
Introduction of Image Processing



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**PUT YOUR
QUESTION HERE**



<https://s.id/lec01QnA>



<https://github.com/achmfirmanasyah/ImageProcessing>

Visit the repository for material and code in this lecture session.

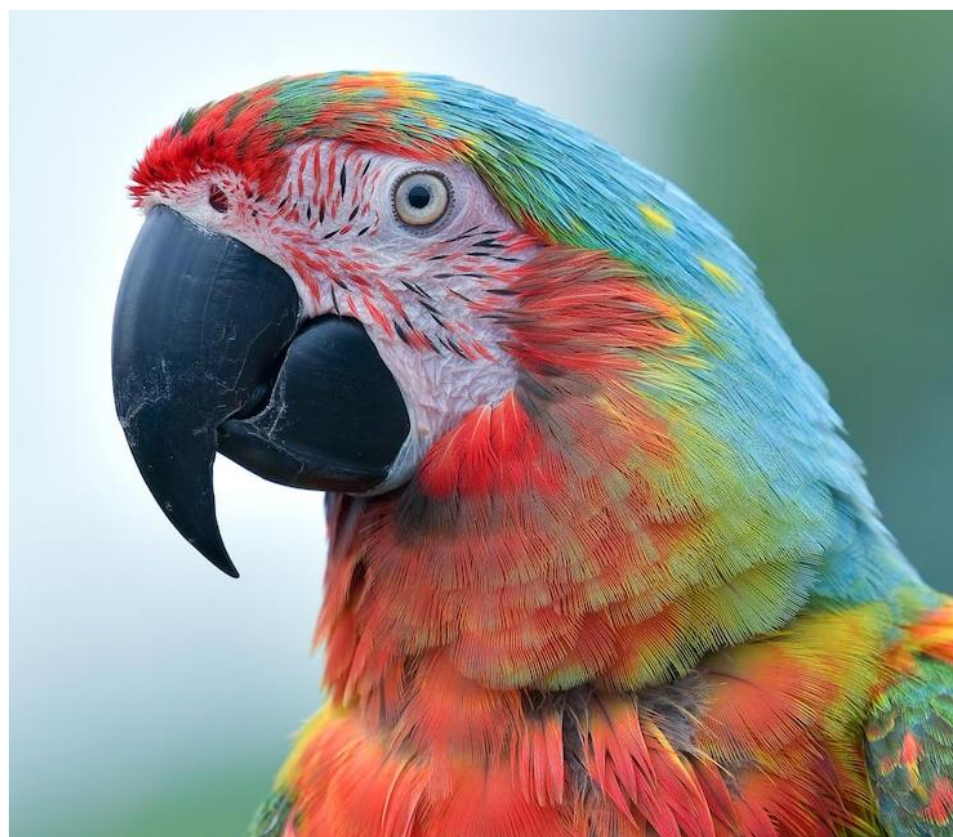
01. What is “Image”?

02. You “SEE” what you care...

03. Tweaking images...

What Will we learn today ?





What is
“Image”



IMAGE



Before we dive into the world of computer vision, we need to understand a simple, yet powerful concept — **the image**.

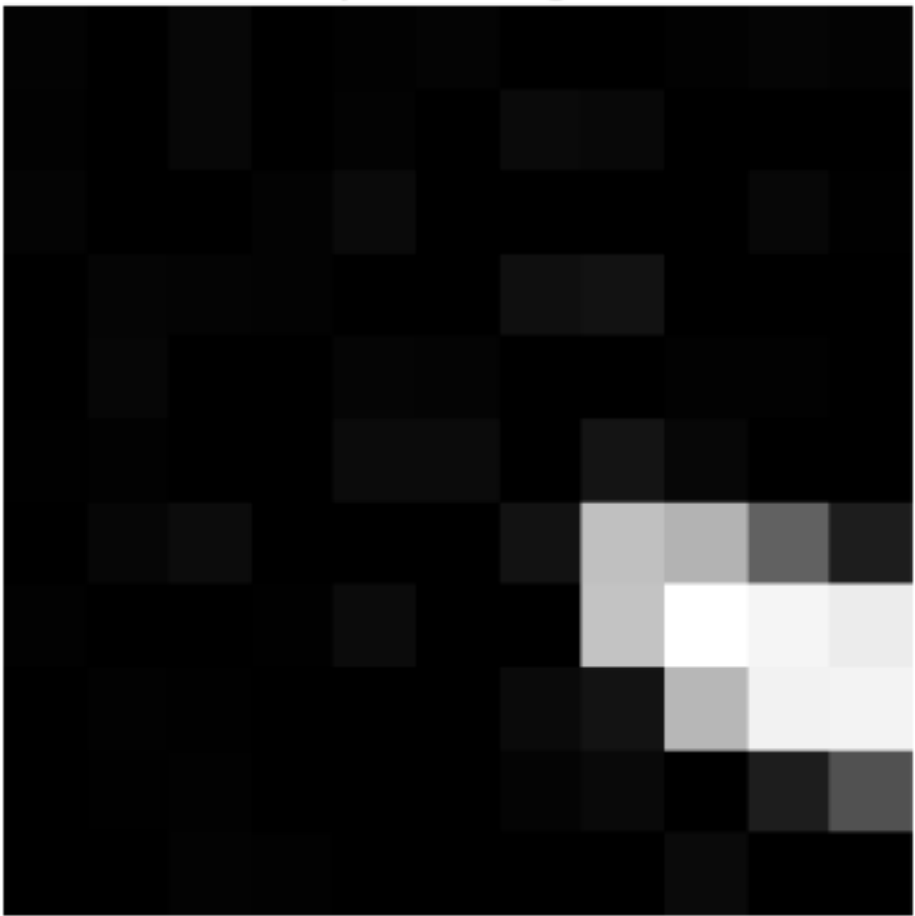
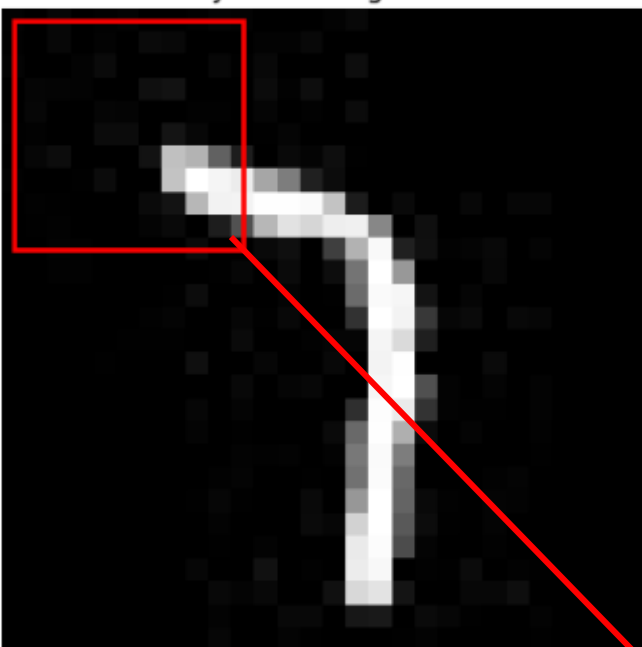
But for a computer, an image is not a picture;

IT'S DATA, represented by matrix of numerical value.



At glance, we see number 7

IMAGE



Representation of top left in Matrix Format:

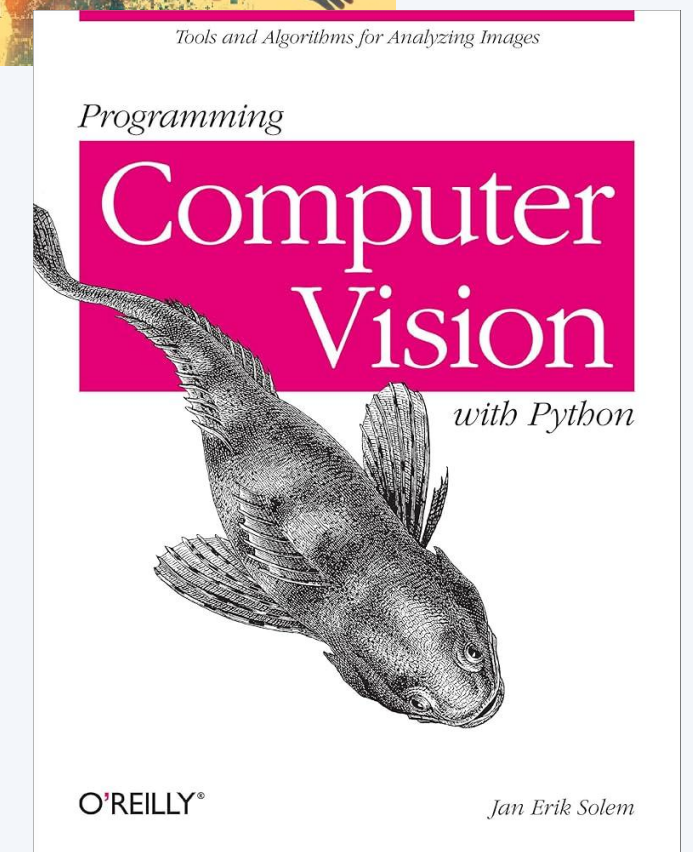
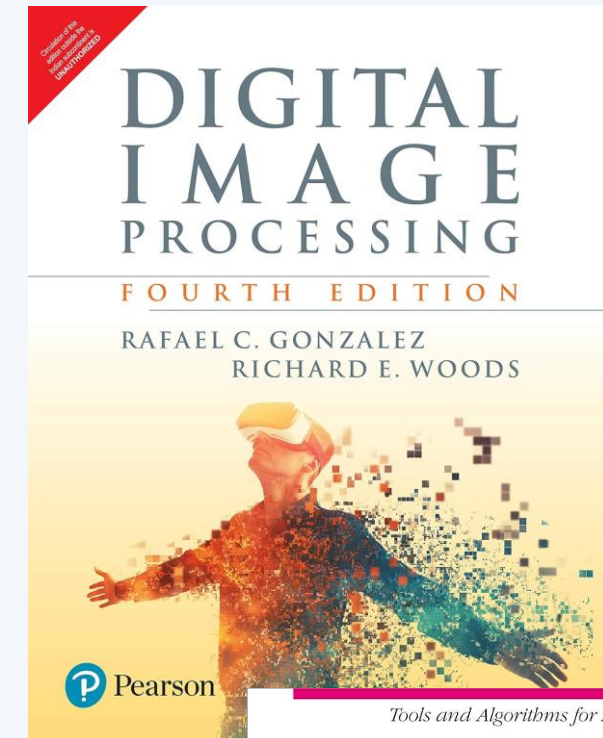
[	3	0	7	0	2	4	0	0	2	5	3]
[	2	0	7	0	3	0	10	8	0	0	0]
[	4	0	0	3	10	0	0	0	0	7	1]
[	0	5	4	3	0	0	15	18	0	0	0]
[	0	6	0	0	5	4	0	0	2	2	0]
[	1	2	0	0	11	11	0	20	7	0	0]
[	0	6	12	0	0	0	18	192	180	98	29]
[	2	0	0	1	11	0	0	196	255	245	236]
[	0	2	1	0	0	0	10	19	183	242	244]
[	0	1	2	0	0	0	4	9	0	29	82]
[	0	0	3	2	0	0	0	0	10	0	0]

Expert Definition



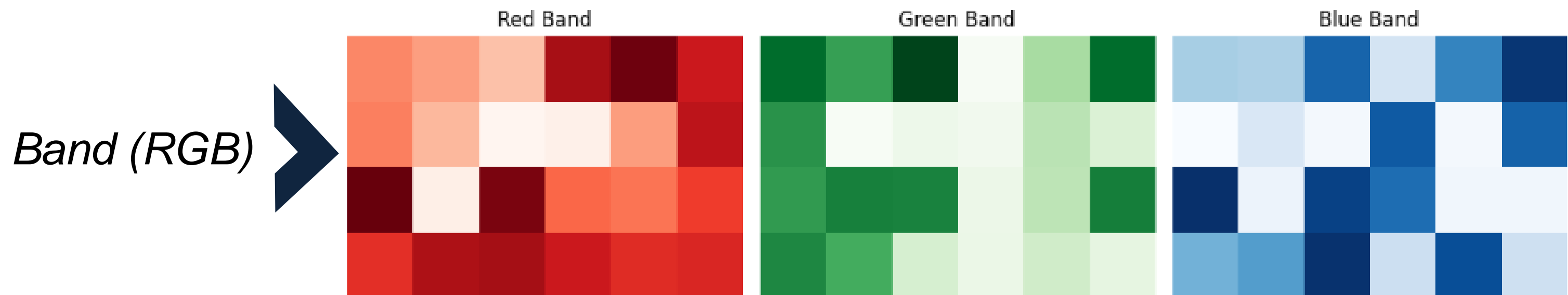
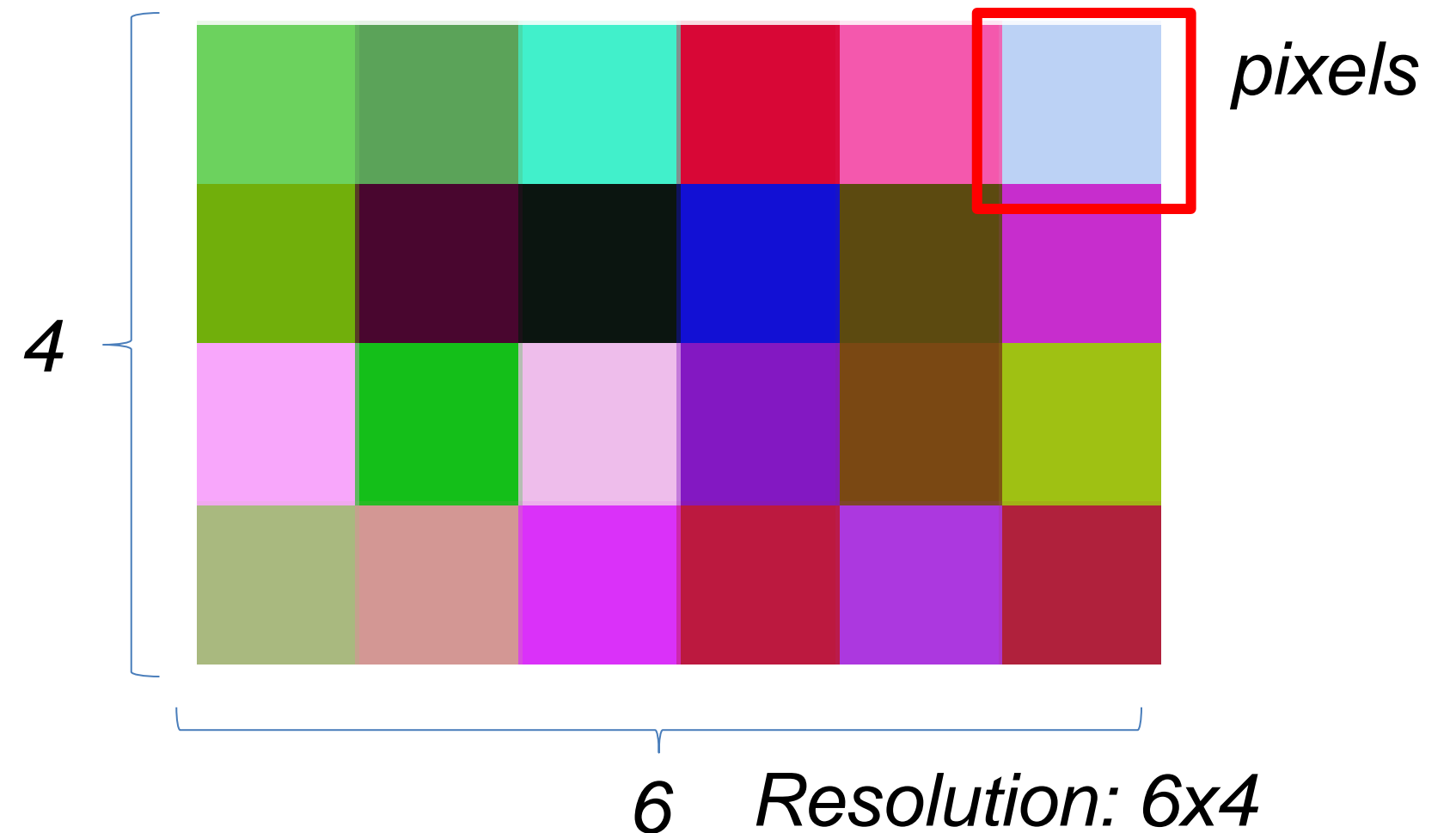
In the context of computer vision, an image is:

- *“A two-dimensional function $f(x,y)$, where x and y are spatial coordinates, and the amplitude of f at any pair (x,y) is called the intensity or gray level or pixels of the image at that point.”*
— Gonzalez & Woods, "Digital Image Processing", 4th Edition, Pearson, 2018
- *“An image is a matrix of pixel values that can be processed to extract features, objects, or other interpretable data.”*
— Solem, "Programming Computer Vision with Python", O'Reilly, 2012



Pixels, Resolution, Band

- **Pixels** is smallest unit of picture that compose an image.
- **Resolution** is size of the image, represented with *length x wide*.
- **Band** is layer of information of image, sometime called “channel”, eg: RGB.





You
“CARE”
What you
“SEE”

“SEEING”



In human terms, seeing means more than receiving light — it implies **understanding**. Our brains interpret the light signals captured by our eyes **to recognize objects, motion, depth, and patterns**.

In computer vision, "seeing" is the **process of converting raw image data into high-level understanding** — for example, detecting a face, identifying a car, or interpreting a handwritten digit.





● ● ●
**Try to
look this
image in
20
seconds**

CARE-01



Which of the following categories best describes the picture?



- *Group picture*
- *Scenery*
- *Environment*
- *Building*
- *People*
- *Garden*

CARE-01



Which of the following categories best describes the picture?



- *Group picture*
- *Scenery*
- *Environment*
- *Building*
- *People*
- *Garden*

*Here, we attempt to “**classify**” the images based on our “**knowledges**”.*

CARE-02



What objects are shown in the picture?

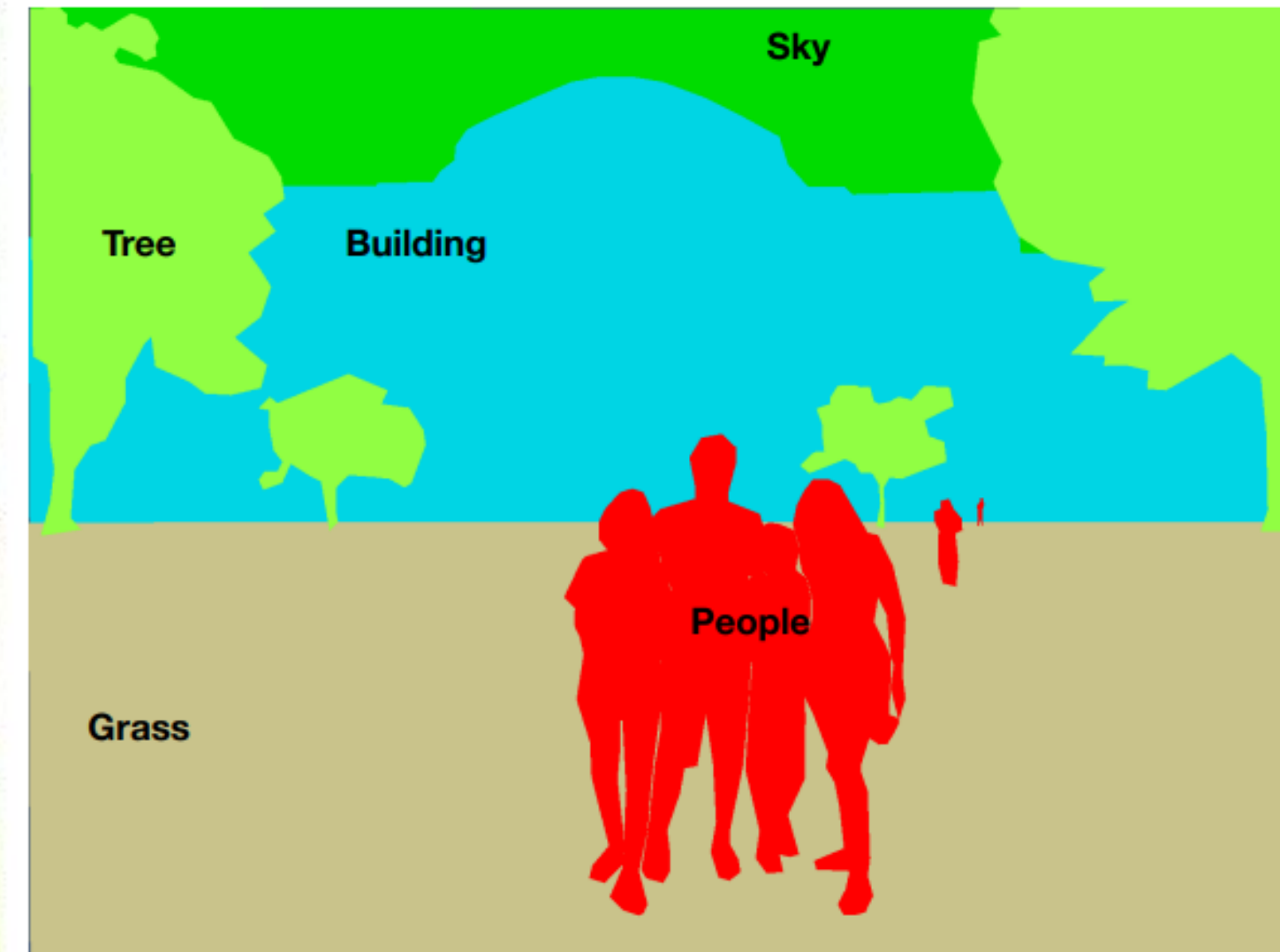


- *Building*
- *People*
- *Sky*
- *Tree*
- *Grass*

CARE-02



What objects are shown in the picture?



*Here, we attempt to “**segment**” the “object” based on our “knowledges”.*

CARE-03



How many people are shown ?



CARE-03



How many people are shown ?



*Here, we attempt to “**detect**” the “people” and “count”*

CARE-04



Do you know him?



CARE-04



Do you know him?



*Here, we attempt to “recognise” the
“man”*

CARE-04



Could you tell me about this picture?



CARE-04



Could you tell me about this picture?



Group of people standing in front of building to take group picture during vacation at noon.

*Here, we attempt to “**narrate**” the picture*

CARE-05



Could you imagine picture of “people standing in front of building at noon”?

CARE-05



Here, we attempt to “generate” the picture

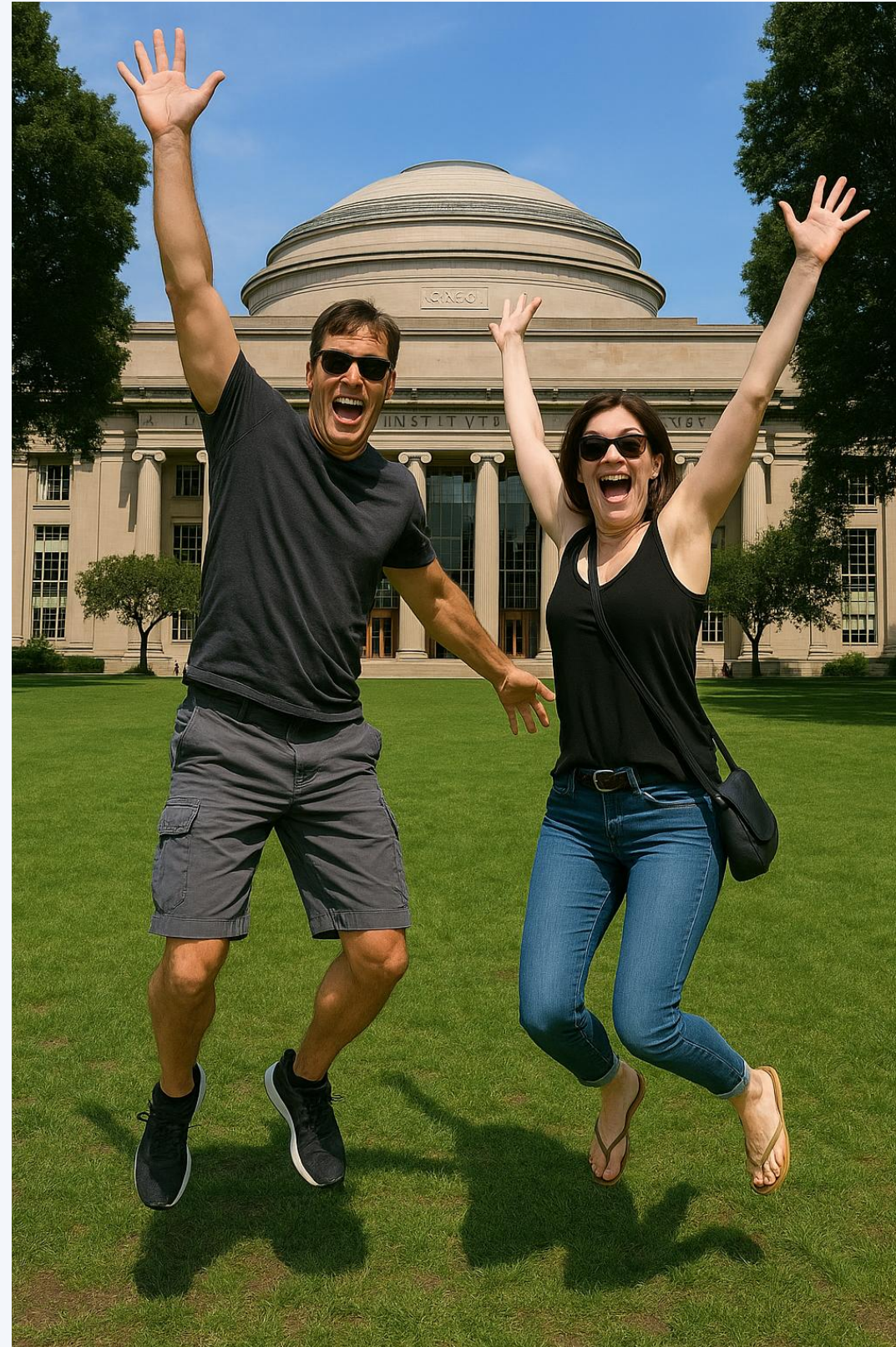
CARE-06



What will happen next?



CARE-06



The children left and the parent take a group picture.

Here, we attempt to “predict/forecast” the next one.

Real Implementation



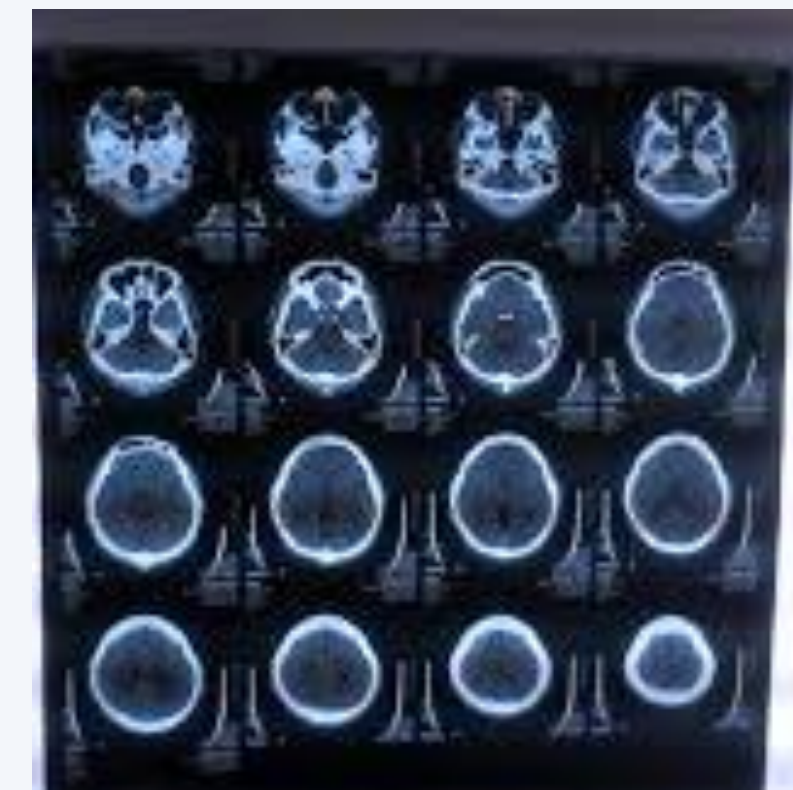
1. Yield Estimation and Fruit Counting

1. Vision systems on robots or phones count apples, grapes, or wheat heads to estimate yield.



1. Tumor Detection in MRI and CT Scans

1. Medical systems use image segmentation to automatically detect brain tumors, lung nodules, or cancers in MRI/CT images.



Translation for (20,20)



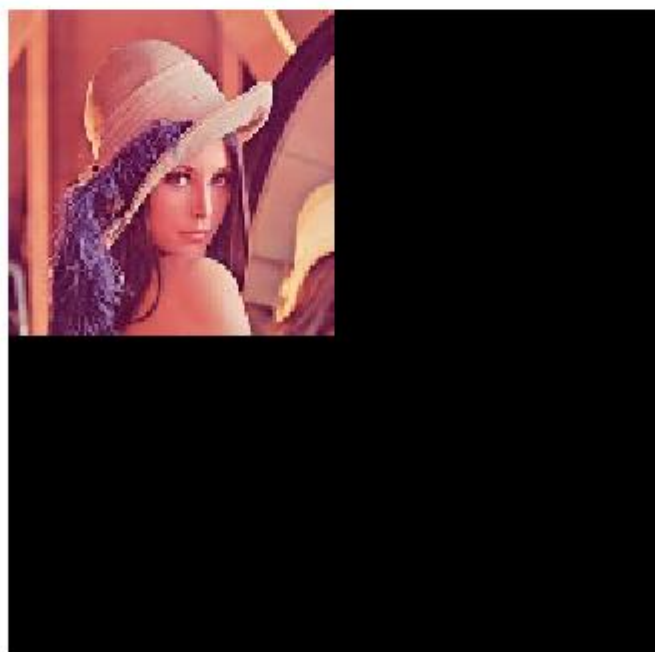
Original Image



Rotation for 45 degree ACW Around Image Center



Scaling for (2,2)



Shearing for (0.5,0.5)



Tweaking Image...

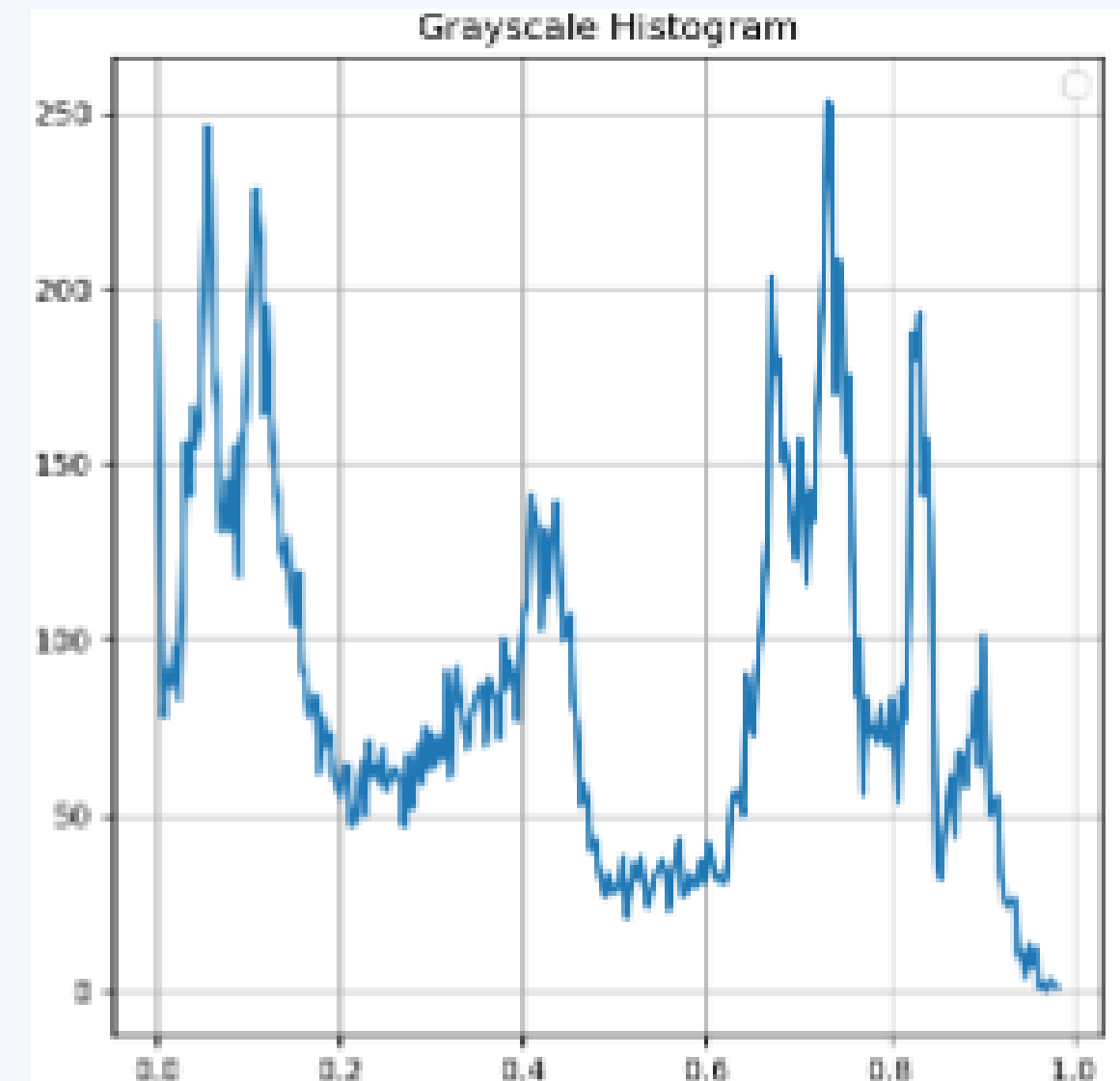
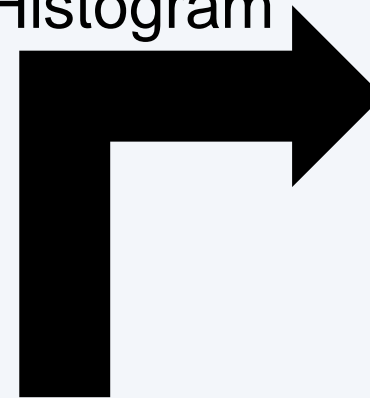


scikit-image is a collection of algorithms for image processing. It is available free. (<https://scikit-image.org/>)

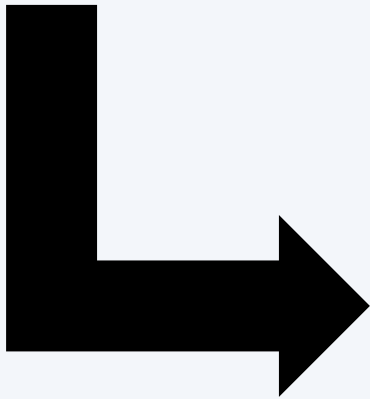
Play with Grayscale Image



Histogram



What is the **histogram** say?
Any idea?


`color.rgb2gray(image)`

Remove the Background



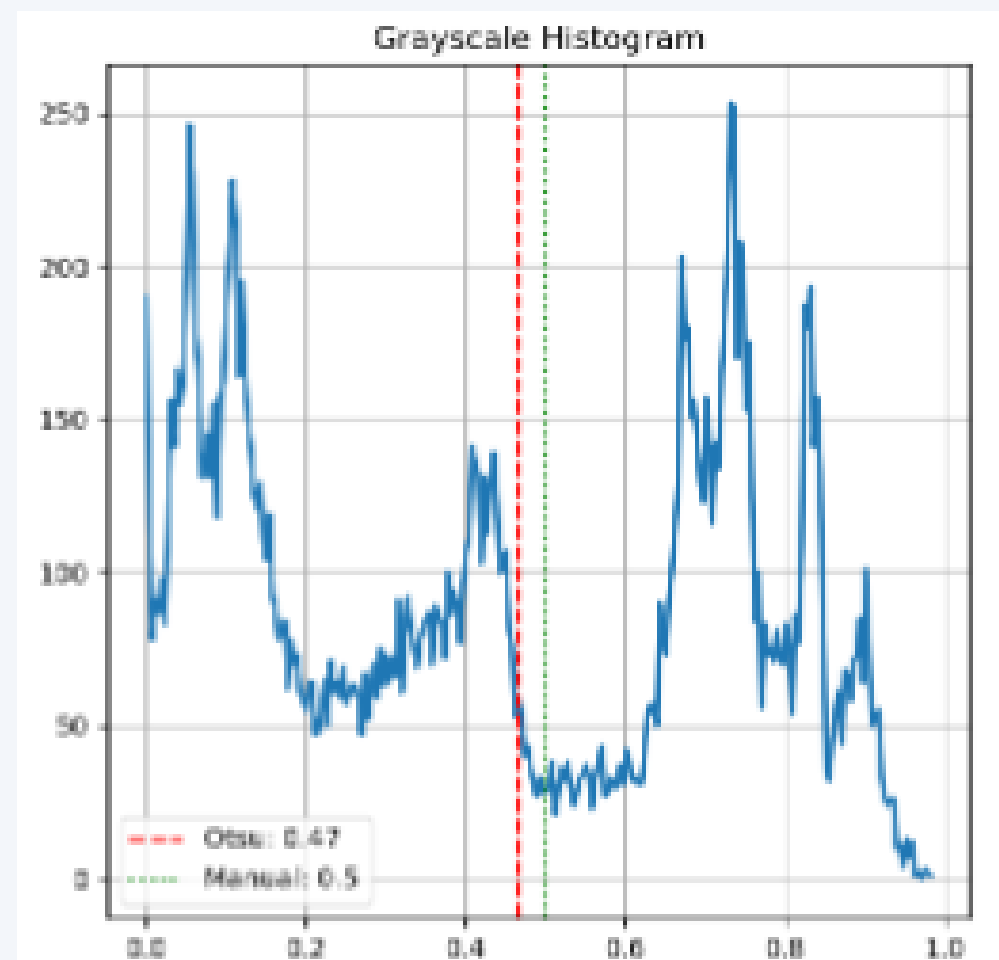
Otsu Thresholding

Otsu's method finds the **optimal threshold value** that minimizes the **intra-class variance** (i.e., the variance within the foreground and background classes) or equivalently **maximizes the inter-class variance** (i.e., the variance between the two classes).



Manual Thresholding

Determine the threshold **manually**.



Resize, Shift, Flip, Rotate



Resize

Shifting



Flipping

Rotate

Convolution (Spatial Filtering) ●●●

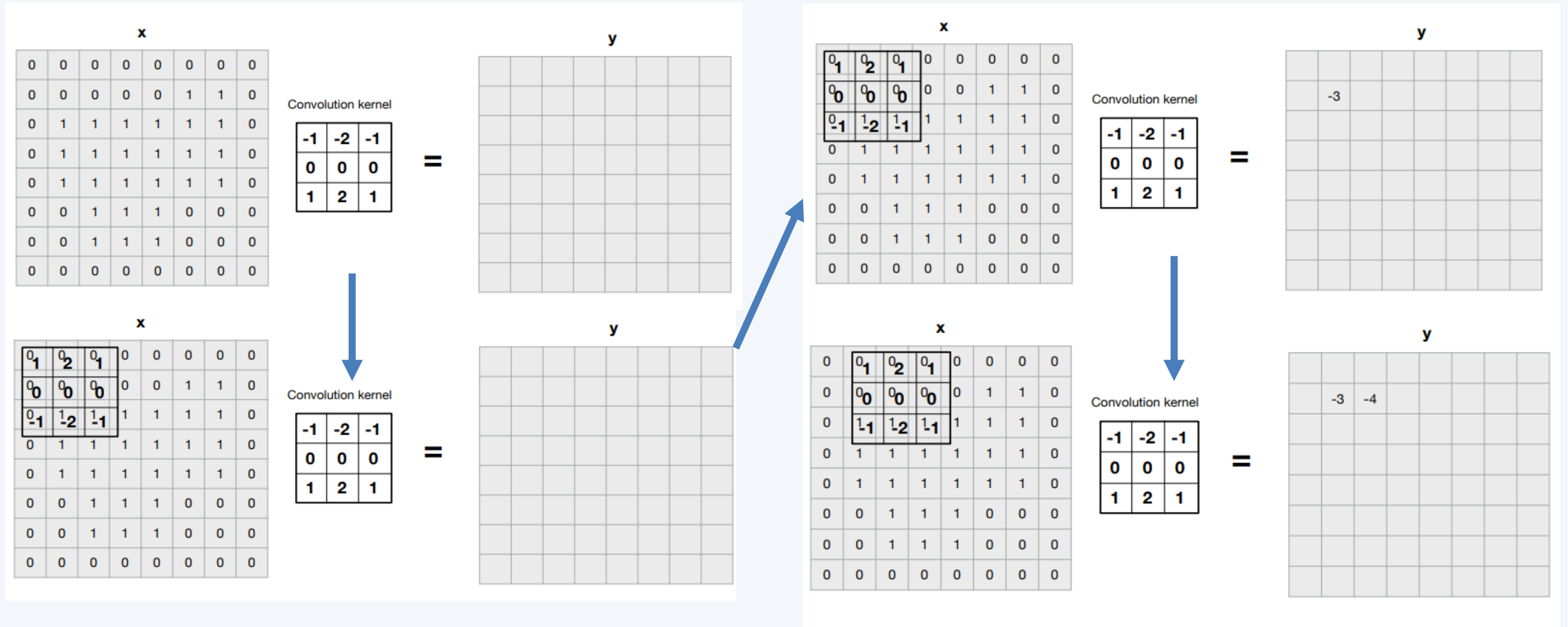
🎯 What is Convolution?

Convolution is a mathematical operation where a small matrix (called a **kernel** or **filter**) is passed over an image, modifying its pixel values based on their neighbors.

🧠 Intuition:

- Think of convolution like **looking at the image through a tiny window** (e.g. 3×3).
- For each pixel, we **compute a weighted sum** using the kernel and assign the result to the output pixel.

Convolution



Take attention! The kernel is inverted, and the result is sum of pair-wise multiplication.

Convolution



x							
0	0	0	0	0	0	0	0
0	0	0	0	0	1	1	0
0	1	1	1	1	1	1	0
0	1	1	1	1	1	1	0
0	1	1	1	1	1	1	0
0	0	1	1	1	0	0	0
0	0	1	1	1	0	0	0
0	0	0	0	0	0	0	0

Convolution kernel

-1	-2	-1
0	0	0
1	2	1

=

?							
	-3	-4	-4	-4	-4	-3	
	-3	-4	-4	-3	-1	0	
	0	0	0	0	0	0	
	2	1	0	1	3	3	
	2	1	0	1	3	3	
	1	3	4	3	1	0	

x							
1	2	1	0	0	0	0	0
0	0	0	0	0	0	0	0
-1	0	0	0	0	1	1	0
	0	1	1	1	1	1	0
	0	1	1	1	1	1	0
	0	1	1	1	1	1	0
	0	0	1	1	1	0	0
	0	0	1	1	1	0	0
	0	0	0	0	0	0	0

Convolution kernel

-1	-2	-1
0	0	0
1	2	1

=

0							
	-3	-4	-4	-4	-4	-3	
	-3	-4	-4	-3	-1	0	
	0	0	0	0	0	0	
	2	1	0	1	3	3	
	2	1	0	1	3	3	
	1	3	4	3	1	0	

Diagram illustrating the convolution process with a 3x3 kernel and a 7x7 input matrix x.

Input matrix x:

1	2	1	0	0	0	0	0
0	0	0	0	0	0	1	1
-1	0	0	0	0	1	1	0
	0	1	1	1	1	1	0
	0	1	1	1	1	1	0
	0	1	1	1	1	1	0
	0	0	1	1	1	0	0
	0	0	1	1	1	0	0
	0	0	0	0	0	0	0

Convolution kernel:

-1	-2	-1
0	0	0
1	2	1

=

Output matrix y:

?							
	-3	-4	-4	-4	-4	-3	
	-3	-4	-4	-3	-1	0	
	0	0	0	0	0	0	
	2	1	0	1	3	3	
	2	1	0	1	3	3	
	1	3	4	3	1	0	

Take attention! The kernel is inverted, and the result is sum of pair-wise multiplication.

Convolution Example



Original



Blur

```
array([[0.11111111, 0.11111111, 0.11111111],
       [0.11111111, 0.11111111, 0.11111111],
       [0.11111111, 0.11111111, 0.11111111]])
```

Blurred



Sharpening

```
array([[ 0, -1,  0],
       [-1,  5, -1],
       [ 0, -1,  0]])
```

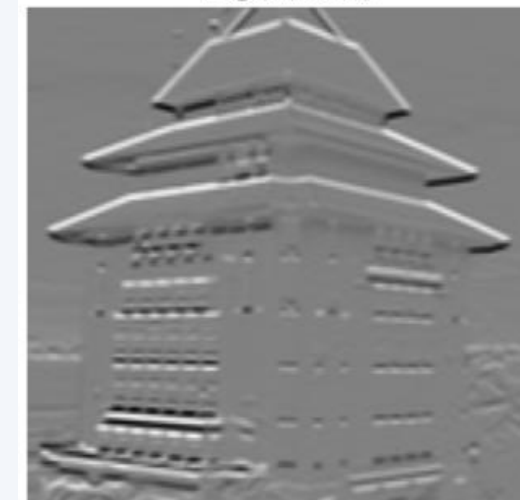
Sharpened



Edge Detection (Sobel)

```
array([[ -1,  -2,  -1],
       [  0,   0,   0],
       [  1,   2,   1]])
```

Edges (Sobel)



More Filtering...



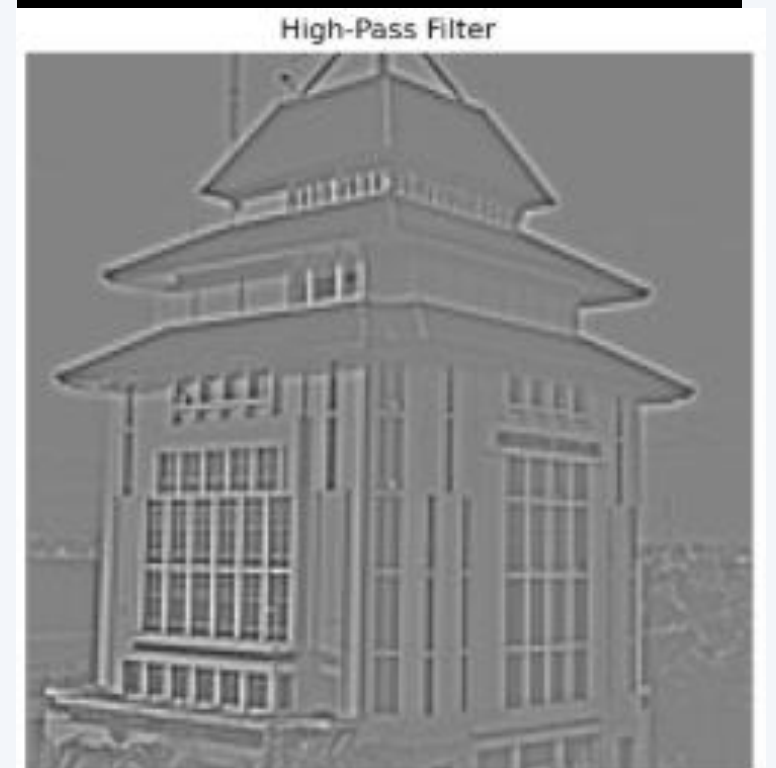
Gaussian Filtering (Smoothing)



Laplacian



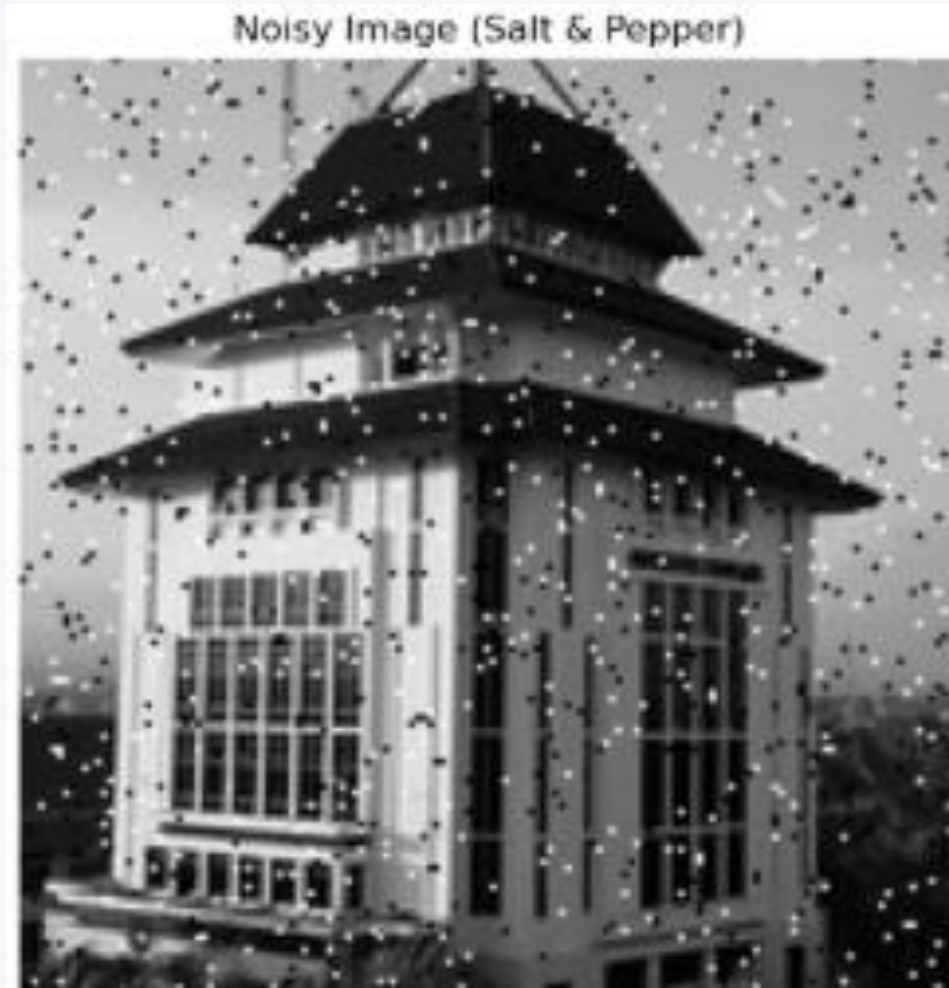
High-Pass Filter



More Filtering...



Noisy (Salt & Pepper)



Median Filtering



LET'S DO FUN



*Let's try segmenting the
object using simple
clustering procedure
(K-means)!*



PIPELINE



1. *Load the images*
2. *Create a data frame with each column represent the band*
3. *Do clustering using k -means (attempt using 3, 5, 7 cluster)*

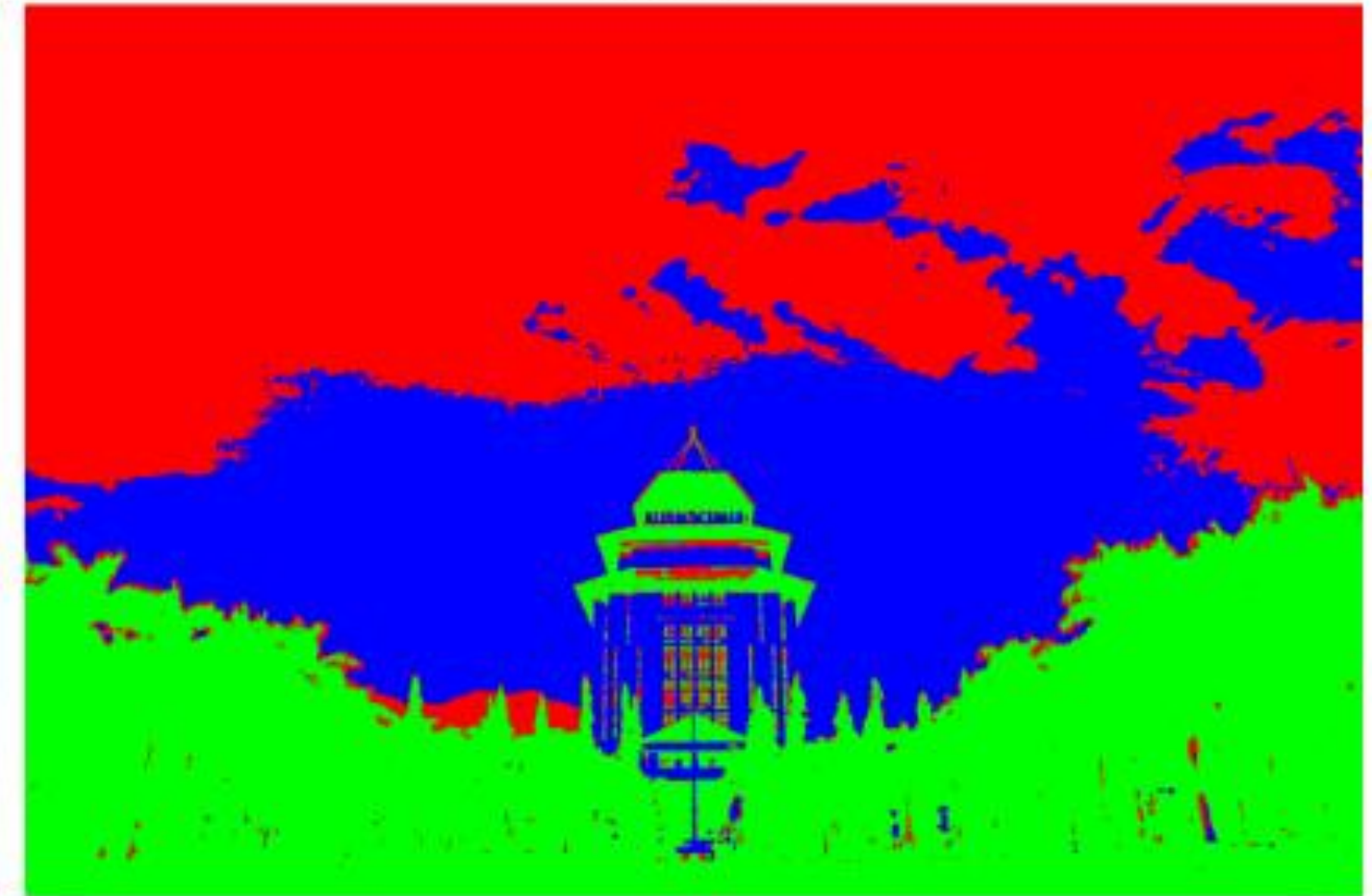
● ● ● —

RESULT

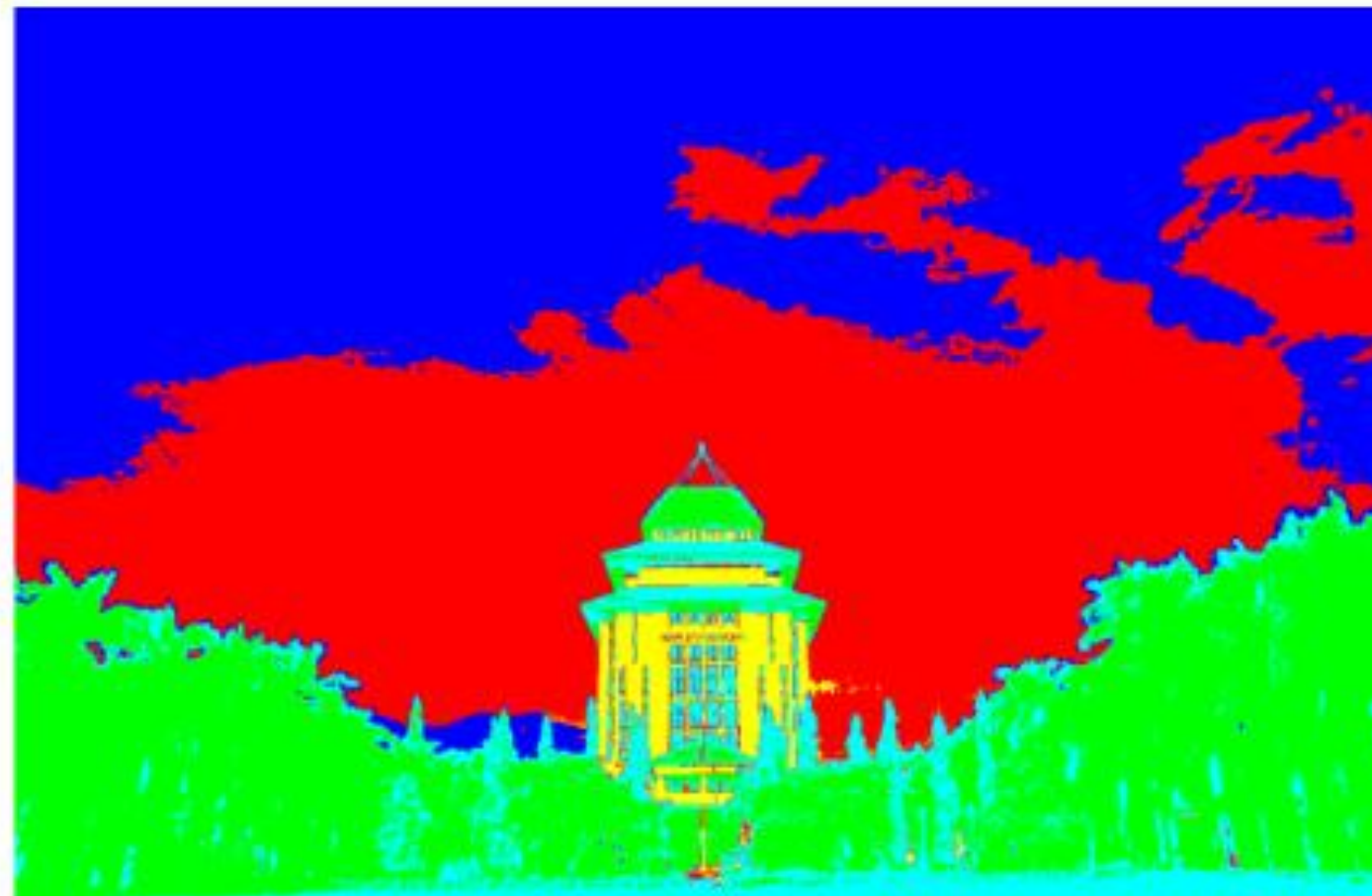
Original Image



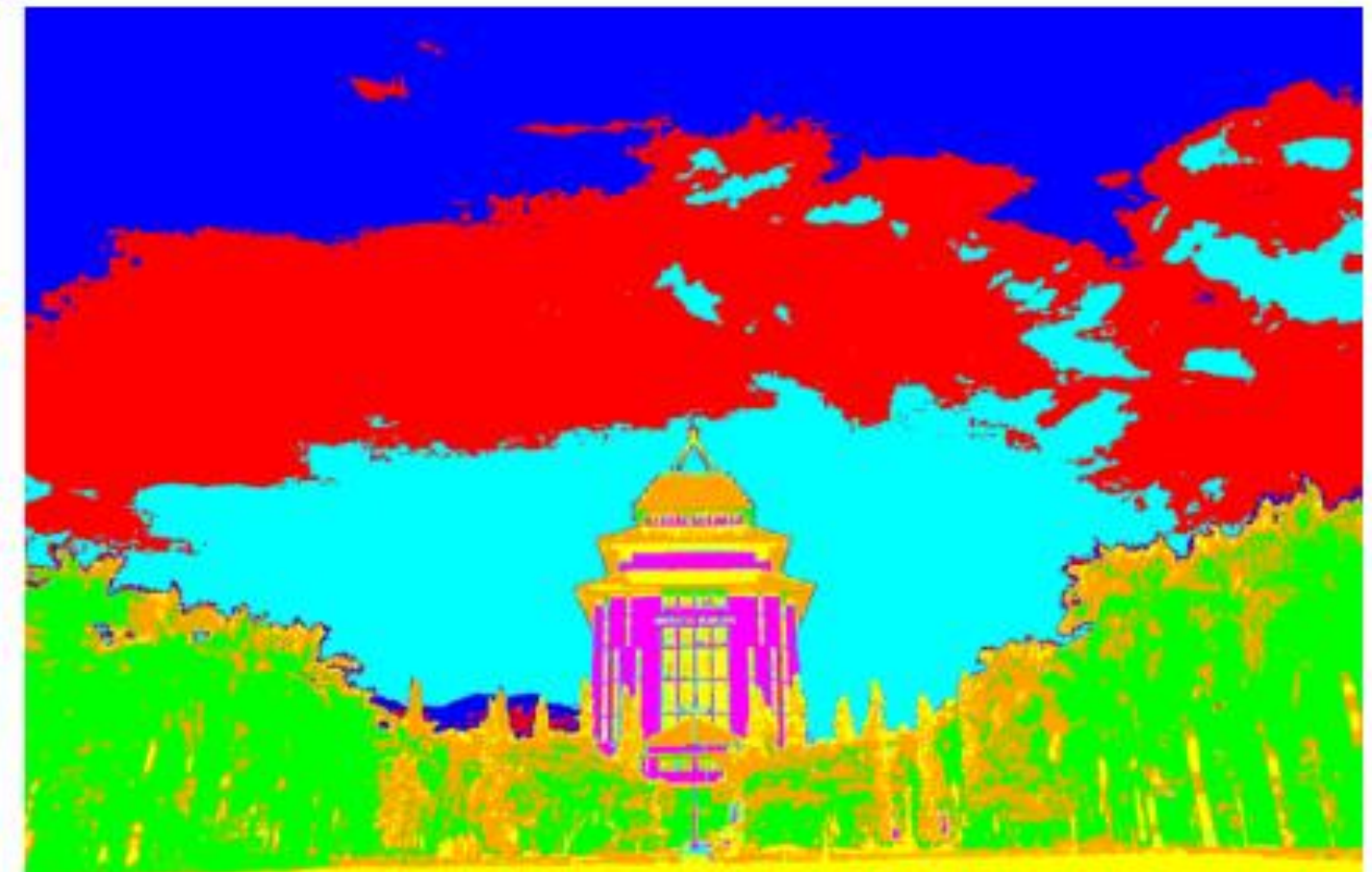
3 Clusters



5 Clusters



7 Clusters



THANKS....



Real Application



150



150

Resolution: 150 x 150



Dilation and Erosion



Dilation
(Expand White Area)

Erosion
(Reduce White Area)



Compression



Compression can be made using the Fourier Transformation.
We change the data into Frequency domain and conduct the reconstructed one.

