



MEDICAL IMAGING PROCESSING

FOURTH STAGE



2025-2026

Pixel Relationships – Arithmetic Operations – Logical Operations – ROI Applications

BY

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Lec 3

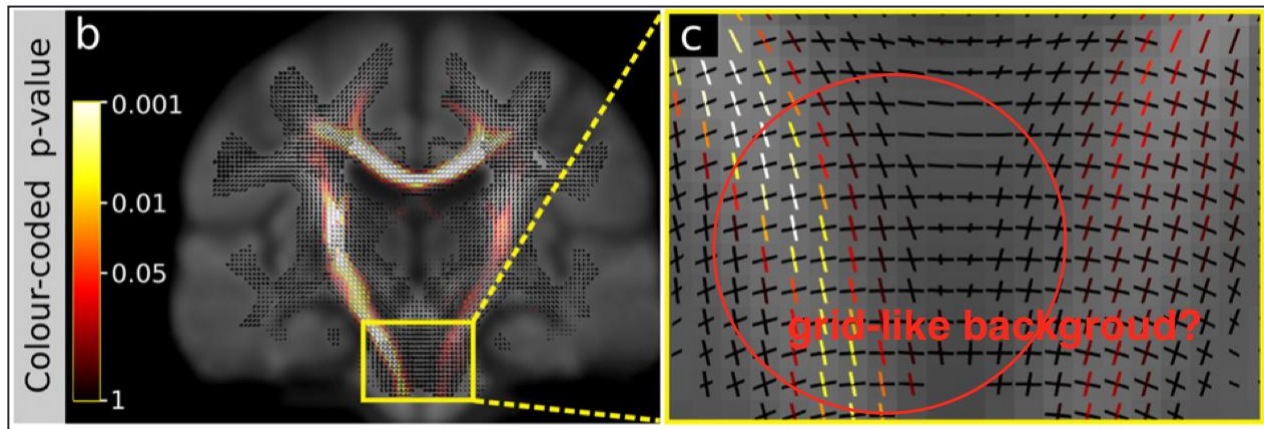
Outline

- Pixel Relationships
- Arithmetic Operations
- Logical Operations
- Region of Interest (ROI)
- Advanced Notes
- Homework

Introduction

A **digital image** is a 2D function $f(x,y)$, where x and y are spatial coordinates, and $f(x,y)$ represents pixel intensity.

Image analysis depends on **relationships between pixels** and their intensity values.



2. Pixel Relationships

- Neighborhood
- Adjacency
- Connectivity
- Paths
- Regions and boundaries

Neighbors of a Pixel

Any pixel $p(x, y)$ has two vertical and two horizontal neighbors, given by

$(x+1, y)$, $(x-1, y)$, $(x, y+1)$, $(x, y-1)$

- This set of pixels are called the 4-neighbors of

P , and is denoted by $N_4(P)$.

- Each of them are at a unit distance from P .

Neighbors of a Pixel (Contd.)

- The four diagonal neighbors of $p(x,y)$ are given by,

$(x+1, y+1), (x+1, y-1), (x-1, y+1), (x-1, y-1)$

- This set is denoted by $ND(P)$.
- Each of them are at Euclidean distance of 1.414 from P.

Types of Pixel Neighborhoods

- **Image sampling:**

Rectangular sampling - In most cases, images are sampled by laying a rectangular grid over an image.

Hexagonal sampling - An alternative sampling scheme is shown.

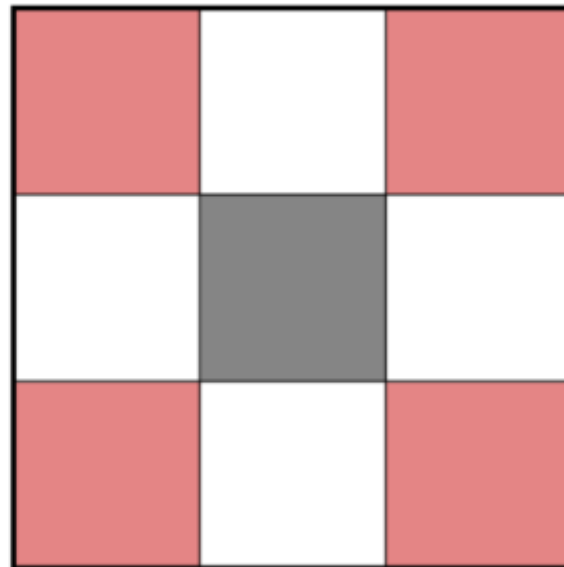
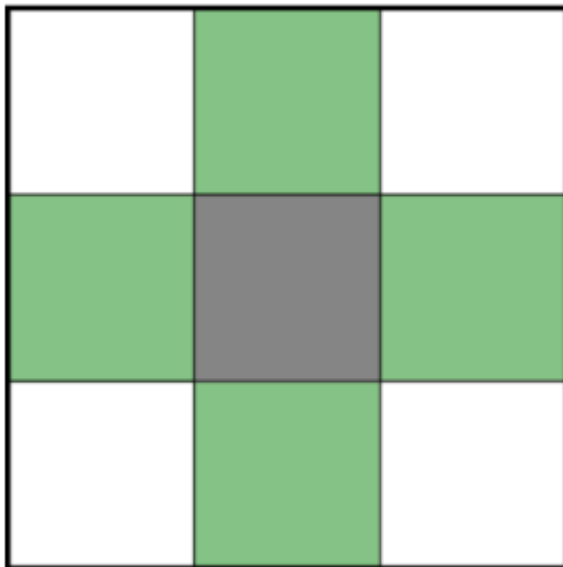
- **Pixel Neighborhoods:**

4-connected and *8-connected* neighborhood (Rectangular sampling)

6-connected neighborhood (Hexagonal sampling)

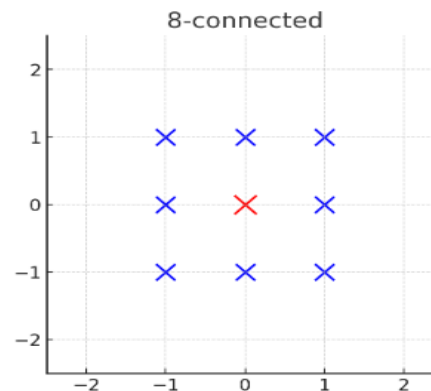
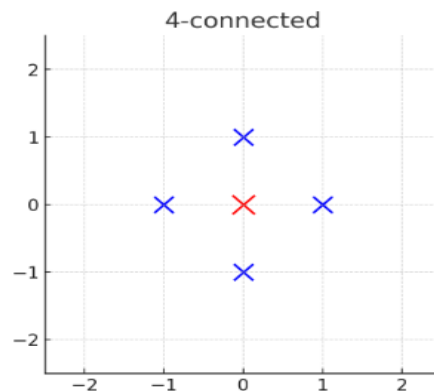
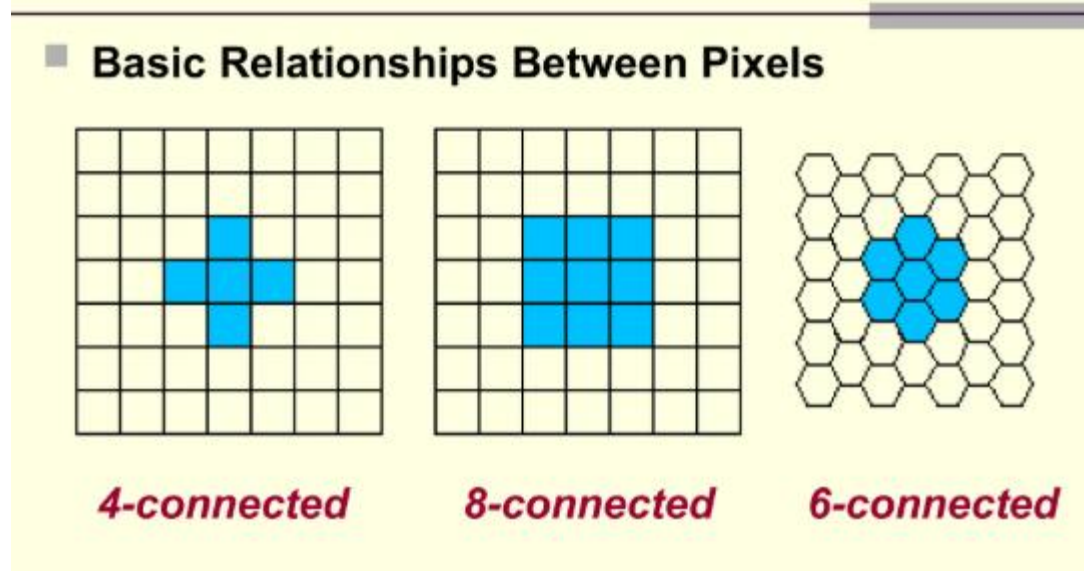
Types of Pixel Neighborhoods

- 4-neighbors: left, right, top, bottom
- 8-neighbors: includes diagonals



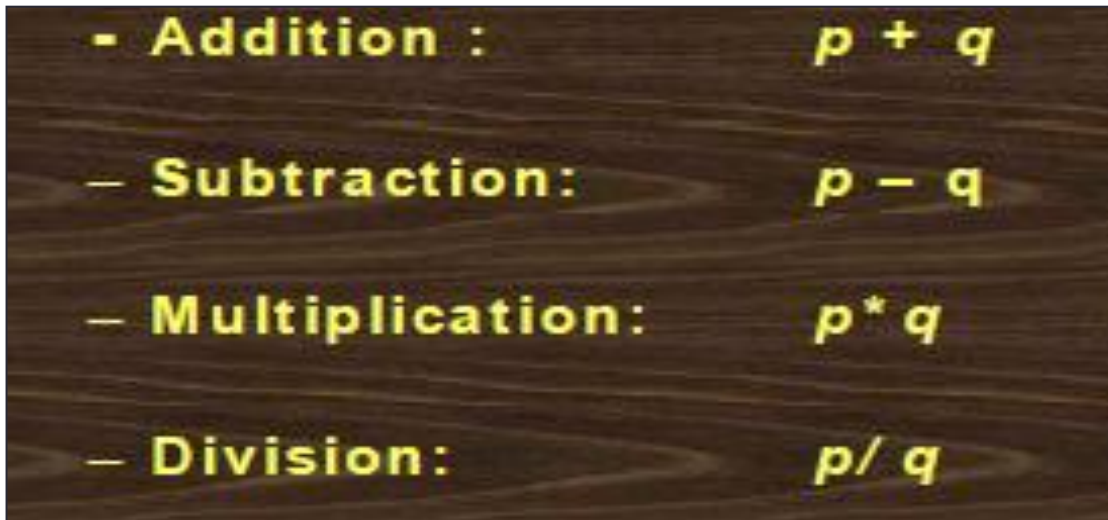
Connectivity in Images

- 4-connectivity
- 8-connectivity
- m-connectivity



Arithmetic Operations

- Addition: increases brightness / merge images
- Subtraction: detects motion or differences
- Multiplication: adjusts contrast
- Division: normalization and scaling



- Addition :	$p + q$
- Subtraction:	$p - q$
- Multiplication:	$p * q$
- Division:	p / q

Logical Operation Examples

- AND: extract common region
- OR: combine regions
- XOR: detect differences
- NOT: image inversion

	AND					OR					XOR			
Input 1	1	1	0	0		1	1	0	0		1	1	0	0
Input 2	1	0	1	0		1	0	1	0		1	0	1	0
output	1	0	0	0		1	1	1	0		0	1	1	0

AND (common)



OR (combine)



XOR (diff)



NOT (inversion)



Region of Interest (ROI) – Concept

- **Definition:** a specific part of an image for processing
- **Focus on important areas**
- **Reduce computation**

ROI Applications

- **Medical imaging:** tumor detection
- **Security:** face recognition

Practical side

Arithmetic Operations

```
I1 = imread('img1.jpg');
```

```
I2 = imread('img2.jpg');
```

```
I_add = I1 + I2;           % Add images
```

```
I_sub = I1 - I2;           % Subtract images
```

Logical Operations

```
BW1 = imread('binary1.png');
```

```
BW2 = imread('binary2.png');
```

BW_and = BW1 & BW2;

% Logical AND

BW_or = BW1 | BW2;

% Logical OR

BW_not = ~BW1;

% Logical NOT

Region of Interest (ROI)

ROI = I(100:200, 150:250); % Extract

ROIimshow(ROI); % Display ROI

Writing Images

```
imwrite(I, 'output.jpg');
```

```
% Save image
```


Homework:?

Truth table (for binary pixels 0/1):

A AND B	A OR B	A XOR B
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A	B
0	0
0	1
1	0
1	1

GOOD LUCK
EVERYONE