LBP and GLCM

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Overview

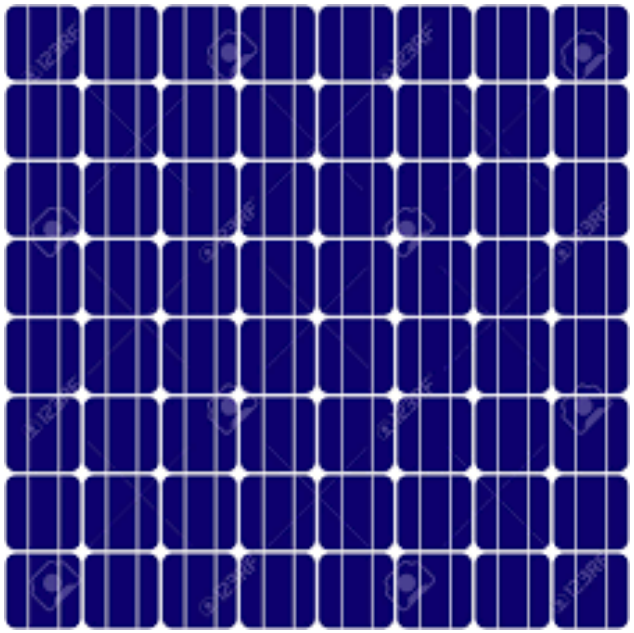
1. Texture Descriptors
   - Local Binary Pattern
   - Gray Level Co-occurrence Matrix(GLCM)

Texture Descriptors

- Texture: **Near** periodical arrangement of pixel values or patches in image
- Textures are important discriminating features

Texture Descriptors (cont.)

- Textures of leaves are different from that of leaves with some disease
- Textures of solar panel with defects are different from without defect

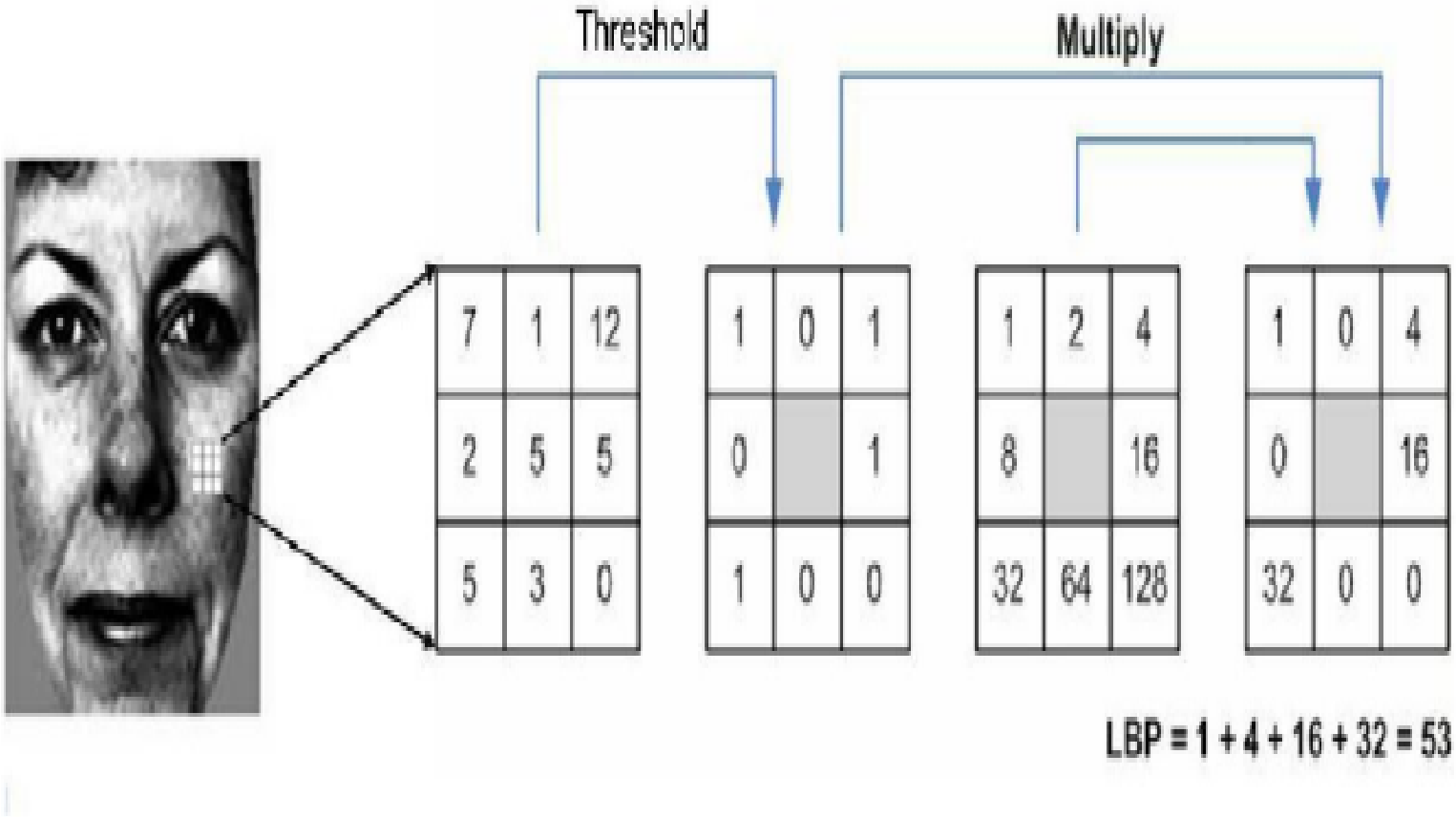


Local Binary Pattern

Local Binary Pattern for a pixel (x, y) in an image f

- Consider 3×3 window centered at (x, y) in f, say w
- Define:
  $w'(x, y) = 1$ if $w(x, y) >$ pixel value at the center of w
  $w'(x, y) = 0$ otherwise
- Arrange the bits from TopLeft, moving clockwise
- Convert the binary sequence to decimal, which is called as LBP for the pixel (x, y)

Local Binary Pattern (cont.)



Local Binary Pattern (cont.)

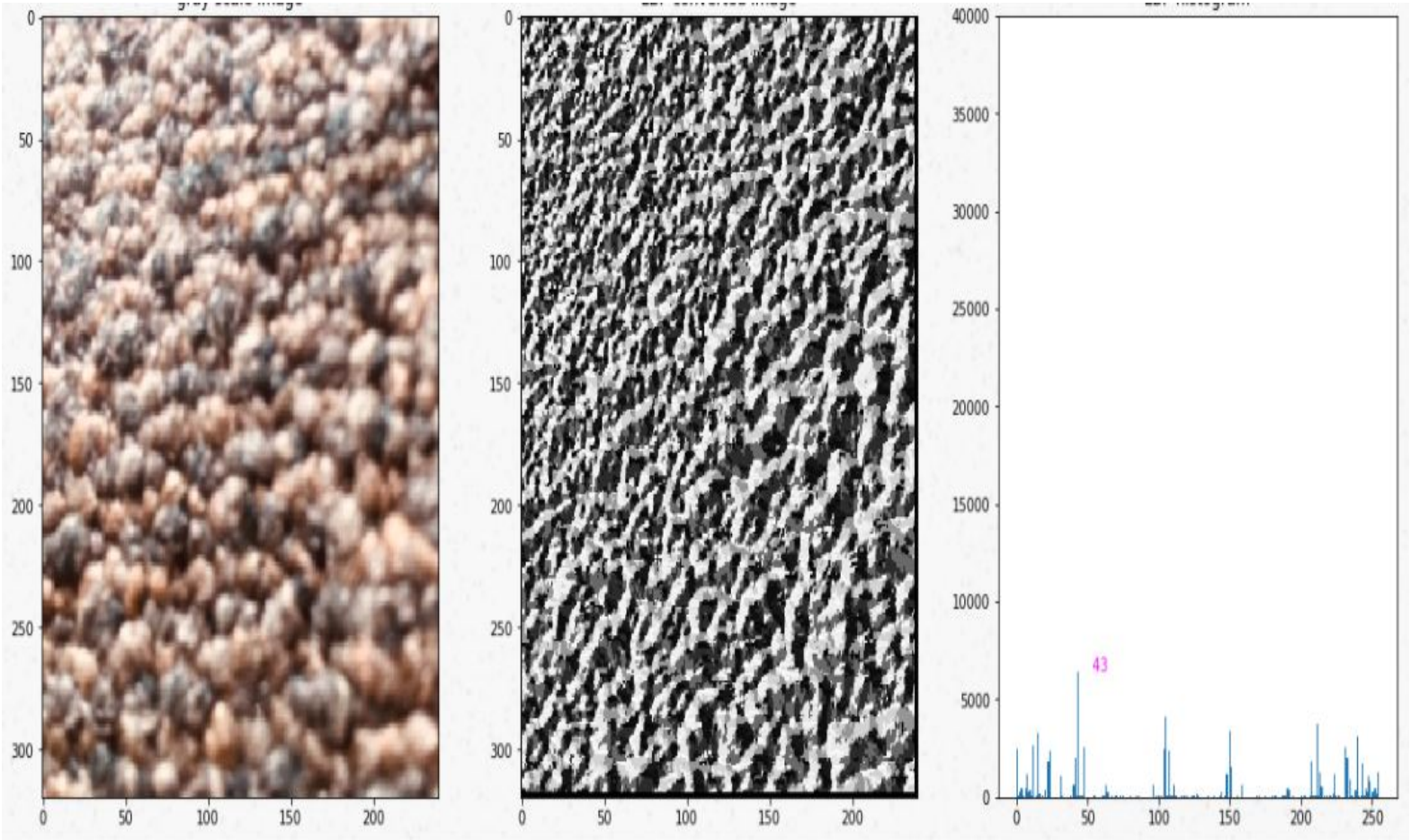
How to find LBP for an image or a segment of an image
Method 1:

- Find LBP for each pixel (x, y)
- Find the histogram of all those LBP values

Issues with the method 1:

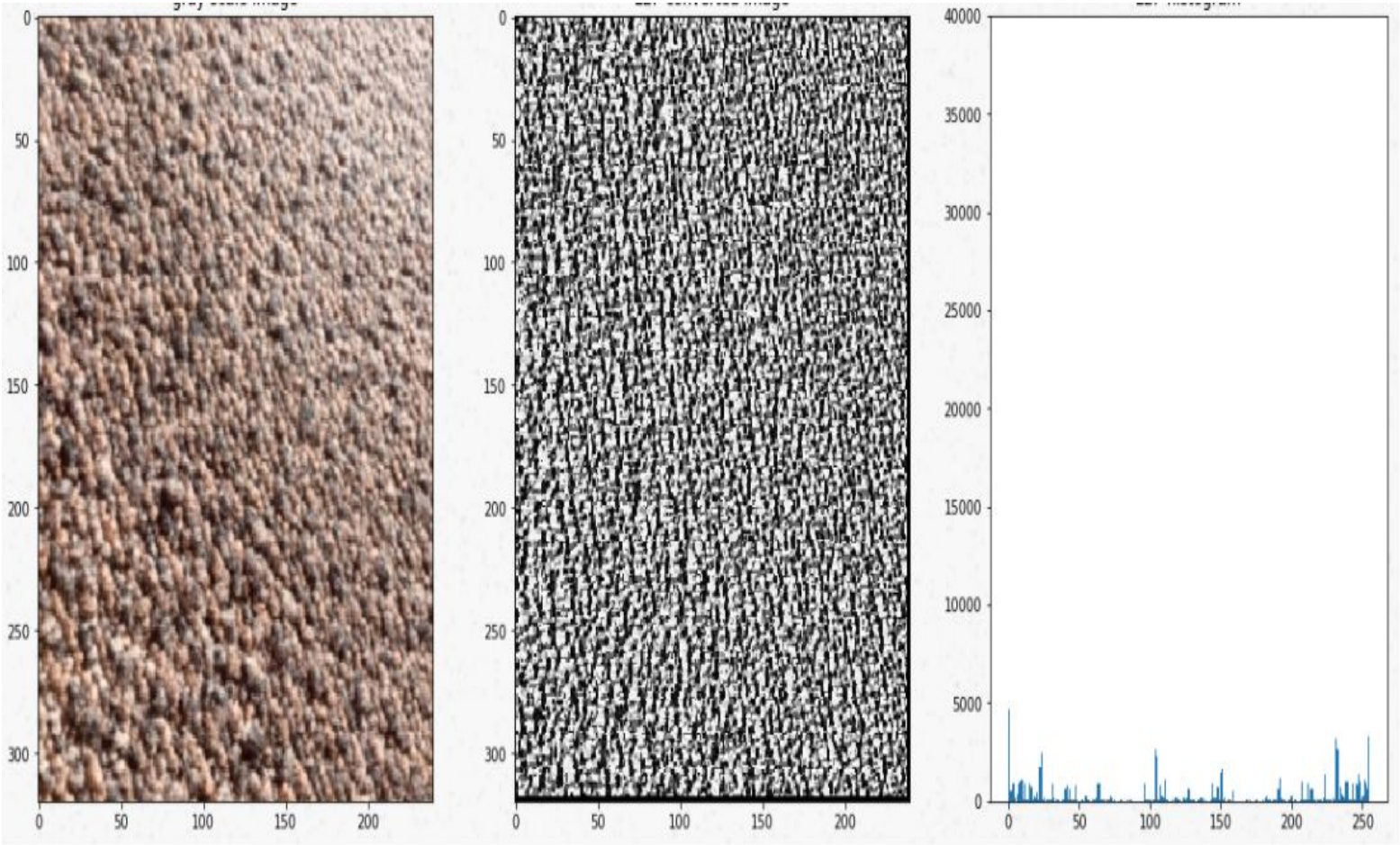
- The local pattern is not captured effectively
  - As LBP of pixels in different locations are aggregated

Local Binary Pattern (cont.)



Image; LBP; Histogram

Local Binary Pattern (cont.)



Image; LBP; Histogram

Local Binary Pattern (cont.)

Method 2:
i/p: Image/Segment of image o/p: feature vector fv that describes image/segment

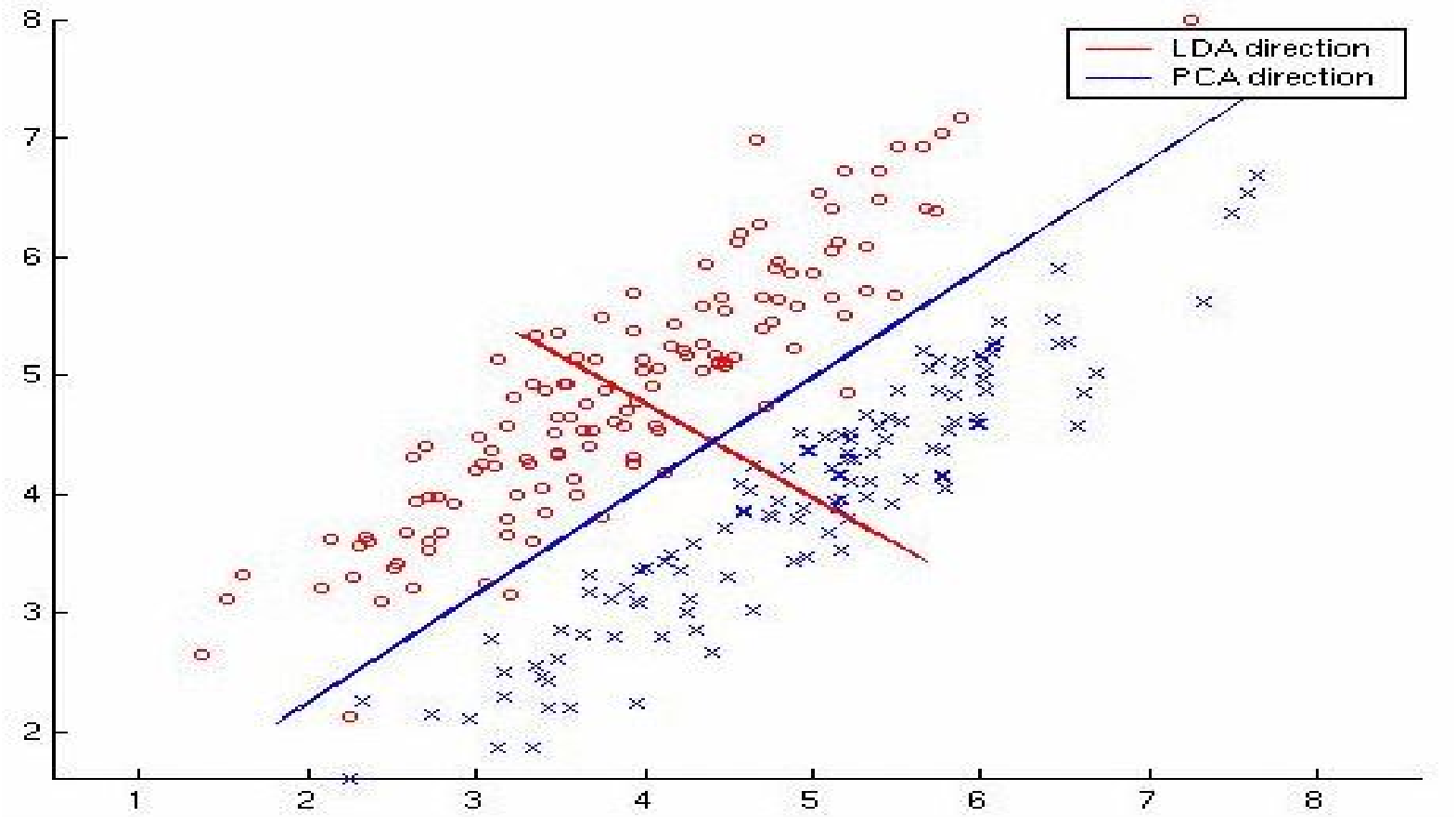
- Divide the image into blocks of size 16×16
- For each block B_i $1 \leq i \leq k$
  - Find LBP for each pixel $(x, y) \in B_i$
  - Find the histogram of all those LBP values, say h_i
  - Normalize h_i, say the resultant is H_i
- Concatenate all H_is , and output $fv = (H_1, H_2, ...H_k)$

Local Binary Pattern (cont.)

- Size of the feature vector $256K$, where k is number of blocks
- Is there a way to reduce the size of the feature vector, and also to increase the discrimination capability
  - PCA : Transform n dimensional feature vectors to k dimension such that variance of the transformed vectors is maximum
  - LDA: Transforms n dimensional feature vector to k dimensional vector such that
    1) inter class variance is high
    2) intra class variance is low
  - ICA: Transforms n dimensional feature vectors to k dimensional vectors such that
    components(features) of the reduced feature vector are statistically independent

Local Binary Pattern (cont.)

PCA vs LDA



Local Binary Pattern (cont.)

Some Applications of LBP features

- To Classify the objects, when different objects have different texture
- SIFT descriptor for each key point may be computed as LBP of the patch centered at the point

Gray Level Co-occurrence Matrix(GLCM)

What is GLCM:

- i/p: Gray scale image;
- o/p: Gray scale image representing frequency or probability of co-occurrence of pixel values i and j as neighbours in a fixed direction d

When the direction is diagonal

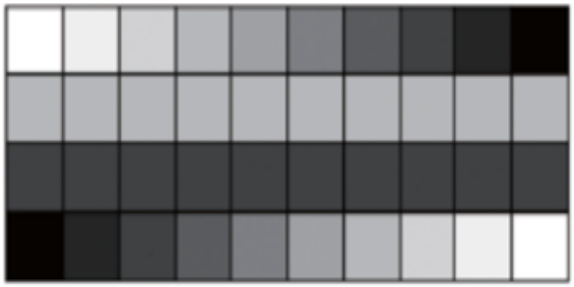
2	1	2	0	1
0	2	1	1	2
0	1	2	2	0
1	2	2	0	1
2	0	1	0	1

$$P_d = \begin{array}{c|ccc} & 0 & 1 & 2 \\ \hline 0 & 0 & 2 & 2 \\ 1 & 2 & 1 & 2 \\ 2 & 2 & 3 & 2 \end{array} \quad i \quad j$$

Gray Level Co-occurrence Matrix(GLCM) (cont.)

When the direction is horizontal

(a) Input Image



(b) Gray Levels of Input Image

10	9	8	7	6	5	4	3	2	1
8	8	8	8	8	8	8	8	8	8
4	4	4	4	4	4	4	4	4	4
1	2	3	4	5	6	7	8	9	10

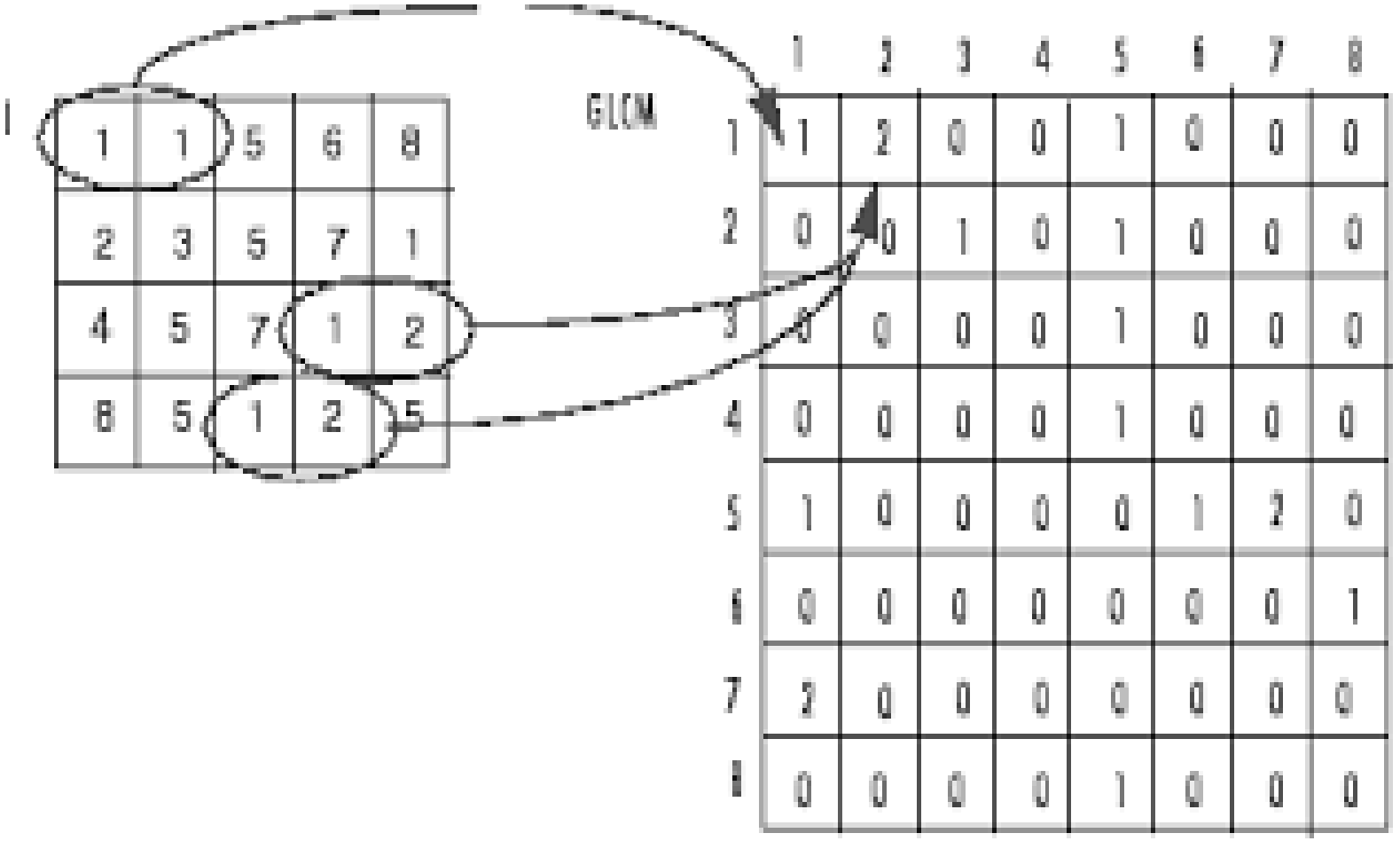
Reference Pixel Neighbor Pixel

(c) Gray Level Co-Occurrence Matrix (GLCM)

	1	2	3	4	5	6	7	8	9	10
1	0	1	0	0	0	0	0	0	0	0
2	1	0	1	0	0	0	0	0	0	0
3	0	1	0	1	0	0	0	0	0	0
4	0	0	1	4	1	0	0	0	0	0
5	0	0	0	1	0	1	0	0	0	0
6	0	0	0	0	1	0	1	0	0	0
7	0	0	0	0	0	1	0	1	0	0
8	0	0	0	0	0	0	1	9	1	0
9	0	0	0	0	0	0	0	1	0	1
10	0	0	0	0	0	0	0	0	1	0

$P_{i,j} = P_{8,9} = 1$

Gray Level Co-occurrence Matrix(GLCM) (cont.)

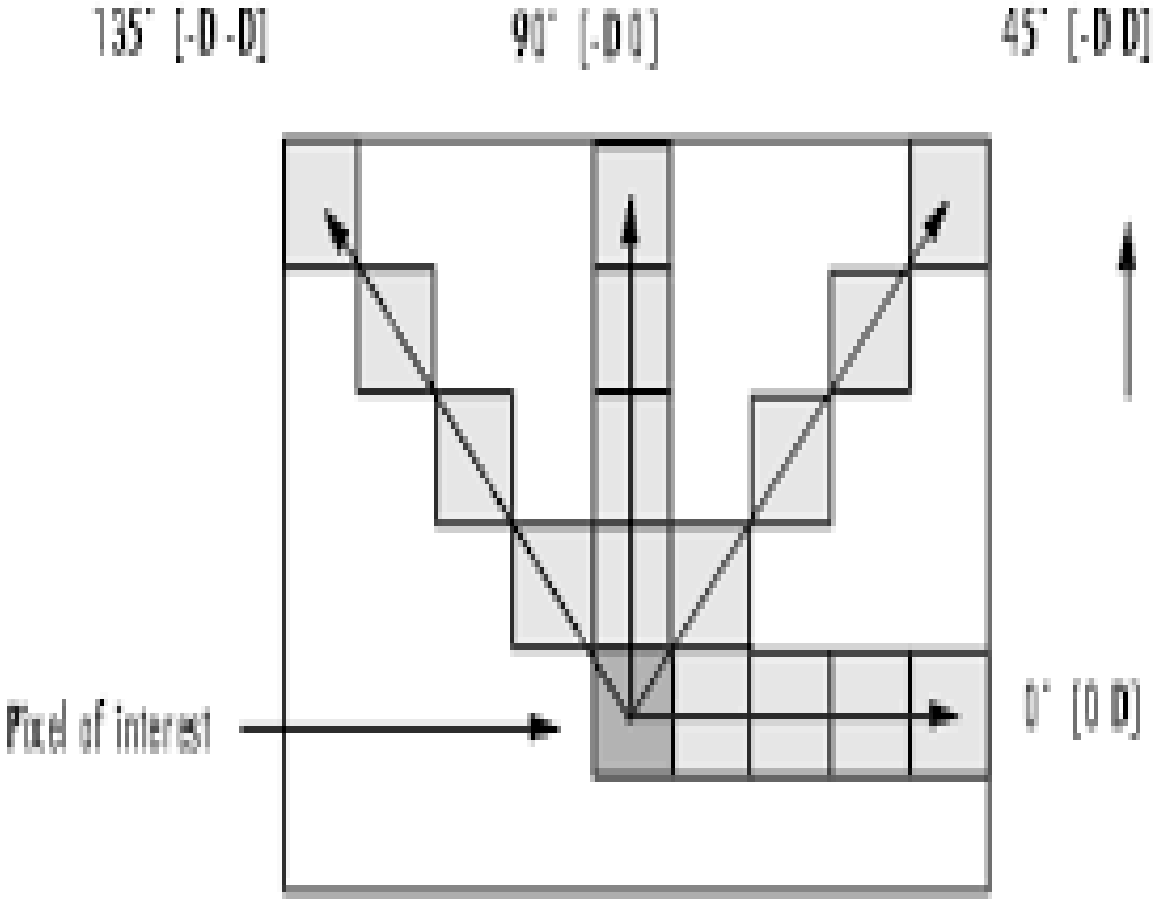


Gray Level Co-occurrence Matrix(GLCM) (cont.)

How many directions are to be considered

- Any number of directions can be considered
- For each direction, one GLCM matrix will be obtained
- Set of directions need to be chosen such that Statistical metrics on GLCM in such directions are
  - Very different for different objects
  - Similar for similar objects

Gray Level Co-occurrence Matrix(GLCM) (cont.)



Gray Level Co-occurrence Matrix(GLCM) (cont.)

Some Statistical measures based on GLCM

Let $P = (p_{i,j})$ be the GLCM, where $p_{i,j}$ is the probability of co-occurence of i and j in a particular direction

- Energy: $\sum p_{i,j}^2$
  - Measures the energy of co-occurrence
  - Energy is more for some distributions, and less for some distributions
- Entropy: $-\sum p_{i,j} ln(p_{i,j})$
  - Measures the uncertainty of co-occurrence of i and j
- Contrast: $\sum p_{i,j}(i-j)^2$
  - Measures the contrast between i and j
- Homogeneity: $\sum \frac{p_{i,j}}{1+|i-j|}$

Gray Level Co-occurrence Matrix(GLCM) (cont.)

- Measures the closeness of the elements in the GLCM to GLCM diagonal

- Correlation: $\sum \frac{(i-\mu i)(j-\mu j)}{\sigma i \sigma j} p_{i,j}$
  - Measures the correlation between i and j, when the co-occur
- Mean of i, when i and j co-occur: $\sum_{i,j} i p_{i,j}$
- Variance of i, when i and j co-occur: $\sum_{i,j} (i - \mu i)^2 p_{i,j}$
- Kth moment of element difference: $\sum (i - j)^k p_{i,j}$

Gray Level Co-occurrence Matrix(GLCM) (cont.)

How to find contrast

0	1	4	9
1	0	1	4
4	1	0	1
9	4	1	0

Contrast weight

*

0.167	0.083	0.042	0
0.083	0.167	0	0
0.042	0	0.25	0.042
0	0	0.042	0.083

Horizontal GLCM

=

0	0.083	0.168	0
0.083	0	0	0
0.168	0	0	0.042
0	0	0.042	0

= .083 + .168 + .083 + .168 + .042 + .042

= .586

Gray Level Co-occurrence Matrix(GLCM) (cont.)

How to find homogeneity

1	0.5	0.333	0.25
0.5	1	0.5	0.333
0.333	0.5	1	0.5
0.25	0.333	0.5	1

similarity weight

*

0.167	0.083	0.042	0
0.083	0.167	0	0
0.042	0	0.25	0.042
0	0	0.042	0.083

Horizontal GLCM

=

0.167	0.042	0.014	0
0.042	0.167	0	0
0.014	0	0.25	0.021
0	0	0.021	0.083

$\Rightarrow$ *0.167+0.042+0.014+0.042+0.167+ 0.014+0.25+0.021+0.021+0.083 = 0.804*

Gray Level Co-occurrence Matrix(GLCM) (cont.)

Graphical view of GLCM of various textures