{576} \times \frac{2}{24}$$
$$= \frac{722}{13824}$$
$$= 0.052$$

$$\sigma i(2,1) = \left(2 - \frac{38}{28}\right)^2 \times \frac{2}{24}$$
$$= \frac{361}{576} \times \frac{2}{24}$$
$$= \frac{722}{13824}$$
$$= 0.052$$

$$\sigma i(2,2) = \left(2 - \frac{29}{24}\right)^2 \times \frac{0}{24}$$
$$= \frac{361}{576} \times \frac{0}{24}$$
$$= \frac{0}{13824}$$
$$= 0$$

$$\sigma i(2,3) = \left(2 - \frac{29}{24}\right)^2 \times \frac{0}{24}$$
$$= \frac{361}{576} \times \frac{0}{24}$$
$$= \frac{0}{13824}$$
$$= 0$$

$$\sigma i(3,0) = \left(3 - \frac{29}{24}\right)^2 \times \frac{2}{24}$$
$$= \frac{1849}{576} \times \frac{2}{24}$$
$$= \frac{3.698}{13824}$$
$$= 0.26$$

$$\sigma i(3,1) = \left(3 - \frac{29}{24}\right)^2 \times \frac{1}{24}$$
$$= \frac{1849}{576} \times \frac{1}{24}$$
$$= \frac{1849}{13824}$$
$$= 0.133$$

$$\sigma i(3,2) = \left(3 - \frac{29}{24}\right)^2 \times \frac{0}{24}$$

$$\sigma i(3,3) = \left(3 - \frac{29}{24}\right)^2 \times \frac{2}{24}$$

$$= \frac{1849}{576} \times \frac{0}{24}$$
$$= \frac{0}{13824}$$
$$= 0$$

$$= \frac{1849}{576} \times \frac{2}{24}$$
$$= \frac{3698}{13824}$$
$$= 0.26$$

$$\sigma i(Total) = \sqrt{(}\ 1.121 + 0.182 + 0.121 + 0.121 + 0.005 + 0 + 0.003 + 0.001 + 0.052 + 0.052 + 0 + 0 + 0.26 + 0.133 + 0 + 0.26)$$
$$= 1.52$$

$$\sigma j(0,0) = \left(0 - \frac{29}{24}\right)^2 \times \frac{2}{24}$$
$$= \frac{841}{576} \times \frac{2}{24}$$
$$= \frac{1682}{13824}$$
$$= 0.121$$

$$\sigma j(0,1) = \left(1 - \frac{29}{24}\right)^2 \times \frac{3}{24}$$
$$= \frac{25}{576} \times \frac{3}{24}$$
$$= \frac{75}{13824}$$
$$= 0.005$$

$$\sigma j(0,2) = \left(2 - \frac{29}{24}\right)^2 \times \frac{2}{24}$$
$$= \frac{361}{784} \times \frac{2}{24}$$
$$= \frac{722}{13824}$$
$$= 0.052$$

$$\sigma j(0,3) = \left(3 - \frac{29}{24}\right)^2 \times \frac{2}{24}$$
$$= \frac{1849}{784} \times \frac{2}{24}$$
$$= \frac{3698}{13824}$$
$$= 0.26$$

$$\sigma j(1,0) = \left(0 - \frac{29}{24}\right)^2 \times \frac{3}{24}$$
$$= \frac{841}{576} \times \frac{3}{24}$$
$$= \frac{2523}{13824}$$
$$= 0.182$$

$$\sigma j(1,1) = \left(1 - \frac{29}{24}\right)^2 \times \frac{0}{24}$$
$$= \frac{25}{576} \times \frac{0}{24}$$
$$= \frac{0}{13824}$$
$$= 0$$

$$\sigma j(1,2) = \left(2 - \frac{29}{24}\right)^2 \times \frac{2}{24}$$
$$= \frac{361}{784} \times \frac{2}{24}$$

$$\sigma j(1,3) = \left(3 - \frac{29}{24}\right)^2 \times \frac{1}{24}$$
$$= \frac{1849}{784} \times \frac{1}{24}$$

$$= \frac{722}{13824}$$
$$= 0.052$$

$$\sigma j(2,0) = \left(0 - \frac{29}{24}\right)^2 \times \frac{2}{24}$$
$$= \frac{841}{576} \times \frac{2}{24}$$
$$= \frac{1682}{13824}$$
$$= 0.121$$

$$\sigma j(2,2) = \left(2 - \frac{29}{24}\right)^2 \times \frac{0}{24}$$
$$= \frac{361}{784} \times \frac{0}{24}$$
$$= \frac{0}{13824}$$
$$= 0$$

$$\sigma j(3,0) = \left(0 - \frac{29}{24}\right)^2 \times \frac{2}{24}$$
$$= \frac{841}{576} \times \frac{2}{24}$$
$$= \frac{1682}{13824}$$
$$= 0.121$$

$$\sigma j(3,2) = \left(2 - \frac{29}{24}\right)^2 \times \frac{0}{24}$$
$$= \frac{361}{784} \times \frac{0}{24}$$
$$= \frac{0}{13824}$$
$$= 0$$

$$= \frac{1849}{13824}$$
$$= 0.133$$

$$\sigma j(2,1) = \left(1 - \frac{29}{24}\right)^2 \times \frac{2}{24}$$
$$= \frac{25}{576} \times \frac{2}{24}$$
$$= \frac{50}{13824}$$
$$= 0.003$$

$$\sigma j(2,3) = \left(3 - \frac{29}{24}\right)^2 \times \frac{0}{24}$$
$$= \frac{1849}{784} \times \frac{0}{24}$$
$$= \frac{0}{13824}$$
$$= 0$$

$$\sigma j(3,1) = \left(1 - \frac{29}{24}\right)^2 \times \frac{1}{24}$$
$$= \frac{25}{576} \times \frac{1}{24}$$
$$= \frac{25}{13824}$$
$$= 0.001$$

$$\sigma j(3,3) = \left(3 - \frac{29}{24}\right)^2 \times \frac{2}{24}$$
$$= \frac{1849}{784} \times \frac{2}{24}$$
$$= \frac{3698}{13824}$$
$$= 0.267$$

$$\sigma j(Total) = \sqrt{(}0.121 + 0.005 + 0.052 + 0.26 + 0.182 + 0 + 0.052 + 0.133 + 0.121 + 0.003 + 0 + 0 + 0.121 + 0.001 + 0 + 0.26)$$
$$= 1.52$$

$$Cor(0.0) = \frac{(0-1.52)(0-1.52)(\frac{2}{24})}{(1.208)(1.208)} = \frac{(-1{,}52)(-1{,}52)(0.083)}{1.459} = \frac{0.191}{1.459}$$

$$Cor(0.1) = \frac{(0-1.52)(1-1.52)(\frac{3}{24})}{(1.208)(1.208)} = \frac{(-1{,}52)(-0{,}52)(0.125)}{1.459} = \frac{-0.098}{1.459}$$

$$Cor(0.2) = \frac{(0-1.52)(2-1.52)(\frac{2}{24})}{(1.208)(1.208)} = \frac{(-1{,}52)(0.78)(0.083)}{1.459} = \frac{-0.098}{1.459}$$

$$Cor(0.3) = \frac{(0-1.52)(3-1.52)(\frac{2}{24})}{(1.208)(1.208)} = \frac{(-1{,}52)(1.48)(0.083)}{1.459} = \frac{-0{,}186}{1.459}$$

$$Cor(1.0) = \frac{(1-1.52)(0-1.52)(\frac{3}{24})}{(1.208)(1.208)} = \frac{(-0{,}52)(-1{,}52)(0.125)}{1.459} = \frac{0.098}{1.459}$$

$$Cor(1.1) = \frac{(1-1.52)(1-1.52)(\frac{0}{24})}{(1.208)(1.208)} = \frac{(-0{,}52)(-0{,}52)(0)}{1.459} = \frac{0}{1.459}$$

$$Cor(1.2) = \frac{(1-1.52)(2-1.52)(\frac{2}{24})}{(1.208)(1.208)} = \frac{(-0{,}52)(0.78)(0.083)}{1.459} = \frac{-0{,}033}{1.459}$$

$$Cor(1.3) = \frac{(1-1.52)(3-1.52)(\frac{1}{24})}{(1.208)(1.208)} = \frac{(-0{,}52)(1.48)(0.041)}{1.459} = \frac{-0.031}{1.459}$$

$$Cor(2.0) = \frac{(2-1.52)(0-1.52)(\frac{2}{24})}{(1.208)(1.208)} = \frac{(0.78)(-1{,}52)(0.083)}{1.459} = \frac{-0{,}098}{1.459}$$

$$Cor(2.1) = \frac{(2-1.52)(1-1.52)(\frac{2}{24})}{(1.208)(1.208)} = \frac{(0.78)(-0{,}52)(0.083)}{1.459} = \frac{-0{,}033}{1.459}$$

$$Cor(2.2) = \frac{(2-1.52)(2-1.52)(\frac{0}{24})}{(1.208)(1.208))}$$

$$Cor(2.3) = \frac{(2-1.52)(3-1.35)(\frac{0}{24})}{(1.208)(1.208)}$$

$$= \frac{(0.78)(0.78)(0)}{1.459} \qquad = \frac{(0.78)(1.48)(0)}{1.459}$$

$$= \frac{0}{1.459} \qquad = \frac{0}{1.459}$$

$$Cor(3.0) = \frac{(3-1.52)(0-1.52)(\frac{2}{24})}{(1.208)(1.208)} \qquad Cor(3.1) = \frac{(3-1.52)(1-1.52)(\frac{1}{24})}{(1.208)(1.208)}$$

$$= \frac{(1.48)(-1{,}52)(0.083)}{1.459} \qquad = \frac{(1.48)(-0{,}52)(0.041)}{1.459}$$

$$= \frac{-0{,}186}{1.459} \qquad = \frac{-0{,}031}{1.459}$$

$$Cor(3.2) = \frac{(3-1.52)(2-1.52)(\frac{0}{24})}{(1.208)(1.208)} \qquad Cor(3.3) = \frac{(3-1.52)(3-1.52)(\frac{2}{24})}{(1.208)(1.208)}$$

$$= \frac{(1.48)(0.78)(0)}{1.459} \qquad = \frac{(1.48)(1.48)(0.083)}{1.459}$$

$$= \frac{0}{1.459} \qquad = \frac{0.178}{1.459}$$

$Cor(Total) =$ (0.191 + (-0.098) + (-0.098) + (-0.186) + 0.098 + 0 + (-0.033) + (-0,031) + (-0.098) + (-0.33) + 0 + 0 + (-0.186) + (-0,031) + 0 + 0.178) / (24/1.459)

$$= \frac{-0{,}327}{16{,}44}$$

$$= -0.0198$$

Homogenety:

$$Hom = \sum_i \sum_j \frac{p(i,j)}{1+|i-j|}$$

$$Hom(0,0) = \frac{{}^{2}/_{24}}{1+|0-0|} \qquad Hom(0,1) = \frac{{}^{3}/_{24}}{1+|0-1|}$$

$$= \frac{2}{24(1+|0-0|)} \qquad = \frac{3}{24(1+|0-1|)}$$

$$= \frac{2}{24} \qquad = \frac{3}{24}$$

$$= 0 \qquad = 0.125$$

$$Hom(0,2) = \frac{{}^{2}/_{24}}{1+|0-2|} = \frac{1}{16(1+|0-2|)} = \frac{0}{48} = 0$$

$$Hom(0,3) = \frac{{}^{2}/_{24}}{1+|0-3|} = \frac{3}{16(1+|0-3|)} = \frac{3}{64} = 0.046$$

$$Hom(1,0) = \frac{{}^{0}/_{24}}{1+|1-0|} = \frac{2}{16(1+|1-0|)} = \frac{2}{32} = 0.062$$

$$Hom(1,1) = \frac{{}^{0}/_{24}}{1+|1-1|} = \frac{0}{16(1+|1-1|)} = \frac{0}{16} = 0$$

$$Hom(1,2) = \frac{{}^{0}/_{24}}{1+|1-2|} = \frac{1}{16(1+|1-2|)} = \frac{1}{32} = 0.031$$

$$Hom(1,3) = \frac{{}^{0}/_{24}}{1+|1-3|} = \frac{1}{16(1+|1-3|)} = \frac{1}{48} = 0.020$$

$$Hom(2,0) = \frac{{}^{0}/_{24}}{1+|2-0|} = \frac{0}{16(1+|2-0|)} = \frac{0}{48} = 0$$

$$Hom(2,1) = \frac{{}^{0}/_{24}}{1+|2-1|} = \frac{1}{16(1+|2-1|)} = \frac{1}{32} = 0.031$$

$$Hom(2,2) = \frac{{}^{0}/_{24}}{1+|2-2|} = \frac{0}{16(1+|2-2|)} = \frac{0}{16} = 0$$

$$Hom(2,3) = \frac{{}^{0}/_{24}}{1+|2-3|} = \frac{1}{16(1+|2-3|)} = \frac{1}{32} = 0.031$$

$$Hom(3,0) = \frac{{}^{0}/_{24}}{1+|3-0|} = \frac{3}{16(1+|3-0|)} = \frac{3}{64}$$

$$Hom(3,1) = \frac{{}^{0}/_{24}}{1+|3-1|} = \frac{1}{16(1+|3-1|)} = \frac{1}{48}$$

$= 0.046$ $= 0.020$

$Hom(3,2) = \frac{0/24}{1+|3-2|}$ $Hom(3,3) = \frac{0/24}{1+|3-3|}$

$= \frac{1}{16(1+|3-2|)}$ $= \frac{0}{16(1+|3-3|)}$

$= \frac{1}{48}$ $= \frac{0}{16}$

$= 0.020$ $= 0$

$$Hom(Total) = 0 + 0.125 + 0 + 0.046 + 0.062 + 0 + 0.031 + 0.020 + 0 + 0.031 + 0 + 0.031 + 0.046 + 0.020 + 0.020 + 0$$

$$= 0.432$$

Energy:

$$Eng = \sum_i \sum_j p(i,j)^2$$

$$Eng = (\frac{2}{24})^2 + (\frac{3}{24})^2 + (\frac{2}{24})^2 + (\frac{2}{24})^2 + (\frac{3}{24})^2 + (\frac{0}{24})^2 + (\frac{2}{24})^2 + (\frac{1}{24})^2 + (\frac{2}{24})^2 + (\frac{2}{24})^2 + (\frac{0}{24})^2 + (\frac{0}{24})^2 + (\frac{2}{24})^2 + (\frac{1}{24})^2 + (\frac{0}{24})^2 + (\frac{2}{24})^2$$

$$Eng = \frac{2^2 + 3^2 + 2^2 + 2^2 + 3^2 + 0^2 + 2^2 + 1^2 + 2^2 + 2^2 + 0^2 + 0^2 + 2^2 + 1^2 + 0^2 + 2^2}{24^2}$$

$$Eng = \frac{52}{576}$$

$$= 0.090$$

Piksel 4×4, $d = 1, \theta = 135°$ Matrix Kookurensi:

1	0	1	2

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

i/j	0	1	2	3
	1	0	0	0
	1	1	0	1
				2
				3

GLCM Simetris:

$$\begin{bmatrix}1&0&1&2\\1&1&0&0\\1&0&0&0\\1&1&0&0\end{bmatrix}+\begin{bmatrix}1&1&1&1\\0&1&0&1\\1&0&0&0\\2&0&0&0\end{bmatrix}=\begin{bmatrix}2&1&2&3\\1&2&0&1\\2&0&0&0\\3&1&0&0\end{bmatrix}=16$$

Normalisasi Matrix:

$$\begin{bmatrix}{}^{2}/_{16}&{}^{1}/_{16}&{}^{2}/_{16}&{}^{3}/_{16}\\{}^{1}/_{16}&{}^{2}/_{16}&{}^{0}/_{16}&{}^{1}/_{16}\\{}^{2}/_{16}&{}^{0}/_{16}&{}^{0}/_{16}&{}^{0}/_{16}\\{}^{3}/_{16}&{}^{1}/_{16}&{}^{0}/_{16}&{}^{0}/_{16}\end{bmatrix}$$

Hasil Normalisasi Matrix:

${}^{2}/_{16}$	${}^{1}/_{16}$	${}^{2}/_{16}$	${}^{3}/_{16}$
${}^{1}/_{16}$	${}^{2}/_{16}$	${}^{0}/_{16}$	${}^{1}/_{16}$
${}^{2}/_{16}$	${}^{0}/_{16}$	${}^{0}/_{16}$	${}^{0}/_{16}$
${}^{3}/_{16}$	${}^{1}/_{16}$	${}^{0}/_{16}$	${}^{0}/_{16}$

Contrast:

$$Con=\sum_i\sum_j (i-j)^2 p(i,j)$$

$Con(0,0) = (0-0)^2 \times ({}^{2}/_{16})$
$= (0)^2 \times ({}^{2}/_{16})$
$= 0$

$Con(0,1) = (0-1)^2 \times ({}^{1}/_{16})$
$= (-1)^2 \times ({}^{1}/_{16})$
$= {}^{1}/_{16}$
$= 0.062$

$Con(0,2) = (0-2)^2 \times ({}^{2}/_{16})$
$= (-2)^2 \times ({}^{2}/_{16})$

$Con(0,3) = (0-3)^2 \times ({}^{3}/_{16})$
$= (-3)^2 \times ({}^{3}/_{16})$

$= {}^{8}/_{16}$

$= 0.5$

$Con(1,0) = (1-0)^2 \times ({}^{1}/_{16})$

$= (1)^2 \times ({}^{2}/_{16})$

$= {}^{2}/_{16}$

$= 0.125$

$Con(1,2) = (1-2)^2 \times ({}^{0}/_{16})$

$= (-1)^2 \times ({}^{0}/_{16})$

$= {}^{0}/_{16}$

$= 0$

$Con(2,0) = (2-0)^2 \times ({}^{2}/_{16})$

$= (2)^2 \times ({}^{2}/_{16})$

$= {}^{8}/_{16}$

$= 0.5$

$Con(2,2) = (2-2)^2 \times ({}^{0}/_{16})$

$= (0)^2 \times ({}^{0}/_{16})$

$= {}^{0}/_{16}$

$= 0$

$Con(3,0) = (3-0)^2 \times ({}^{3}/_{16})$

$= (3)^2 \times ({}^{3}/_{16})$

$= {}^{27}/_{16}$

1.687

$Con(3,2) = (3-2)^2 \times ({}^{0}/_{16})$

$= (1)^2 \times ({}^{1}/_{16})$

$= {}^{1}/_{16}$

$= 0$

$= {}^{27}/_{16}$

$= 1.687$

$Con(1,1) = (1-1)^2 \times ({}^{2}/_{16})$

$= (0)^2 \times ({}^{2}/_{16})$

$= {}^{0}/_{16}$

$= 0$

$Con(1,3) = (1-3)^2 \times ({}^{1}/_{16})$

$= (-2)^2 \times ({}^{1}/_{16})$

$= {}^{4}/_{16}$

$= 0.25$

$Con(2,1) = (2-1)^2 \times ({}^{0}/_{16})$

$= (1)^2 \times ({}^{0}/_{16})$

$= {}^{0}/_{16}$

$= 0$

$Con(2,3) = (2-3)^2 \times ({}^{0}/_{16})$

$= (-1)^2 \times ({}^{0}/_{16})$

$= {}^{0}/_{16}$

$= 0$

$Con(3,1) = (3-1)^2 \times ({}^{1}/_{16})$

$= (2)^2 \times ({}^{1}/_{16})$

$= {}^{4}/_{16}$

$= 0.25$

$Con(3,3) = (3-3)^2 \times ({}^{0}/_{16})$

$= (0)^2 \times ({}^{0}/_{16})$

$= {}^{0}/_{16}$

$= 0$

$$Con(Total) = 0 + 0.062 + 0.5 + 1.687 + 0.125 + 0 + 0 + 0.25 + 0.5 + 0 + 0 + 0 + 1.687 + 0.25 + 0 + 0$$
$$= 5.061$$

Correlation:

$$Cor = \sum_i \sum_j \frac{(i - \mu i)(j - \mu j)p_{(i,j)}}{\sigma i \, \sigma j}$$

Dimana:

$$\mu i = \sum_i \sum_j i p_{(i,j)}$$

$$\mu j = \sum_i \sum_j j p_{(i,j)}$$

$$\sigma i = \sqrt{\sum_i \sum_j (i - \mu i)^2 p_{(i,j)}}$$

$$\sigma j = \sqrt{\sum_i \sum_j (j - \mu j)^2 p_{(i,j)}}$$

$$\mu i = \big((0 \times 2) + (0 \times 1) + (0 \times 2) + (0 \times 3) + (1 \times 1) + (1 \times 2) + (1 \times 0) + (1 \times 1) + (2 \times 2) + (2 \times 0) + (2 \times 0) + (2 \times 0) + (3 \times 3) + (3 \times 1) + (3 \times 0) + (3 \times 0)\big) / \ 16$$

$$\mu i = \frac{20}{16}$$

$$\mu i = 1.25$$

$$\mu j = \big((0 \times 2) + (1 \times 1) + (2 \times 2) + (3 \times 2) + (0 \times 1) + (1 \times 2) + (2 \times 0) + (3 \times 1) + (0 \times 2) + (1 \times 0) + (2 \times 0) + (3 \times 0) + (0 \times 3) + (1 \times 1) + (2 \times 0) + (3 \times 0)\big) / \ 16$$

$$\mu j = \frac{17}{16}$$

$$\mu j = 1.06$$

$$\sigma i(0,0) = \left(0 - \frac{20}{16}\right)^2 \times \frac{2}{16}$$
$$= \frac{400}{256} \times \frac{2}{16}$$
$$= \frac{800}{4096}$$
$$= 0.195$$

$$\sigma i(0,1) = \left(0 - \frac{20}{16}\right)^2 \times \frac{1}{16}$$
$$= \frac{400}{256} \times \frac{1}{16}$$
$$= \frac{400}{4096}$$
$$= 0.097$$

$$\sigma i(0,2) = \left(0 - \frac{20}{16}\right)^2 \times \frac{2}{16}$$
$$= \frac{400}{256} \times \frac{2}{16}$$
$$= \frac{800}{4096}$$
$$= 0.195$$

$$\sigma i(0,3) = \left(0 - \frac{20}{16}\right)^2 \times \frac{3}{16}$$
$$= \frac{400}{256} \times \frac{3}{16}$$
$$= \frac{1200}{4096}$$
$$= 0.29$$

$$\sigma i(1,0) = \left(1 - \frac{20}{16}\right)^2 \times \frac{1}{16}$$
$$= \frac{16}{256} \times \frac{1}{16}$$
$$= \frac{16}{4096}$$
$$= 0.003$$

$$\sigma i(1,1) = \left(1 - \frac{20}{16}\right)^2 \times \frac{2}{16}$$
$$= \frac{16}{256} \times \frac{2}{16}$$
$$= \frac{32}{4096}$$
$$= 0.007$$

$$\sigma i(1,2) = \left(1 - \frac{20}{16}\right)^2 \times \frac{0}{16}$$
$$= \frac{16}{256} \times \frac{0}{16}$$
$$= \frac{0}{4096}$$
$$= 0$$

$$\sigma i(1,3) = \left(1 - \frac{20}{16}\right)^2 \times \frac{1}{16}$$
$$= \frac{16}{256} \times \frac{1}{16}$$
$$= \frac{16}{4096}$$
$$= 0.003$$

$$\sigma i(2,0) = \left(2 - \frac{20}{16}\right)^2 \times \frac{2}{16}$$
$$= \frac{144}{256} \times \frac{2}{16}$$
$$= \frac{288}{4096}$$
$$= 0.070$$

$$\sigma i(2,1) = \left(2 - \frac{20}{16}\right)^2 \times \frac{0}{16}$$
$$= \frac{144}{256} \times \frac{0}{16}$$
$$= \frac{0}{4096}$$
$$= 0$$

$$\sigma i(2,2) = \left(2 - \frac{20}{16}\right)^2 \times \frac{0}{16} = \frac{144}{256} \times \frac{0}{16} = \frac{0}{4096} = 0$$

$$\sigma i(2,3) = \left(2 - \frac{20}{16}\right)^2 \times \frac{0}{16} = \frac{144}{256} \times \frac{0}{16} = \frac{0}{4096} = 0$$

$$\sigma i(3,0) = \left(3 - \frac{20}{16}\right)^2 \times \frac{3}{16} = \frac{784}{256} \times \frac{3}{16} = \frac{2352}{4096} = 0.57$$

$$\sigma i(3,1) = \left(3 - \frac{20}{16}\right)^2 \times \frac{1}{16} = \frac{784}{256} \times \frac{1}{16} = \frac{784}{4096} = 0.191$$

$$\sigma i(3,2) = \left(3 - \frac{20}{16}\right)^2 \times \frac{0}{16} = \frac{784}{256} \times \frac{0}{16} = \frac{0}{4096} = 0$$

$$\sigma i(3,3) = \left(3 - \frac{20}{16}\right)^2 \times \frac{0}{16} = \frac{784}{256} \times \frac{0}{16} = \frac{0}{4096} = 0$$

$$\sigma i(Total) = \sqrt{(0.195 + 0.097 + 0.195 + 0.29 + 0.003 + 0.007 + 0 + 0.003 + 0.070 + 0 + 0 + 0 + 0.57 + 0.191 + 0 + 0)} = 1.27$$

$$\sigma j(0,0) = \left(0 - \frac{17}{16}\right)^2 \times \frac{2}{16} = \frac{289}{256} \times \frac{2}{16} = \frac{578}{4096} = 0.141$$

$$\sigma j(0,1) = \left(1 - \frac{17}{16}\right)^2 \times \frac{1}{16} = \frac{1}{256} \times \frac{1}{16} = \frac{1}{4096} = 0.0002$$

$$\sigma j(0,2) = \left(2 - \frac{17}{16}\right)^2 \times \frac{2}{16}$$
$$= \frac{225}{256} \times \frac{2}{16}$$
$$= \frac{450}{4096}$$
$$= 0.109$$

$$\sigma j(0,3) = \left(3 - \frac{17}{16}\right)^2 \times \frac{3}{16}$$
$$= \frac{961}{256} \times \frac{3}{16}$$
$$= \frac{2883}{4096}$$
$$= 0.70$$

$$\sigma j(1,0) = \left(0 - \frac{17}{16}\right)^2 \times \frac{1}{16}$$
$$= \frac{289}{256} \times \frac{1}{16}$$
$$= \frac{289}{4096}$$
$$= 0.070$$

$$\sigma j(1,1) = \left(1 - \frac{17}{16}\right)^2 \times \frac{2}{16}$$
$$= \frac{1}{256} \times \frac{2}{16}$$
$$= \frac{2}{4096}$$
$$= 0.0004$$

$$\sigma j(1,2) = \left(2 - \frac{17}{16}\right)^2 \times \frac{0}{16}$$
$$= \frac{225}{256} \times \frac{0}{16}$$
$$= \frac{0}{4096}$$
$$= 0$$

$$\sigma j(1,3) = \left(3 - \frac{17}{16}\right)^2 \times \frac{1}{16}$$
$$= \frac{961}{256} \times \frac{1}{16}$$
$$= \frac{961}{4096}$$
$$= 0.23$$

$$\sigma j(2,0) = \left(0 - \frac{17}{16}\right)^2 \times \frac{2}{16}$$
$$= \frac{289}{256} \times \frac{2}{16}$$
$$= \frac{578}{4096}$$
$$= 0.141$$

$$\sigma j(2,1) = \left(1 - \frac{17}{16}\right)^2 \times \frac{0}{28}$$
$$= \frac{1}{256} \times \frac{0}{16}$$
$$= \frac{0}{4096}$$
$$= 0$$

$$\sigma j(2,2) = \left(2 - \frac{17}{16}\right)^2 \times \frac{0}{16}$$
$$= \frac{225}{256} \times \frac{0}{16}$$
$$= \frac{0}{4096}$$
$$= 0$$

$$\sigma j(2,3) = \left(3 - \frac{17}{16}\right)^2 \times \frac{0}{16}$$
$$= \frac{961}{256} \times \frac{0}{16}$$
$$= \frac{0}{4096}$$
$$= 0$$

$$\sigma j(3,0) = \left(0 - \frac{17}{16}\right)^2 \times \frac{3}{16} \qquad \sigma j(3,1) = \left(1 - \frac{17}{16}\right)^2 \times \frac{1}{16}$$

$$= \frac{289}{256} \times \frac{3}{16} \qquad = \frac{1}{256} \times \frac{1}{16}$$

$$= \frac{867}{4096} \qquad = \frac{1}{4096}$$

$$= 0.211 \qquad = 0.0002$$

$$\sigma j(3,2) = \left(2 - \frac{17}{16}\right)^2 \times \frac{0}{16} \qquad \sigma j(3,3) = \left(3 - \frac{17}{16}\right)^2 \times \frac{0}{16}$$

$$= \frac{225}{256} \times \frac{0}{16} \qquad = \frac{961}{256} \times \frac{0}{16}$$

$$= \frac{0}{4096} \qquad = \frac{0}{4096}$$

$$= 0 \qquad = 0$$

$$\sigma j(Total) = \sqrt{(}\ 0.141 + 0.0002 + 0.109 + 0.70 + 0.070 + 0.0004 + 0 + 0.23 + 0.141 + 0 + 0 + 0 + 0.211 + 0.0002 + 0 + 0\ )$$

$$= 1.26$$

$$Cor(0.0) = \frac{(0 - 1.27)(0 - 1.26)(\frac{2}{16})}{(1.25)(1.062)} \qquad Cor(0.1) = \frac{(0 - 1.27)(1 - 1.26)(\frac{1}{16})}{(1.25)(1.062)}$$

$$= \frac{(-1.27)(-1.26)(0.125)}{(1.25)(1.062)} \qquad = \frac{(-1.27)(-0.26)(0.062)}{(1.25)(1.062)}$$

$$= \frac{0.200}{1.327} \qquad = \frac{0.020}{1.327}$$

$$Cor(0.2) = \frac{(0 - 1.27)(2 - 1.26)(\frac{2}{16})}{(1.25)(1.062)} \qquad Cor(0.3) = \frac{(0 - 1.27)(3 - 1.26)(\frac{3}{16})}{(1.25)(1.062)}$$

$$= \frac{(-1.27)(0.74)(0.125)}{(1.25)(1.062)} \qquad = \frac{(-1.27)(1{,}74)(0.187)}{(1.25)(1.062)}$$

$$= \frac{-0.117}{1.327} \qquad = \frac{-0.41}{1.327}$$

$$Cor(1.0) = \frac{(1-1.27)(2-1.26)(\frac{1}{16})}{(1.25)(1.062)} = \frac{(-0.27)(0.74)(0.062)}{(1.25)(1.062)} = \frac{0.012}{1.327}$$

$$Cor(1.1) = \frac{(1-1.27)(1-1.26)(\frac{2}{16})}{(1.25)(1.062)} = \frac{(-0.27)(-0.27)(0.125)}{(1.25)(1.062)} = \frac{0.09}{1.327}$$

$$Cor(1.2) = \frac{(1-1.27)(2-1.26)(\frac{0}{16})}{(1.25)(1.062)} = \frac{(-0.27)(0.74)(0)}{(1.25)(1.062)} = \frac{0}{1.327}$$

$$Cor(1.3) = \frac{(1-1.27)(3-1.26)(\frac{1}{16})}{(1.25)(1.062)} = \frac{(-0.27)(1.74)(0.062)}{(1.25)(1.062)} = \frac{-0,029}{1.327}$$

$$Cor(2.0) = \frac{(2-1.27)(0-1.26)(\frac{2}{16})}{(1.25)(1.062)} = \frac{(0.73)(-1.26)(0.125)}{(1.25)(1.062)} = \frac{-0,114}{1.327}$$

$$Cor(2.1) = \frac{(2-1.27)(1-1.26)(\frac{0}{16})}{(1.25)(1.062)} = \frac{(0.73)(-0.26)(0)}{(1.25)(1.062)} = \frac{0}{1.327}$$

$$Cor(2.2) = \frac{(2-1.27)(2-1.26)(\frac{0}{16})}{(1.25)(1.062)} = \frac{(0.73)(0.74)(0)}{(1.25)(1.062)} = \frac{0}{1.327}$$

$$Cor(2.3) = \frac{(2-1.27)(3-1.26)(\frac{0}{16})}{(1.25)(1.062)} = \frac{(0.73)(1.74)(0)}{(1.25)(1.062)} = \frac{0}{1.327}$$

$$Cor(3.0) = \frac{(3-1.27)(0-1.26)(\frac{3}{16})}{(1.25)(1.062)} = \frac{(1.73)(-1.26)(0.187)}{(1.25)(1.062)} = \frac{-0.40}{1.327}$$

$$Cor(3.1) = \frac{(3-1.27)(1-1.26)(\frac{1}{16})}{(1.25)(1.062)} = \frac{(1.73)(-0.26)(0.062)}{(1.25)(1.062)} = \frac{-0,027}{1.327}$$

$$Cor(3.2) = \frac{(3-1.35)(2-1.35)(\frac{0}{16})}{(1.25)(1.062)}$$

$$Cor(3.3) = \frac{(3-1.35)(3-1.35)(\frac{0}{16})}{(1.25)(1.062)}$$

$$= \frac{(1.73)(0.65)(0)}{(1.25)(1.062)} \qquad = \frac{(1.73)(1.65)(0)}{(1.25)(1.062)}$$

$$= \frac{0}{1.327} \qquad = \frac{0}{1.327}$$

$Cor(Total) =$ (0.200 + 0.020 + (-0.117) + (-0.41) + 0.012 + 0.09 +0 +(-0.029) + (-0.114) + 0 + 0 + 0 +(-0.40) + (-0.027) + 0.037 + 0) / (16/1.327)

$$= \frac{-0.738}{12.057}$$

$$= -0.061$$

Homogenety:

$$Hom = \sum_i \sum_j \frac{p(i,j)}{1 + |i - j|}$$

$Hom(0,0) = \frac{2/16}{1+|0-0|}$ $= \frac{2}{16(1+|0-0|)}$ $= \frac{2}{16}$ $= 0.125$

$Hom(0,1) = \frac{1/16}{1+|0-1|}$ $= \frac{1}{16(1+|0-1|)}$ $= \frac{1}{16}$ $= 0.062$

$Hom(0,2) = \frac{2/16}{1+|0-2|}$ $= \frac{2}{16(1+|0-2|)}$ $= \frac{2}{48}$ $= 0.041$

$Hom(0,3) = \frac{3/16}{1+|0-3|}$ $= \frac{3}{16(1+|0-3|)}$ $= \frac{3}{64}$ $= 0.046$

$Hom(1,0) = \frac{1/16}{1+|1-0|}$ $= \frac{1}{16(1+|1-0|)}$

$Hom(1,1) = \frac{2/16}{1+|1-1|}$ $= \frac{2}{16(1+|1-1|)}$

$$= \frac{1}{32}$$
$$= 0.021$$

$$Hom(1,2) = \frac{0/16}{1+|1-2|}$$
$$= \frac{0}{16(1+|1-2|)}$$
$$= \frac{0}{32}$$
$$= 0$$

$$Hom(2,0) = \frac{2/16}{1+|2-0|}$$
$$= \frac{2}{16(1+|2-0|)}$$
$$= \frac{2}{48}$$
$$= 0.041$$

$$Hom(2,2) = \frac{0/16}{1+|2-2|}$$
$$= \frac{0}{16(1+|2-2|)}$$
$$= \frac{0}{16}$$
$$= 0$$

$$Hom(3,0) = \frac{3/16}{1+|3-0|}$$
$$= \frac{3}{16(1+|3-0|)}$$
$$= \frac{3}{64}$$
$$= 0.046$$

$$Hom(3,2) = \frac{0/16}{1+|3-2|}$$
$$= \frac{0}{16(1+|3-2|)}$$
$$= \frac{0}{48}$$
$$= 0$$

$$= \frac{2}{16}$$
$$= 0.125$$

$$Hom(1,3) = \frac{1/16}{1+|1-3|}$$
$$= \frac{1}{16(1+|1-3|)}$$
$$= \frac{1}{48}$$
$$= 0.020$$

$$Hom(2,1) = \frac{0/16}{1+|2-1|}$$
$$= \frac{0}{16(1+|2-1|)}$$
$$= \frac{0}{32}$$
$$= 0$$

$$Hom(2,3) = \frac{0/16}{1+|2-3|}$$
$$= \frac{0}{16(1+|2-3|)}$$
$$= \frac{0}{32}$$
$$= 0$$

$$Hom(3,1) = \frac{1/16}{1+|3-1|}$$
$$= \frac{1}{16(1+|3-1|)}$$
$$= \frac{1}{48}$$
$$= 0.020$$

$$Hom(3,3) = \frac{0/16}{1+|3-3|}$$
$$= \frac{0}{16(1+|3-3|)}$$
$$= \frac{0}{16}$$
$$= 0$$

$$Hom(Total) = 0.125 + 0.062 + 0.041 + 0.046 + 0.021 + 0.125 + 0 +$$

$$0.020 + 0.041 + 0 + 0 + 0 + 0.046 + 0.020 + 0 + 0$$
$$= 0.547$$

Energy:

$$Eng = \sum_i \sum_j p(i,j)^2$$

$$Eng = (\frac{2}{16})^2 + (\frac{1}{16})^2 + (\frac{2}{16})^2 + (\frac{3}{16})^2 + (\frac{1}{16})^2 + (\frac{2}{16})^2 + (\frac{0}{16})^2 + (\frac{1}{16})^2 + (\frac{2}{16})^2 + (\frac{0}{16})^2 + (\frac{0}{16})^2 + (\frac{0}{16})^2 + (\frac{3}{16})^2 + (\frac{1}{16})^2 + (\frac{0}{16})^2 + (\frac{0}{16})^2$$

$$Eng = \frac{2^2 + 1^2 + 2^2 + 3^2 + 1^2 + 2^2 + 0^2 + 1^2 + 2^2 + 0^2 + 0^2 + 0^2 + 3^2 + 1^2 + 0^2 + 0^2}{16^2}$$

$$Eng = \frac{38}{256}$$
$$= 0.148$$

Rata – Rata Nilai Fitur

$$Contrast = \frac{Contrast\ 0° + Contrast\ 45° + Contrast\ 90° + Contrast\ 135°}{4}$$

$$Contrast = \frac{2.817 + 4.979 + 2.908 + 5.061}{4}$$

$$Contrast = \frac{15.765}{4}$$

$$Contrast = 3.9412$$

$$Corelation = Corelation\ 0° + Corelation\ 45° + Corelation\ 135° + Corelation\ 135° \ / 4$$

$$Corelation = \frac{0.044 + (-0.0629) + (-0.0198) + (-0.061)}{4}$$

$$Corelation = \frac{-0.0997}{4}$$

$$Corelation = -0.0249$$

$$Homogenety = Homogenety\ 0° + Homogenety\ 45° + Homogenety\ 135° + Homogenety\ 135°\ /\ 4$$

$$Homogenety = \frac{0.668 + 0.398 + 0.432 + 0.547}{4}$$

$$Homogenety = \frac{2.045}{4}$$

$$Homogenety = 0.5112$$

$$Energy = Energy\ 0° + Energy\ 45° + Energy\ 135° + Energy\ 135°\ /\ 4$$

$$Energy = \frac{0.1352 + 0.125 + 0.090 + 0.145}{4}$$

$$Energy = \frac{0.4982}{4}$$

$$Energy = 1.9928$$

Hasil dari perhitungan ekstraksi fitur dengan *Grey Level Co-Occurrence Matrix* (GLCM) menggunakan empat fitur dan empat arah sudut dapat dilihat pada tabel 4.1.

Tabel 4. 1 Hasil perhitungan ekstraksi fitur dengan GLCM

Fitur	Sudut 0	Sudut 45	Sudut 90	Sudut 135
Contrast	2.817	4.979	2,908	5,061
Correlation	0.044	-0.0629	-0,0198	-0.061
Energy	0.1352	0.125	0.090	0.148
Homogenety	0.668	0.398	0.432	0.547

Setelah semua proses perhitungan ekstraksi fitur dengan *Grey Level Co-Occurrence Matrix* (GLCM) dilakukan, langkah selanjutnya adalah merata-ratakan nilai dari semua sudut agar didapatkan satu nilai tunggal dari setiap fitur yang telah di dapatkan sehingga memudahkan dalam penamaan klasifikasi. Nilai

rata-rata dari empat fitur *Grey Level Co-Occurrence Matrix* (GLCM) dapat dilihat pada tabel 4.2.

Tabel 4. 2 Nilai rata-rata dari empat fitur GLCM

Kelas	Contrast	Correlation	Energy	Homogenety
A	3.9412	-0.0249	1.9928	0.5112

4.1.3.2 Analisis Data dengan *Support Vector Machine* (SVM)

Berikut ini merupakan data fitur dari ekstraksi ciri citra motif songket Batu Bara yang telah dilakukan pada sistem yang telah dibuat:

Tabel 4. 3 Hasil Nilai Ekstraksi Fitur pada sistem

Jenis Motif	**Contrast**	**Correlation**	**Energy**	**Homogenety**
Bunga Tanjung 1	0.0552	0.8929	0.8075	0.9793
Pucuk Betikam 1	0.2468	0.8568	0.2306	0.8822
Pucuk Cempaka 1	0.4383	0.9521	0.1429	08598
Pucuk Pandan 1	0.2597	0.9424	0.1366	0.8846
Pucuk Tampuk Manggis 1	0.8065	0.9048	0.1012	0.7491
Tolab Berantai 1	0.9875	0.7726	0.1248	0.7435

Didalam sub bab ini akan menjelaskan bagaimana melakukan perhitungan dengan menggunakan metode *Support Vector Machine* (SVM) dengan data mentah yang telah diperoleh yang akan diproses melalui beberapa tahapan sebagai berikut:

1. Data Latih

Dataset yang digunakan untuk mengklasifikasi jenis motif songket berasal dari data latih citra motif songket Batu Bara hasil ekstraksi fitur tekstur *Grey Level Co-Occurence Matrix* (GLCM), dataset yang digunakan diambil 4 fitur hasil ekstraksi fitur *Grey Level Co-Occurence Matrix* (GLCM) yang tampak seperti tabel 4.4 dibawah ini:

Tabel 4. 4 Data yang digunakan

No.	Jenis Motif Songket	Nilai Hasil Ekstraksi Fitur GLCM			
		X1	X2	X3	X4
1.	Bunga Tanjung 1	0.0552	0.8929	0.8075	0.9793
2.	Pucuk Betikam 1	0.2468	0.8568	0.2306	0.8822
3.	Pucuk Cempaka 1	0.4383	0.9521	0.1429	08598
4.	Pucuk Pandan 1	0.2597	0.9424	0.1366	0.8846
5.	Tampuk Manggis 1	0.8065	0.9048	0.1012	0.7491
6.	Tolab Berantai 1	0.9875	0.7726	0.1248	0.7435

2. Normalisasi Data Latih

Dataset awal mempunyai data yang belum dinormalisasi tampak pada nilai fitur yang memiliki banyak angka dibelakang koma. Maka dari itu akan dilakukan normalisasi data. Normalisasi data terdiri dari berbagai cara. Pada penelitian ini, penulis menggunakan cara mengambil 2 angka di belakang koma nilai fitur sehingga pada nilai fitur tidak memliki banyak angka dibelakang koma. Dataset hasil normalisai dapat dilihat pada tabel 4.5 dibawah ini:

Tabel 4. 5 Dataset Hasil Normalisasi

No.	Jenis Motif Songket	Nilai Hasil Ekstraksi Fitur GLCM			
		X1	X2	X3	X4
1.	Bunga Tanjung 1	0.06	0.89	0.81	0.98
2.	Pucuk Betikam 1	0.25	0.86	0.23	0.88
3.	Pucuk Cempaka 1	0.44	0.95	0.14	086
4.	Pucuk Pandan 1	0.26	0.94	0.14	0.88
5.	Tampuk Manggis 1	0.81	0.90	0.10	0.75
6.	Tolab Berantai 1	0.99	0.77	0.12	0.74

3. Penentuan Nilai *Output* (y)

Dari hasil normalisasi, maka akan ditentukan nilai *output* (y) dengan cara

memberi nilai y = 1 untuk kelas pertama yang akan dicari fungsi keputusannya dan memberikan nilai y = -1 untuk kelas lainnya. Sehingga akan menghasilkan 6 fungsi keputusan sesuai dengan kelas yang ada. Hasil penentuan nilai *output* (y) dapat dilihat dari tabel 4.6 dibawah ini:

Tabel 4. 6 Nilai X dan Y

No.	X1	X2	X3	X4	Y
1.	0.06	0.89	0.81	0.98	1
2.	0.25	0.86	0.23	0.88	-1
3.	0.44	0.95	0.14	086	-1
4.	0.26	0.94	0.14	0.88	-1
5.	0.81	0.90	0.10	0.75	-1
6.	0.99	0.77	0.12	0.74	-1

4. Penentuan Nilai *Weight* (w) dan Bias (b)

Untuk menghitung nilai *weight* (w), maka digunakan rumus $y_i(w.x_i + b) \geq 1$ untuk kelas pertama yang akan dicari fungsi keputusannya dan digunakan rumus $y_i(w.x_i + b) \leq 1$ untuk kelas lainnya. Dimana i = 1,2,3, ..., N. Maka diperoleh beberapa persamaan yaitu:

$(w1 + w2 + w3 + w4 + b) \geq 1\ Untuk\ y1 = 1, x1 = 0.06, x2 = 0.89, x3 = 0.81, x4 = 0.98$ ……. (1)

$(w1 + w2 + w3 + w4 + b) \leq -1\ Untuk\ y2 = -1, x1 = 0.25, x2 = 0.86, x3 = 0.23, x4 = 0.88$ ……. (2)

$(w1 + w2 + w3 + w4 + b) \leq -1\ Untuk\ y3 = -1, x1 = 0.44, x2 = 0.95, x3 = 0.14, x4 = 0.86$ ……. (3)

$(w1 + w2 + w3 + w4 + b) \leq -1\ Untuk\ y4 = -1, x1 = 0.26, x2 = 0.94, x3 = 0.14, x4 = 0.88$ ……. (4)

$(w1 + w2 + w3 + w4 + b) \leq -1\ Untuk\ y5 = -1, x1 = 0.81, x2 = 0.90, x3 = 0.10, x4 = 0.75$ ……. (5)

$$(w1 + w2 + w3 + w4 + b) \leq -1 \; Untuk \; y6 = -1, x1 = 0.99, x2 = 0.77, x3 = 0.12, x4 = 0.74 \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (6)$$

Setelah mendapat persamaan diatas, maka dilakukan pencarian nilai w1,w2,w3 dan w4 dan nilai b dengan mengeliminasi persamaan 1 dan 2, persamaan 1 dan 3, persamaan 1 dan 4, persamaan 1 dan 5, persamaan 1 dan 6 sebagai berikut:

Eliminasi persamaan 1 dan 2:

$0.06w1 + 0.89w2 + 0.81w3 + 0.98w4 + b = 1 \ldots\ldots\ldots\ldots\ldots\ldots (1)$

$0.25w1 - 0.86w2 - 0.23w3 - 0.88w4 - b = -1 \ldots\ldots\ldots\ldots\ldots (2)$ _

$-0.19w1 + 1.75w2 + 1.04w3 + 1.86w4 + 2b = 2 \ldots\ldots\ldots\ldots\ldots\ldots (7)$

Hasil eliminasi persamaan 1 dan 2 menghasilkan persamaan 7

Eliminasi persamaan 1 dan 3:

$0.06w1 + 0.89w2 + 0.81w3 + 0.98w4 + b = 1 \ldots\ldots\ldots\ldots\ldots\ldots (1)$

$0.44w1 - 0.95w2 - 0.14w3 - 0.86w4 - b = -1 \ldots\ldots\ldots\ldots\ldots (3)$ _

$-0.38w1 + 1.54w2 + 0.95w3 + 1.84w4 + 2b = 2 \ldots\ldots\ldots\ldots\ldots\ldots (8)$

Hasil eliminasi persamaan 1 dan 3 menghasilkan persamaan 8

Eliminasi persamaan 1 dan 4:

$0.06w1 + 0.89w2 + 0.81w3 + 0.98w4 + b = 1 \ldots\ldots\ldots\ldots\ldots\ldots (1)$

$0.26w1 - 0.94w2 - 0.14w3 - 0.88w4 - b = -1 \ldots\ldots\ldots\ldots\ldots\ldots (4)$ _

$-0.2w1 + 1.83w2 + 0.95w3 + 1.86w4 + 2b = 2 \ldots\ldots\ldots\ldots\ldots\ldots (9)$

Hasil eliminasi persamaan 1 dan 4 menghasilkan persamaan 9

Eliminasi persamaan 1 dan 5:

$0.06w1 + 0.89w2 + 0.81w3 + 0.98w4 + b = 1 \ldots\ldots\ldots\ldots\ldots\ldots (1)$

$0.81w1 - 0.90w2 - 0.10w3 - 0.75w4 - b = -1 \ldots\ldots\ldots\ldots\ldots\ldots (5)$ _

$-0.75w1 + 1.79w2 + 0.91w3 + 1.73w4 + 2b = 2 \ldots\ldots\ldots\ldots\ldots\ldots (10)$

Hasil eliminasi persamaan 1 dan 5 menghasilkan persamaan 10

Eliminasi persamaan 1 dan 6:

$0.06w1 + 0.89w2 + 0.81w3 + 0.98w4 + b = 1 \ldots\ldots\ldots\ldots\ldots\ldots (1)$

$0.99w1 - 0.77w2 - 0.12w3 - 0.74w4 - b = -1 \ldots\ldots\ldots\ldots\ldots (6)$ _

$-0.93w1 + 1.66w2 + 0.93w3 + 1.72w4 + 2b = 2 \ldots\ldots\ldots\ldots\ldots\ldots (11)$

Hasil eliminasi persamaan 1 dan 6 menghasilkan persamaan 11

Melakukan eliminasi w4 menggunakan persamaan 7 dan 8 dengan cara perkalian silang indeks w4

$-0.19w1 + 1.75w2 + 1.04w3 + 1.86w4 + 2b = 2 \ldots\ldots\ldots\ldots\ldots\ldots (7)$

$-0.38w1 + 1.54w2 + 0.95w3 + 1.84w4 + 2b = 2 \ldots\ldots\ldots\ldots\ldots\ldots (8)$ _

$-0.34w1 + 3.22w2 + 1.91w3 + 3.42w4 + 3.68b = 3.68$

$-0.70w1 + 2.86w2 + 1.76w3 + 3.42w4 + 3.72b = 3.72$ _

$0.36w1 + 0.36w2 + 0.15w3 - 0.04b = -0.04 \ldots\ldots\ldots\ldots\ldots (12)$

Hasil eliminasi w4 menjadi persamaan 12

Melakukan eliminasi w4 menggunakan persamaan 8 dan 9 dengan cara perkalian silang indeks w4

$-0.38w1 + 1.54w2 + 0.95w3 + 1.84w4 + 2b = 2 \ldots\ldots\ldots\ldots\ldots\ldots (8)$

$-0.2w1 + 1.83w2 + 0.95w3 + 1.86w4 + 2b = 2 \ldots\ldots\ldots\ldots\ldots\ldots (9)$ _

$-0.70w1 + 2.86w2 + 1.76w3 + 3.42w4 + 3.72b = 3.72$

$-0.36w1 + 3.36w2 + 1.74w3 + 3.42w4 + 3.68b = 3.68$ _

$-0.34w1 \pm 0.5w2 + 0.02w3 + 0.04b = 0.04 \ldots\ldots\ldots\ldots\ldots (13)$

Hasil eliminasi w4 menjadi persamaan 13

Melakukan eliminasi w3 menggunakan persamaan 10 dan 11 dengan cara perkalian silang indeks w4

$-0.75w1 + 1.79w2 + 0.91w3 + 1.73w4 + 2b = 2 \ldots\ldots\ldots\ldots\ldots\ldots (10)$

$-0.93w1 + 1.66w2 + 0.93w3 + 1.72w4 + 2b = 2 \ldots\ldots\ldots\ldots\ldots\ldots (11)$ _

$$-1.29w1 + 3.07w2 + 1.54w3 + 2.97w4 + 3.44b = 3.44$$
$$-1.60w1 + 2.87w2 + 1.60w3 + 2.97w4 + 3.46b = 3.46$$ –
$$0.31w1 \pm 0.2w2 - 0.06w3 - 0.02b = -0.04 \ldots\ldots\ldots\ldots\ldots (14)$$

Hasil eliminasi w3 menjadi persamaan 14

Melakukan eliminasi w2 menggunakan persamaan 12 dan 13 dengan cara perkalian silang indeks w3

$$0.36w1 + 0.36w2 + 0.15w3 - 0.04b = -0.04 \ldots\ldots\ldots.. (12)$$
$$-0.34w1 + 0.5w2 + 0.02w3 + 0.04b = 0.04 \ldots\ldots\ldots\ldots\ldots (13)$$ –
$$0.007w1 + 0.007w2 + 0.003w3 - 0.0008b = -0.0016$$
$$0.013w1 - 0.02w2 + 0.003w3 - 0.0016b = -0.0016$$ –
$$-0.006w1 + 0.027w2 - 0.0008b = 0 \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (15)$$

Hasil eliminasi w2 menjadi persamaan 15

Melakukan eliminasi w2 menggunakan persamaan 13 dan 14 dengan cara perkalian silang indeks w3

$$-0.34w1 + 0.5w2 + 0.02w3 + 0.04b = 0.04 \ldots\ldots\ldots\ldots\ldots (13)$$
$$0.31w1 + 0.2w2 - 0.06w3 - 0.02b = -0.04 \ldots\ldots\ldots\ldots\ldots (14)$$ –
$$0.020w1 - 0.03w2 + 0.0012w3 - 0.0024b = -0.0024$$
$$0.006w1 + 0.004w2 + 0.0012w3 - 0.0024b = -0.0008$$ –
$$0.014w1 - 0.034w2 + 0b = -0.0016 \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (16)$$

Hasil eliminasi w2 menjadi persamaan 16

Melakukan eliminasi w2 menggunakan persamaan 15 dan 16 dengan cara perkalian silang indeks w2

$$-0.006w1 + 0.027w2 - 0.0008b = 0$$
$$0.014w1 - 0.034w2 + 0b = -0.0016$$ –
$$0.00020w1 + 0.00091w2 + 0.000027b = 0$$
$$0.00037w1 + 0.00091w2 + 0b = -0.000043$$ –
$$-0.00017w1 + 0.000027b = 0.000043$$

Mencari nilai w1

$-0.00017w1 = 0.000043$

$w1 = -0.25$

Mencari nilai w2 dengan menggunakan persamaan 16 mensubstitusi w1

$0.014w1 - 0.034w2 + 0b = -0.0016 \ldots\ldots\ldots (16)$

$0.014(-0.25) - 0.034w2 + 0b = -0.0016$

$-0.0035 - 0.034w2 + 0b = -0.0016$

$0.014w1 - 0.034w2 = -0.0016$

$w2 = 0.047$

Mencari nilai w3 dengan menggunakan persamaan 13 mensubstitusi w1 dan w2

$w1 = -0.25; w2 = 0.047;$

$-0.34w1 + 0.5w2 + 0.02w3 + 0.04b = 0.04 \ldots\ldots\ldots\ldots\ldots (13)$

$-0.34(-0.25) + 0.5(0.047) + 0.02w3 + 0.04b = 0.04$

$0.085 + 0.023 + 0.02w3 + 0.04b = 0.04$

$0.108 + 0.02w3 = 0.04$

$w3 = 2$

Mencari nilai w4 dengan menggunakan persamaan 8 mensubstitusi w1, w2, w3

$w1 = -0.25; w2 = 0.047; w3 = 2$

$-0.38w1 + 1.54w2 + 0.95w3 + 1.84w4 + 2b = 2 \ldots\ldots\ldots\ldots\ldots\ldots (8)$

$-0.38(-0.25) + 1.54(0.047) + 0.95(2) + 1.84w4 + 2b = 2$

$0.095 + 0.072 + 1.9 + 1.84w4 + 2b = 2$

$2.067 + 1.84w4 + 2b = 2$

$2.067 + 1.84w4 = 2$

$w4 = 1.08$

Mencari nilai bias dengan menggunakan persamaan 7 mensubstitusi w1,w2,w3,w4

$w1 = -0.25; w2 = 0.047; w3 = 2; w4 = 1.08$

$-0.19w1 + 1.75w2 + 1.04w3 + 1.86w4 + 2b = 2$ ……. (7)

$-0.19(-0.25) + 1.75(0.047) + 1.04(2) + 1.86(1.08) + 2b = 2$

$0.047 + 0.082 + 2.08 + 2.0 + 2b = 2$

$2.409 + 2b = 2$

$b = 0.01$

5. Penentuan Nilai *Hyperplane*

Untuk menentukan nilai hyperplane, maka digunakan persamaan berikut:

$f(x) = w1.x1 + w2.x2 + w3.x3 + w4.x4 + b = 0$

Dari persamaan diatas, digabungkan dengan nilai *weight* (w) dan bias(b), maka diperoleh nilai *hyperlpane* sebagai berikut:

$f(x) = -0.25.x1 + 0.047.x2 + 2.x3 + 1.08.x4 + 0.01 = 0$

Setelah mendapatkan nilai *hyperplane* yang pertama maka proses perhitungan diatas dilakukan kembali mulai dari penentuan nilai *output* (y) hingga penentuan nilai *hyperplane* sampai mendapatkan 6 *hyperplane* yang mana didalam metode svm *one against all hyperplane* adalah fungsi keputusan yang akan menentukan kelas dari data yang dilatih dan diuji.

6. *Hyperplane* Sebagai Fungsi Keputusan

Dari hasil perhitungan yang dilakukan secara berulang maka didapatkan 6 *hyperplane* sebagai fungsi keputusan seperti berikut:

$f1(x) = -0.25.x1 + 0.047.x2 + 2.x3 + 1.08.x4 + 0.01 = 0$

$f2(x) = 0.05.x1 + 0.025.x2 + 1.05.x3 + 0.045.x4 + 0.04 = 0$

$f3(x) = -0.001.x1 + 0.004.x2 + 0.006.x3 + 0.0047.x4 + 0.003 = 0$

$f4(x) = 0.005.x1 + -0.002.x2 + 0.10.x3 + 1.080.x4 + 0.01 = 0$

$f5(x) = 0.25.x1 + 0.002.x2 + 1.002.x3 + 0.04.x4 + 0.003 = 0$

$f6(x) = 0.029x1 + 0.0024.x2 + 2.01.x3 + 0.10.x4 + 0.01 = 0$

7. Pengujian Data

Pada tabel 4.7 dibawah ini merupakan data uji yang mana diambil 1

sample data uji untuk dilakukan proses klasifikasi motif songket Batu Bara yang akan dilakukan menggunakan 6 fungsi keputusan.

Tabel 4. 7 Data Uji

No.	Jenis Motif Songket	Nilai Hasil Ekstraksi Fitur GLCM			
		X1	X2	X3	X4
1.	Bunga Tanjung 1	0.0552	0.8929	0.8075	0.9793

Tabel 4. 8 Data Uji Hasil Normalisasi

No.	Jenis Motif Songket	Nilai Hasil Ekstraksi Fitur GLCM			
		X1	X2	X3	X4
1.	Bunga Tanjung 1	0.06	0.89	0.81	0.98

Tabel 4. 9 Nilai X dan Y

No.	X1	X2	X3	X4	Y
1.	0.06	0.89	0.81	0.98	1

Tabel 4. 10 Fungsi Keputusan Metode *One Against All*

$y_i = 1$	$y_i = -1$	Hipotesis
Bunga Tanjung	Bukan Bunga Tanjung	f1(x)=(w1.x1+ w2.x2+ w3.x3+ w4.x4+b)
Pucuk Betikam	Bukan Pucuk Betikam	f2(x)=(w1.x1+ w2.x2+ w3.x3+ w4.x4+b)
Pucuk Cempaka	Bukan Pucuk Cempaka	f3(x)=(w1.x1+ w2.x2+ w3.x3+ w4.x4+b)
Pucuk Pandan	Bukan Pucuk Pandan	f4(x)=(w1.x1+ w2.x2+ w3.x3+ w4.x4+b)
TampukManggis	Bukan TampukManggis	f5(x)=(w1.x1+ w2.x2+ w3.x3+ w4.x4+b)
Tolab Berantai	Bukan Tolab Berantai	f6(x)=(w1.x1+ w2.x2+ w3.x3+ w4.x4+b)

Dengan menggunakan data uji yang tampak pada tabel 4.10, maka dilakukan klasifikasi motif songket Batu Bara dengan menggunakan persamaan fungsi keputusan metode *one against all* dengan kelas = *sign*(f(x)). Fungsi *sign* yang digunakan merupakan pengecekan pada hasil perhitungan yang dilakukan pada data uji. Hasil pengujian pada data uji yang menghasilkan fungsi keputusan

dengan nilai paling maksimal maka akan diberi nilai $y_i = 1$, sedangkan pada fungsi keputusan lainnya akan diberi nilai $y_i = -1$. Hasil pengujian dapat dilihat pada tabel 4.11 dibawah ini:

Tabel 4. 11 Hasil Pengujian

No.	Data Uji				Fungsi Keputusan Metode One Against All	y_i
	X1	X2	X3	X4	f1(x)=sign(w1.x1+w2.x2+w3.x3+w4.x4+b)	-1
1.	0.06	0.89	0.81	0.98	Sign(-0.339)	-1
2.	0.25	0.86	0.23	0.88	Sign(1.502)	-1
3.	0.44	0.95	0.14	086	Sign (-1.078	-1
4.	0.26	0.94	0.14	0.88	Sign (1.991)	1
5.	0.81	0.90	0.10	0.75	Sign(0.776)	-1
6.	0.99	0.77	0.12	0.74	Sign(0.182)	-1

Pada tabel 4.11 diperlihatkan hasil pengenalan data dengan menggunakan 6 persamaan fungsi keputusan. Dari hasil pengenalan data, diperoleh nilai 1 pada fungsi keputusan ke 4 dan nilai -1 pada fungsi keputusan ke 1,2,3,5 dan 6. Dimana fungsi keputusan ke 4 merupakan kelas jenis motif songket Batu Bara Pucuk Pandan dan fungsi keputusan 1,2,3,5 dan 6 merupakan kelas jenis motif songket bunga tanjung, pucuk betikam, pucuk cempaka, pucuk perak dan pucuk rebung. Maka dari itu hasil dari pengujian data yang dilakukan benar bahwa data yang diuji adalah motif songket jenis pucuk pandan.

Tabel 4. 12 Hasil Pengenalan Data

No.	Data Uji				Hasil Pengenalan data	Keterangan
	X1	X2	X3	X4		
1.	0.06	0.89	0.81	0.98	-1	Bukan Kelas Bunga Tanjung
2.	0.25	0.86	0.23	0.88	-1	Bukan Kelas Pucuk Betikam
3.	0.44	0.95	0.14	-1	-1	Kelas Pucuk Cempaka
4.	0.26	0.94	0.14	0.88	1	Bukan Kelas Pucuk Pandan
5.	0.81	0.90	0.10	0.75	-1	Bukan Kelas Tampuk

						Manggis
6.	0.99	0.77	0.12	0.74	-1	Bukan Kelas Tolab Berantai

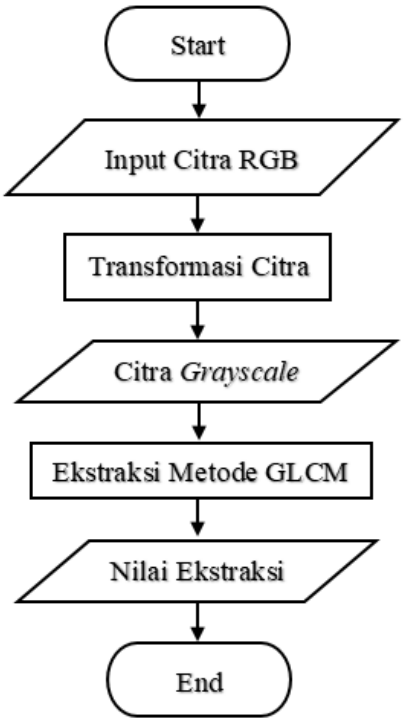
Untuk hasil klasifikasi data uji yang lain tidak lagi dilakukan dengan cara manual seperti diatas, akan tetapi dilakukan klasifikasi menggunakan aplikasi yang sudah dibuat.

4.1.4 Perancangan

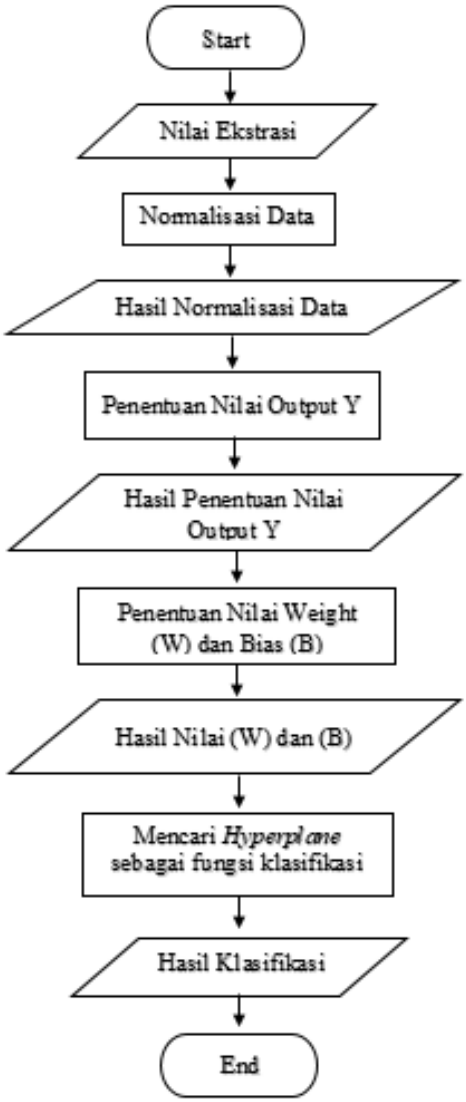
Berdasarkan analisis yang telah dilakukan terhadap metode *Grey Level Co-Occurrence Matrix* (GLCM) dan *Support Vector Machine* (SVM) untuk melakukan klasifikasi jenis motif songket Batu Bara, maka perancangan yang dilakukan oleh penulis adalah sebagai berikut:

1. Flowchart

Perancangan *flowchart* klasifikasi jenis motif songket Batu Bara berdasarkan fitur menggunakan metode *Grey Level Co-Occurrence Matrix* (GLCM) dan *Support Vector Machine* (SVM) dapat dilihat pada gambar 4.2 dan 4.3 dibawah:

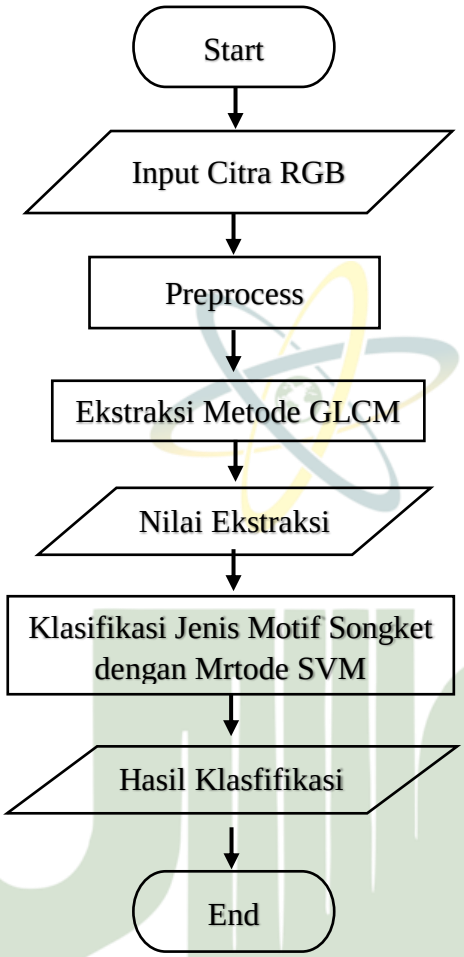


Gambar 4. 2 Flowchart Metode Grey Level Co-Occurrence Matrix (GLCM)



Gambar 4. 3 Flowchart Metode *Support Vector Machine*

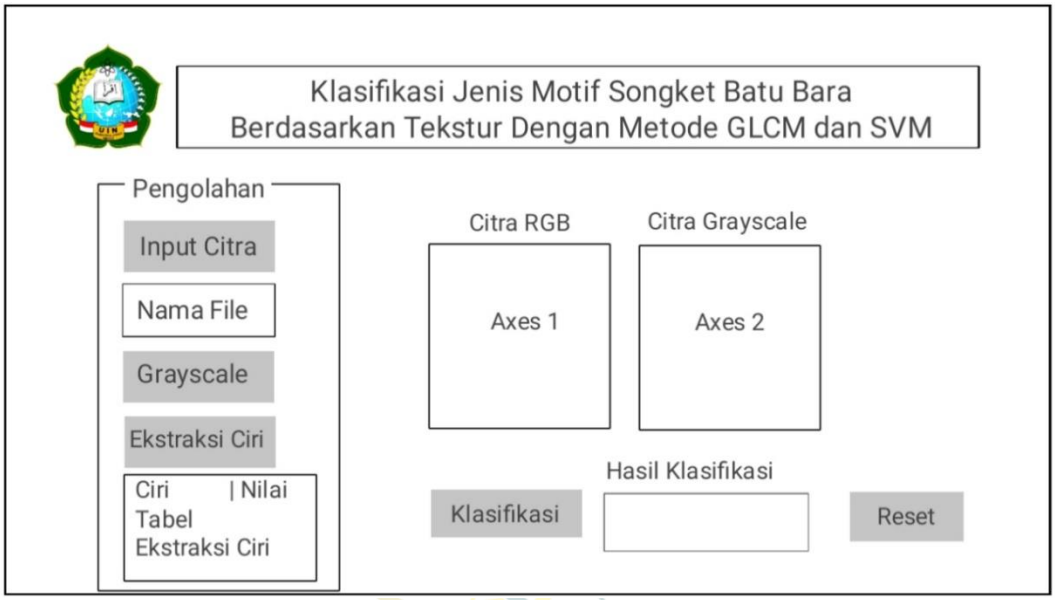
Perancangan *flowchart* sistem klasifikasi jenis motif songket Batu Bara berdasarkan fitur dapat dilihat pada gambar 4.4 dibawah:



Gambar 4. 4 Flowchart Metode *Support Vector Machine*

2. Rancangan Sistem Aplikasi

Sebelum diimplementasi ke dalam sebuah program aplikasi, terlebih dahulu merancang sistem klasifikasi jenis motif songket Batu Bara berdasarkan tekstur agar sistem dapat berjalan sebagaimana mestinya.Sistem ini dirancang dengan menggunakan *tools* matlab. Pada gambar 4.5 dibawah terdapat gambar perancangan antarmuka bertujuan untuk memudahkan *user* dalam menggunakan sistem yang telah dibuat.



Gambar 4. 5 Rancangan Sistem Aplikasi

Berdasarkan pada gambar di atas, perancangan pada sistem ini terdiri dari:

a. Logo Universitas Islam Negeri Sumatera Utara.
b. *Static Text* Judul Skripsi.
c. *Axes1* berfungsi untuk menampung data citra jenis motif songket RGB yang telah dipilih.
d. *Axes 2* berfungsi untuk menampung data citra jenis motif songket *grayscale.*
e. *Button* Input Citra berfungsi untuk memilih dan mencari citra motif songket Batu Bara yang akan di uji.
f. *Edit Text 1* berfungsi untuk menampilkan informasi nama dari citra motif songket yang di uji.
g. *Button grayscale* berfungsi untuk memproses citra RGB menjadi citra berjenis *grayscale.*
h. *Button* ekstraksi ciri berfungsi untuk mengekstraksi ciri citra dengan metode *Grey Level Co-Occurrence Matrix.*
i. *Table* berfungsi untuk menampilkan nilai citra yang sudah diekstraksi.
j. *Button* klasifikasi berfungsi untuk memproses citra untuk diklasifikasikan.
k. *Edit Text 2* berfungsi untuk menampilkan hasil klasifikasi jenis citra yang diinput.
l. *Button* reset berfungsi untuk mereset ulang tampilan seperti awal pertama

muncul.

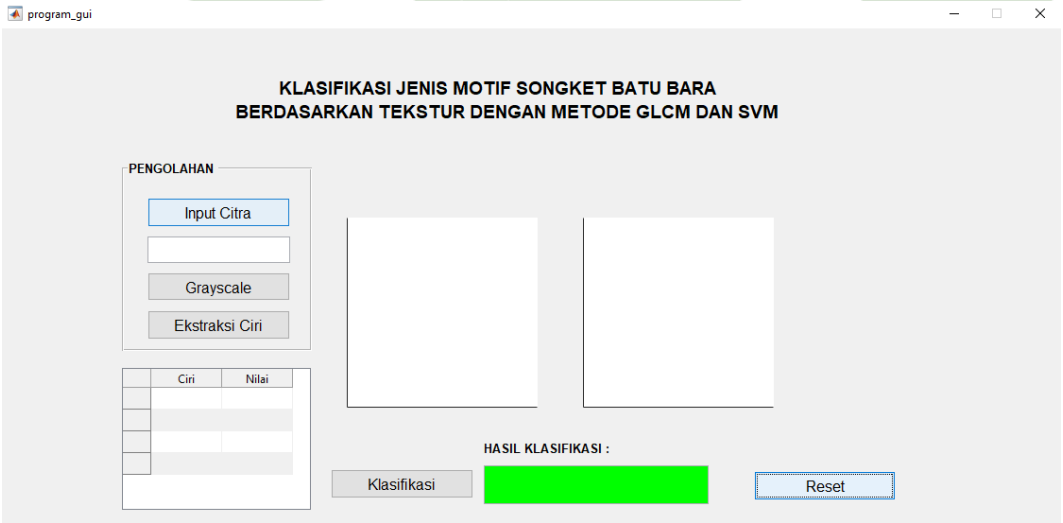
4.2 Hasil

4.2.1 Pengujian

Berdasarkan *sample* citra yang sudah ada maka akan dilakukan proses pengujian terhadap citra. Pada tahap ini akan dilakukan pengujian terhadap citra digital dengan format (*.jpg) yang berukuran 512x512 piksel. Adapun proses pengujian sistem dapat dilihat pada proses dibawah:

1. Tampilan Awal Aplikasi

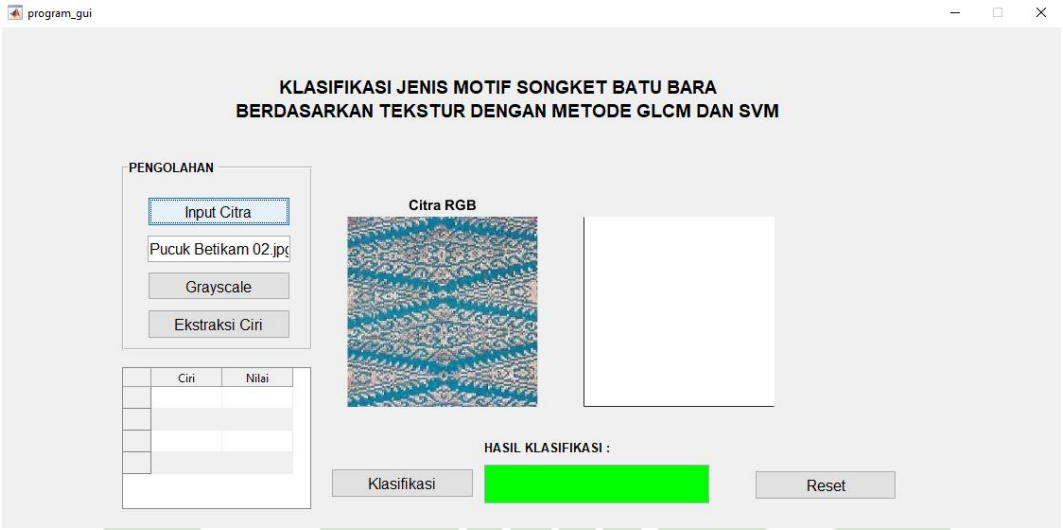
Form awal adalah halaman utama untuk menjalankan program yang akan dikerjakan. *Form* ini berisi logo Universitas Islam Negeri Sumatera Utara. Judul skripsi "Klasifikasi Jenis Motif Songket Batu Bara Berdasarkan Tekstur dengan Metode *Grey Level Co-Occurrence Matrix* (GLCM) dan *Support Vector Machine* (SVM)", tombol - tombol untuk mengoperasikan sistem yang berupa tombol Input Citra untuk menginput citra yang akan di olah, *Grayscale* untuk mengubah citra RGB menjadi format *Grayscale*, Tombol Ekstraksi Ciri untuk mengestraksi ciri menggunakan ekstraksi ciri *Grey Level Co-Occurrence Matrix* (GLCM) serta mengeluarkan nilai ekstraksi ciri pada tabel, tombol klasifikasi untuk memproses klasifikasi citra yang diinput menggunakan metode *Support Vector Machine* (SVM) dan tombol reset untuk mengembalikan tampilan sistem ke tampilan awal.



Gambar 4. 6 Form Tampilan Awal

2. Tampilan Input Citra

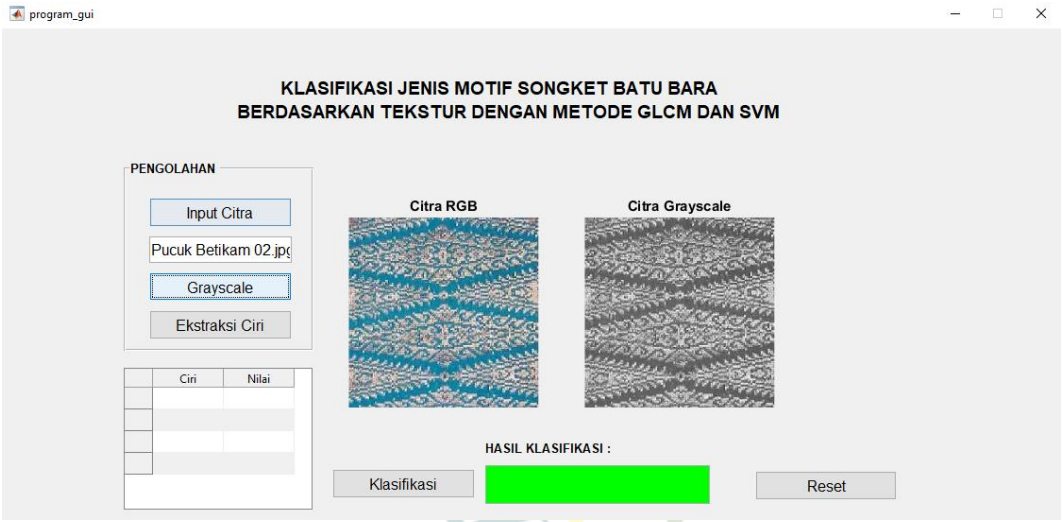
Tampilan pada form ini dilakukan penginputan citra dengan cara menekan tombol Input Citra, lalu sistem akan mengarahkan untuk memilih data yang akan di uji, kemudian sistem akan secara otomatis menampilkan citra yang diinput dan menampilkan secara otomatis nama file citra tersebut.



Gambar 4. 7 Form Tampilan Input Citra

3. Tampilan *Grayscale*

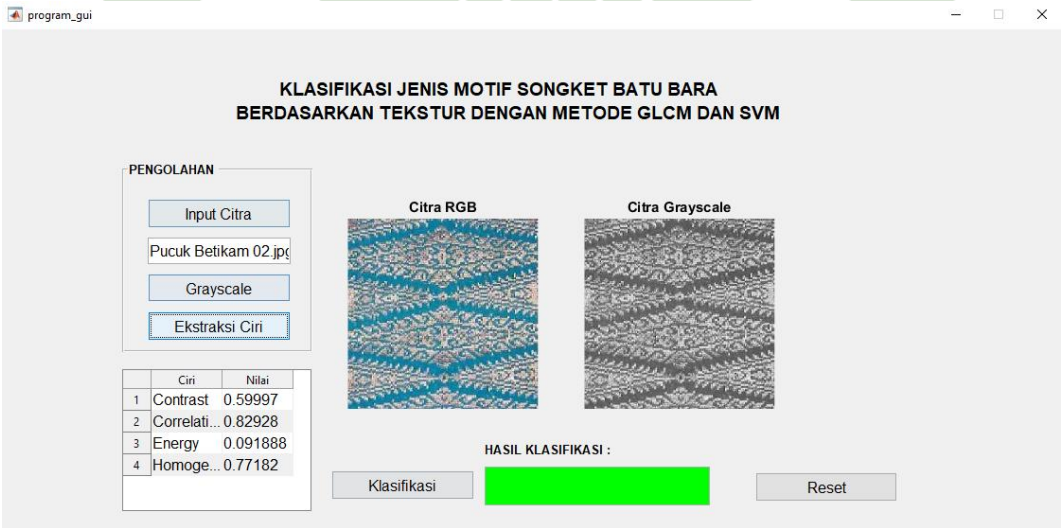
Tampilan pada form ini akan dilakukan proses Grayscale, dengan cara menekan tombol *grayscale* , maka sistem akan memproses file RGB menjadi *grayscale* dan menampilkan citra hasil *grayscale* pada *axes2*.



Gambar 4. 8 Form Tampilan RGB menjadi *Grayscale*

4. Tampilan Ekstraksi Ciri *Grey Level Co-Occurrence Matrix* (GLCM)

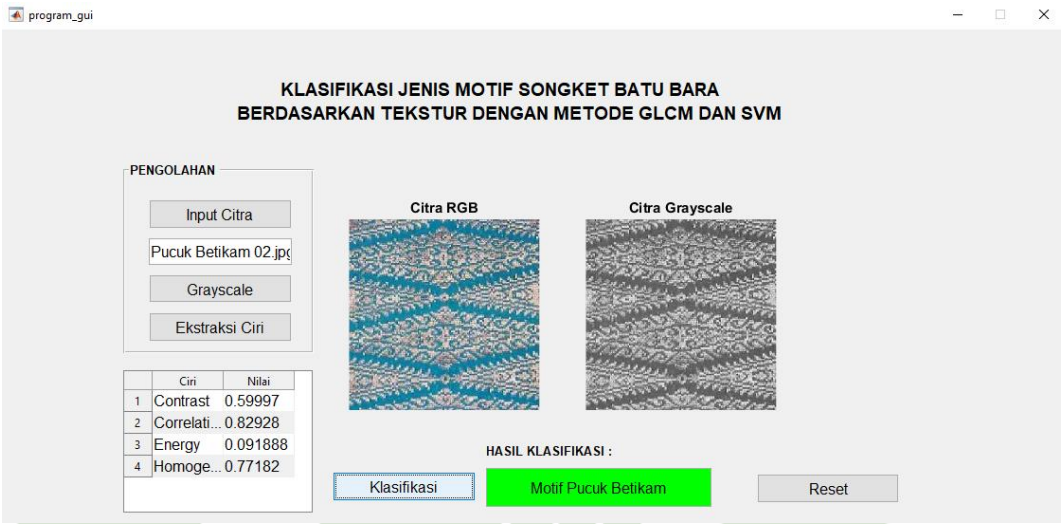
Tampilan pada form ini akan dilakukan ekstraksi ciri pada citra dengan menekan tombol Ektraksi Ciri, maka akan menampilkan nilai ekstraksi ciri *Grey Level Co-Occurence Matrix* (GLCM) pada tabel.



Gambar 4. 9 Form Tampilan Ekstraksi Ciri *Grey Level Co-Occurence Matrix*

5. Tampilan Hasil Klasifikasi

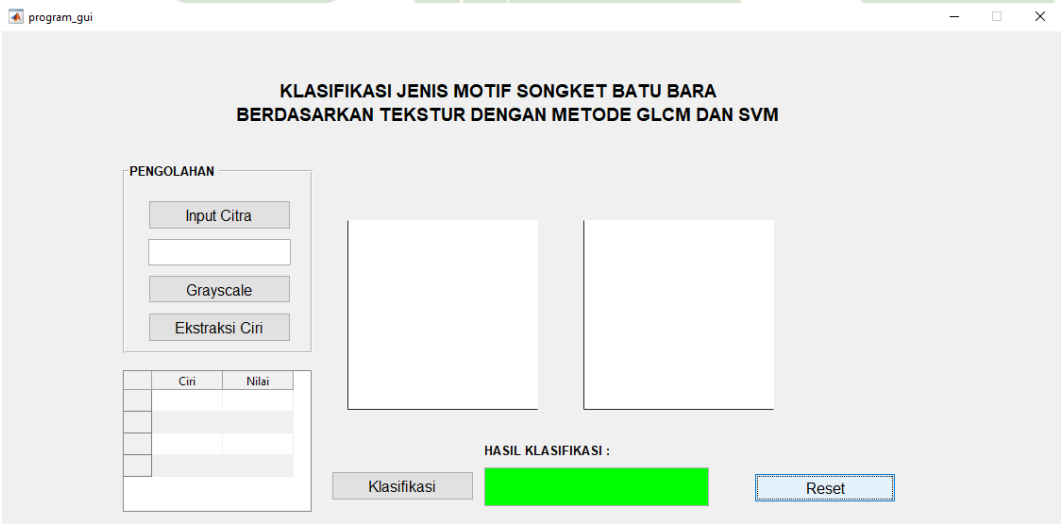
Tampilan pada form ini merupakan tampilan hasil klasifikasi pada citrra yang diinput, untuk menampilkan hasil klasifikasi dengan cara menekan tombol Klasifikasi, maka sistem akan secara otomatis menampilkan hasil klasifikasi citra yang diinput.



Gambar 4. 10 Form Tampilan Hasil Klasifikasi Citra Motif Songket Batu Bara

6. Tampilan Tombol Reset

Tampilan pada form ini dilakukan untuk menampilkan sistem kembali seperti semula yaitu dengan cara menekan tombol reset makan secara otomatis sistem akan mereset ulang tampilan kembali seperti awal.



Gambar 4. 11 Form Tampilan Tombol Reset

4.2.2 Hasil Pengujian Sistem

Berdasarkan data uji pada citra jenis motif songket Batu Bara yang sudah ada maka dalam hal ini akan dilakukan proses pengujian terhadap citra motif songket Batu Bara dengan format (*.jpg). Pada proses pengujian klasifikasi motif songket dibawah terdapat 30 data uji dengan 5 data dari setiap jenis motif songket, 5 data uji citra motif bunga tanjung, 5 data uji citra motif pucuk betikam, 5 data uji citra motif pucuk cempaka, 5 data uji citra motif pucuk pandan, 5 data uji citra motif pucuk tampuk manggis, dan 5 data uji citra motif tolab berantai. Dari hasil pengujian seluruh data uji sebanyak 30 data uji.

Dibawah ini merupakan hasil pengujian sistem pada masing-masing citra motif songket yang telah di uji untuk memperoleh klasifikasi jenis motif songket Batu Bara. Dapat dilihat pada tabel 4.13 dibawah:

Tabel 4. 13 Pengujian Data

No.	Data Uji	Fungsi Keputusan SVM MultiClass One Against All
1.	Bunga Tanjung 01.jpg	f1(x)=sign(w1.x1+ w2.x2+ w3.x3+ w4.x4+b)
2.	Bunga Tanjung 02.jpg	f1(x)=sign(w1.x1+ w2.x2+ w3.x3+ w4.x4+b)
3.	Bunga Tanjung 03.jpg	f1(x)=sign(w1.x1+ w2.x2+ w3.x3+ w4.x4+b)
4.	Bunga Tanjung 04.jpg	f1(x)=sign(w1.x1+ w2.x2+ w3.x3+ w4.x4+b)
5.	Bunga Tanjung 05.jpg	f1(x)=sign(w1.x1+ w2.x2+ w3.x3+ w4.x4+b)
6.	Pucuk Betikam 01 .jpg	f2(x)=sign(w1.x1+ w2.x2+ w3.x3+ w4.x4+b)
7.	Pucuk Betikam 02.jpg	f2(x)=sign(w1.x1+ w2.x2+ w3.x3+ w4.x4+b)
8.	Pucuk Betikam 03.jpg	f2(x)=sign(w1.x1+ w2.x2+ w3.x3+ w4.x4+b)
9.	Pucuk Betikam 04.jpg	f2(x)=sign(w1.x1+ w2.x2+ w3.x3+ w4.x4+b)
10.	Pucuk Betikam 05.jpg	f2(x)=sign(w1.x1+ w2.x2+ w3.x3+ w4.x4+b)
11.	Pucuk Cempaka 01.jpg	f3(x)=sign(w1.x1+ w2.x2+ w3.x3+ w4.x4+b)
12.	Pucuk Cempaka 02.jpg	f3(x)=sign(w1.x1+ w2.x2+ w3.x3+ w4.x4+b)
13.	Pucuk Cempaka 03.jpg	f3(x)=sign(w1.x1+ w2.x2+ w3.x3+ w4.x4+b)

14.	Pucuk Cempaka 04.jpg	f3(x)=sign(w1.x1+ w2.x2+ w3.x3+ w4.x4+b)
15.	Pucuk Cempaka 05.jpg	f3(x)=sign(w1.x1+ w2.x2+ w3.x3+ w4.x4+b)
16.	Pucuk Pandan 01.jpg	f4(x)=sign(w1.x1+ w2.x2+ w3.x3+ w4.x4+b)
17.	Pucuk Pandan 02.jpg	f4(x)=sign(w1.x1+ w2.x2+ w3.x3+ w4.x4+b)
18.	Pucuk Pandan 03.jpg	f4(x)=sign(w1.x1+ w2.x2+ w3.x3+ w4.x4+b)
19.	Pucuk Pandan 04.jpg	f4(x)=sign(w1.x1+ w2.x2+ w3.x3+ w4.x4+b)
20.	Pucuk Pandan 05.jpg	f4(x)=sign(w1.x1+ w2.x2+ w3.x3+ w4.x4+b)
21.	Tampuk Manggis01.jpg	f5(x)=sign(w1.x1+ w2.x2+ w3.x3+ w4.x4+b)
22.	Tampuk Manggis02.jpg	f5(x)=sign(w1.x1+ w2.x2+ w3.x3+ w4.x4+b)
23.	Tampuk Manggis03.jpg	f5(x)=sign(w1.x1+ w2.x2+ w3.x3+ w4.x4+b)
24.	Tampuk Manggis04.jpg	f5(x)=sign(w1.x1+ w2.x2+ w3.x3+ w4.x4+b)
25.	Tampuk Manggis05.jpg	f5(x)=sign(w1.x1+ w2.x2+ w3.x3+ w4.x4+b)
26.	Tolab Berantai 01.jpg	f6(x)=sign(w1.x1+ w2.x2+ w3.x3+ w4.x4+b)
27.	Tolab Berantai 02.jpg	f5(x)=sign(w1.x1+ w2.x2+ w3.x3+ w4.x4+b)
28.	Tolab Berantai 03.jpg	f5(x)=sign(w1.x1+ w2.x2+ w3.x3+ w4.x4+b)
29.	Tolab Berantai 04.jpg	f5(x)=sign(w1.x1+ w2.x2+ w3.x3+ w4.x4+b)
30.	Tolab Berantai 05.jpg	f5(x)=sign(w1.x1+ w2.x2+ w3.x3+ w4.x4+b)

Tabel 4. 14 Hasil Pengujian Data

No.	Fungsi Keputusan SVM MultiClass One Against All	Nilai yi	Jenis Songket Batu Bara	Hasil Klasifikasi	Keterangan
1.	f1(x)=sign(w1.x1+ w2.x2+ w3.x3+ w4.x4+b)	1	Bunga Tanjung	'Motif Bunga Tanjung'	Benar
2.	f1(x)=sign(w1.x1+ w2.x2+ w3.x3+ w4.x4+b)	1	Bunga Tanjung	'Motif Bunga Tanjung'	Benar
3.	f1(x)=sign(w1.x1+ w2.x2+ w3.x3+ w4.x4+b)	1	Bunga Tanjung	'Motif Bunga Tanjung'	Benar
4.	f1(x)=sign(w1.x1+ w2.x2+ w3.x3+	1	Bunga	'Motif Bunga	Benar

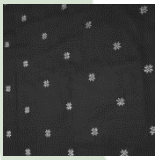
	w4.x4+b)		Tanjung	Tanjung'	
5.	f1(x)=sign(w1.x1+ w2.x2+ w3.x3+ w4.x4+b)	1	Bunga Tanjung	'Motif Bunga Tanjung'	Benar
6.	f2(x)=sign(w1.x1+ w2.x2+ w3.x3+ w4.x4+b)	-1	Pucuk Betikam	'Motif Pucuk Pandan'	Salah
7.	f2(x)=sign(w1.x1+ w2.x2+ w3.x3+ w4.x4+b)	1	Pucuk Betikam	'Motif Pucuk Betikam'	Benar
8.	f2(x)=sign(w1.x1+ w2.x2+ w3.x3+ w4.x4+b)	1	Pucuk Betikam	'Motif Pucuk Betikam'	Benar
9.	f2(x)=sign(w1.x1+ w2.x2+ w3.x3+ w4.x4+b)	-1	Pucuk Betikam	'Motif Pucuk Pandan'	Salah
10.	f2(x)=sign(w1.x1+ w2.x2+ w3.x3+ w4.x4+b)	-1	Pucuk Betikam	'Motif Pucuk Pandan'	Salah
11.	f3(x)=sign(w1.x1+ w2.x2+ w3.x3+ w4.x4+b)	-1	Pucuk Cempaka	'Motif Pucuk Pandan'	Salah
12.	f3(x)=sign(w1.x1+ w2.x2+ w3.x3+ w4.x4+b)	-1	Pucuk Cempaka	'Motif Pucuk Pandan'	Salah
13.	f3(x)=sign(w1.x1+ w2.x2+ w3.x3+ w4.x4+b)	-1	Pucuk Cempaka	'Motif Pucuk Pandan'	Salah
14.	f3(x)=sign(w1.x1+ w2.x2+ w3.x3+ w4.x4+b)	-1	Pucuk Cempaka	'Motif Pucuk Betikam'	Salah
15.	f3(x)=sign(w1.x1+ w2.x2+ w3.x3+ w4.x4+b)	-1	Pucuk Cempaka	'Motif Pucuk Pandan'	Salah
16.	f4(x)=sign(w1.x1+	1	Pucuk	'Motif Pucuk Pandan'	Benar

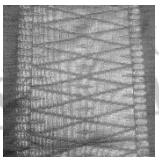
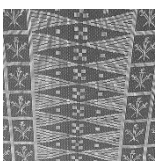
	w2.x2+ w3.x3+ w4.x4+b)		Pandan		
17.	f4(x)=sign(w1.x1+ w2.x2+ w3.x3+ w4.x4+b)	-1	Pucuk Pandan	'Motif Tolab Berantai'	Salah
18.	f4(x)=sign(w1.x1+ w2.x2+ w3.x3+ w4.x4+b)	1	Pucuk Pandan	'Motif Pucuk Pandan'	Benar
19.	f4(x)=sign(w1.x1+ w2.x2+ w3.x3+ w4.x4+b)	1	Pucuk Pandan	'Motif Pucuk Pandan'	Benar
20.	f4(x)=sign(w1.x1+ w2.x2+ w3.x3+ w4.x4+b)	1	Pucuk Pandan	'Motif Pucuk Pandan'	Benar
21.	f5(x)=sign(w1.x1+ w2.x2+ w3.x3+ w4.x4+b)	1	Tampuk Manggis	'Motif Tampuk Manggis'	Benar
22.	f5(x)=sign(w1.x1+ w2.x2+ w3.x3+ w4.x4+b)	-1	Tampuk Manggis	'Motif Pucuk Pandan'	Salah
23.	f5(x)=sign(w1.x1+ w2.x2+ w3.x3+ w4.x4+b)	-1	Tampuk Manggis	'Motif Pucuk Pandan'	Salah
24.	f5(x)=sign(w1.x1+ w2.x2+ w3.x3+ w4.x4+b)	-1	Tampuk Manggis	'Motif Pucuk Pandan'	Salah
25.	f5(x)=sign(w1.x1+ w2.x2+ w3.x3+ w4.x4+b)	-1	Tampuk Manggis	'Motif Pucuk Cempaka'	Salah
26.	f6(x)=sign(w1.x1+ w2.x2+ w3.x3+ w4.x4+b)	1	Tolab Berantai	'Motif Tolab Berantai'	Benar
27.	f6(x)=sign(w1.x1+ w2.x2+ w3.x3+ w4.x4+b)	1	Tolab Berantai	'Motif Tolab Berantai'	Benar
28.	f6(x)=sign(w1.x1+ w2.x2+ w3.x3+ w4.x4+b)	1	Tolab Berantai	'Motif Tolab Berantai'	Benar
29.	f6(x)=sign(w1.x1+ w2.x2+ w3.x3+ w4.x4+b)	1	Tolab Berantai	'Motif Tolab Berantai'	Benar

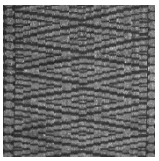
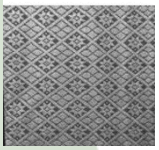
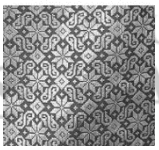
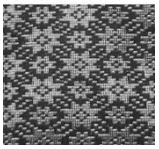
30.	f6(x)=sign(w1.x1+ w2.x2+ w3.x3+ w4.x4+b)	1	Tolab Berantai	'Motif Tolab Berantai'	Benar

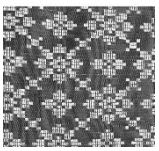
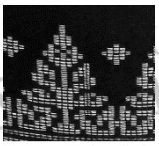
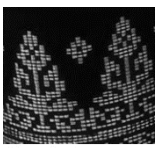
Pada tabel 4.14 terdapat 30 data uji dengan 5 data dari setiap jenis motif songket. Pada setiap data uji terdapat fungsi keputusan SVM *one against all* sesuai dengan kelasnya masing-masing. Dengan menyertakan nilai yi, akan dilihat hasil klasifikasi dan jenis motif songket. Dapat dilihat jika nilai yi bernilai 1 maka hasil klasifikasi dinyatakan benar dan sesuai dengan jenis motif songket yang diujikan, sebaliknya jika nilai yi bernilai -1 maka hasil klasifikasi dinyatakan salah dan tidak mengeluarkan *output* yang sesuai dengan jenis motif songket di tabel.

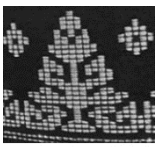
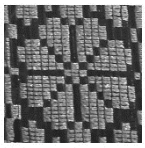
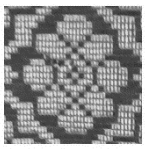
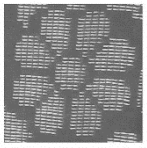
Tabel 4. 15 Hasil Pengujian Data

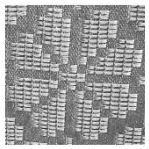
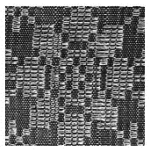
No.	**File Citra**	**Hasil Klasifikasi**	**Rata-Rata Hasil Ekstraksi**
1.	 Bunga Tanjung 01.jpg	‘Motif Bunga Tanjung’	Contrast = 0.055182 Correlation = 0.89292 Energy = 0.80746 Homogenety = 0.97932
2.	 Bunga Tanjung 02.jpg	‘Motif Bunga Tanjung’	Contrast = 0.054825 Correlation = 0.90229 Energy = 0.89758 Homogenety = 0.98303
3.		'Motif Bunga Tanjung'	Contrast = 0.044537 Correlation = 0.9417 Energy = 0.79726

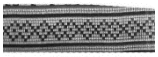
	Bunga Tanjung 03.jpg		Homogenety = 0.98128
4.	 Bunga Tanjung 04.jpg	'Motif Bunga Tanjung'	Contrast = 0.081439 Correlation = 0.81279 Energy = 0.91401 Homogenety = 0.98792
5.	 Bunga Tanjung 05.jpg	'Motif Bunga Tanjung'	Contrast = 0.029251 Correlation = 0.91165 Energy = 0.76756 Homogenety = 0.98585
6.	 Pucuk Betikam 01 .jpg	'Motif Pucuk Pandan'	Contrast = 0.59997 Correlation = 0.82928 Energy = 0.091888 Homogenety = 0.77182
7.	 Pucuk Betikam 02.jpg	'Motif Pucuk Betikam'	Contrast = 0.45013 Correlation = 0.75828 Energy = 0.14618 Homogenety = 0.81243
8.		'Motif Pucuk Betikam'	Contrast = 1.4175 Correlation = 0.67485 Energy = 0.097793 Homogenety = 0.70073

	Pucuk Betikam 03.jpg		
9.	 Pucuk Betikam 04.jpg	'Motif Pucuk Pandan'	Contrast = 0.4908 Correlation = 0.91867 Energy = 0.10273 Homogenety = 0.80891
10.	 Pucuk Betikam 05.jpg	'Motif Pucuk Pandan'	Contrast = 0.40894 Correlation = 0.85346 Energy = 0.11702 Homogenety = 0.82458
11.	 Pucuk Cempaka 01.jpg	'Motif Pucuk Pandan'	Contrast = 0.27883 Correlation = 0.92845 Energy = 0.12754 Homogenety = 0.86776
12.	 Pucuk Cempaka 02.jpg	'Motif Pucuk Pandan'	Contrast = 0.53642 Correlation = 0.92068 Energy = 0.070588 Homogenety = 0.79759
13.		'Motif Pucuk Pandan'	Contrast = 0.47518 Correlation = 0.93722 Energy = 0.087429 Homogenety = 0.81312

	Pucuk Cempaka 03.jpg		
14.	 Pucuk Cempaka 04.jpg	'Motif Pucuk Betikam'	Contrast = 2.06 Correlation = 0.78755 Energy = 0.060153 Homogenety = 0.64077
15.	 Pucuk Cempaka 05.jpg	'Motif Pucuk Pandan'	Contrast = 0.26947 Correlation = 0.9625 Energy = 0.13427 Homogenety = 0.89281
16.	 Pucuk Pandan 01.jpg	'Motif Pucuk Pandan'	Contrast = 0.20786 Correlation = 0.98435 Energy = 0.20333 Homogenety = 0.91465
17.	 Pucuk Pandan 02.jpg	'Motif Tolab Berantai'	Contrast = 0.7327 Correlation = 0.9424 Energy = 0.32664 Homogenety = 0.85992
18.		'Motif Pucuk Pandan'	Contrast = 0.2666 Correlation = 0.97432 Energy = 0.30293 Homogenety = 0.90128

	Pucuk Pandan 03.jpg		
19.	 Pucuk Pandan 04.jpg	'Motif Pucuk Pandan'	Contrast = 0.27675 Correlation = 0.97278 Energy = 0.19923 Homogenety = 0.89126
20.	 Pucuk Pandan 05.jpg	'Motif Pucuk Pandan'	Contrast = 0.21481 Correlation = 0.98068 Energy = 0.25459 Homogenety = 0.91031
21.	 Tampuk Manggis 01.jpg	'Motif Tampuk Manggis'	Contrast = 0.52105 Correlation = 0.94653 Energy = 0.14224 Homogenety = 0.85553
22.	 Tampuk Manggis 02.jpg	'Motif Pucuk Pandan'	Contrast = 0.29603 Correlation = 0.95872 Energy = 0.13533 Homogenety = 0.88979
23.		'Motif Pucuk Pandan'	Contrast = 0.56491 Correlation = 0.9307 Energy = 0.28442 Homogenety = 0.87347

	Tampuk Manggis 03.jpg		
24.	 Tampuk Manggis 04.jpg	'Motif Pucuk Pandan'	Contrast = 0.81957 Correlation = 0.88644 Energy = 0.085617 Homogenety = 0.7813
25.	 Tampuk Manggis 05.jpg	'Motif Pucuk Cempaka'	Contrast = 1.7677 Correlation = 0.86206 Energy = 0.064323 Homogenety = 0.69035
26.	 Tolab Berantai 01.jpg	'Motif Tolab Berantai'	Contrast = 0.33832 Correlation = 0.96599 Energy = 0.46026 Homogenety = 0.90777
27.	 Tolab Berantai 02.jpg	'Motif Tolab Berantai'	Contrast = 0.82393 Correlation = 0.88715 Energy = 0.46915 Homogenety = 0.86199
28.	 Tolab Berantai 03.jpg	'Motif Tolab Berantai'	Contrast = 0.62157 Correlation = 0.88225 Energy = 0.46947 Homogenety = 0.87839

29.	 Tolab Berantai 04.jpg	'Motif Tolab Berantai'	Contrast = 0.24126 Correlation = 0.96976 Energy = 0.47912 Homogenety = 0.92227
30.	 Tolab Berantai 05.jpg	'Motif Tolab Berantai'	Contrast = 0.37501 Correlation = 0.97167 Energy = 0.46261 Homogenety = 0.90785

Pada tabel 4.15 terdapat 30 data uji dengan 5 data dari setiap jenis motif songket. Terdapat file citra songket dengan nama file sesuai nama motif songketnya. Hasil klasifikasi terdapat pada sistem sesuai dengan kelas motiif songket yang diujikan. Rata- rata hasil klasifikasi didapatkan pada sistem sesuai kelas motif songket yang diujikan.

Dari hasil pengujian seluruh data uji yang sebanyak 30 data uji, terdapat 13 jenis motif songket yang salah dalam penempatan jenis motif songket sesuai kelasnya, maka dari hasil klasifikasi jenis motif songket didapatka hasil akurasi dengan nilai 57% dengan keterangan 17 data uji yang benar penempatan kelasnya dan 13 data uji yang salah dalam penempatan kelasnya. Adapun selanjutnya menghitung tingkat akurasi berdasarkan citra motif songket uji yang digunakan. Adapun rumusnya sebagai berikut:

$$Akurasi = \frac{Jumlah\ Klasifikasi\ Benar}{Jumlah\ data} \times 100\ \%$$

$$Akurasi = \frac{17}{30} \times 100\ \%$$

$$Akurasi = 57\ \%$$

Berdasarkan dari hasil uji akurasi, didapatkan nilai akurasi sebesar 57 % untuk proses klasifikasi jenis motif songket berdasarkan citra motif songket data uji sebanyak 30 data.