Features

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Co-occurrence matrix

- Spatial relationship of pixels.

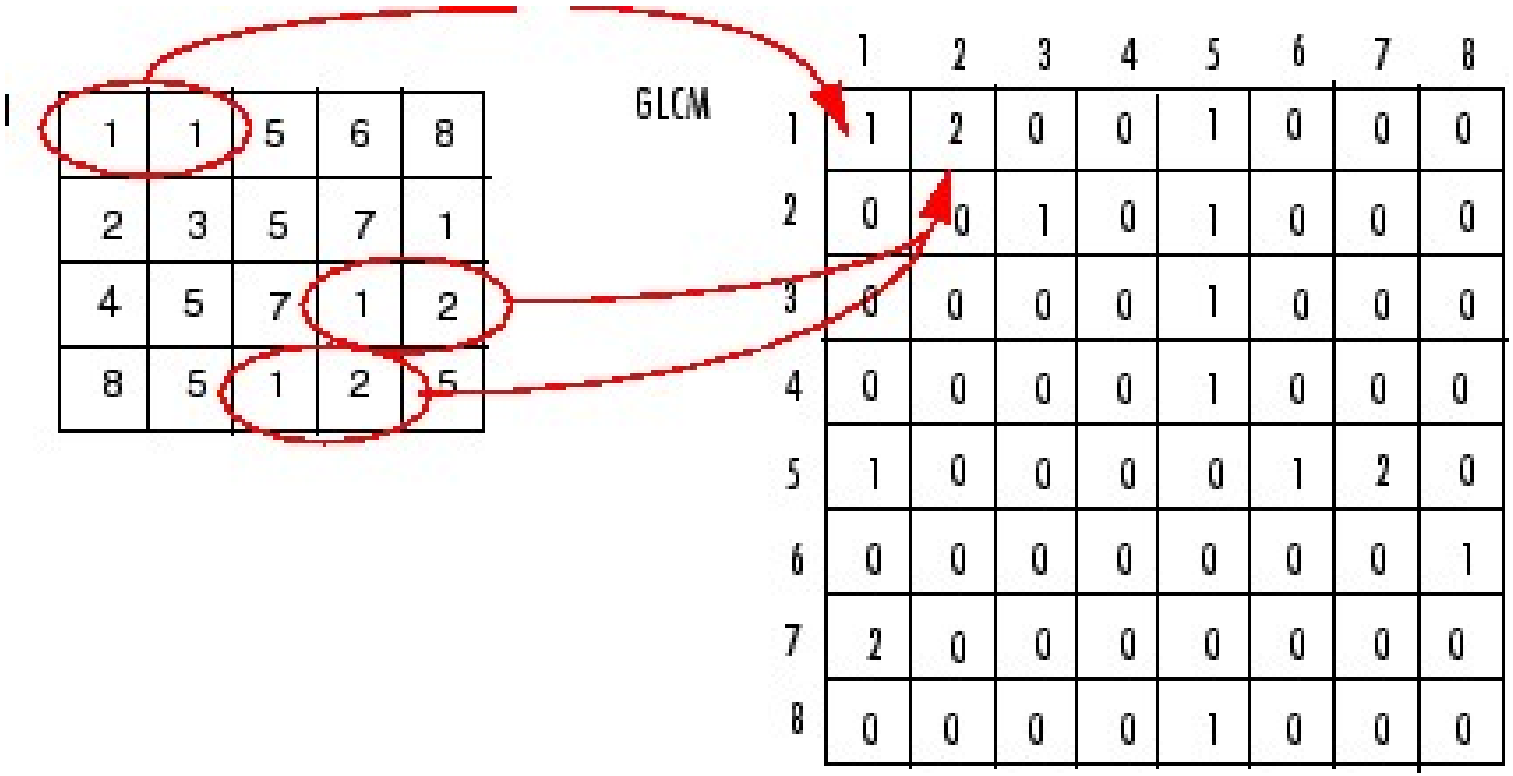
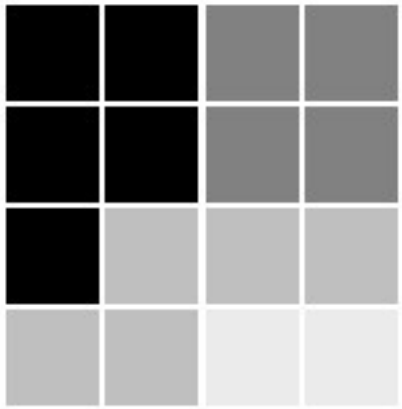


Fig1: Co-occurrence Matrix

Co-occurrence matrix



The image as it appears:

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

The GL associated with each pixel:

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

GLCM

Calculating P_{ij} Matrix

Suppose GLCM:

4	2	1	0
2	4	0	0
1	0	6	1
0	0	1	2

Matrix of P_{ij}

0.166	0.083	0.042	0
0.083	0.166	0	0
0.042	0	.249	0.042
0	0	0.042	0.083

4+2+1+2+4+1+6+1+1+2=24

4/24=.166

2/24=.083

1/24=.042

6/24=.249

Contrast

- Contrast is the difference in luminance or color that makes an object distinguishable.
- Measure of intensity contrast between a pixel and its neighbor over the entire image.

$$\sum_{i,j=0}^{N-1} P_{i,j}\left(i-j\right)^2$$

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

Contrast weights: $(i-j)^2$

$(0-0)^2=0$ $(0-1)^2=1$ $(0-2)^2=4$ $(0-3)^2=9$
$(1-0)^2=1$ $(1-1)^2=0$ $(1-2)^2=1$ $(1-3)^2=4$
$(2-0)^2=4$ $(2-1)^2=1$ $(2-2)^2=0$ $(2-3)^2=1$
$(3-0)^2=9$ $(3-1)^2=4$ $(3-2)^2=1$ $(3-3)^2=0$

Contrast

$$\sum_{i,j=0}^{N-1} P_{i,j}(i-j)^2$$

$(i-j)^2$ X P_{ij} = Multiplication Result

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

0.166	0.083	0.042	0
0.083	0.166	0	0
0.042	0	.249	0.042
0	0	0.042	0.083

0	0.083	.168	0
0.083	0	0	0
.168	0	0	.042
0	0	.042	0

Sum of Multiplication results matrix = 0.586

Contrast

In detail:

$.166*(0-0)^2 + .083*(0-1)^2 + .042*(0-2)^2 + 0*(0-3)^2 + .083*(1-0)^2 + .166*(1-1)^2 + 0*(1-2)^2 + 0*(1-3)^2 + .042*(2-0)^2 + 0*(2-1)^2 + .250*(2-2)^2 + .042*(2-3)^2 + 0*(3-0)^2 + 0*(3-1)^2 + .042*(3-2)^2 + .083*(3-3)^2$

$= .166(0) + .083(1) + .042(4) + .083(1) + .166(0) + .042(4) + .25(0) + .042(1) + .042(1) + .083(0)$

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

$= \mathbf{.586}$

Contrast

Homogeneity

- measures the uniformity of the entries in the GLCM

$$\sum_{i,j=0}^{N-1} \frac{P_{i,j}}{1+(i-j)^2}$$

P_{ii}

0.166	0.083	0.042	0
0.083	0.166	0	0
0.042	0	0.25	0.042
0	0	0.042	0.083

$1/((1+(i-j)^2))$

1.000	0.50	0.333	0.250
0.500	1.00	0.500	0.333
0.333	0.50	1.000	0.500
0.250	0.333	0.500	1.000

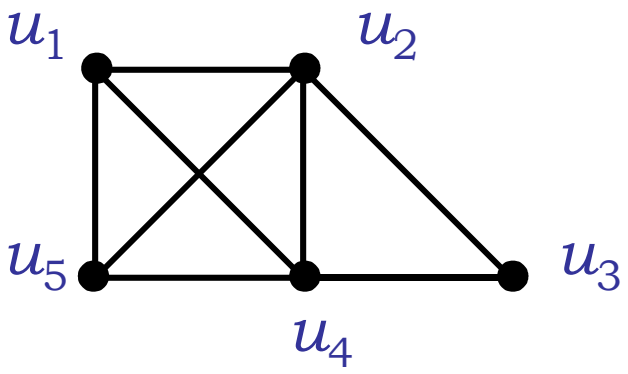
=

$P_{ii}/1+(i-j)^2$

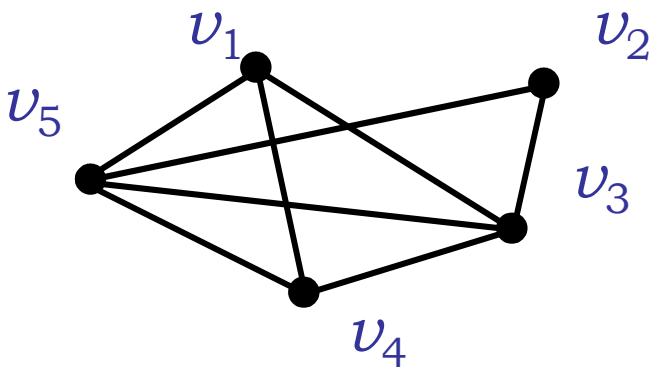
.166	.042	.014	0
.042	.166	0	0
.014	0	.25	.021
0	0	.021	.083

Contrast, $P_{ij}/1+(i-j)^2$ = 0.804

Homogeneity



G



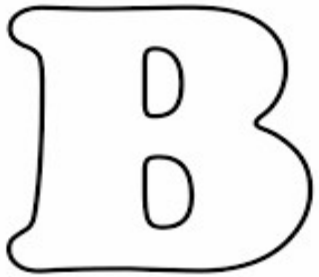
H

- They both have 5 vertices
- They both have 8 edges
- They have the same number of vertices with the same degrees: 2, 3, 3, 4, 4.

Correlation

- A mutual relationship between two or more things.
- measures the linear dependency of grey levels on those of neighboring pixels.

$$\sum_{i,j=0}^{N-1} P_{i,j}\left[\frac{(i-\mu_i)(j-\mu_j)}{\sqrt{(\sigma_i^2)(\sigma_j^2)}}\right]$$



Energy

- Energy shows how the gray levels are distributed.
- Angular Second Moment (ASM) and Energy use each Pij as a weight for itself.
- The square root of the ASM is sometimes used as a texture measure, and is called Energy.

$$\sum_{i,j=0}^{N-1} P_{i,j}^{\,2}$$

matrix of P_{ij}^2:

0.027	0.007	0.002	0
0.007	0.028	0	0
0.002	0	0.0625	0.002
0	0	0.002	0.007

summed = .145