MENOUFIA UNIVERSITY
FACULTY OF COMPUTERS AND INFORMATION
ALL DEPARTMENTS
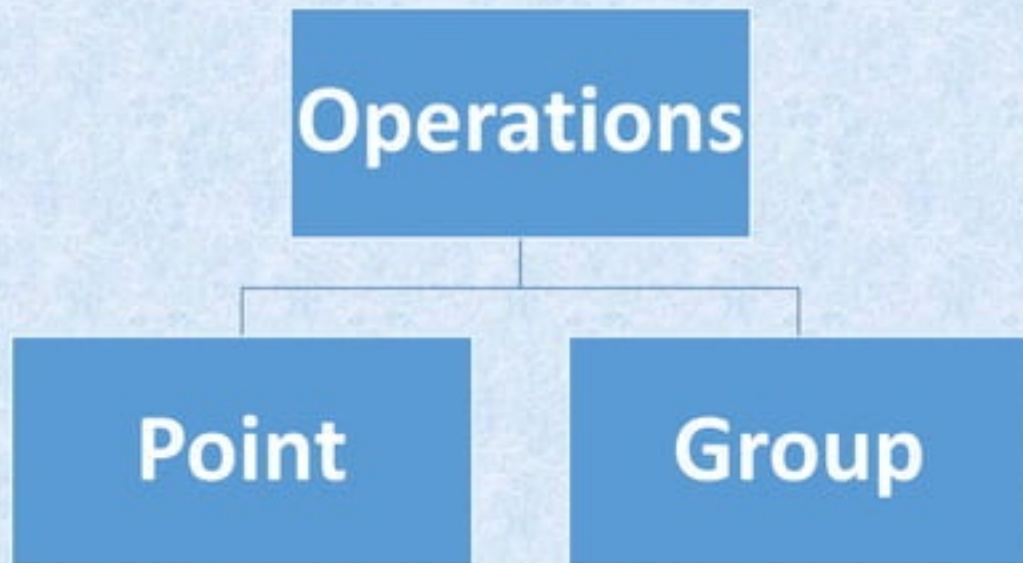
جامعة المنوفية
كلية الحاسبات والمعلومات
جميع الأقسام

Operations in Digital Image Processing + Convolution by Example

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Point Operations

Add 2

Arithmetic Operations + - * /

58	3	213	81	78
185	87	32	27	11
70	66	60	2	19
61	91	129	89	38
14	7	58	14	42

Point Operations

Add 2

Arithmetic Operations + - * /

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Point Operations

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Point Operations

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60	5	213	81	78
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Arithmetic Operations + - * /

60	5	213	81	78
185	87	32	27	11
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14	7	58	14	42

Point Operations

Add 2

Arithmetic Operations + - * /

60	5	215	81	78
185	87	32	27	11
70	66	60	2	19
61	91	129	89	38
14	7	58	14	42

Point Operations

Add 2

Arithmetic Operations + - * /

60	5	215	83	80
187	89	34	29	13
72	68	62	4	21
63	93	131	91	40
16	9	60	16	44

Group Operations

Mean

Median

Mode

58	3	213	81	78
185	87	32	27	11
70	66	60	2	19
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Group Operations

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Median
Mode

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Group Operations

Mean

Median

Mode

58	3	213	81	78
185	87	32	27	11
70	66	60	2	19
61	91	129	89	38
14	7	58	14	42

$$\frac{58 + 3 + 213 + 185 + 87 + 32 + 70 + 66 + 60}{9} = 86$$

Group Operations – Template Operations

1 Operation

- Mean
- Median
- Mode

2 Template

ODD

- 3x3
- 5x5
- 7x7

Why odd?

Group Operations

Mean

Median

Mode

58	3	213	81	78
185	87	32	27	11
70	66	60	2	19
61	91	129	89	38
14	7	58	14	42

$$\frac{58 + 3 + 213 + 185 + 87 + 32 + 70 + 66 + 60}{9} = 86$$

Put the results in the center.

Group Operations

Mean			58	3	213	81	78
			185	87	32	27	11
Median			70	66	60	2	19
			61	91	129	89	38
Mode			14	7	58	14	42

$$\frac{58 + 3 + 213 + 185 + 87 + 32 + 70 + 66 + 60}{9} = 86$$

Put the results in the center.

Group Operations – Even Template Size

Mean

Median

Mode

58	3	213	81	78
185	87	32	27	11
70	66	60	2	19
61	91	129	89	38
14	7	58	14	42

$$\frac{58 + 3 + 185 + 87}{4} = 83.25 \cong 84$$

Even template sizes has no center.
E.g. 2x3, 2x2, 5x6, …

Group Operations – Even Template Size

| Mean |
| Median |
| Mode |

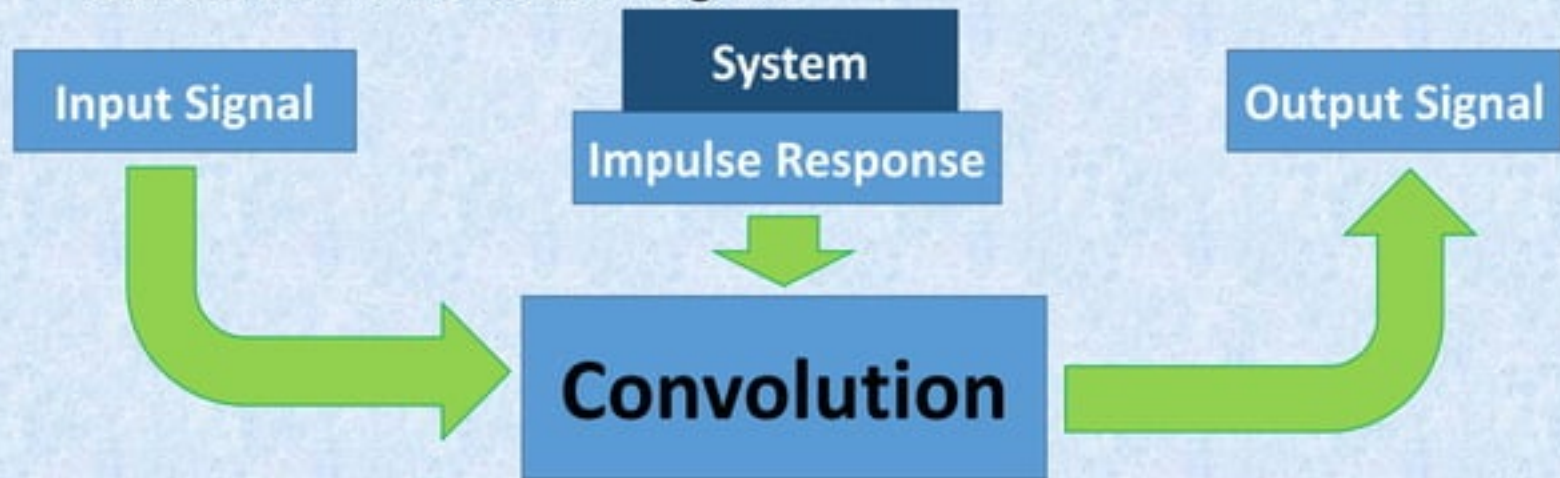| 58	3	213	81	78
185	87	32	27	11
	60	2	19
???	129	89	38
14	7	58	14	42

84

$$\frac{58 + 3 + 185 + 87}{4} = 83.25 \cong 84$$

Even template sizes has no center.
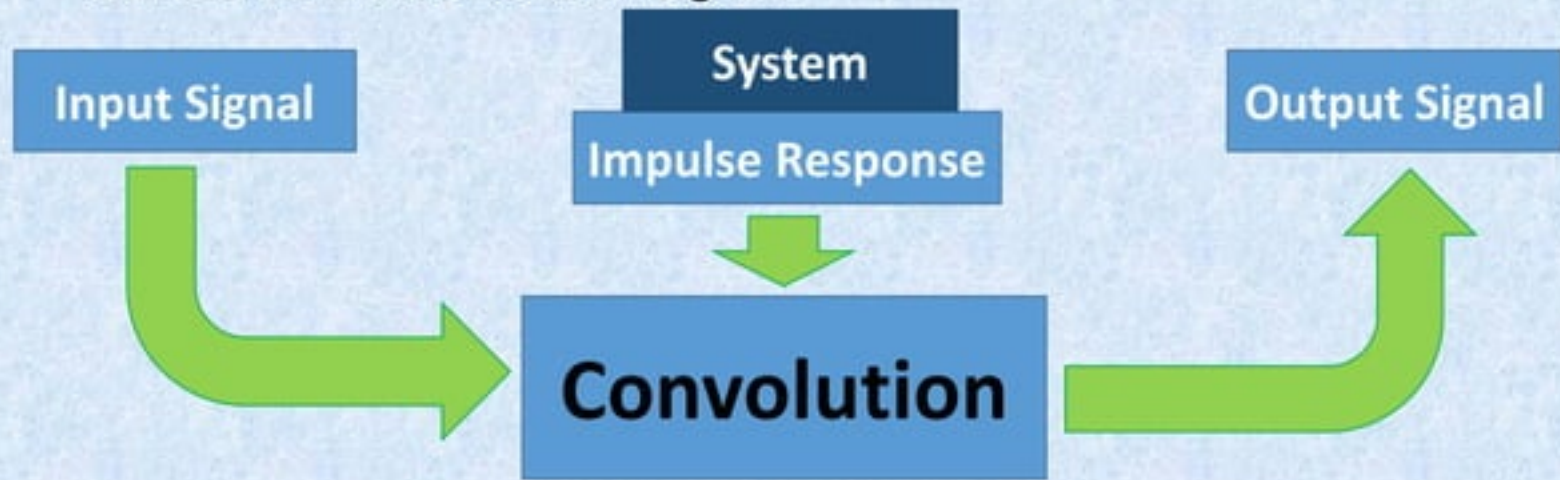E.g. 2x3, 2x2, 5x6, …

What is Convolution?

- It is a mathematical way to combine two signals to generate a third signal. Convolution is not limited on digital image processing and it is a broad term that works on signals.

Input Signal

System
Impulse Response

Output Signal

Convolution

What is Convolution?

58	3	213	81	78
185	87	32	27	11
70	66	60	2	19
61	91	129	89	38
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- It is a mathematical way to combine two signals to generate a third signal. Convolution is not limited on digital image processing and it is a broad term that works on signals.

Input Signal

System

Impulse Response

Output Signal

Convolution

Convolution for 2D Image Signal

1	3	4	3	10
2	7	4	1	11
6	2	5	2	5
13	6	8	9	1
2	7	12	14	8

Template – 3x3

2	1	-4
3	2	5
-1	8	1

Convolution for 2D Image Signal

1	3	4	3	10
2	7	4	1	11
6	2	5	2	5
13	6	8	9	1
2	7	12	14	8

Template – 3x3

2	1	-4
3	2	5
-1	8	1

Convolution for 2D Image Signal

1	3	4	3	10
2	7	4	1	11
6	2	5	2	5
13	6	8	9	1
2	7	12	14	8

Template – 3x3

2	1	-4
3	2	5
-1	8	1

Convolution for 2D Image Signal

1	3	4	3	10
2	44	4	1	11
6	2	5	2	5
13	6	8	9	1
2	7	12	14	8

$$2 * 1 + 1 * 3 - 4 * 4 + 3 * 2 + 2 * 7 + 5 * 4$$
$$- 1 * 6 + 8 * 2 + 1 * 5$$
$$= 44$$

Convolution for 2D Image Signal

2	3	-4	3	10
3	21	5	1	11
-1	8	5	2	5
13	6	8	9	1
2	7	12	14	8

Convolution for 2D Image Signal

1	3	4	3	10
2	44	72	1	11
6	2	5	2	5
13	6	8	9	1
2	7	12	14	8

$$2*3 + 1*4 - 4*3 + 3*7 + 2*4 + 5*1$$
$$- 1*2 + 8*5 + 1*2$$
$$= 72$$

Convolution for 2D Image Signal

Convolution for 2D Image Signal

1	3	4	3	10
2	44	72	2	11
6	2	5	2	5
13	6	8	9	1
2	7	12	14	8

$$2*4 + 1*3 - 4*10 + 3*4 + 2*1 + 5$$
$$*11 - 1*5 + 8*2 + 1*5$$
$$= 2$$

Convolution for 2D Image Signal

1	3	2	1	10
2	44	32	2	51
6	2	1	8	5
13	6	8	9	1
2	7	12	14	8

Convolution for 2D Image Signal

1	3	4	2	10	-4
2	44	72	3	12	5
6	2	5	-1	8	1
13	6	8	9	1	
2	7	12	14	8	

Convolution for 2D Image Signal

1	3	4	3	10
2	44	72	2	82
6	2	5	2	5
13	6	8	9	1
2	7	12	14	8

$$2*3 + 1*10 - 4*0 + 3*2 + 2*11 + 5$$
$$*0 - 1*2 + 8*5 + 1*0$$
$$= 82$$

Convolution for 2D Image Signal

1	3	4	3	10
2	44	72	2	82
6	2	5	2	5
13	6	8	9	1
2	7	12	14	8

Convolution for 2D Image Signal

1	3	4	3	10
2	44	72	2	82
6	2	5	2	5
12	6	8	9	1
3	2	12	14	8
-1	8	1		

Convolution for 2D Image Signal

1	3	4	3	10
2	44	72	2	82
6	2	5	2	5
13	6	8	9	1
2	80	12	14	8

$$2 * 13 + 1 * 6 - 4 * 8 + 3 * 2 + 2 * 7 + 5$$
$$* 12 - 1 * 0 + 8 * 0 + 1 * 0$$
$$= 80$$

Convolution for 2D Image Signal

1	3	4	3	10	
2	44	72	2	82	
6	2	5	2	5	
13	6	8	2	1	-4
2	80	12	13	2	5
			-1	8	1

Convolution for 2D Image Signal

1	3	4	3	10
2	44	72	2	82
6	2	5	2	5
13	6	8	9	1
2	80	12	14	77

$$2 * 9 + 1 * 1 - 4 * 0 + 3 * 14 + 2 * 8 + 5$$
$$* 0 - 1 * 0 + 8 * 0 + 1 * 0$$
$$= 77$$

Convolution for 2D Signal

•**Continue.**

1	3	4	3	10
2	44	72	2	82
6	2	5	2	5
13	6	8	9	1
2	80	12	14	77

Convolution for 2D Signal

- ## **Template for Mean.**

$\frac{1}{9}$	$\frac{1}{9}$	$\frac{1}{9}$
$\frac{1}{9}$	$\frac{1}{9}$	$\frac{1}{9}$
$\frac{1}{9}$	$\frac{1}{9}$	$\frac{1}{9}$

58	3	213	81	78
185	87	32	27	11
70	66	60	2	19
61	91	129	89	38
14	7	58	14	42

$$\frac{1}{9}*58 + \frac{1}{9}*3 + \frac{1}{9}*213 + \frac{1}{9}*185 + \frac{1}{9}*87 + \frac{1}{9}*32$$

$$+ \frac{1}{9}*70 + \frac{1}{9}*66 + \frac{1}{9}*60$$

$$= 86$$