# Adaptive Image Denoising based on Edge Detection


## Supervised by

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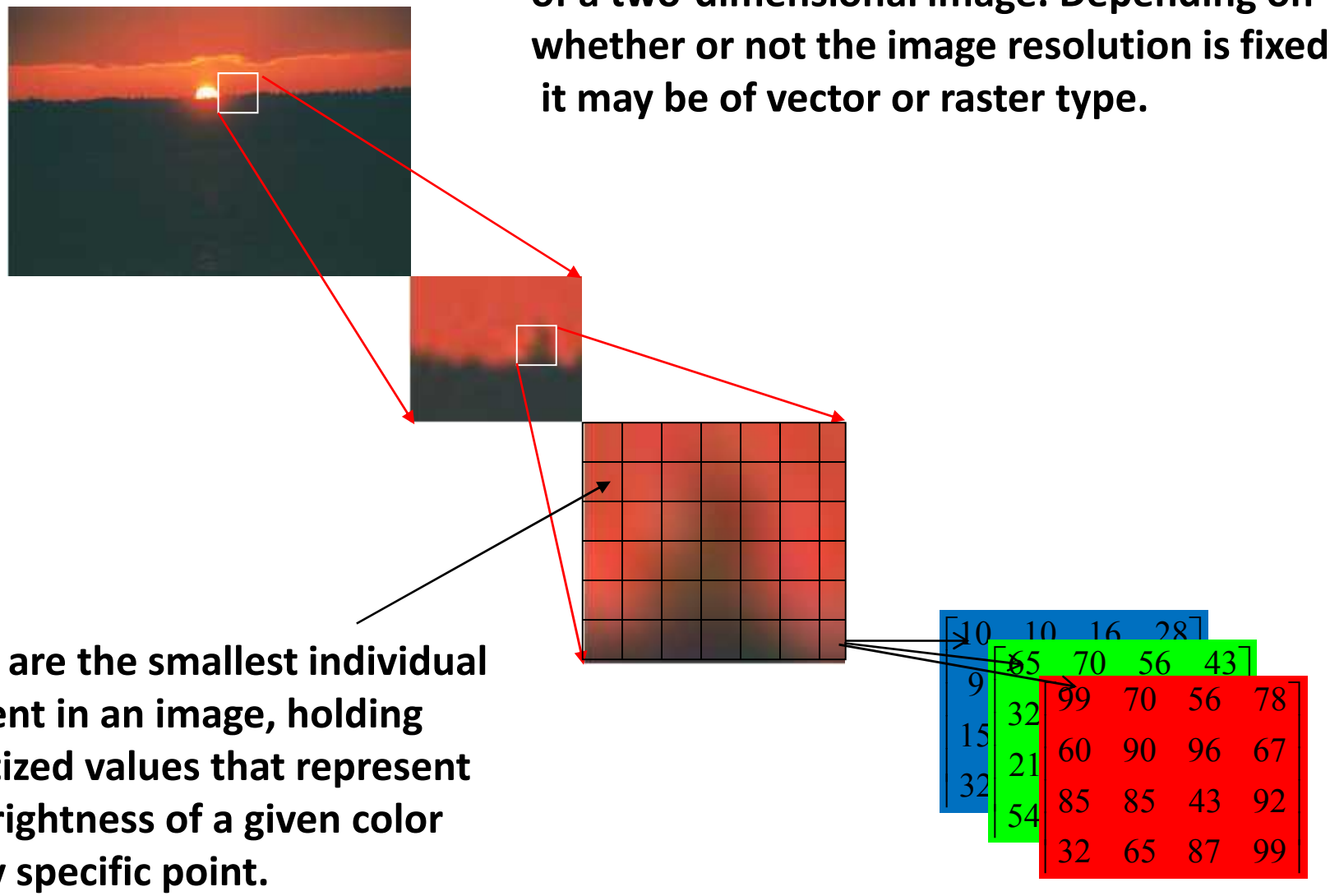
# Implementation

- A criteria for sorting out pixels affected by noise
- Algorithms based on that criteria.

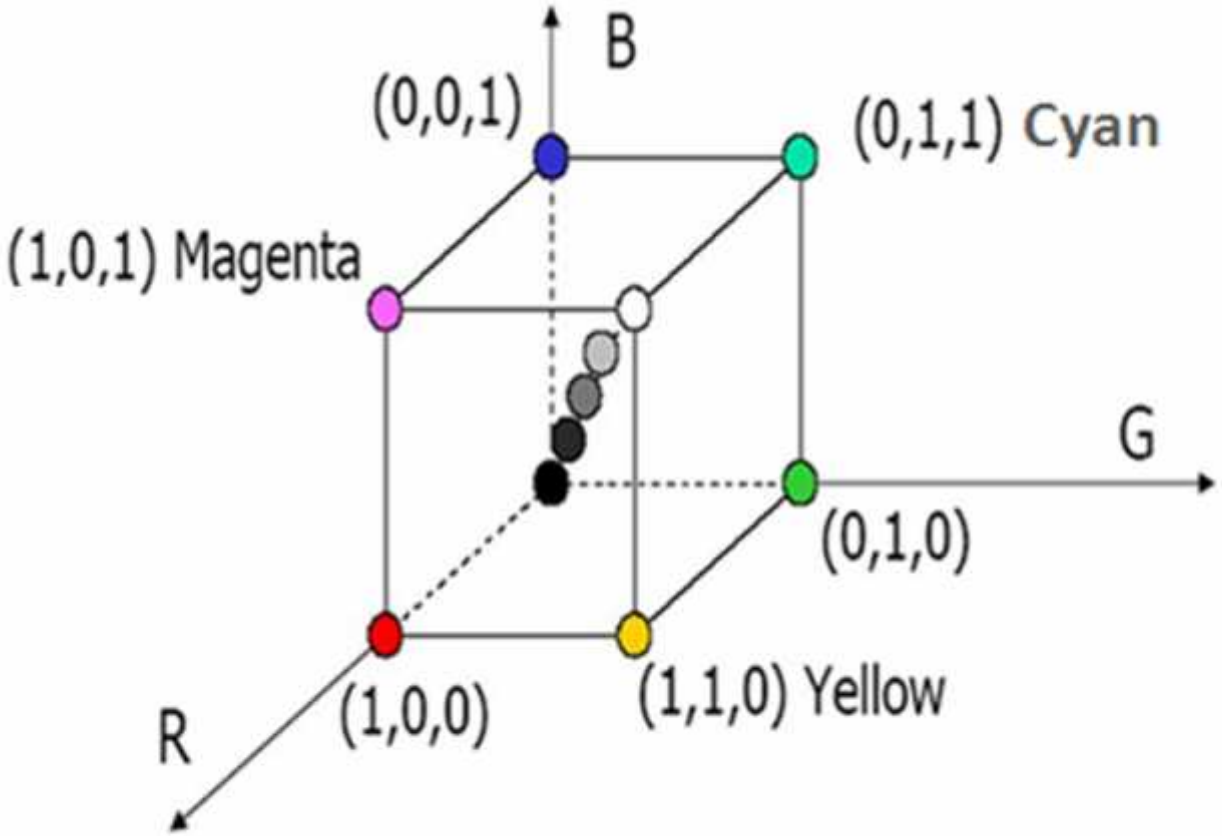
## *Digital Image :*

**A digital image is a numeric representation of a two-dimensional image. Depending on whether or not the image resolution is fixed, it may be of vector or raster type.**




**Pixels are the smallest individual element in an image, holding quantized values that represent the brightness of a given color at any specific point.**

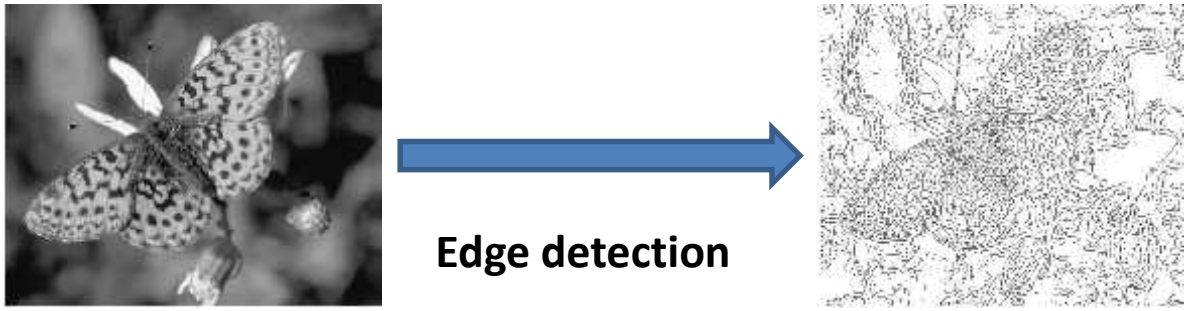
## *RGB Color Model :*



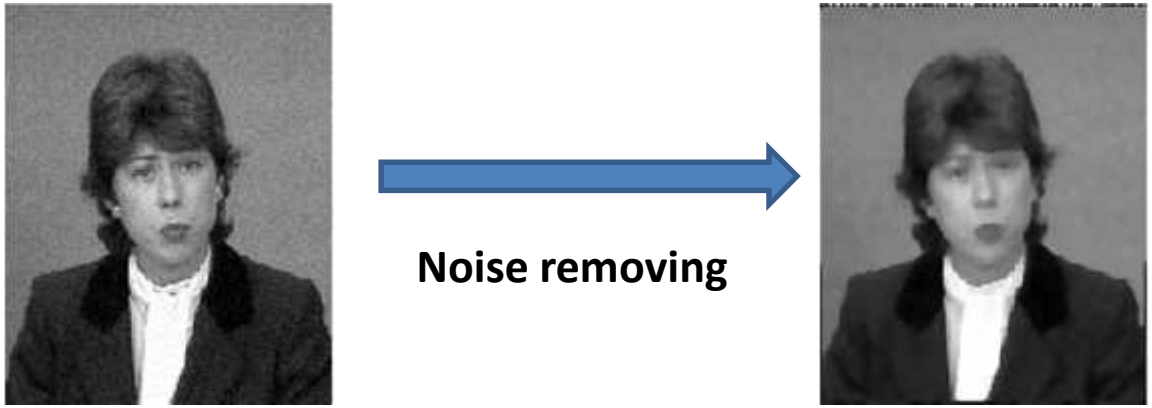

Color cube

## *Digital Image Processing :*

**Digital image processing is the use of computer algorithms to perform image processing on digital images.**




**Before processing** **After processing**




**Before processing** **After processing**

## *Image with noise :*

Image noise is the random variation of brightness or color information in images produced by the sensor and circuitry of a scanner or digital camera.

Original

Salt and pepper noise

Contains random occurrences of black and white pixels

Impulse noise

Gaussian noise

Variations in intensity

## *Image Denoising :*

**Image denoising refers to the recovery of a digital image that has been contaminated by noise which arises during image acquisition (digitization) or transmission.**

**Image with noise**

**Denoising Algorithm**

**Image after denoising**

## *Spatial Domain :*

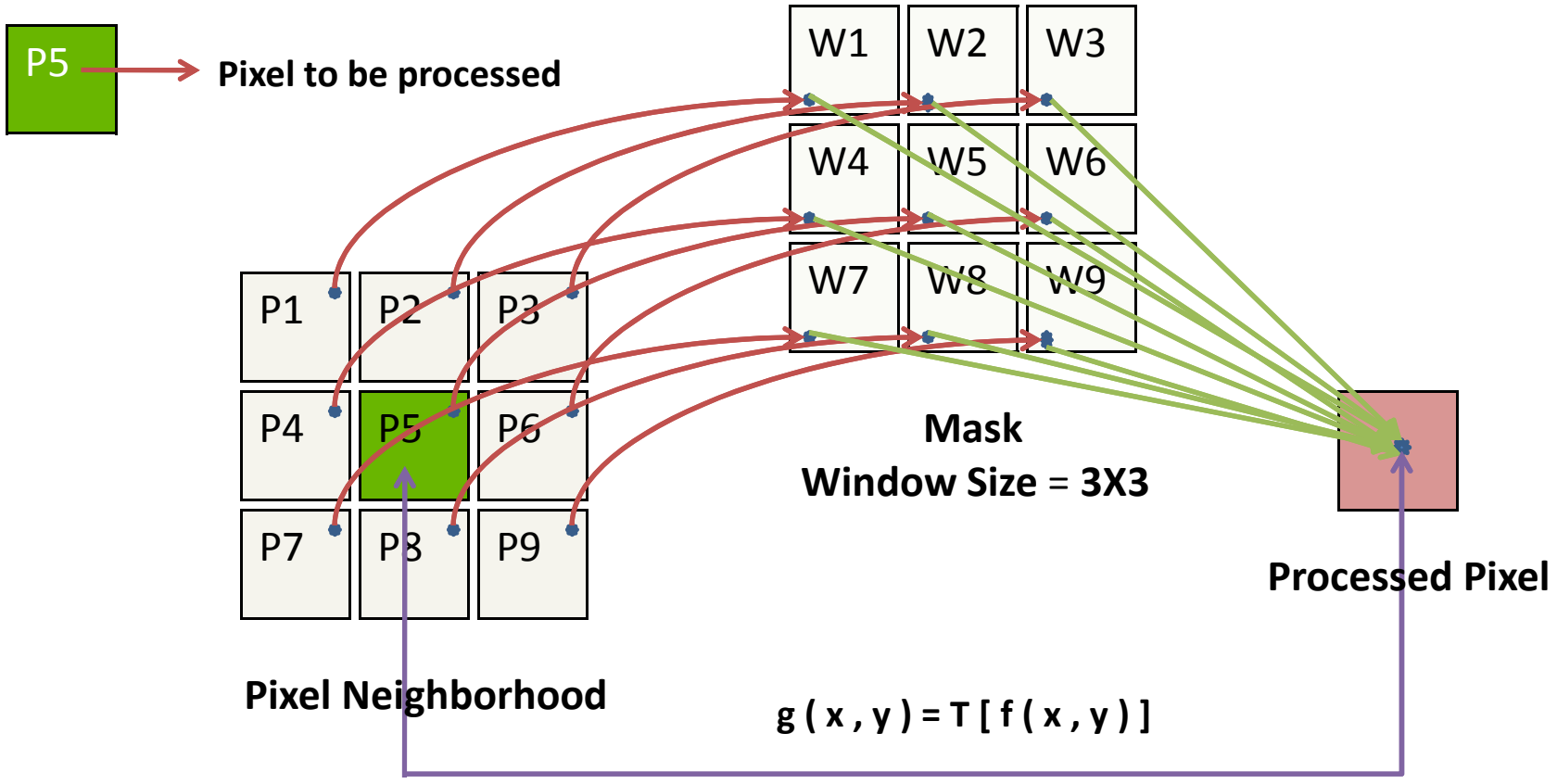
**Spatial domain methods operate directly on pixels unlike the frequency domain, denoted by the expression.**

**g ( x , y ) = T [ f ( x , y ) ] ;**

**f(x, y) : input image**

**g(x, y) : processed image**

***T* : operator on *f* over neighborhood of (x, y).**



# Arithmetic Mean Filter :

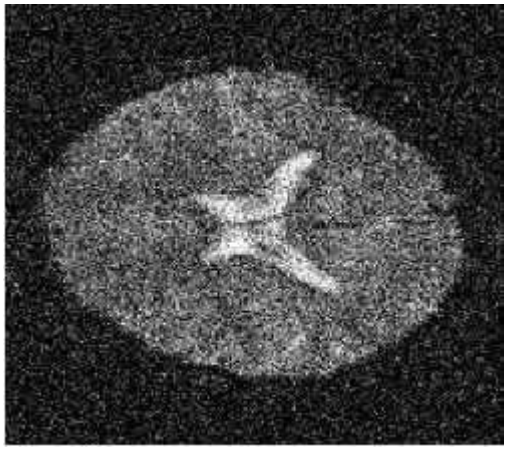
**Arithmetic Mean Filter :**

**Summation of neighborhood pixel's color values**

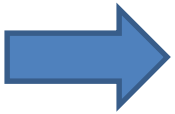
**Window area**

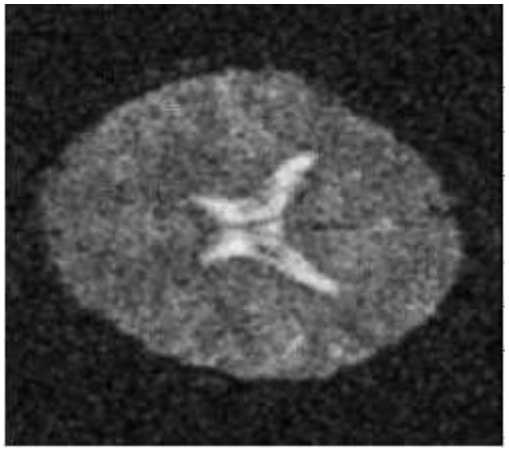
| | | |
|---|---|---|
| 1/9 | 1/9 | 1/9 |
| 1/9 | 1/9 | 1/9 |
| 1/9 | 1/9 | 1/9 |

Fig:3×3 averaging kernel used in mean filtering



**Noisy image**





**Filtered image**

# *Advantages and Disadvantages of Mean Filter:*

### *Advantages :*

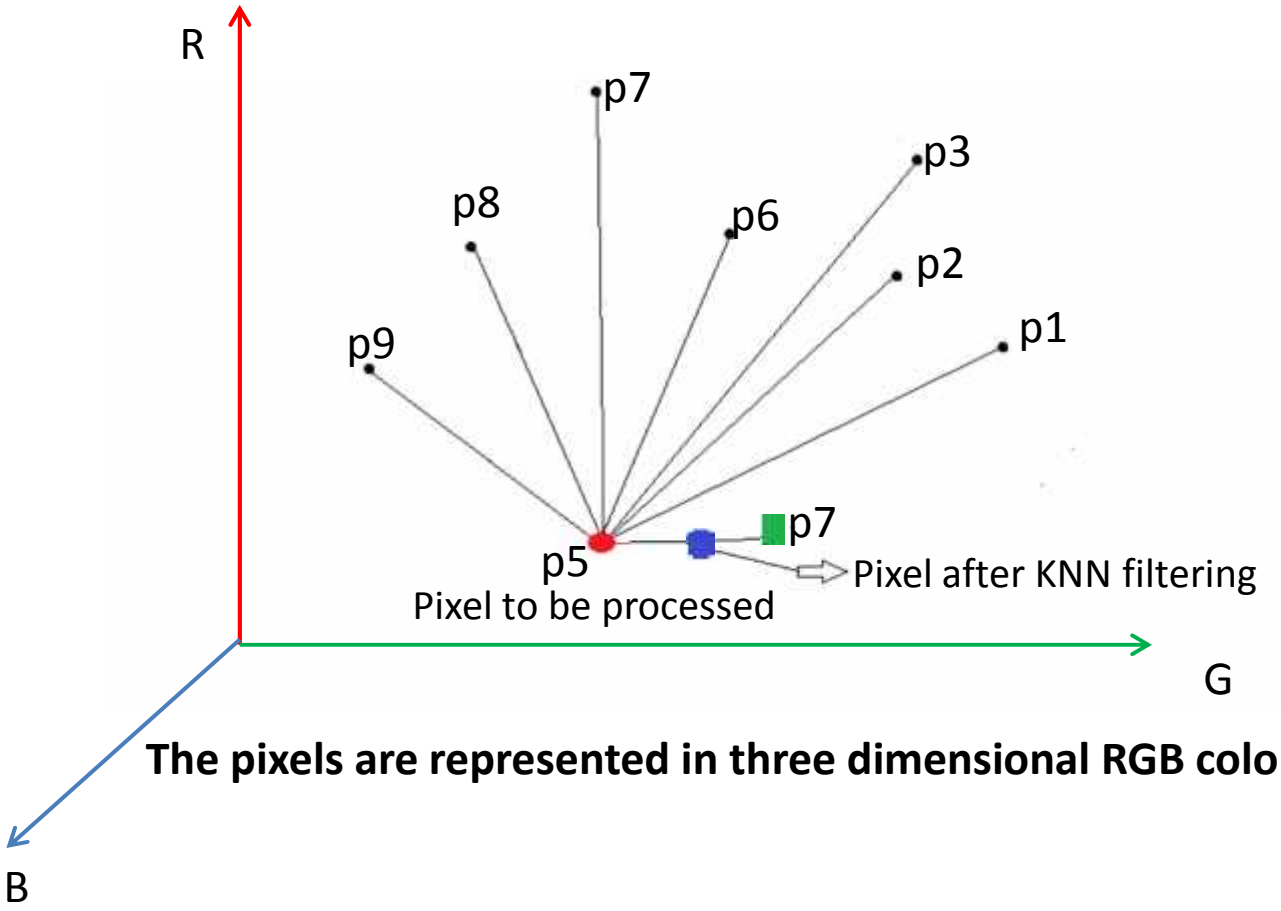
- A mean filter simply smoothens local variations in an image. Noise is reduced as a result of blurring.

### *Disadvantages :*

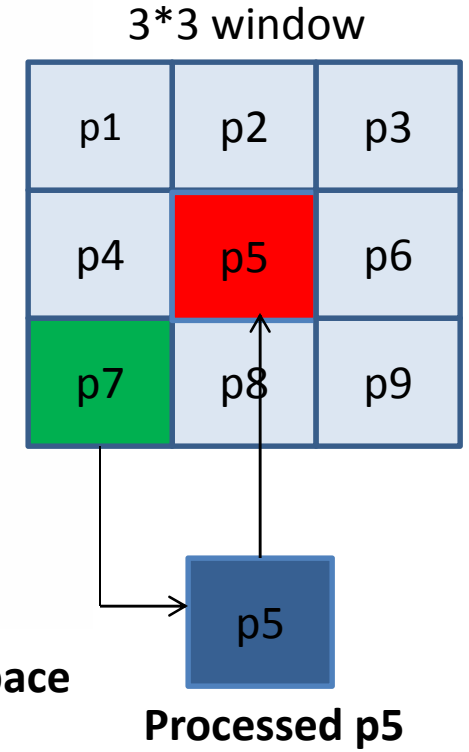
- A single pixel with a very unrepresentative value can significantly affect the mean value of all the pixels in its neighborhood.
- When the filter neighborhood straddles an edge, the filter will interpolate new values for pixels on the edge and so will blur that edge. This may be a problem if sharp edges are required in the output.

# *K-Nearest Neighbor Algorithm :*

**KNN algorithm replaces the base or selected pixel value with the average value of base pixel and its closest neighbor pixel value ; when K=1.**




**The pixels are represented in three dimensional RGB color space**

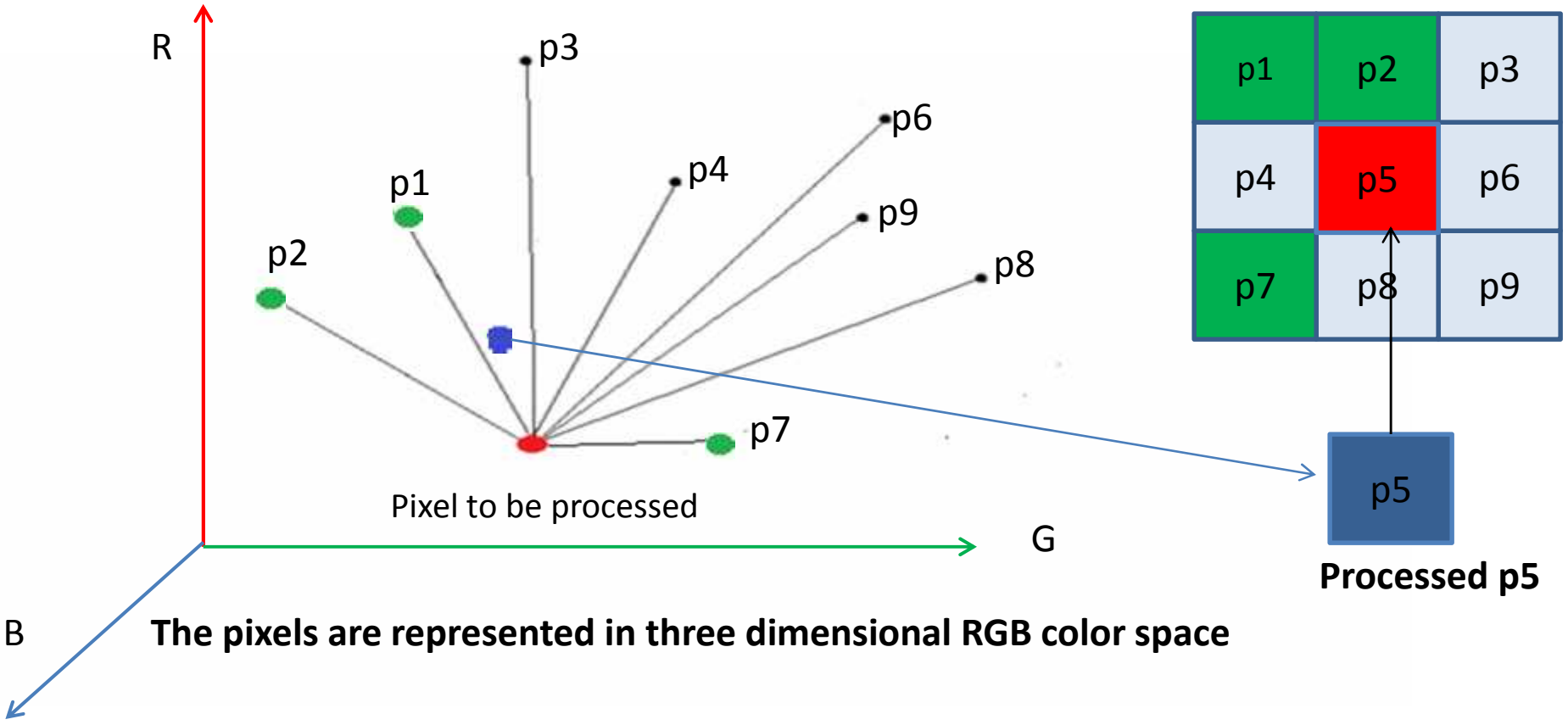



**Processed p5**

## *K-Nearest Neighbor Algorithm :*

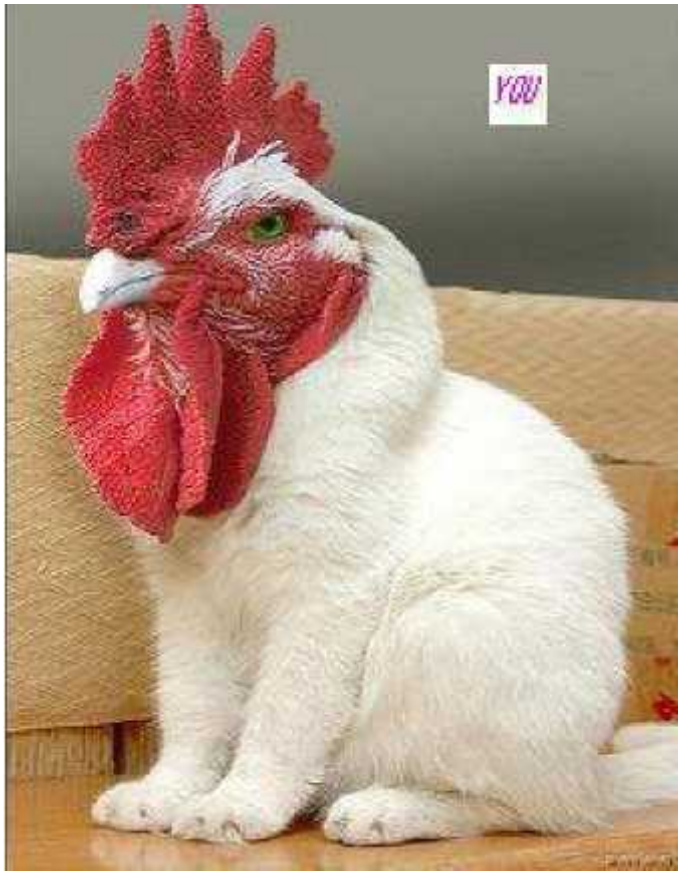
**When K= n, KNN algorithm replaces the color components of the original pixel with the average values of the color components of the nearest n neighbors and its own components .**

**Here in this example n=3**

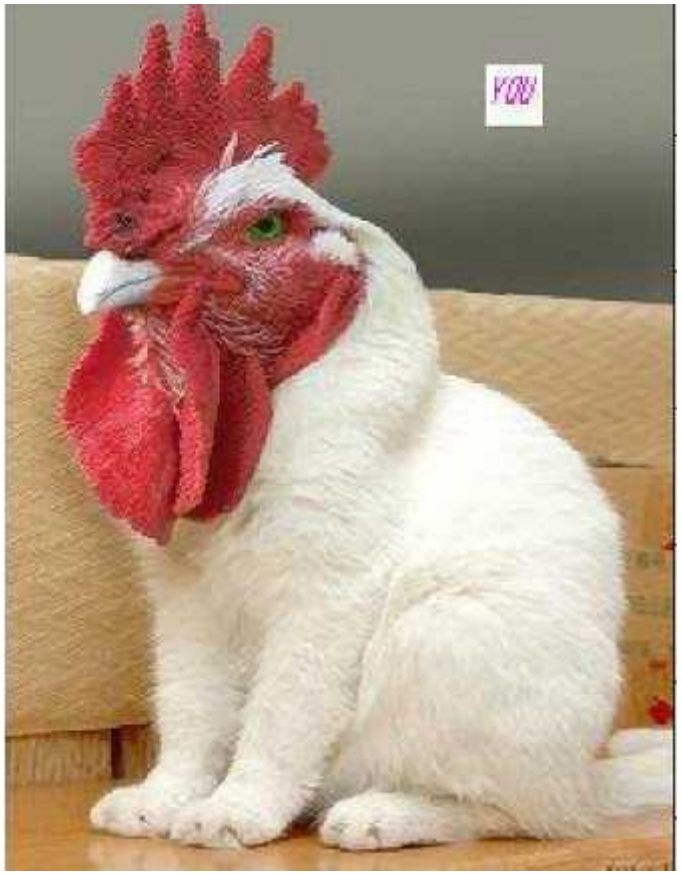



**The pixels are represented in three dimensional RGB color space**

## *Effects of K-NN :*

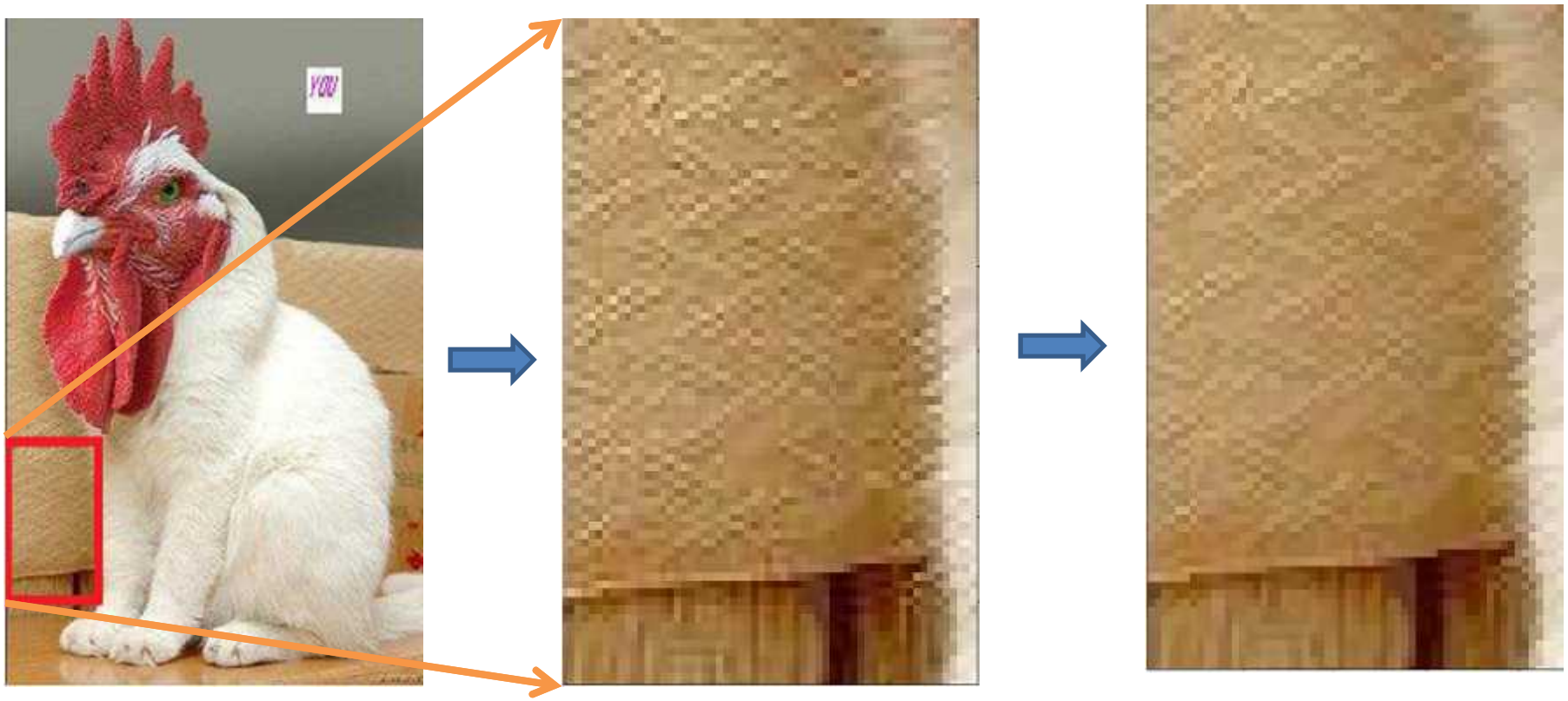


**Before processing**



**After processing**

## *Effects of K-NN :*



**Before processing**

**After processing(KNN)**

# *Advantages and Disadvantages of K-NN:*

## *Advantages :*

- **Fast and Efficient**
- **Performs better than many algorithms like mean filtering, median filtering etc. in terms of image quality.**

## *Disadvantages :*

- **Changes each and every pixel even those not affected by noise to an extent not desirable**
- **Drastically damages minute objects, those containing few pixels**
- **Pixels at the edges of different objects get their colors blended with those of the neighboring objects**

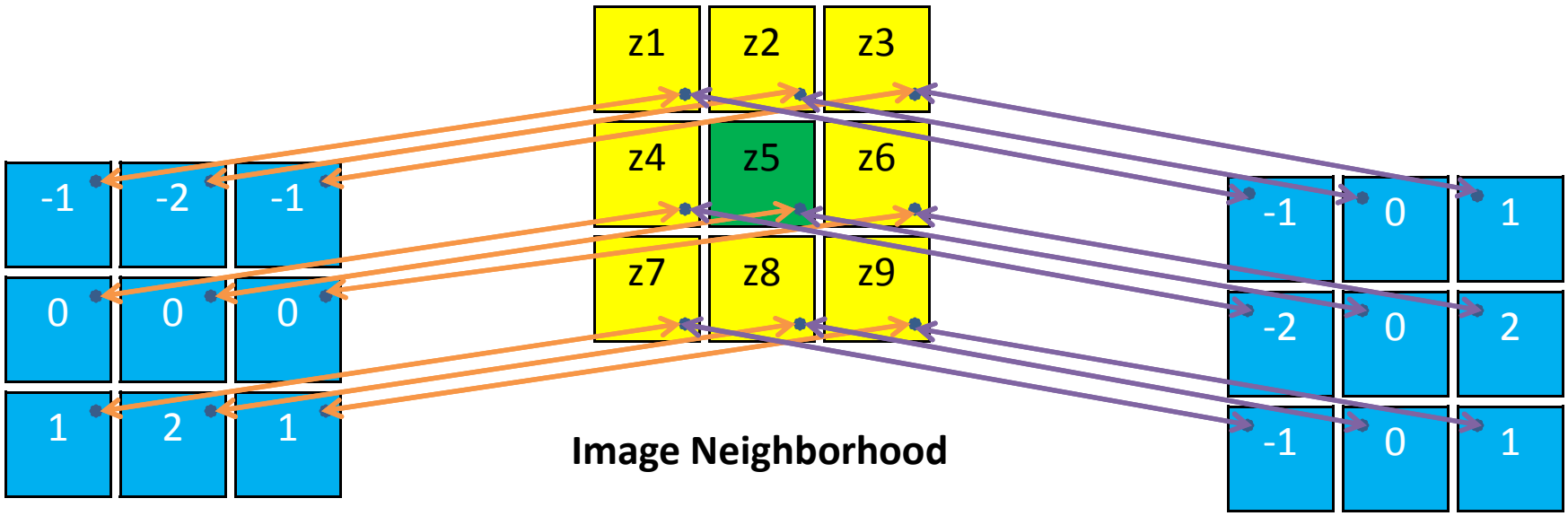
# Introduction Of Edge Detection

- Edge - Area of significant change in the image intensity contrast.

- Edge Detection – Locating areas with strong intensity contrasts.

# Sobel Edge Detection:

**Sobel Mask:**




**Horizontal Kernel :**

Gx=(z7+2*z8+z9)-(z1+2*z2+z3)

**Sobel Edge Detector :**

$G=[Gx^2 + Gy^2]^{1/2}$

**Vertical Kernel :**

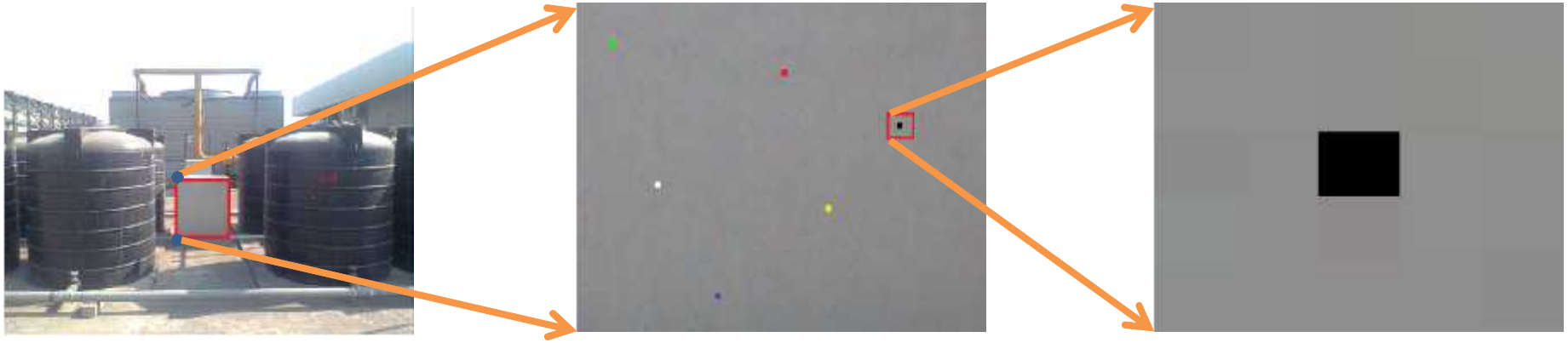
Gy=(z3+2*z6+z9)-(z1+2*z4+z7)

# Sobel Edge Detection(Continuing)*:*

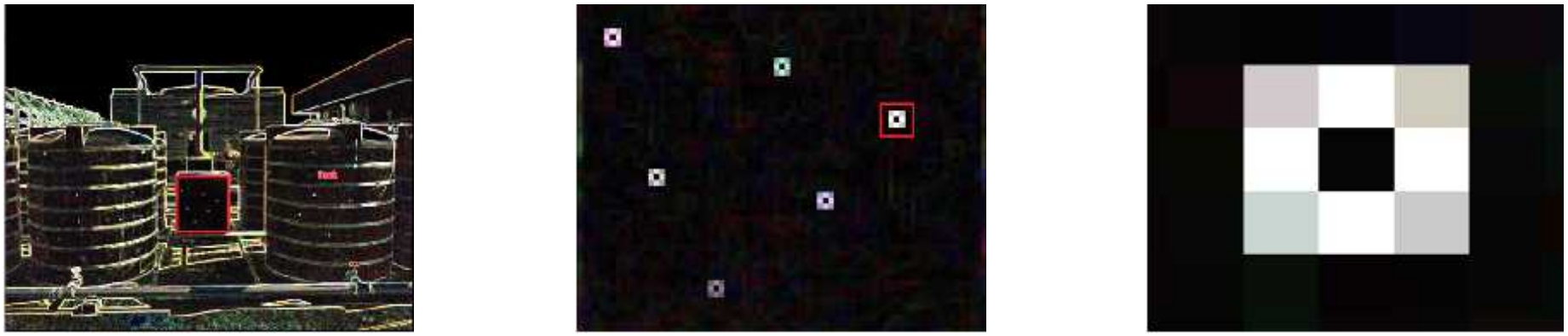
Input Image

Output Image(Edge Detected)

# Sobel Edge Detection (Continuing):

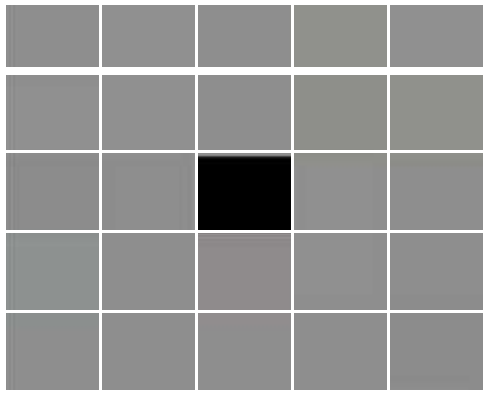


Original Image

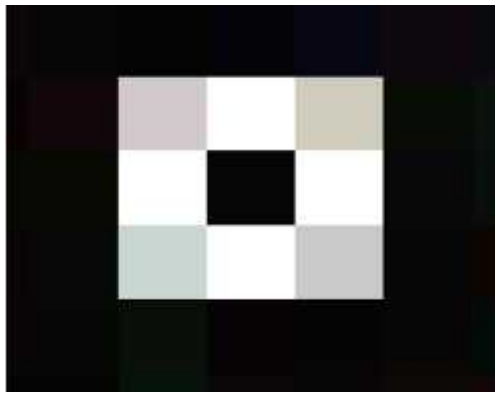


Edge Detected Image

# Sobel Edge Detection (Continuing)*:*



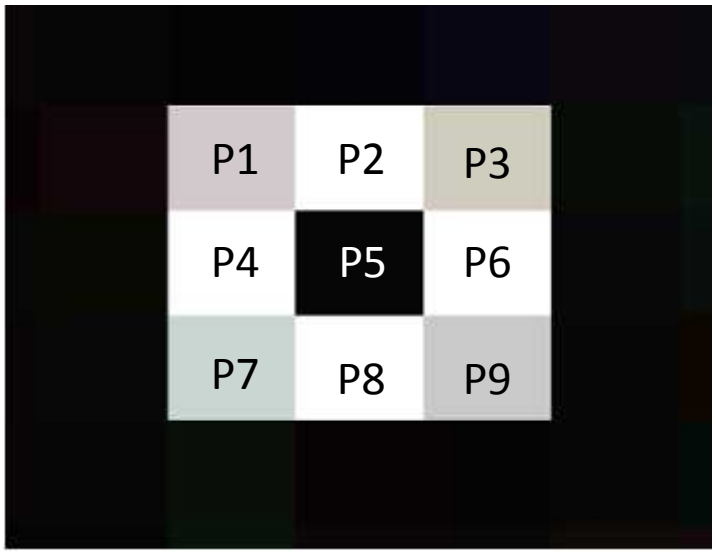
Original Image

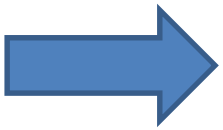


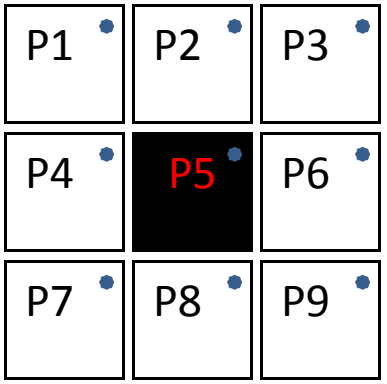
Edge Detected Image

# Edge Detection:

Calculating the Edge Value :



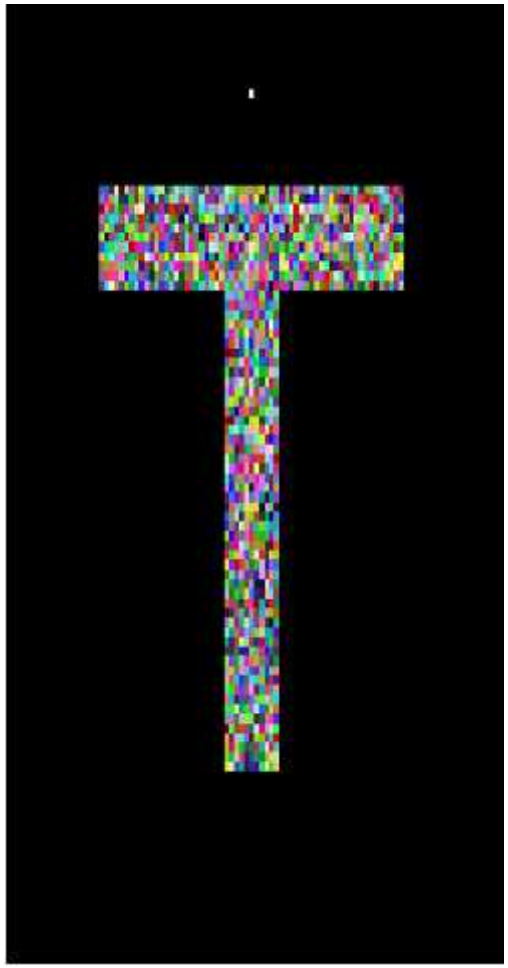





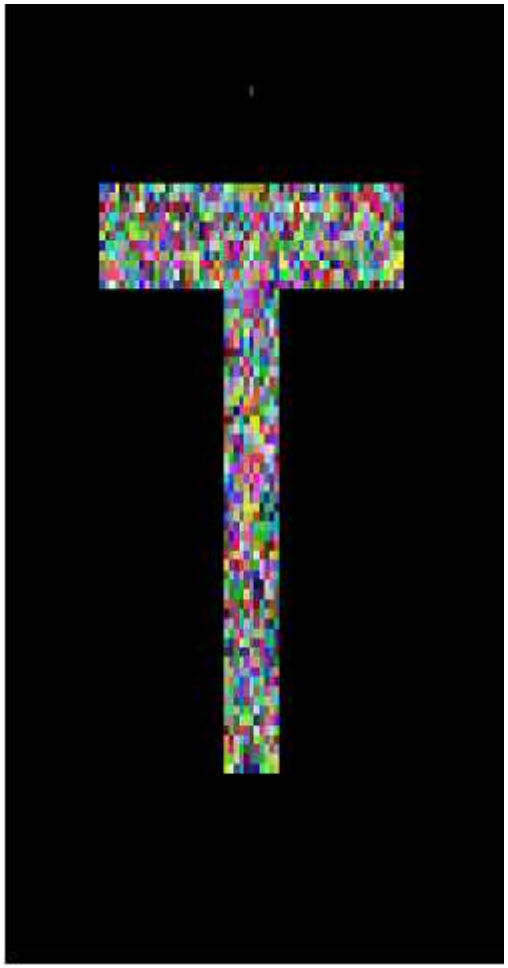

Decision variable =

**( P1 + P2 + P3 + P4 + P6 + P7 + P8 + P9 ) * .5 ^ P5**

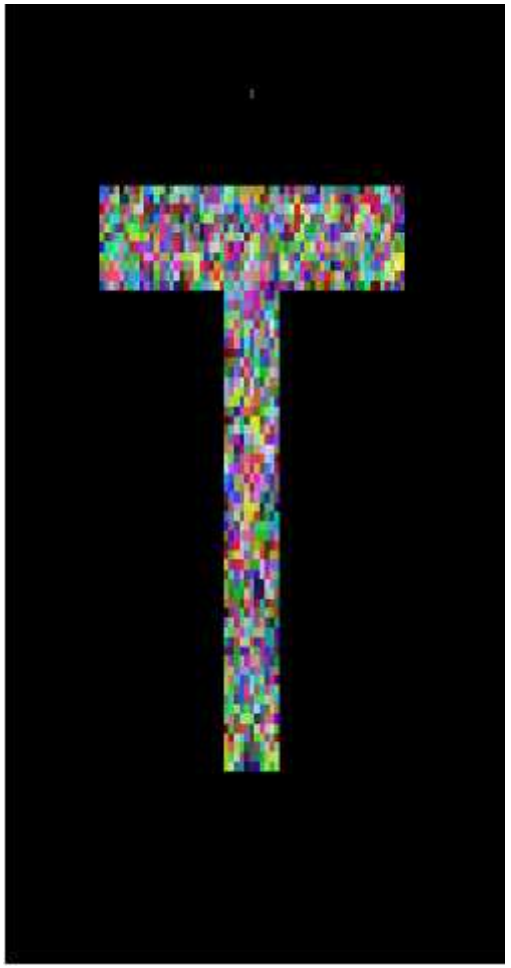
Color Distance Vs. Edge Detection



Original Image



After Processing
(Edge Detection)



After Processing
(Color Distance)

# Edge Based Adaptive KNN *(EBA-KNN) :*

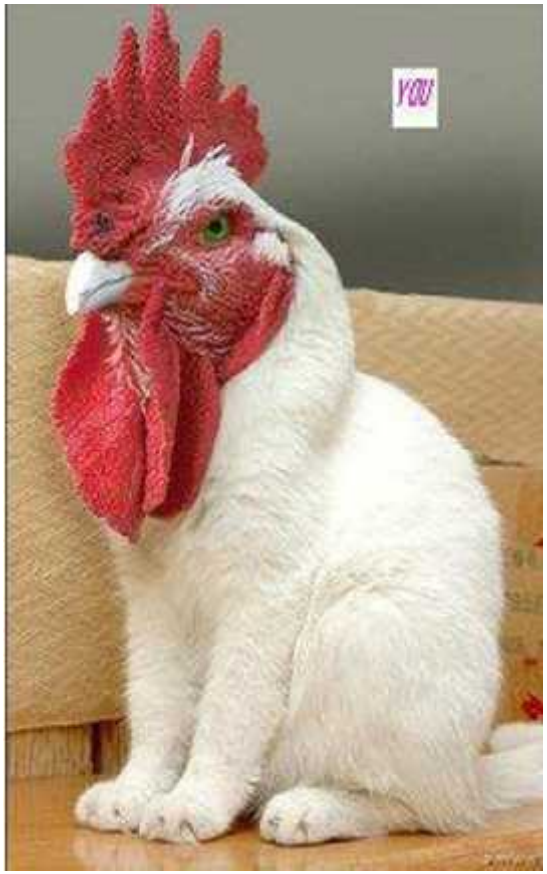
***Combines the concepts of :***

- Edge Detection using Sobel Mask
- Run K-NN based on combined condition

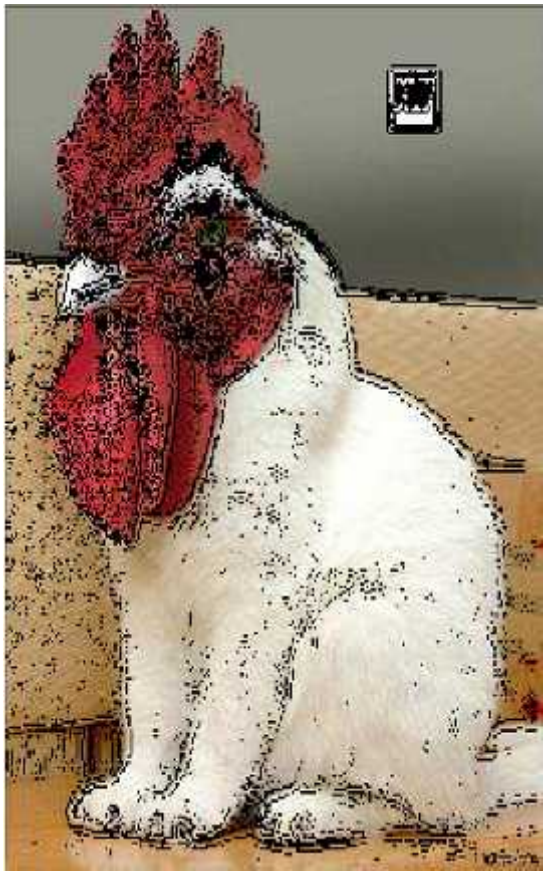
***This algorithm indirectly :***

- Performs denoising operation on basis of objects
- Change is made in proportion to the effect of noise

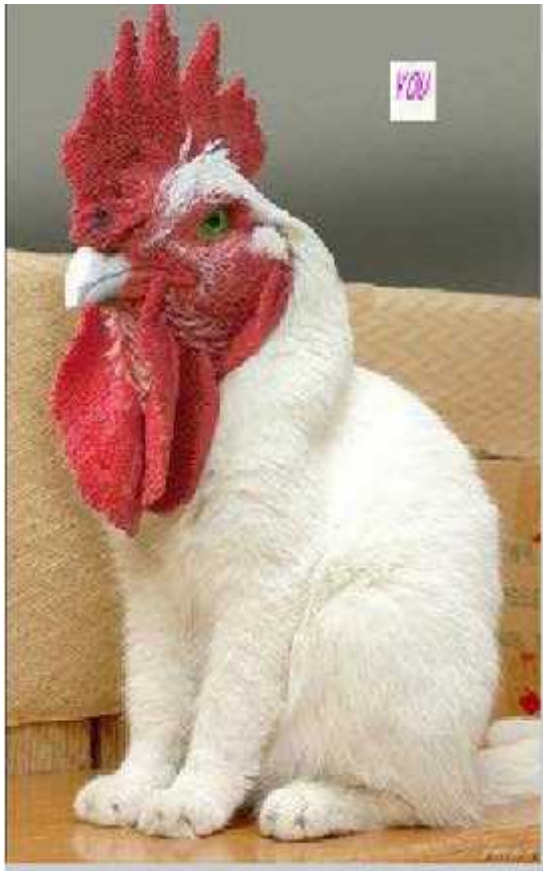
# Effects of EBA-KNN:



**Before processing**

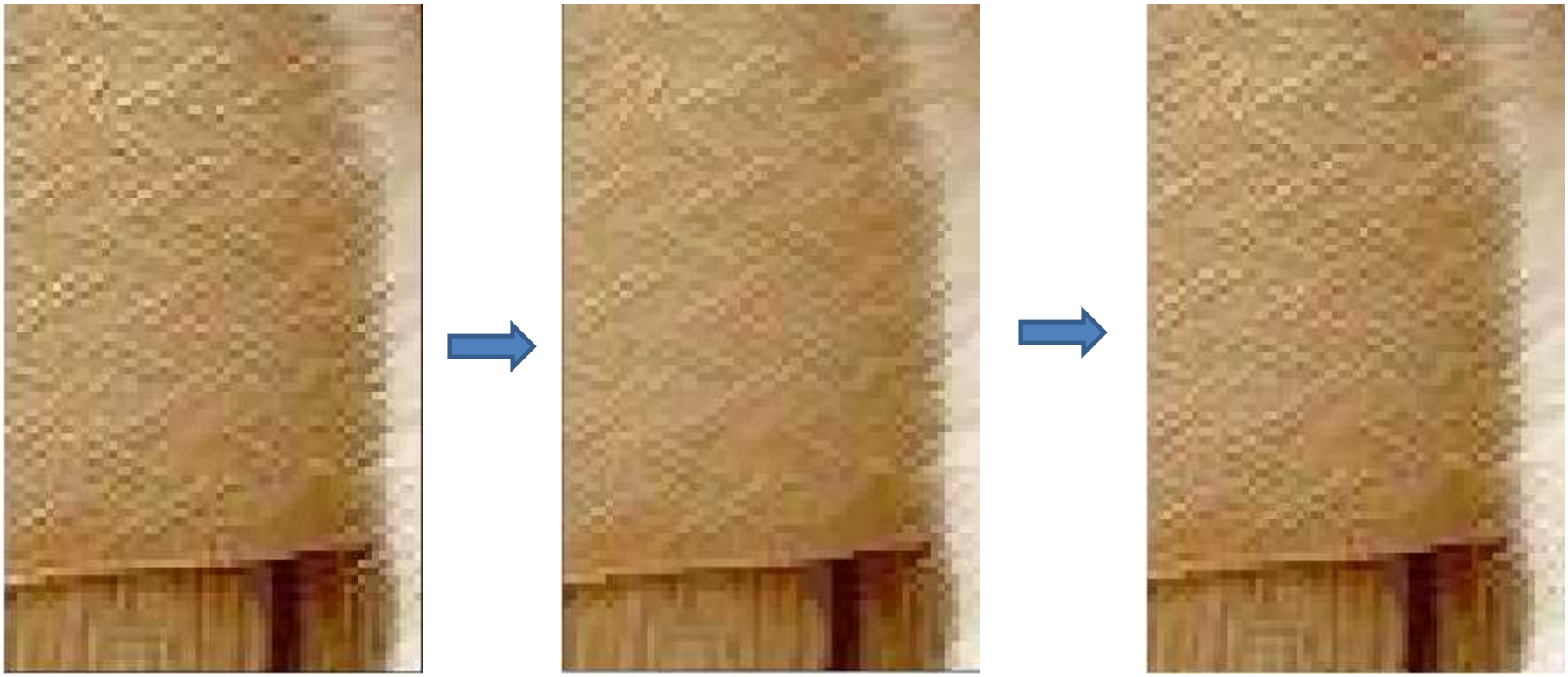


**Pixels to be processed (Black)**



**After processing (**EBA-KNN**)**

## *Effects of* EBA-KNN *:*



**Before processing** **After processing(KNN)** **After processing(EBA-KNN)**

## *Advantages and Disadvantages of EBA-KNN :*

### Advantages:

- Removes more noises than KNN
- Keeps the originality of image without blurring.
- Change is made in proportion to the effect of noise
- Minimizes the change done to pixels not affected by noise

### Disadvantages:

- Slower because it needs more calculation than KNN.

# Edge Based Adaptive Mean Filter *(EBA-MF) :*

***Combines the concepts of :***

- Edge Detection using Sobel Mask
- Variation of Mean Filter

***This algorithm indirectly :***

- Performs denoising operation on basis of objects
- Change is made in proportion to the effect of noise

*This algorithm is likely to work well when there is less than one noisy pixel per window on average.*

# Edge Based Adaptive Mean Filter *(EBA-MF):*

**Before processing**

# Effects of Edge Based Adaptive Mean Filter (EBA-MF) :

**Pixel to be processed (White)**

# Effects of Edge Based Adaptive Mean Filter (EBA-MF) :

**After processing (EBA-MF)**

# Effects of Mean Filter :

**After processing (Mean Filter)**

## Effects of Edge Based Adaptive Mean Filter *(EBA-MF) :*

Original Image

After processing (EBA-MF)

After processing (MF)

# *Advantages and Disadvantages of EBA-MF*

***Advantages :***

- Change is made in proportion to the effect of noise
- Preserves the originality of images
- Performs better than mean filtering

***Disadvantages :***

- Pixels at the edges of different objects get their colors blended with those of the neighboring objects.
- Slower than Mean Filter because it needs more calculation than Mean Filter.

# Implementation :

**We have implemented these algorithms in MATLAB R2008a**