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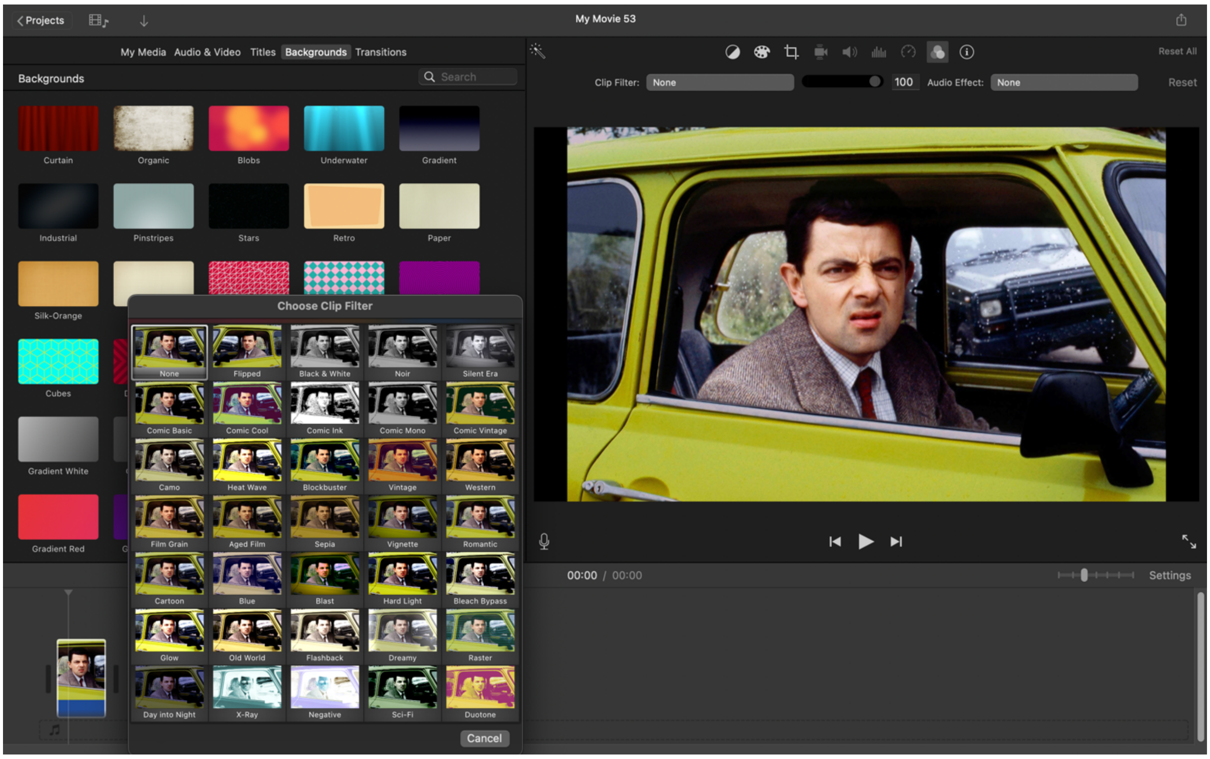
Q4: Software and Question for a Question

1) Image Processing Software:

iMovie is an Image processing software which is used to edit and add filters and effects to Photographs, video clips and also has a feature to merge different images into a clip with other audio files.

Link:
https://apps.apple.com/in/app/imovie/id408981434?mt=12



iMovie uses various image processing techniques which were taught in the lectures.
It has a filter tab which has various filters which could be added to our image.
It also provides other features like changing background, adding frames etc to an image.

One of its intriguing features is “Clip Filter”
This feature has various effects which could be added to our image as depicted below:

Fig: “Clip filter” feature window

One of the filters called “Comic Basic” when applied to an image gives Cartoon effect. This Cartoon rendition effect can be achieved by applying **Bilateral filter** on the input image with **high** σ_s and iterating on the image.

A Bilateral filter is used for denoising an image, its kernel depends on spatial as well as intensity range distribution.

$$BF[I]_{\mathbf{p}} = \frac{1}{W_{\mathbf{p}}} \sum_{\mathbf{q} \in \mathcal{S}} G_{\sigma_s}(\|\mathbf{p} - \mathbf{q}\|) \, G_{\sigma_r}(|I_{\mathbf{p}} - I_{\mathbf{q}}|) \, I_{\mathbf{q}},$$

where

$$W_{\mathbf{p}} = \sum_{\mathbf{q} \in \mathcal{S}} G_{\sigma_s}(\|\mathbf{p} - \mathbf{q}\|) \, G_{\sigma_r}(|I_{\mathbf{p}} - I_{\mathbf{q}}|)$$

The amount of filtering is controlled via σ_S and σ_R, where:
σ_S (spatial) : Controls influence of distant pixels
σ_R (range) : Controls influence of pixel intensity change

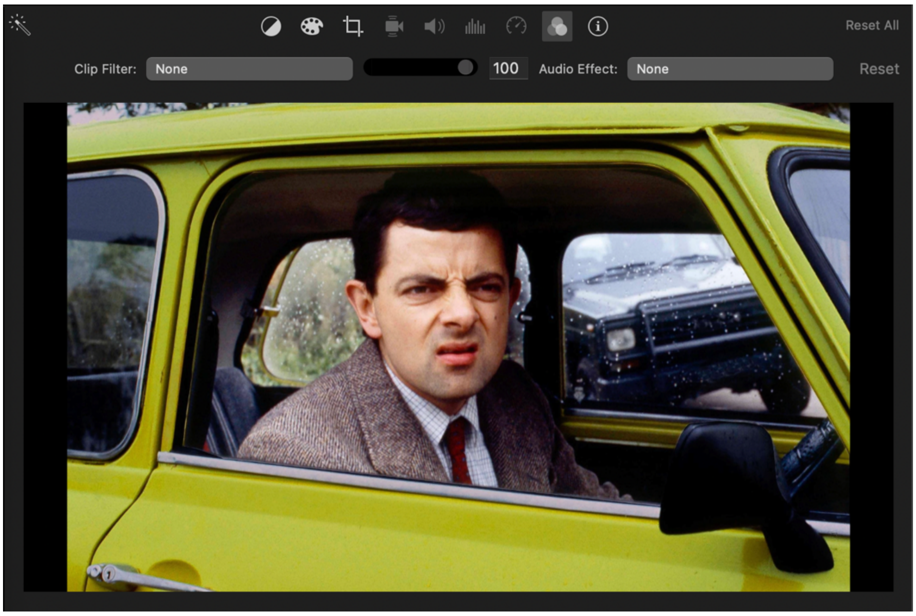


Fig 1: Input image (No Filter)

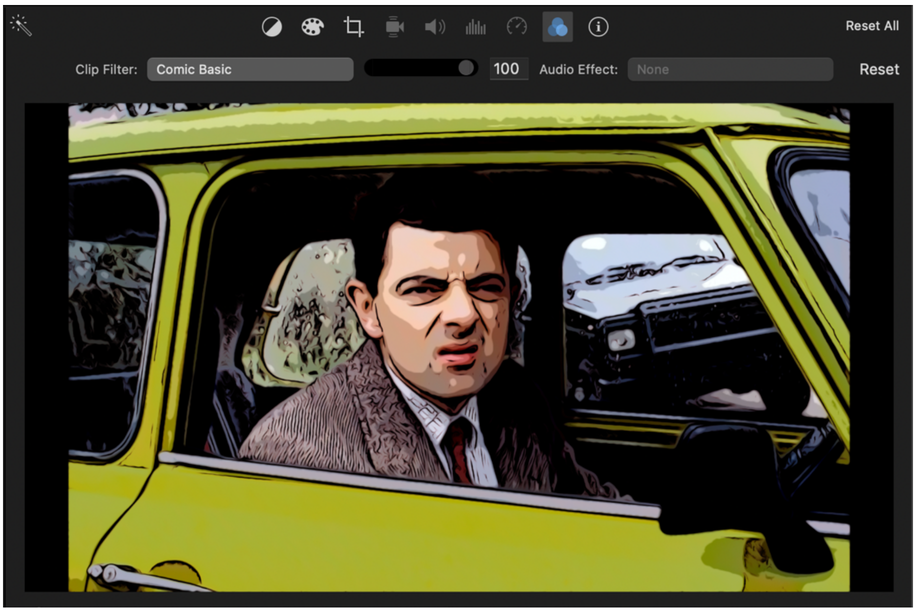


Fig 2: Output Image ("Comic Basic" Filter)

Some other filters are:

- Negative: This filter changes the R,G,B channels of the image to its difference from 255 to give the output image as shown below.

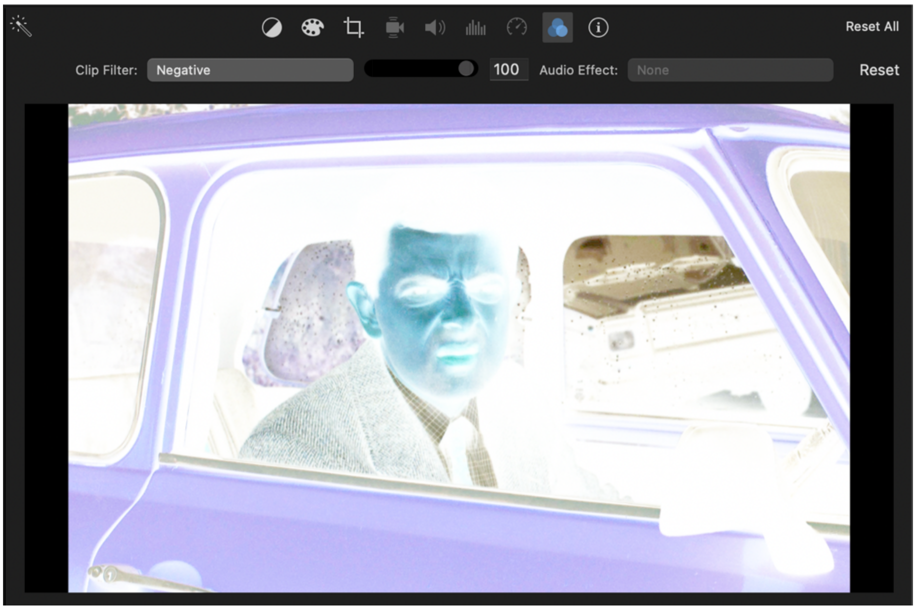


Fig: Output image (“Negative” Filter)

- Comic Ink: This filter uses edge detectors on the input image and after that it applies thresholding to give the output as show in the figure.
  This filter detects edges in a non-uniform and patchy manner.

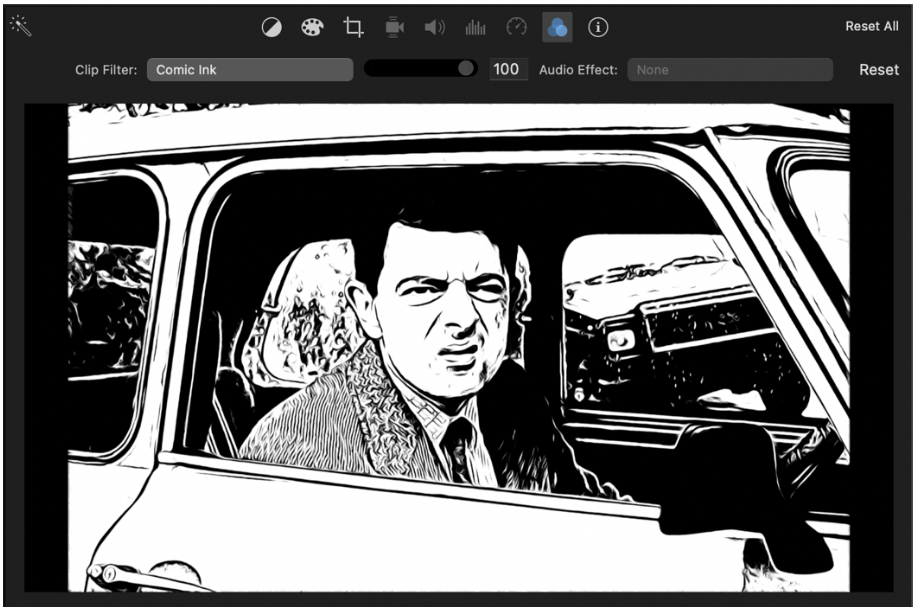


Fig: Output image (“Comic Ink” Filter)

2) Questions for a Question:

i) Analytical:

Q1) Find out the gaussian kernel of size 3 with $\sigma = 0.8$.
Also find its convolution output with the input matrix as given below:

$$X = \begin{vmatrix} 7 & 9 & 5 \\ 4 & 6 & 8 \\ 2 & 0 & 1 \end{vmatrix}$$

Ans: Attached on the next page

ii) Multiple correct question:

Q1) Tick the **correct** properties of JPEG 2000 compared to JPEG.

a) It uses Discrete Cosine Transform
b) It uses Discrete Wavelet Transform
c) It has higher compression ratio
d) It has less computations
e) It has lower compression ratio
f) It has higher computations
g) It has better quality at low bit rate
h) It has lower quality at low bit rate

Ans: b, c, f, g

Q2) Which of the following are **correct** for Region Growing in image processing?

a) Every pixel belongs to some region
b) A pixel can be assigned to one or multiple regions as well
c) Each pixel is assigned to only one region
d) All the pixels in a region share similar property
e) Some pixels in a region may have different properties
f) All pixels in different regions have distinct properties
g) Only seed points and similarity measures are pre requisites for region growing

Ans: a ,c, d, f

Ans:- Gaussian filter

$$G[I]_p = \sum_{q \in S} G_\sigma(\|p-q\|)\, I_q$$

where, $G_\sigma(x) = \frac{1}{2\pi\sigma^2} e^{\frac{-x^2}{2\sigma^2}}$

For $k = 3$ & $\sigma = 0.8$

$\downarrow$

size of kernel

1) Calculation of gaussian kernel ÷

$$\begin{bmatrix} x_{00} & x_{01} & x_{02} \\ x_{10} & x_{11} & x_{12} \\ x_{20} & x_{21} & x_{22} \end{bmatrix} \rightleftharpoons \begin{bmatrix} x_{(-1,-1)} & x_{(-1,0)} & x_{(-1,1)} \\ x_{(0,-1)} & x_{(0,0)} & x_{(0,1)} \\ x_{(1,-1)} & x_{(1,0)} & x_{(1,1)} \end{bmatrix}$$

$$\Rightarrow \frac{1}{2\pi\sigma^2} \begin{bmatrix} e^{-\frac{[(-1)^2+(-1)^2]}{2\sigma^2}} & e^{-\frac{[(-1)^2+0^2]}{2\sigma^2}} & e^{-\frac{[(-1)^2+1^2]}{2\sigma^2}} \\ e^{-\frac{[0^2+(-1)^2]}{2\sigma^2}} & e^{-\frac{(0^2+0^2)}{2\sigma^2}} & e^{-\frac{(0^2+1^2)}{2\sigma^2}} \\ e^{-\frac{(1^2+(-1)^2)}{2\sigma^2}} & e^{-\frac{(1^2+0^2)}{2\sigma^2}} & e^{-\frac{(1^2+1^2)}{2\sigma^2}} \end{bmatrix}$$

$$= \frac{1}{2\pi\sigma^2} \begin{bmatrix} e^{\frac{-1}{\sigma^2}} & e^{\frac{-1}{2\sigma^2}} & e^{\frac{-1}{\sigma^2}} \\ e^{\frac{-1}{2\sigma^2}} & 1 & e^{\frac{-1}{2\sigma^2}} \\ e^{\frac{-1}{\sigma^2}} & e^{\frac{-1}{2\sigma^2}} & e^{\frac{-1}{\sigma^2}} \end{bmatrix}$$

on putting $\sigma = 0.8$ we get ÷

$$G[I] = \begin{bmatrix} 0.05212 & 0.1138 & 0.05212 \\ 0.1138 & 0.2486 & 0.1138 \\ 0.05212 & 0.1138 & 0.05212 \end{bmatrix}$$

Approximately
G [I] is equivalent to :

$$\begin{pmatrix} 3.98 \approx 4 \\ 1.82 \approx 2 \\ 0.83 \approx 1 \end{pmatrix}$$

$$\frac{1}{16} \begin{bmatrix} 1 & 2 & 1 \\ 2 & 4 & 2 \\ 1 & 2 & 1 \end{bmatrix}$$

2) Convolution of kernel with input matrix

$$\text{Input matrix } x = \begin{bmatrix} 7 & 9 & 5 \\ 4 & 6 & 8 \\ 2 & 0 & 1 \end{bmatrix}$$

During convolution, the gaussian kernel is overlapped with the centre of the element, whose gaussian value after convolution is being calculated

eg: for 6 :

overlap

$$\frac{1}{16} \begin{bmatrix} 1 & 2 & 1 \\ 2 & 4 & 2 \\ 1 & 2 & 1 \end{bmatrix} \begin{bmatrix} 7 & 9 & 5 \\ 4 & 6 & 8 \\ 2 & 0 & 1 \end{bmatrix}$$

Now the digits are multiplied with corresponding kernel weights and divided by the normalising factor.

Output
$$\begin{bmatrix} y(-1,-1) & y(-1,0) & y(-1,1) \\ y(0,-1) & y(0,0) & y(0,1) \\ y(1,-1) & y(1,0) & y(1,1) \end{bmatrix}$$

The boundary values which are overlapped with the kernel, result in missing elements which need to be padded, such elements canbe assumed to be 0.

$$y(0,0) = \frac{7\times 0.83 + 9\times 1.82 + 5\times 0.83 + 4\times 1.82 + 6\times 3.98 + 8\times 1.82 + 2\times 0.83 + 0\times 1.82 + 1\times 0.83}{16}$$

$$= 4.66$$

$$y(0,1) = \frac{8\times 3.98 + 5\times 1.82 + 0.83\times 9 + 1\times 1.82 + 0\times 0.82 + 1.82\times 6}{16}$$

$$= 3.82$$

$y(0,-1) = 3.17$

$y(-1,0) = 4.91$

$y(1,0) = 1.65$

$y(-1,1) = 3.49$

$y(1,1) = 1.47$

$y(-1,-1) = 3.53$

$y(1,-1) = 1.27$

$$y = \begin{bmatrix} 3.53 & 4.91 & 3.49 \\ 3.17 & 4.66 & 3.82 \\ 1.27 & 1.65 & 1.47 \end{bmatrix}$$