# ED5340 - Data Science: Theory and Practise

**L27 - Convolution** 

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Course web page: https://ed.iitm.ac.in/~raman/datascience.html

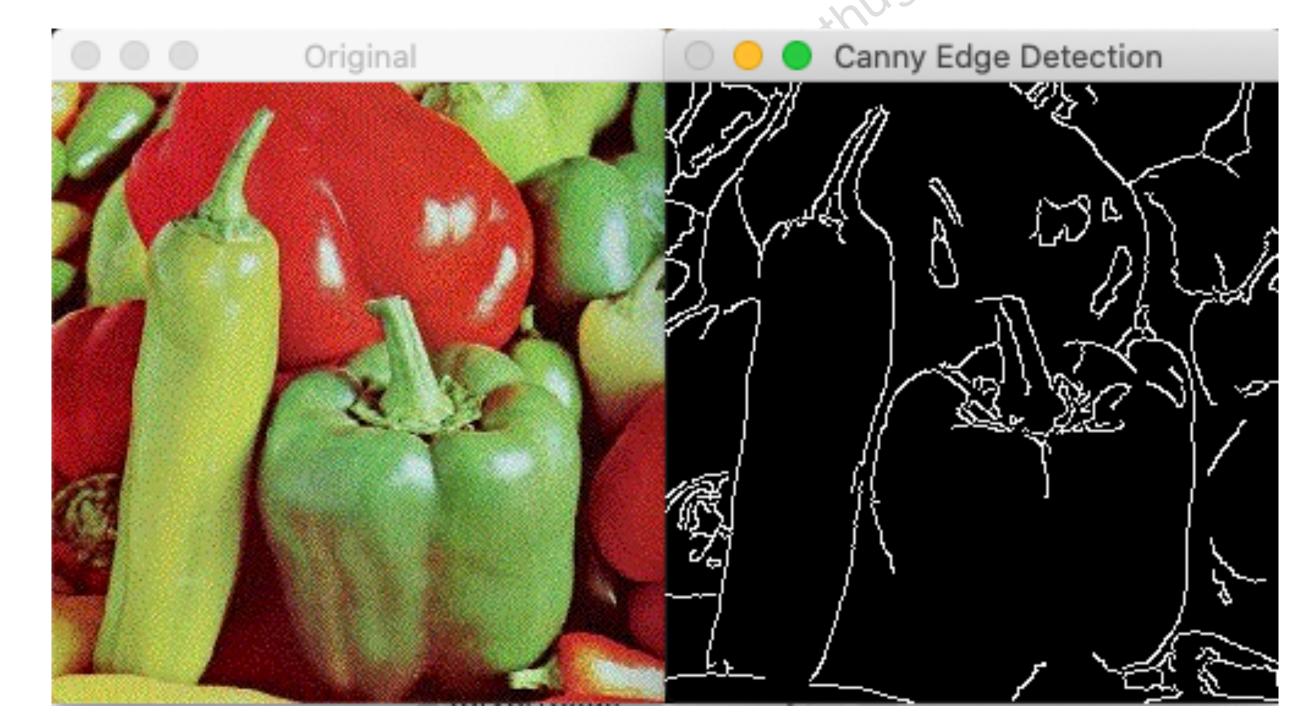
Moodle page: Available at https://courses.iitm.ac.in/

### On Images

- Pixel (Picture element)
- Binary ({0, 255})
- Grayscale (One channel 8-bit representation)
- RGB (Three channels, one for each colour)
- Discussion to one channel

### Observation

- Pixels close to one another represent same information
- 'Edges' that separate the information



### Hypothesis

- Train the NN for regions of same information
- Train to find 'Edges'
- 'Objects' can be identified.

### Idea

- Capture 'local' information
- Split the image into patches (square)
- Use a 'moving window' approach

### Patch

- Patch Array of numbers
- 4 X 4 Array of numbers

2	4	3	6
Muiti2108108	1	3	0
9	0	1	2
7	5	1	2

- Uses a filter F (a.k.a Kernel)
  - 3 X 3
  - 2 X 2
  - 1 X 1
- Operates on the patches.
- If the numbers from convolution are larger, then the 'region' (or the patch) resembles the filter.

1	0	-1
1 00		-1
	0	-1

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

1	ana.Path	-1
Multhur	0	-1
1	0	-1

#### Superimpose, multiply and add

2 1	4 0	3 -1	6
2 1	1 0	3 -1	0
9 1	0 0	1 -1	2
7	5	1	2

$$2*1 + 2*1 + +9*1 + 1*0 + 1*0 + 0*0 + 3*(-1) + 3*(-1) + 1*(-1)$$

$$= 6$$

#### Then stride (slide) by 1 to right

2	4 1	3 0	6 -1
2	1 <b>1</b>	3 0	0 -1
9	0 <b>1</b>	1 0	2 -1
7	5	1	2

$$4*1 + 1*1 + +0*1 + 3*0 + 3*0 + 1*0 + 6*(-1) + 0*(-1) + 2*(-1)$$

$$= -3$$

Then stride (slide) by 1 to right (not possible)

2	4	3 1	6 0
2	1	3 <b>1</b>	0 0
9	0	1 <b>1</b>	2 0
7	5	1	2

### Then stride (slide) down by 1

2	4	3	6
2 1	1 0	3 <b>-1</b>	0
9 1	0 0	1 -1	2
7 1	5 0	1 -1	2

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Ramanathan

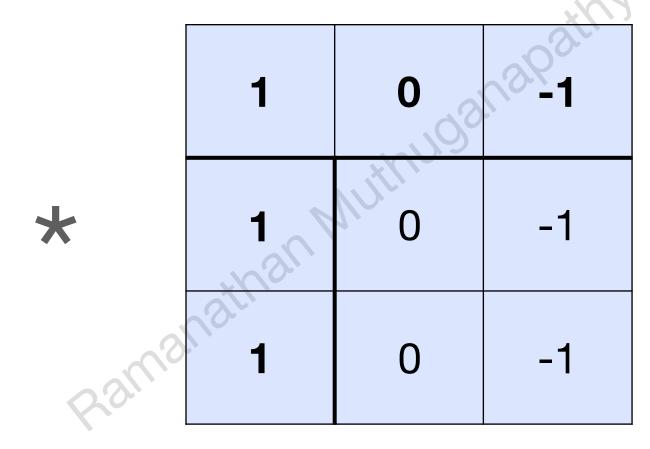
### Then stride (slide) right by 1

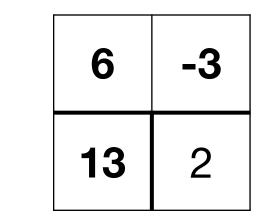
2	4	3	6
2	1 <b>1</b>	3 <b>0</b>	0 <b>-1</b>
9	0 <b>1</b>	1 0	2 -1
7	5 <b>1</b>	1 0	2 -1

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





2	4	3	6			1031	S. Patilly	
2	1	3	0			Uith 1	0	-1
9	0	1	2		Manaihan	1	0	-1
7	5	1	2			1	0	-1

2 1	4 0	3 -1	6		nainaithain Muithuganaipaithi
2 1	1 0	3 -1	0		Multinules
9 1	0 0	1 -1	2		War Silver
7	5	1	2	6.0	

2	4 1	3 0	6 -1		mainain Muithugana. Pailin
2	1 <b>1</b>	3 0	0 -1		Multhules
9	0 <b>1</b>	1 0	2 -1		War Sir Lor
7	5	1	2	6.0	

2	4	3 1	6 0	-1		namathain Multhuganapalin
2	1	3 <b>1</b>	0 0	1		Multhules
9	0	1 <b>1</b>	2 0	-1		USIUSIIU.
7	5	1	2		6.0	

2	4	3	6 1	0	-1	nanaihan Muithuganapa
2	1	3	0 1	0	-1	Nuithules
9	0	1	2 <b>1</b>	0	-1	Wall Silver
7	5	1	2		<b>P</b> -c	

2	4	3	6		mainathan Muthuganapatiny
2 1	1 0	3 <b>-1</b>	0		Multhules
9 1	0 0	1 -1	2		War Silver
7 1	5 0	1 -1	2	P.O	

2	4	3	6	manathan Muthuganapathy
2	1 <b>1</b>	3 <b>0</b>	0 <b>-1</b>	
9	0 1	1 0	2 -1	a Mainaith a
7	5 <b>1</b>	1 0	2 -1	

2	4	3	6			Mainain Muithugana. Paith
2	1	3 <b>1</b>	0 0	-1		Multhules
9	0	1 <b>1</b>	2 0	-1		War.
7	5	1 <b>1</b>	2 0	-1	6.0	

2	4	3	6			mainain Muithuganain
2	1	3	0 <b>1</b>	0	-1	Multhules
9	0	1	2 1	0	-1	Wail Silly or
7	5	1	2 <b>1</b>	0	-1	

2	4	3	6		nainain Multhuoanapatin
2	1	3	0		Multhules
9 1	0 <b>0</b>	1 <b>-1</b>	2		USIUSIIU.
7 1	5 0	1 -1	2	6.0	
1	0	-1			

2	4	3	6		mainain Multhugana. Path
2	1	3	0		Multhules
9	0 <b>1</b>	1 0	2 <b>-1</b>		War Silver
7	5 <b>1</b>	1 0	2 -1	P.C	
	1	0	-1		

2	4	3	6			Manathan Muthuganapathi
2	1	3	0			Multhules
9	0	1 1	2 <b>0</b>	-1		War Sir War
7	5	1 <b>1</b>	2 0	-1	6.0	
		1	0	-1		

2	4	3	6			naihain
2	1	3	0			
9	0	1	2 <b>1</b>	0	-1	Wailyai
7	5	1	2 <b>1</b>	0	-1	
			1	0	-1	

2	4	3	6		nainaihan Muithuganapath
2	1	3	0		Multhules
9	0	1	2		Wailugi.
7 1	5 <b>0</b>	1 <b>-1</b>	2	S.c	
1	0	-1			
1	0	-1			

2	4	3	6		manathan Muthuganapath
2	1	3	0		Nuithue
9	0	1	2		Wally Silly or
7	5 <b>1</b>	1 0	2 <b>-1</b>	6.0	
	1	0	-1		
	1	0	-1		

2	4	3	6			mainathain Muithuganalpai
2	1	3	0			Multhules
9	0	1	2			Wall aillian
7	5	1 <b>1</b>	2 <b>0</b>	-1	6.0	
		1	0	-1		
		1	0	-1		

2	4	3	6		
2	1	3	0		
9	0	1	2		
7	5	1	2 1	0	-1
			1	0	-1
			1	0	-1

2 1	4 0	3 -1	6		nainain Muithuganapaith
2 1	1 0	3 -1	0		Multhules
9 1	0 0	1 -1	2		USIUSIIV.
7	5	1	2	<b>P</b> .0	

2	4	3 1	6 0	-1		nanathan Muthuganapatiny
2	1	3 <b>1</b>	0 0	-1		Multhules
9	0	1 <b>1</b>	2 0	-1		Valuative.
7	5	1	2		6.0	

2	4	3	6		mainathan Muithuganapatin
2	1	3	0		Multhule
9 1	0 <b>0</b>	1 <b>-1</b>	2		War Silver
7 1	5 0	1 -1	2	P.o	
1	0	-1			

2	4	3	6			Manathan Multhuganalpath
2	1	3	0			Multhule
9	0	1 <b>1</b>	2 <b>0</b>	-1		Waji Waji Wa
7	5	1 <b>1</b>	2 0	-1	6.0	
		1	0	-1		

### Padding

- Adding rows and columns outside your main data
- Typically zeros are added.
- Capture the boundaries (edges) better

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

### Padding

- Adding rows and columns outside your main data
- Typically zeros are added.
- Capture the boundaries (edges) better

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

0	0	0	0	0	0
0	2	4	3	6	0
0	2	1	3	0	
0	9	0	1	2.21	0
0	7	5	1	2	0
0	0	0	0	0	0

1	0	-1
1	0	-1
1	0	-1

0 1	0 <b>0</b>	0 -1	0	0	0
0 1	2 0	4 -1	3	6	0
0 <b>1</b>	2 0	1 -1	3	0	o ainain
0	9	0	1	2011	0
0	7	5	1	2	0
0	0	0	0	0	0

-5		

0	0 1	0 <b>0</b>	0 -1	0	0
0	2 <b>1</b>	4 0	3 -1	6	0
0	2 <b>1</b>	1 0	3 -1	0	O all
0	9	0	1	2011	0
0	7	5	1	2	0
0	0	0	0	0	0

-5	-2	

0	0	0 1	0 <b>0</b>	0 -1	0
0	2	4 <b>1</b>	3 0	6 -1	0
0	2	1 <b>1</b>	3 0	0 -1	0,01
0	9	0	1	2,310	0
0	7	5	1	2	0
0	0	0	0	0	0

-5	-2	-1	

0	0	0	0 <b>1</b>	0 <b>0</b>	0 -1
0	2	4	3 <b>1</b>	6 0	0 -1
0	2	1	3 <b>1</b>	0 0	0 -1
0	9	0	1	2.21	0
0	7	5	1	2	0
0	0	0	0	0	0

-5	-2	-1	6

0	0	0	0	0	0
0 <b>1</b>	2 <b>0</b>	4 <b>-1</b>	3	6	0
0 <b>1</b>	2 0	1 -1	3	0	O all
0 <b>1</b>	9 0	0 -1	1	2.31	0
0	7	5	1	2	0
0	0	0	0	0	0

-5	-2	-1	6
-5			

0	0	0	0	0	0
0	2 <b>1</b>	4 <b>0</b>	3 <b>-1</b>	6	0
0	2 <b>1</b>	1 0	3 -1	0	o athan
0	9 <b>1</b>	0 0	1 -1	2.01	0
0	7	5	1	2	0
0	0	0	0	0	0

-5	-2	-1	6
-5	6		

0	0	0	0	0	0
0	2	4 <b>1</b>	3 <b>0</b>	6 <b>-1</b>	0
0	2	1 <b>1</b>	3 0	0 -1	o sinai
0	9	0 <b>1</b>	1 0	2 -1	0
0	7	5	1	2	0
0	0	0	0	0	0

-5	-2	-1	6
-5	6	-3	

0	0	0	0	0	0
0	2	4	3 <b>1</b>	6 <b>0</b>	0 -1
0	2	1	3 <b>1</b>	0 0	0 -1
0	9	0	1 <b>1</b>	2 0	0 -1
0	7	5	1	2	0
0	0	0	0	0	0

-5	-2	-1	6
-5	6	-3	7

0	0	0	0	0	0
0	2	4	3	6	0
0 <b>1</b>	2 <b>0</b>	1 - <b>1</b>	3	0	O Silvair
0 <b>1</b>	9 0	0 -1	1	2.01	0
0 <b>1</b>	7 0	5 -1	1	2	0
0	0	0	0	0	0

-5	-2	-1	6
-5	6	-3	7
-6			

0	0	0	0	0	0
0	2	4	3	6	0
0	2 <b>1</b>	1 0	3 <b>-1</b>	0	O air
0	9 <b>1</b>	0 0	1 -1	2011	0
0	7 <b>1</b>	5 0	1 -1	2	0
0	0	0	0	0	0

-5	-2	-1	6
-5	6	-3	7
-6	18		

0	0	0	0	0	0
0	2	4	3	6	0
0	2	1 <b>1</b>	3 <b>0</b>	0 -1	O Silvair
0	9	0 <b>1</b>	1 0	2 -1	0
0	7	5 <b>1</b>	1 0	2 -1	0
0	0	0	0	0	0

-5	-2	-1	6
-5	6	-3	7
-6	18	2	

0	0	0	0	0	0
0	2	4	3	6	0
0	2	1	3 <b>1</b>	0 <b>0</b>	0 -1
0	9	0	1 <b>1</b>	2 0	0 -1
0	7	5	1 <b>1</b>	2 0	0 -1
0	0	0	0	0	0

-5	-2	-1	6
-5	6	-3	7
-6	18	2	5

0	0	0	0	0	0
0	2	4	3	6	0
0	2	1	3	0	0,00
0 1	9 <b>0</b>	0 -1	1	2310	0
0 <b>1</b>	7 0	5 -1	1	2	0
0 <b>1</b>	0 0	0 -1	0	0	0

-5	-2	-1	6
-5	6	3	7
-6	18	2	5
-5			

0	0	0	0	0	0
0	2	4	3	6	0
0	2	1	3	0	0,20
0	9 <b>1</b>	0 <b>0</b>	1 <b>-1</b>	2310	0
0	7 1	5 0	1 -1	2	0
0	0 1	0 0	0 -1	0	0

-5	-2	-1	6
-5	6	-3	7
-6	18	2	5
-5	14		

0	0	0	0	0	0
0	2	4	3	6	0
0	2	1	3	0	O all
0	9	0 <b>1</b>	1 <b>0</b>	2 -1	0
0	7	5 <b>1</b>	1 0	2 -1	0
0	0	0 <b>1</b>	0 0	0 -1	0

-5	-2	-1	6
-5	6	-3	7
-6	18	2	5
-5	14	1	

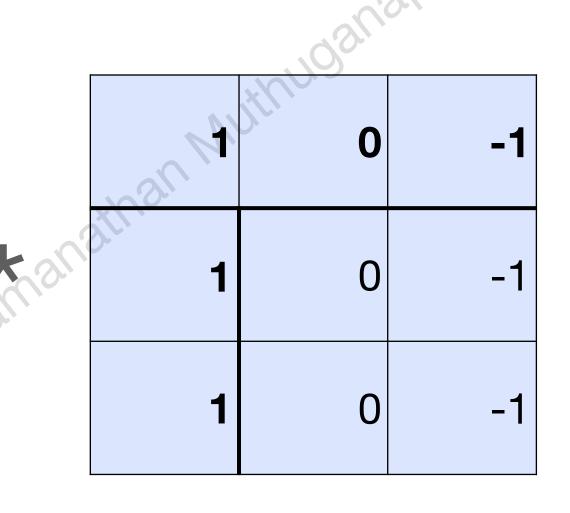
0	0	0	0	0	0
0	2	4	3	6	0
0	2	1	3	0	O all
0	9	0	1 <b>1</b>	2.0	0 -1
0	7	5	1 <b>1</b>	2 0	0 <b>-1</b> 0 -1

-5	-2	-1	6
-5	6	-3	7
-6	18	2	5
-5	14	1	2

### Padding + Apply Stride + Convolution

#### with a Kernel (filter)

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



-5	-2	-1	6
-5	6	-3	7
-6	18	2	5
-5	14	1	2

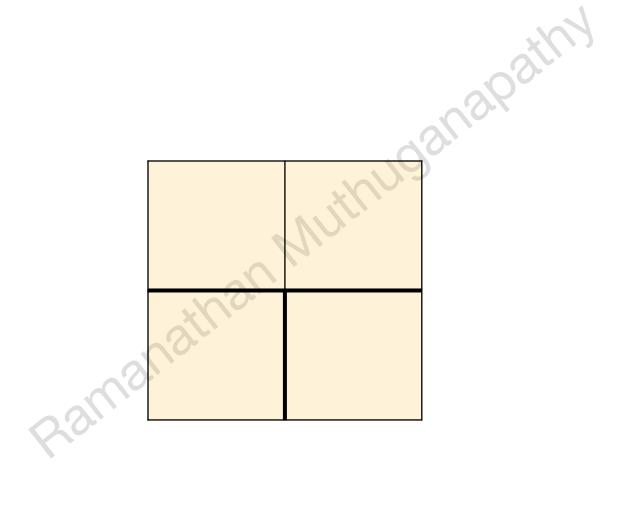
### Pooling

- Fixed operator Max or Average pooling.
- Filter size and stride are hyper-parameters.
- Capture the boundaries (edges) better

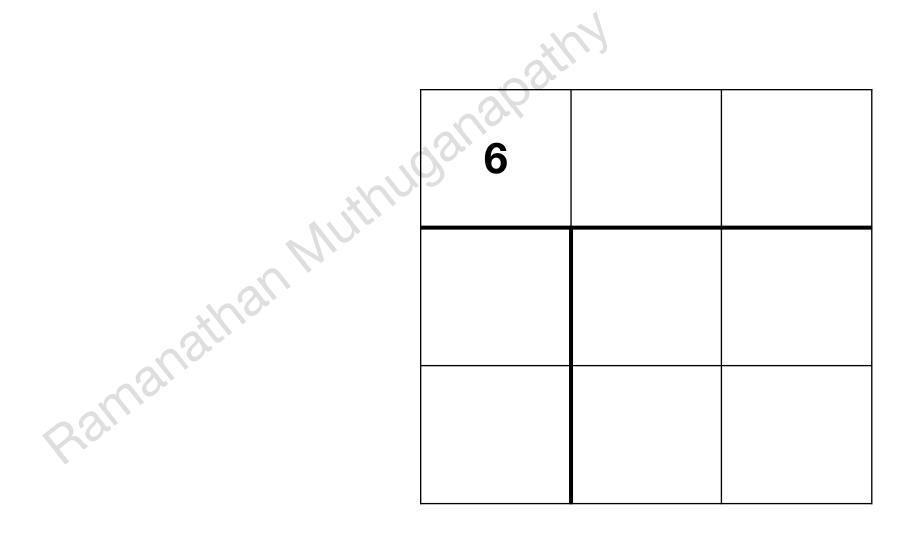
### Filter with size 2 X 2

#### Max. pooling

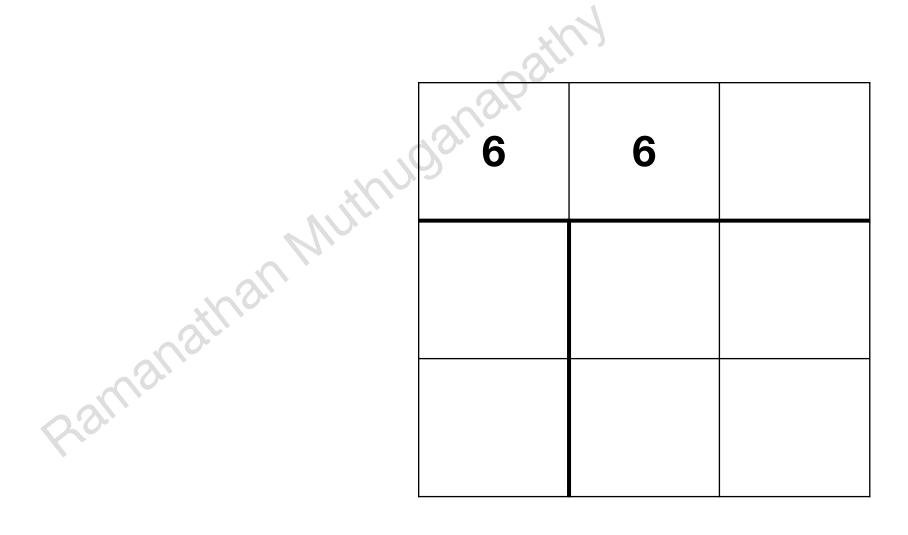
-5	-2	-1	6
-5	6	-3	7
-6	18	2	5
-5	14	1	2



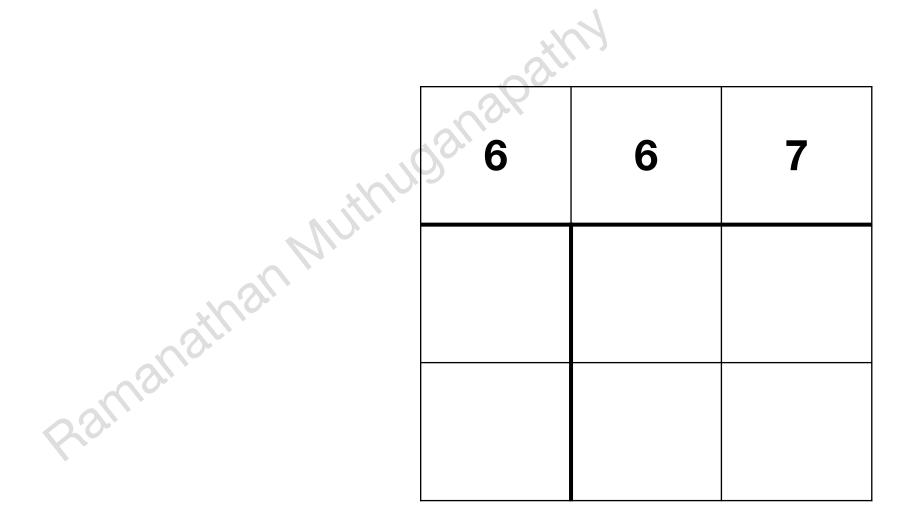
-5	-2	-1	6
-5	6	<u>ფ</u>	7
-6	18	2	5
-5	14	1	2



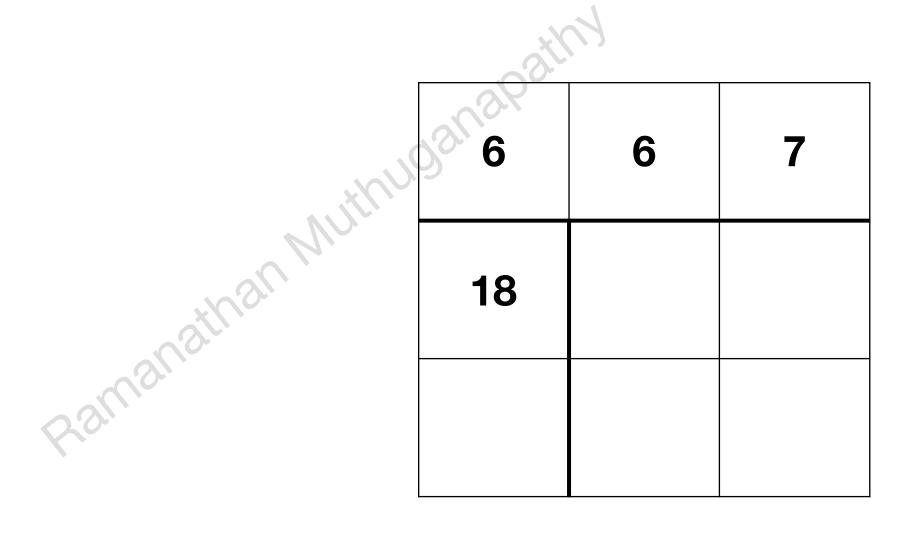
-5	-2	-1	6
-5	6	-3	7
-6	18	2	5
-5	14	1	2



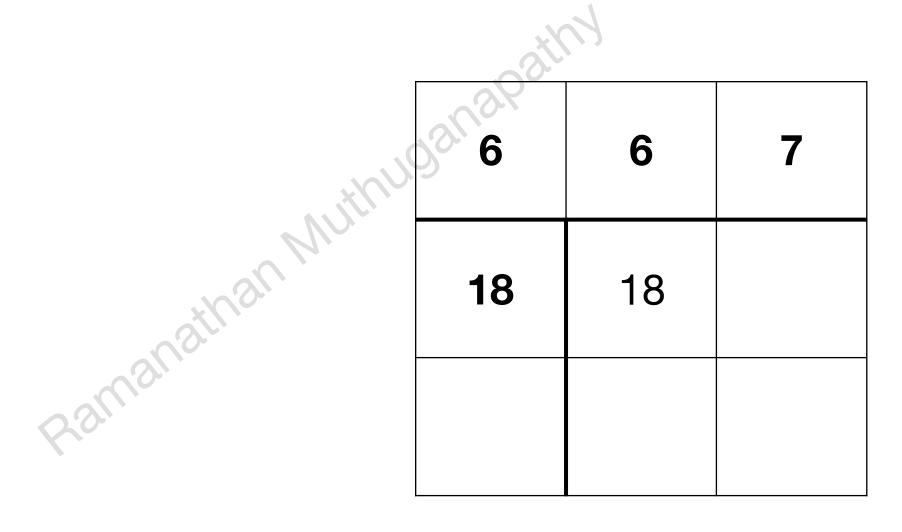
-5	-2	-1	6
-5	6	-3	7
-6	18	2	5
-5	14	1	2



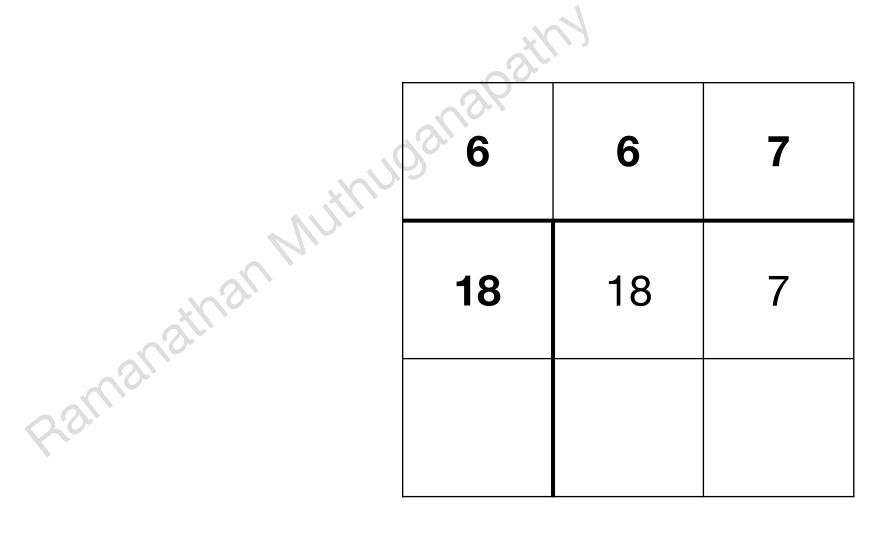
-5	-2	-1	6
-5	6	-3	7
-6	18	2	5
-5	14	1	2



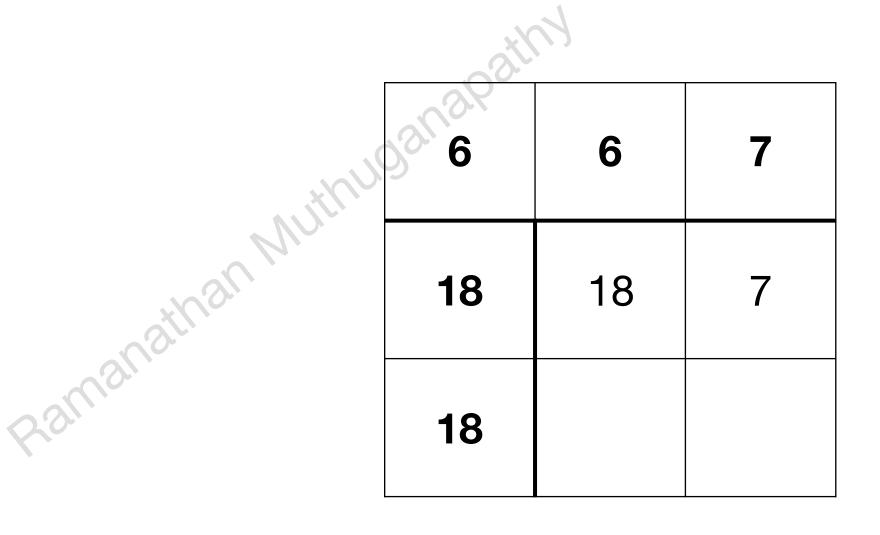
-5	-2	-1	6
-5	6	-3	7
-6	18	2	5
-5	14	1	2



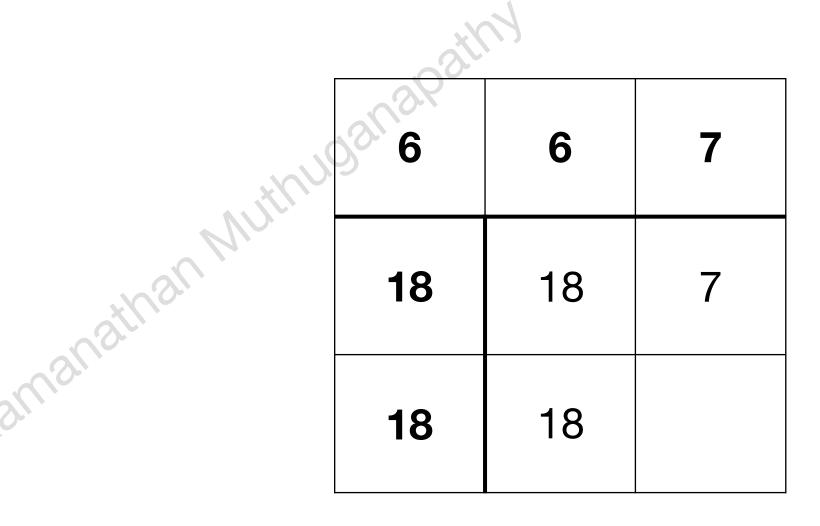
-5	-2	-1	6
-5	6	-3	7
-6	18	2	5
-5	14	1	2



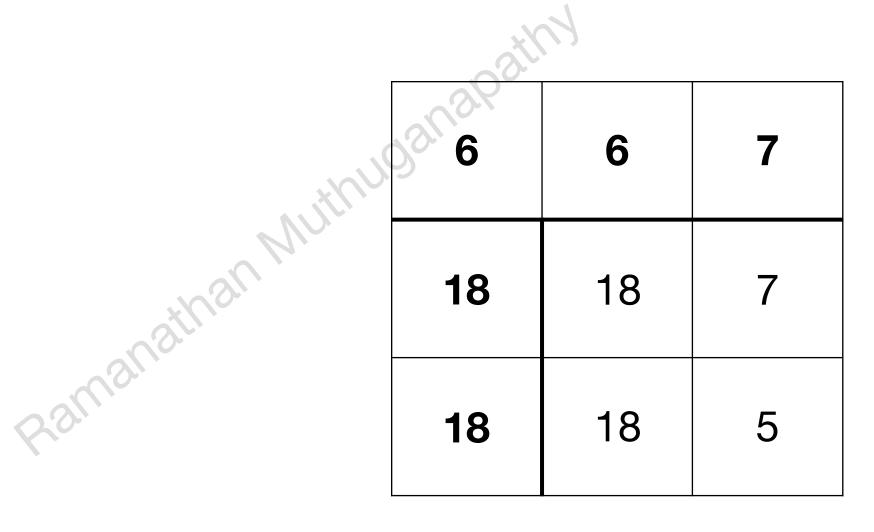
-5	-2	-1	6
-5	6	-3	7
-6	18	2	5
-5	14	1	2



-5	-2	-1	6
-5	6	-3	7
-6	18	2	5
-5	14	1	2



-5	-2	-1	6
-5	6	-3	7
-6	18	2	5
-5	14	1	2



### Pooling

- Filter (size)
- Padding
- Strides
- Pooling



### Edge detection filters

0	-1	0
-1	4	-1
0	-1	0

	-1	an a pail	-1
	MUİNUN	8	-1
2.amainain	-1	-1	-1

### CNN

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