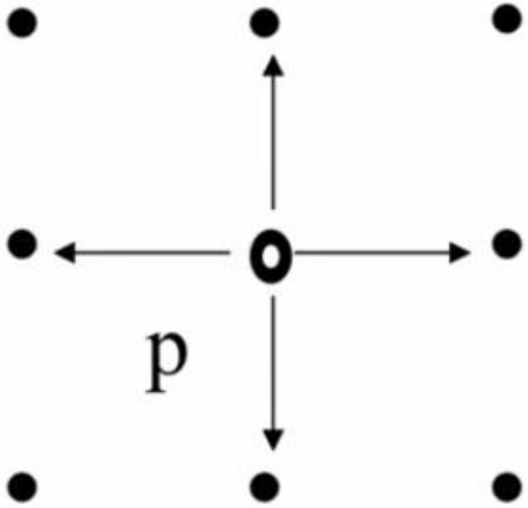
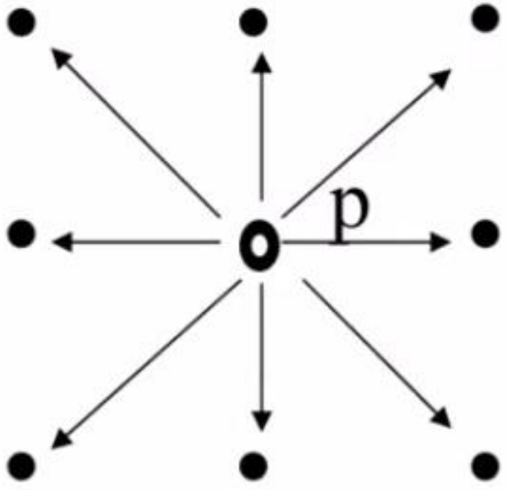
Neighbors of a Pixel

The points $N_D(P)$ and $N_4(P)$ are together known as 8-neighbors of the point P, denoted by $N_8(P)$.

• Some of the points in the $N_4(P)$, $N_D(P)$ and $N_8(P)$ may fall outside a finite resolution image when P lies on the border of image.



$N_4(p)$



$N_8(p)$

Adjacency

Let V be the set of gray-level values used to define connectivity;
then two pixels p, q that have values from the set V are:

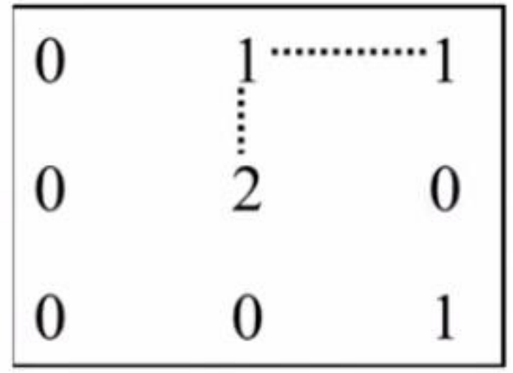
$V = \{1,2\}$

a. 4-connected,if q is in the set $N_4(P)$

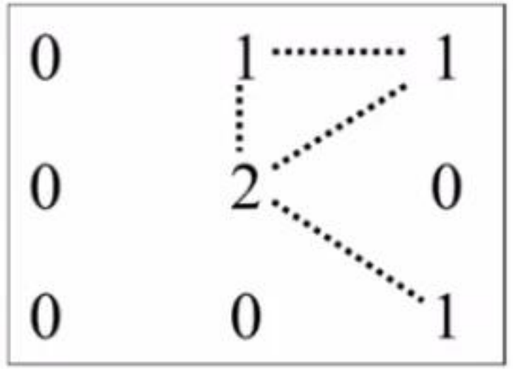
b. 8-connected,if q is in the set $N_8(P)$

c. m-connected, iff
– q is in $N_4(P)$.
– q is in $N_D(P)$ and the set $[N_4(P) \cap N_4(Q)]$ is empty
(has no pixels whose values are from V)

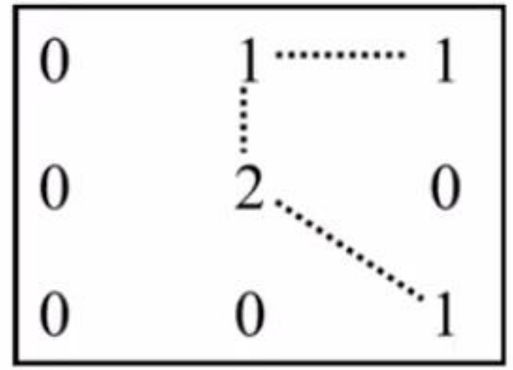
(a)



(b)

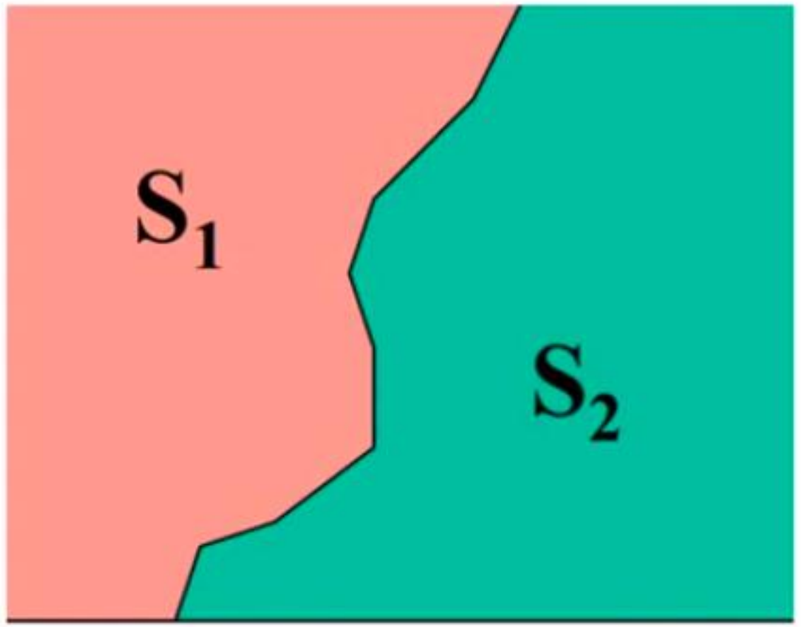


(c)



Adjacency

- Two image subsets S_1 and S_2 are adjacent if some pixel in S_1 is adjacent to some pixel in S_2



Paths

A path from pixel p with coordinates (x, y) to pixel q with coordinates (s, t) is a sequence of **distinct** pixels with coordinates:

$$(x_0, y_0), (x_1, y_1), (x_2, y_2) \dots (x_{n-1}, y_{n-1})$$

where

- $(x_0, y_0) = (x, y)$
- $(x_{n-1}, y_{n-1}) = (s, t)$
- (x_i, y_i) is **adjacent** to (x_{i-1}, y_{i-1}) $\quad 1 \leq i \leq n-1$

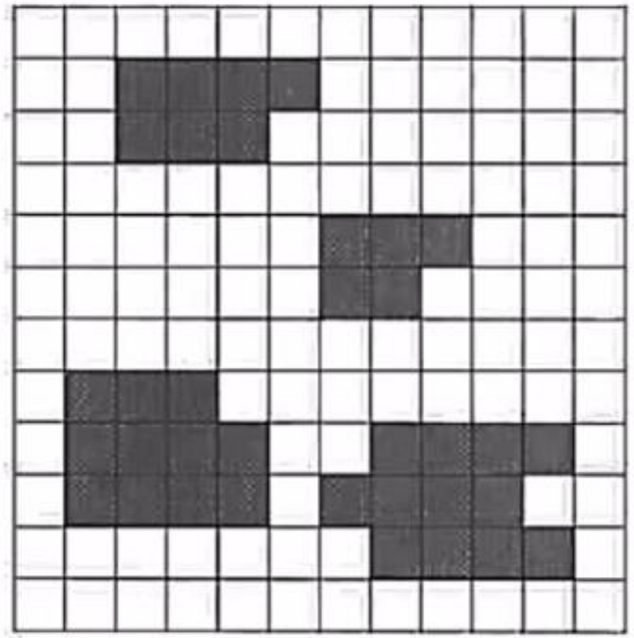
Here **n** is the length of the path.

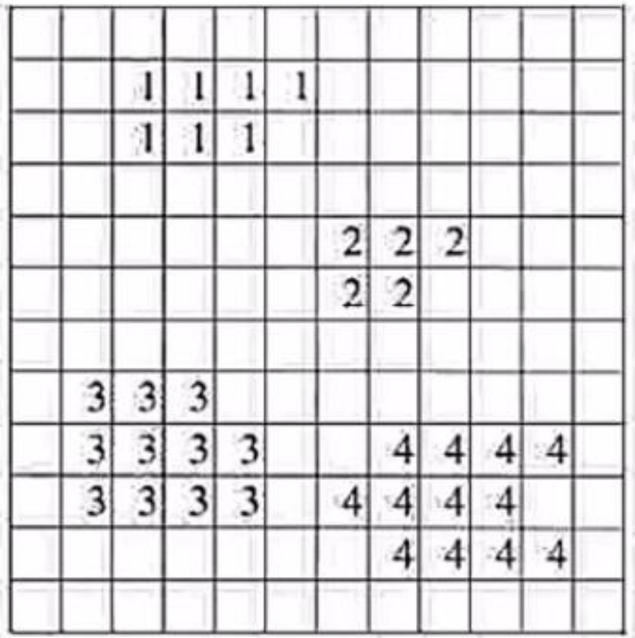
We can define 4-, 8-, and m-paths based on type of adjacency used.

Connected Components

If p and q are pixels of an image subset S then p is connected to q in S if there is a path from p to q consisting entirely of pixels in S.

- For every pixel p in S, the set of pixels in S that are connected to p is called a connected component of S.
- If S has only one connected component then S is called Connected Set.





Connected Components

- **Recursive algorithm**

- Let is assume that region pixels have the value 0 (black) and that background pixels have the value 255 (white).

(1) Scan the image to find an unlabeled 0 (pixel and assign it a new label L.

(2) Recursively assign a label L to all of its 0 neighbors.

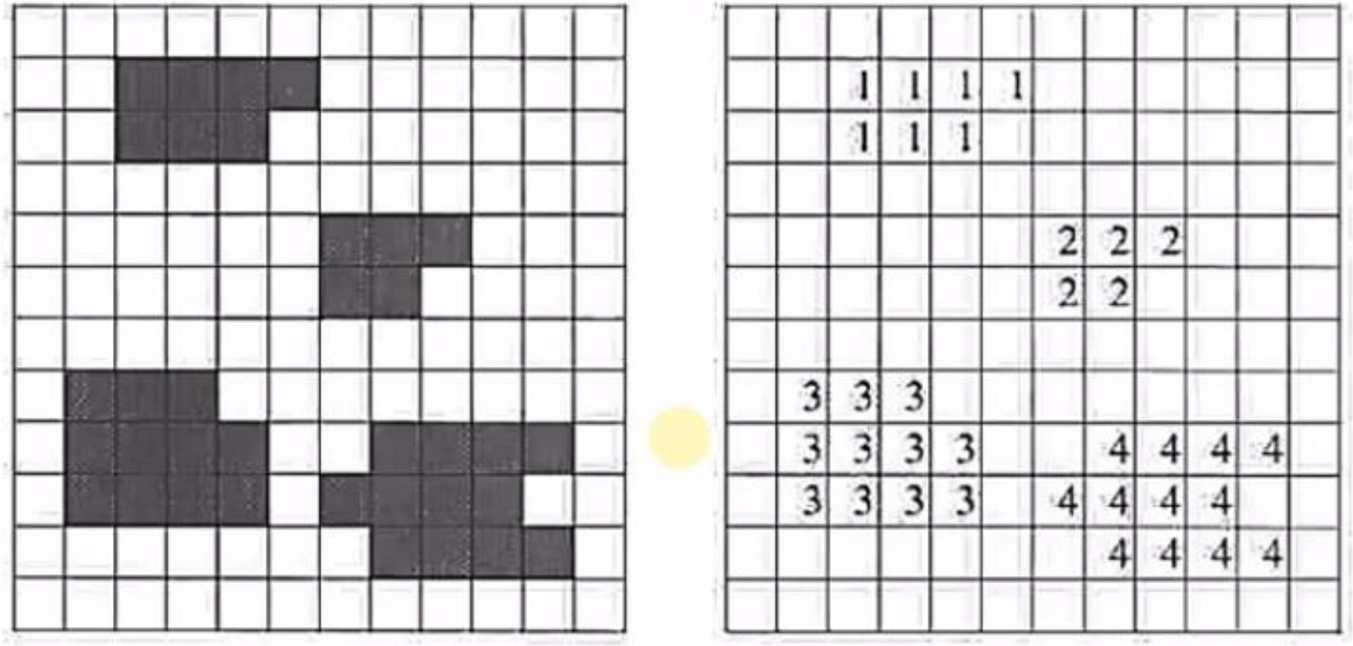
(3) Stop if there are no more unlabeled 0 pixels.

(4) Go to step 1.

Connected Components

- **Recursive algorithm**

Top to bottom, Left to right



• Sequential algorithm

- The sequential algorithm usually requires two passes over the image.

- It works with only two rows of an image at a time.

(1) Scan the image left to right, top to bottom.

(2) If the pixel is 0, then:

(2.1) If only one of its upper and left neighbors has a label, then copy the label.

(2.2) If both have the same label, then copy the label.

(2.3) If both have different labels, then copy the upper's label and enter the labels in the equivalence table as equivalent labels.

(2.4) Otherwise assign a new label to this pixel and enter this label in the equivalence table.

(3) If there are no more pixels to consider, then go to step 2.

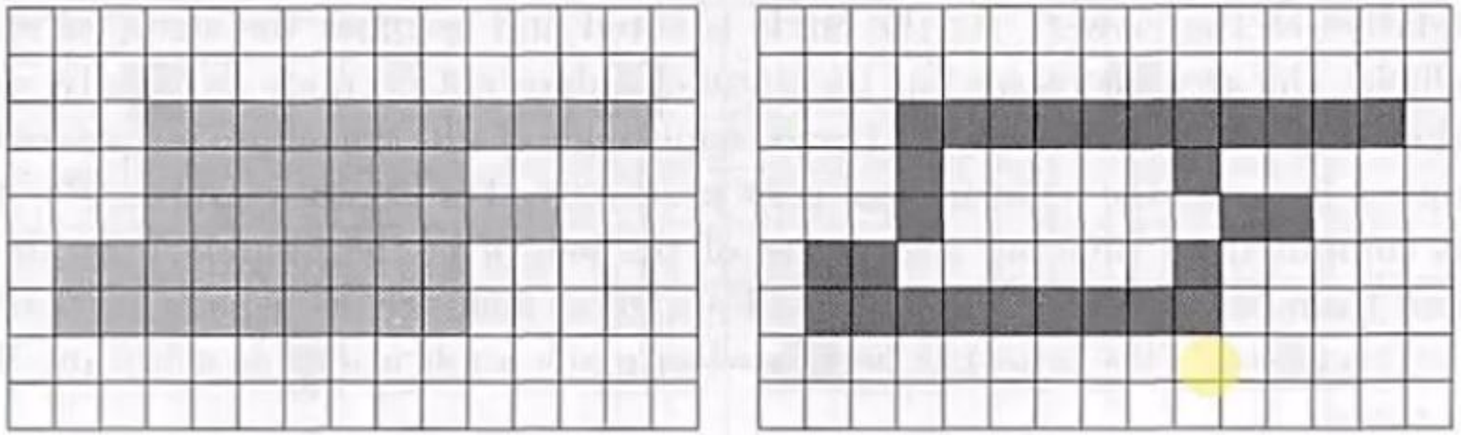
(4) Find the lowest label for each equivalent set in the equivalence table.

(5) Scan the image. Replace each label by the lowest label in its equivalent set.

• Region boundary

- The boundary of a connected component S is the set of pixels of S that are adjacent to background.

- In most applications, one wants to track pixels on the boundary of a region in a particular order (e.g., clockwise).



Distance Measures

Given pixels p, q and z with coordinates (x, y), (s, t), (u, v) respectively, the distance function D has following properties:

- $D(p, q) \geq 0$, [D(p, q) = 0, iff p = q]
- $D(p, q) = D(q, p)$
- $D(p, z) \leq D(p, q) + D(q, z)$

Distance Measures

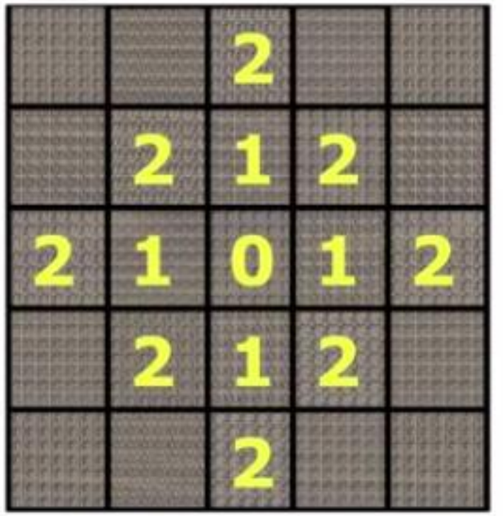
The following are the different Distance measures:

Euclidean Distance :

$$D_e(p,q) = [(x-s)^2 + (y-t)^2]^{1/2}$$

Cityblock Distance :

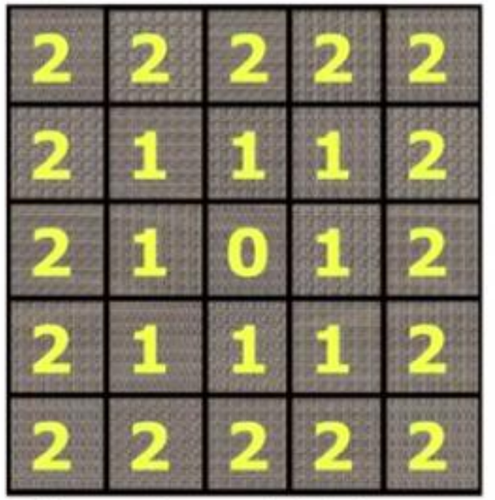
$$D_4(p,q) = |x-s| + |y-t|$$



Cityblock Distance

Chess-board Distance :

$$D_8(p,q) = max(|x-s|, |y-t|)$$



Chess-board Distance

Distance Measures

The following are the different Distance measures:

Euclidean Distance :

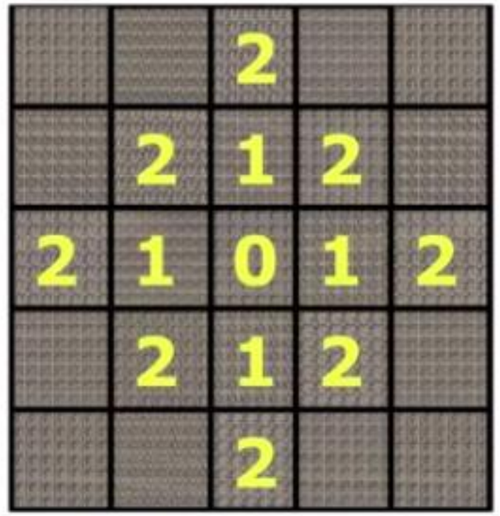
l_2 distance

$$D_e(p,q) = [(x-s)^2 + (y-t)^2]^{1/2}$$

Cityblock Distance :

l_1 distance

$$D_4(p,q) = |x-s| + |y-t|$$

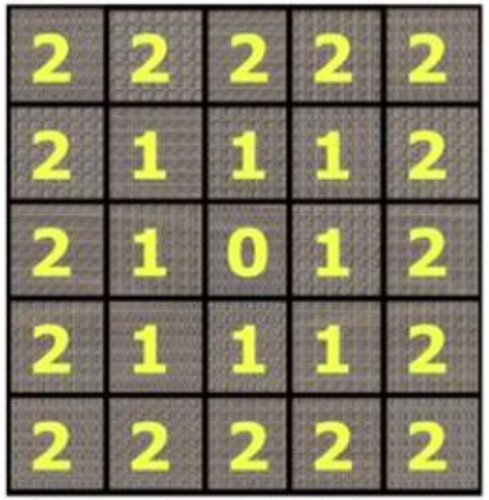


Cityblock Distance

Chess-board Distance :

l_∞ distance

$$D_8(p,q) = max(|x-s|, |y-t|)$$



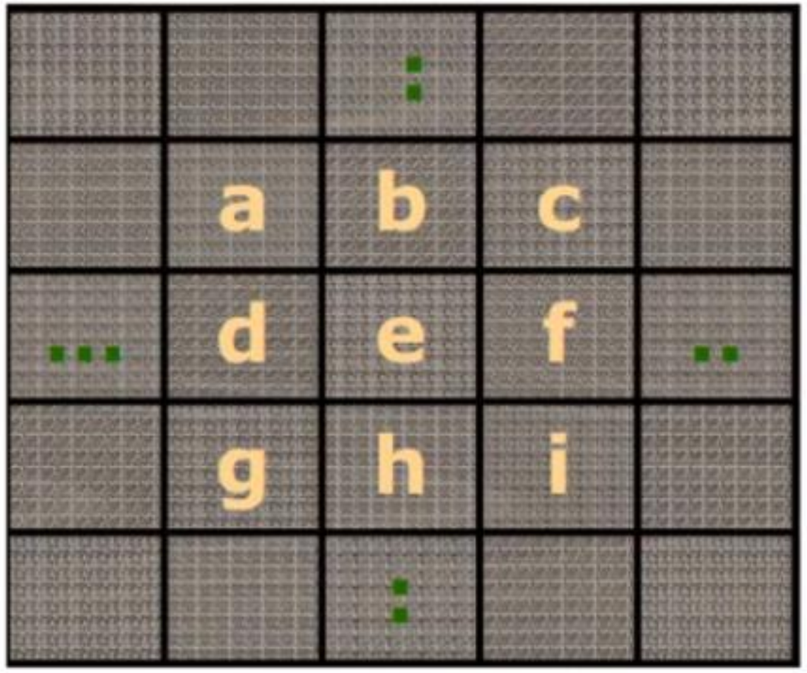
Chess-board Distance

Arithmetic/Logic Operations:

- Addition : p + q
- Subtraction : p –q
- Multiplication : p*q
- Division : p/q
- AND : p AND q
- OR : p OR q
- Complement: NOT(q)

Neighborhood based arithmetic/Logic:

Value assigned to a pixel at position 'e' is a function of its neighbors and a set of window functions.



$$p = (w_1 a + w_2 b + w_3 c + w_4 d + w_5 e + w_6 f + w_7 g + w_8 h + w_9 i)$$

$$= \sum w_i f_i$$

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Newachievable_phase_CP_upper_frec
Newoptimized_phase_error_minimizati
Newoptimized_phase_error_minimizati
Newphase_distribution_final_CP_Both

WORKSPACE

Value Size Class

demo2_GeometricTransforms.m demo3_interpolation.m

```
clc
clear all
close all
f=rgb2gray(imread('jc.jpg'));
%% scaling
for i=1:size(f,1)
    for j=1:size(f,2)

f_1(2*i,2*j)=f(i,j);
    end
end
disp(size(f))
disp(size(f_1))
imshow(f)
figure,imshow(f_1)
%% rotation
theta=-pi/6;
A=[cos(theta), -sin(theta);sin(theta), cos(theta)];
for i=1:size(f,1)
    for j=1:size(f,2)
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
        v=A*[i;j];
```

COMMAND WINDOW

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>>

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Press Esc to exit full screen

```
clc
clear all
close all
f=rgb2gray(imread('jc.jpg'));
%% scaling
for i=1:size(f,1)
    for j=1:size(f,2)

f_1(2*i,2*j)=f(i,j);
    end
end
disp(size(f))
disp(size(f_1))
imshow(f)
figure,imshow(f_1)
%% rotation
theta=-pi/6;
A=[cos(theta), -sin(theta);sin(theta), cos(theta)];
for i=1:size(f,1)
    for j=1:size(f,2)
%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
        v=A*[i;j];
        f_r(v(1),v(2))=f(i,j);
%%%% Corr%%%%%%%%%%%%%%%%%%%%%%%
%        v = uint8(A*[i;j]);
%        if v(1)>0 && v(2)>0
%        f_r(v(1),v(2))=f(i,j);
%        end
```

1:04:18 / 1:40:22

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- check_histogram.m
- circ_hough.m
- color.jpg
- dct_application.m
- dct_application2.m
- Demo1_ImageBasics.m
- demo2_GeometricTransforms.m
- demo3_interpolation.m
- demo_hough.m

WORKSPACE

Name	Value	Size
A	[0.8660,0.5...	2×2
f	264×191 ui...	264×191
f_l	528×382 ui...	528×382
i	1	1×1
j	1	1×1
theta	-0.5236	1×1
v	[1.3660;0.3...	2×1

demo2_GeometricTransforms.m | demo3_interpolation.m

```
15 -  figure,imshow(f_1)
16    %% rotation
17 -  theta=-pi/6;
18 -  A=[cos(theta), -sin(theta);sin(theta), cos(theta)];
19 -  for i=1:size(f,1)
20 -      for j=1:size(f,2)
21    %%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
22 -          v=A*[i;j];
23 -          f_r(v(1),v(2))=f(i,j);
24    %%%% Corr%%%%%%%%%%%%%%%%%%%%%%%
25    %           v = uint8(A*[i;j]);
26    %           if v(1)>0 && v(2)>0
27    %           f_r(v(1),v(2))=f(i,j);
28    %           end
29    %%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
30 -      end
31 -  end
32 -  close all
```

COMMAND WINDOW

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```
Index in position 1 is invalid. Array indices must be positive integers or logical values.

Error in demo3_interpolation (line 23)
        f_r(v(1),v(2))=f(i,j);

>>
```

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- check_histogram.m
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- color.jpg
- dct_application.m
- dct_application2.m
- Demo1_ImageBasics.m
- demo2_GeometricTransforms.m
- demo3_interpolation.m
- demo_hough.m

demo2_GeometricTransforms.m | demo3_interpolation.m

```
20        for j=1:size(f,2)
21  %%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
22  %          v=A*[i;j];
23  %          f_r(v(1),v(2))=f(i,j);
24  %%%% Corr%%%%%%%%%%%%%%%%%%%%%%
25            v = uint8(A*[i;j]);
26            if v(1)>1 && v(2)>1
27            f_r(v(1),v(2))=f(i,j);
28            end
29  %%%%%%%%%%%%%%%%%%%%%%%%%%%%%%%
30        end
31  end
32  close all
33  imshow(f_r)
34  %% Interpolation
35  f_d0=imresize(f, 2, 'nearest');
36  f_d1=imresize(f, 2, 'bilinear');
37  f_d2=imresize(f,2,'bicubic');
```

Figure 1

WORKSPACE

Name	Value	Size
A	[0.8660,0.5...	2×2
	264×191 ui...	264×191
..._I	528×382 ui...	528×382
..._r	255×165 ui...	255×165
	264	1×1
	191	1×1
theta	-0.5236	1×1
v	[255;33]	2×1

COMMAND WINDOW

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```
Index in position 1 is invalid. Array indices must be positive integers or logical values.

Error in demo3_interpolation (line 23)
        f_r(v(1),v(2))=f(i,j);

>>
```

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- check_histogram.m
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- dct_application.m
- dct_application2.m
- Demo1_ImageBasics.m
- demo2_GeometricTransforms.m
- demo3_interpolation.m
- demo_hough.m

WORKSPACE

Name	Value	Size
A	[0.5000,0.8...	2×2
f	264×191 ui...	264×15
f_d0	528×382 ui...	528×38
f_d1	528×382 ui...	528×38
f_d2	528×382 ui...	528×38
f_l	528×382 ui...	528×38
f_r	255×165 ui...	255×16
i	264	1×1
j	191	1×1
theta	-1.0472	1×1

demo2_GeometricTransforms.m | demo3_interpolation.m

```
2 -  clear all
3 -  close all
4 -  im1=rgb2gray(imread('color.jpg'));
5 -  [m,n,p]=size(im1);
6 -  imshow(im1)
7    %% Translation
8 -  im_t = imtranslate(im1,[15, 25]);
9 -  figure; imshow(im_t);
10   %% Scaling
11 -  im_sc=imresize(im1,[0.5*m,2*n]);
12 -  figure, imshow(im_sc)
13   %% Rotation
14 -  thet = 30;
15 -  im_r=imrotate(im1,-30,'bilinear','crop');
16 -  figure, imshow(im_r)
17   %% Shearing
18 -  a = 0.45;
19 -  T = maketform('affine', [1 0 0; a 1 0; 0 0 1] );
```

Figure 1

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```
clear all
close all
im1=rgb2gray(imread('color.jpg'));
[m,n,p]=size(im1);
imshow(im1)
%% Translation
im_t = imtranslate(im1,[15, 25]);
figure; imshow(im_t);
%% Scaling
im_sc=imresize(im1,[0.5*m,2*n]);
figure, imshow(im_sc)
%% Rotation
thet = 30;
im_r=imrotate(im1,-30,'bilinear','crop');
figure, imshow(im_r)
%% Shearing
a = 0.45;
```

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- Demo1_ImageBasics.m
- demo2_GeometricTransforms.m
- demo3_interpolation.m
- demo_hough.m

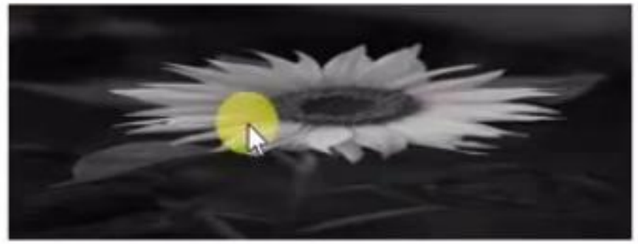
WORKSPACE

	Value	Size
im1	275×183 ui...	275×183
im_sc	138×366 ui...	138×366
im_t	275×183 ui...	275×183
m	275	1×1
n	183	1×1
p	1	1×1

demo2_GeometricTransforms.m | demo3_interpolation.m

```
clear all
close all
im1=rgb2gray(imread('color.jpg'));
[m,n,p]=size(im1);
imshow(im1)
%% Translation
im_t = imtranslate(im1,[15, 25]);
figure; imshow(im_t);
%% Scaling
im_sc=imresize(im1,[0.5*m,2*n]);
figure, imshow(im_sc)
%% Rotation
thet = 30;
im_r=imrotate(im1,-30,'bilinear','crop');
figure, imshow(im_r)
%% Shearing
a = 0.45;
```

Figure 1 | Figure 2 | Figure 3



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- demo3_interpolation.m
- demo_hough.m

WORKSPACE

Name	Value	Size
m1	275×183 ui...	275×183
m_r	275×183 ui...	275×183
m_sc	138×366 ui...	138×366
m_t	275×183 ui...	275×183
m	275	1×1
n	183	1×1
p	1	1×1
thet	30	1×1

demo2_GeometricTransforms.m | demo3_interpolation.m

```
clear all
close all
im1=rgb2gray(imread('color.jpg'));
[m,n,p]=size(im1);
imshow(im1)
%% Translation
im_t = imtranslate(im1,[15, 25]);
figure; imshow(im_t);
%% Scaling
im_sc=imresize(im1,[0.5*m,2*n]);
figure, imshow(im_sc)
%% Rotation
thet = 30;
im_r=imrotate(im1,-30,'bilinear','crop');
figure, imshow(im_r)
%% Shearing
a = 0.45;
```

Figure 1 | Figure 4

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- check_histogram.m
- circ_hough.m
- color.jpg
- dct_application.m
- dct_application2.m
- Demo1_ImageBasics.m
- demo2_GeometricTransforms.m
- demo3_interpolation.m
- demo_hough.m

WORKSPACE

Name	Value	Size
im1	275×183 ui...	275×183
im_r	330×296 ui...	330×296
im_sc	138×366 ui...	138×366
im_t	275×183 ui...	275×183
m	275	1×1
n	183	1×1
p	1	1×1
thet	30	1×1

demo2_GeometricTransforms.m * | demo3_interpolation.m

```
2 -  clear all
3 -  close all
4 -  im1=rgb2gray(imread('color.jpg'));
5 -  [m,n,p]=size(im1);
6 -  imshow(im1)
7    %% Translation
8 -  im_t = imtranslate(im1,[15, 25]);
9 -  figure; imshow(im_t);
10   %% Scaling
11 -  im_sc=imresize(im1,[0.5*m,2*n]);
12 -  figure, imshow(im_sc)
13   %% Rotation
14 -  thet = 30;
15 -  im_r=imrotate(im1,-30,'bilinear','loose');
16 -  figure, imshow(im_r)
17   %% Shearing
18 -  a = 0.45;
19 -  T = maketform('affine', [1 0 0; a 1 0; 0 0 1] );
```

Figure 1 | Figure 4 | Figure 2

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Digital Image Processing (Autumn 2020-21): Lecture 7 - YouTube - Google Chrome

matlab.mathworks.com

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CURRENT FOLDER

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- demo_hough.m

WORKSPACE

	Value	Size
a	0.4500	1×1
im1	275×183 ui...	275×18
im_r	330×296 ui...	330×29
im_s	275×307 ui...	275×30
im_sc	138×366 ui...	138×36
im_t	275×183 ui...	275×18
m	275	1×1
n	183	1×1
p	1	1×1
T	1×1 struct	1×1

demo2_GeometricTransforms.m | demo3_interpolation.m

```
16 -  figure, imshow(im_r)
17    %% Shearing
18 -  a = 0.45;
19 -  T = maketform('affine', [1 0 0; a 1 0; 0 0 1] );
20 -  im_s = imtransform(im1,T);
21 -  figure; imshow(im_s);
22    %% Projective
23
24 -  udata = [0 1];  vdata = [0 1];
25 -  tform = maketform('projective',[ 0 0;  1  0;  1  1;
26                                    [-4 2; -8 -3; -3 -5;
27 -  im_p = imtransform(im1,tform,'bicubic', ...
28                                  'udata',udata,...
29                                  'vdata',vdata,...
30                                  'size',size(im1),...
31                                  'fill',128);
32 -  figure, imshow(im_p)
33
```

Figure 1 | Figure 4 | Figure 2 | Figure 3

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WORKSPACE

Name	Value	Size
a	0.4500	1×1
im1	275×183 ui...	275×18
im_p	275×183 ui...	275×18
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im_t	275×183 ui...	275×18
m	275	1×1
n	183	1×1
p	1	1×1

demo2_GeometricTransforms.m | demo3_interpolation.m

```
a = 0.45;
T = maketform('affine', [1 0 0; a 1 0; 0 0 1] );
im_s = imtransform(im1,T);
figure; imshow(im_s);
%% Projective

udata = [0 1];  vdata = [0 1];
tform = maketform('projective',[ 0 0;  1  0;  1  1; 0 1],...
                               [-4 2; -8 -3; -3 -5; 6 3]);
im_p = imtransform(im1,tform,'bicubic', ...
                             'udata',udata,...
                             'vdata',vdata,...
                             'size',size(im1),...
                             'fill',128);
figure, imshow(im_p)

%%%% Change -8 -3 to -6 -3 and see
%%%% Change -3 -5 to -1 -5
```

Figure 1 | Figure 4 | Figure 2 | Figure 3 | Figure 5

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