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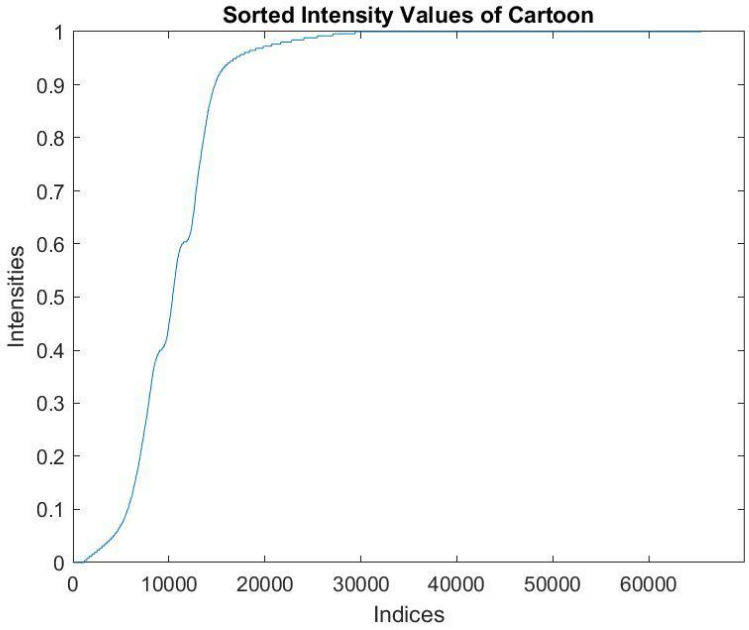
CS211A: Visual Computing

Professor Aditi Majumder

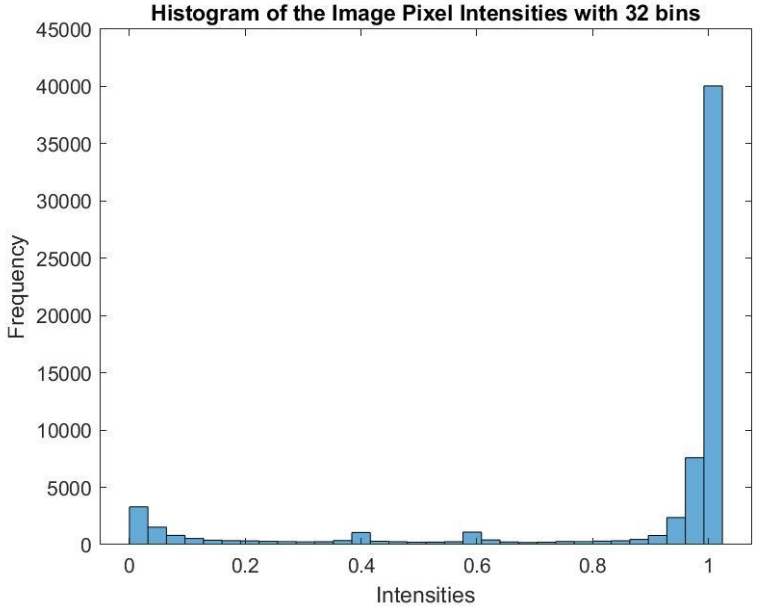
HW1 – Image Processing

Part 0: Getting Started

a. Sort all the intensities in A, put the result in a single 10000-dimensional vector x, and plot the values in x.



b. Display a figure showing a histogram of A's intensities with 32 bins.

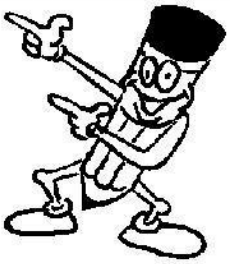


c. Create and display a new binary image with the same size as A, which is white wherever the intensity in A is greater than a threshold t, and black everywhere else.

Binary Of Cartoon With Threshold 0

Binary Of Cartoon With Threshold 0.2

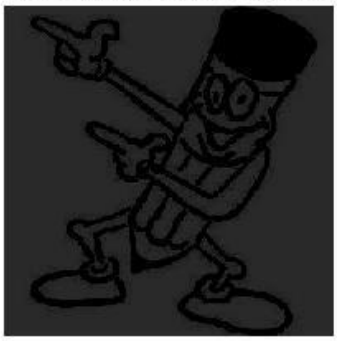
Binary Of Cartoon With Threshold 0.8



Binary Of Cartoon With Threshold 1

d. Generate a new image (matrix), which has the same size as A, but with A's mean intensity value subtracted from each pixel. Set any negative values to 0.

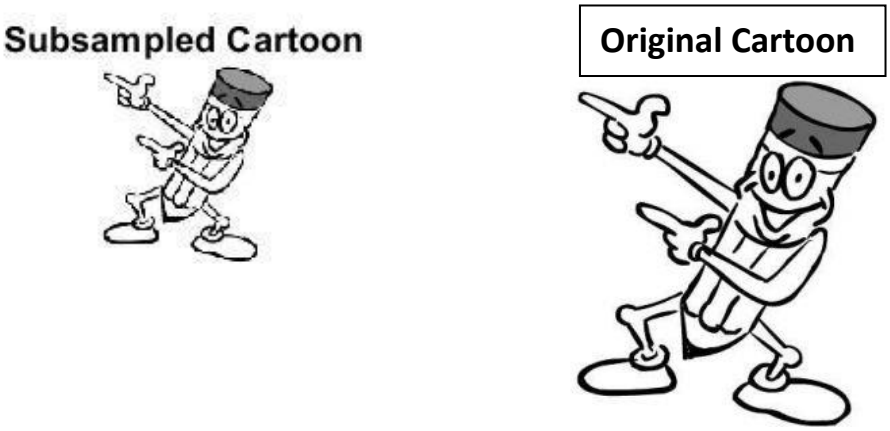
Mean Subtracted Cartoon



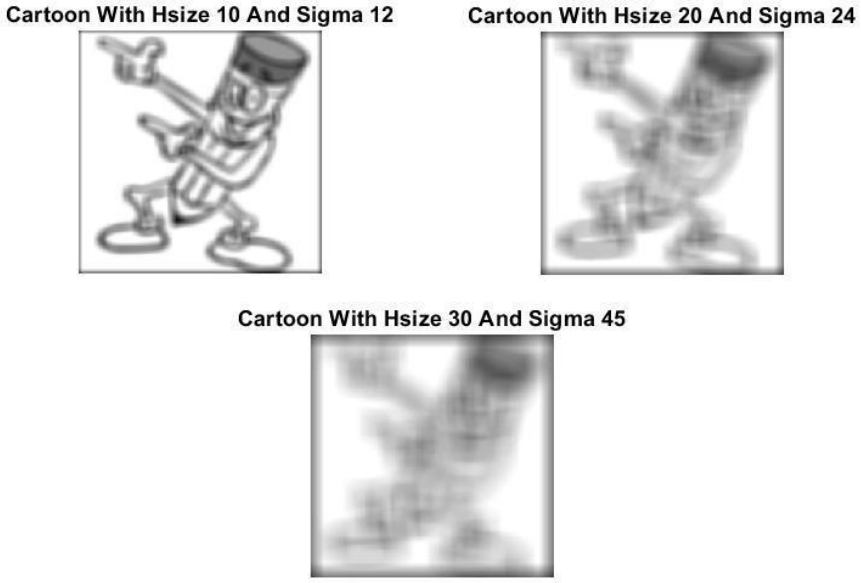
e. Let y be the vector: y = [1: 8]. Use the reshape command to form a new matrix s whose first column is [1, 2, 3, 4]', and whose second column is [5, 6, 7, 8]'.

```
Command Window
y =

     1     2     3     4     5     6     7     8


B =

     1     5
     2     6
     3     7
     4     8

fx >>
```

f. Create a vector [1, 3, 5 …, 99]. Extract the corresponding pixel from the image in its two dimensions, i.e., subsample the original image to its half size.



g. Use *fspecial* to create a Gaussian Filter and then apply the *imfilter* function to the image with the created Gaussian Filter, by doing so you should see a blurred image. Change three combinations of parameters of the Gaussian Filter and compare the results.



h. Apply the *conv2* instead of *imfilter* function to the same process (for one Gaussian Filter), do you see any changes? Why?

- The output below is for gaussian filter with size 10 and variance 12. There is a slight difference between the two outputs because imfilter uses correlation to filter images by default. Had we specified the parameter - 'conv' for imfilter, the two outputs would have been the same

Cartoon With Conv2 Filter

Part 1: Gaussian Pyramid

- Create the Gaussian pyramid for all images in the gallery and put the images in the PDF file. Please consider that all the images in different levels should have same size.
    - Each level of the gaussian pyramid is given below and the resultant blurred image at the corresponding levels have been resized to understand the effect better.

CARTOON Gaussian Pyramid Layer = 0

CARTOON Gaussian Pyramid Layer = 2

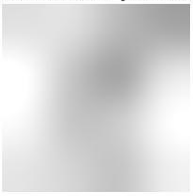
CARTOON Gaussian Pyramid Layer = 1

CARTOON Gaussian Pyramid Layer = 3

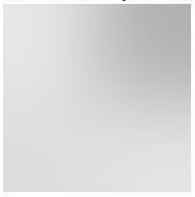
CARTOON Gaussian Pyramid Layer = 4

CARTOON Gaussian Pyramid Layer = 5

CARTOON Gaussian Pyramid Layer = 6



CARTOON Gaussian Pyramid Layer = 7



CARTOON Gaussian Pyramid Layer = 8

- Flowergray

Flowergray Gaussian Pyramid Layer = 0

Flowergray Gaussian Pyramid Layer = 1

Flowergray Gaussian Pyramid Layer = 2

Flowergray Gaussian Pyramid Layer = 3

Flowergray Gaussian Pyramid Layer = 4

Flowergray Gaussian Pyramid Layer = 5

Flowergray Gaussian Pyramid Layer = 6

Flowergray Gaussian Pyramid Layer = 7

Flowergray Gaussian Pyramid Layer = 8

- Kitty

Kitty Gaussian Pyramid Layer = 0

Kitty Gaussian Pyramid Layer = 1

Kitty Gaussian Pyramid Layer = 2

Kitty Gaussian Pyramid Layer = 3

Kitty Gaussian Pyramid Layer = 4

Kitty Gaussian Pyramid Layer = 5

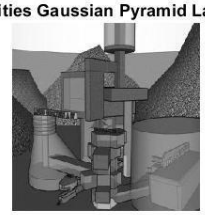
Kitty Gaussian Pyramid Layer = 6

Kitty Gaussian Pyramid Layer = 7

Kitty Gaussian Pyramid Layer = 8

- Polarcities

Polarcities Gaussian Pyramid Layer = 0



Polarcities Gaussian Pyramid Layer = 2

Polarcities Gaussian Pyramid Layer = 1

Polarcities Gaussian Pyramid Layer = 3

Polarcities Gaussian Pyramid Layer = 4

Polarcities Gaussian Pyramid Layer = 5

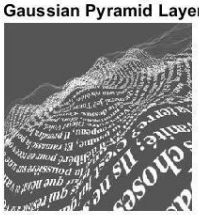
Polarcities Gaussian Pyramid Layer = 6

Polarcities Gaussian Pyramid Layer = 7

Polarcities Gaussian Pyramid Layer = 8

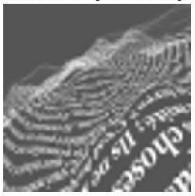
- Text

Text Gaussian Pyramid Layer = 0



Text Gaussian Pyramid Layer = 1

Text Gaussian Pyramid Layer = 2



Text Gaussian Pyramid Layer = 3

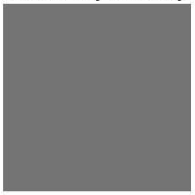
Text Gaussian Pyramid Layer = 4

Text Gaussian Pyramid Layer = 5

Text Gaussian Pyramid Layer = 6

Text Gaussian Pyramid Layer = 7

Text Gaussian Pyramid Layer = 8



Part 2: Laplacian Pyramid

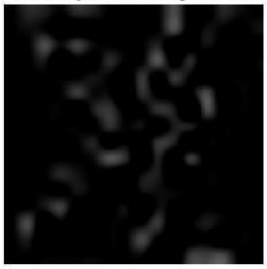
- Write a program to generate the Laplacian pyramid by subtracting the consecutive levels of the Gaussian pyramid. Create the Laplacian pyramid for all the images in the gallery and put the results in the PDF format.
- Cartoon

CARTOON Laplacian Pyramid Layer 1

CARTOON Laplacian Pyramid Layer 2

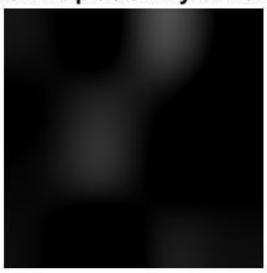
CARTOON Laplacian Pyramid Layer 3

CARTOON Laplacian Pyramid Layer 4



CARTOON Laplacian Pyramid Layer 5

CARTOON Laplacian Pyramid Layer 6

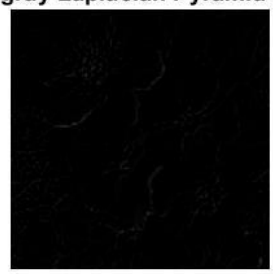


CARTOON Laplacian Pyramid Layer 7

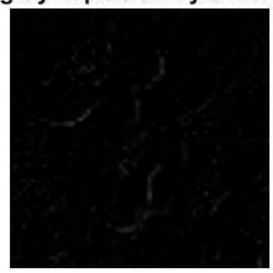
CARTOON Laplacian Pyramid Layer 8

- Flower

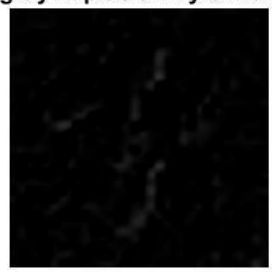
Flowergray Laplacian Pyramid Layer 1



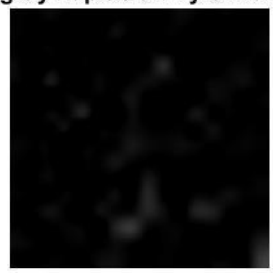
Flowergray Laplacian Pyramid Layer 2



Flowergray Laplacian Pyramid Layer 3

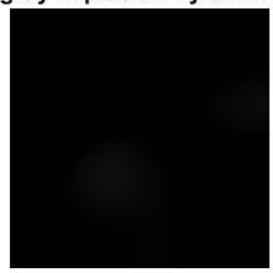


Flowergray Laplacian Pyramid Layer 4



Flowergray Laplacian Pyramid Layer 5

Flowergray Laplacian Pyramid Layer 6



Flowergray Laplacian Pyramid Layer 7

Flowergray Laplacian Pyramid Layer 8

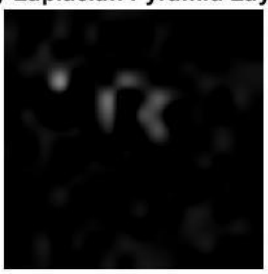
- Kitty

Kitty Laplacian Pyramid Layer 1

Kitty Laplacian Pyramid Layer 2

Kitty Laplacian Pyramid Layer 3

Kitty Laplacian Pyramid Layer 4



Kitty Laplacian Pyramid Layer 5

Kitty Laplacian Pyramid Layer 6

Kitty Laplacian Pyramid Layer 7

Kitty Laplacian Pyramid Layer 8

- Polarcities

Polarcities Laplacian Pyramid Layer 1

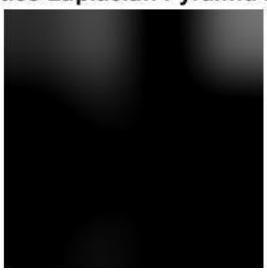
Polarcities Laplacian Pyramid Layer 2

Polarcities Laplacian Pyramid Layer 3

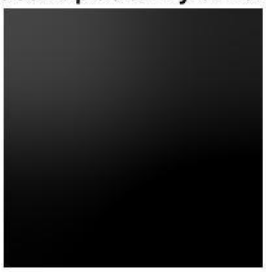
Polarcities Laplacian Pyramid Layer 4

Polarcities Laplacian Pyramid Layer 5

Polarcities Laplacian Pyramid Layer 6



Polarcities Laplacian Pyramid Layer 7



Polarcities Laplacian Pyramid Layer 8

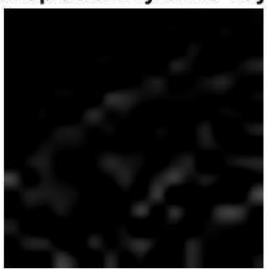
- Text

Text Laplacian Pyramid Layer 1

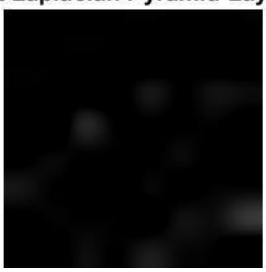
Text Laplacian Pyramid Layer 2

Text Laplacian Pyramid Layer 3

Text Laplacian Pyramid Layer 4



Text Laplacian Pyramid Layer 5



Text Laplacian Pyramid Layer 6

Text Laplacian Pyramid Layer 7

Text Laplacian Pyramid Layer 8

Multi-Scale Edge Detection

Step 1: Generate the second order derivative images at different scales (or resolution) using a Laplacian operator given below:

- Cartoon

CARTOON Laplacian Operator Layer = 0

CARTOON Laplacian Operator Layer = 1

CARTOON Laplacian Operator Layer = 2

CARTOON Laplacian Operator Layer = 3

CARTOON Laplacian Operator Layer = 4

CARTOON Laplacian Operator Layer = 5

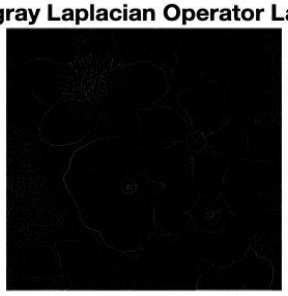
CARTOON Laplacian Operator Layer = 6

CARTOON Laplacian Operator Layer = 7

CARTOON Laplacian Operator Layer = 8

- Flowergray

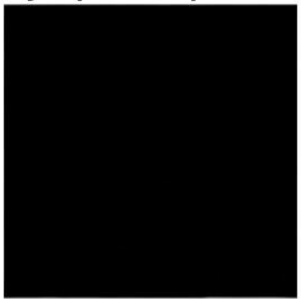
Flowergray Laplacian Operator Layer = 0



Flowergray Laplacian Operator Layer = 1

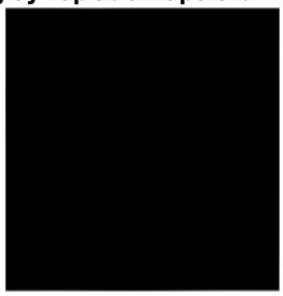
Flowergray Laplacian Operator Layer = 2

Flowergray Laplacian Operator Layer = 3



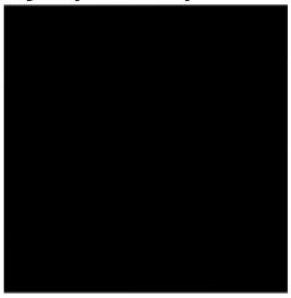
Flowergray Laplacian Operator Layer = 4

Flowergray Laplacian Operator Layer = 5



Flowergray Laplacian Operator Layer = 6

Flowergray Laplacian Operator Layer = 7



Flowergray Laplacian Operator Layer = 8

Kitty Laplacian Operator Layer = 0

Kitty Laplacian Operator Layer = 1

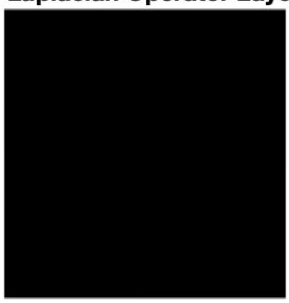
Kitty Laplacian Operator Layer = 2

Kitty Laplacian Operator Layer = 3

Kitty Laplacian Operator Layer = 4

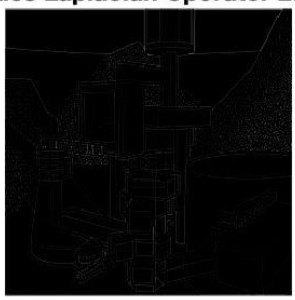
Kitty Laplacian Operator Layer = 5

Kitty Laplacian Operator Layer = 7



Kitty Laplacian Operator Layer = 8

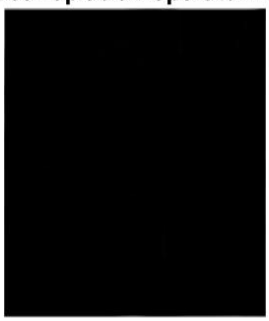
Polarcities Laplacian Operator Layer = 0



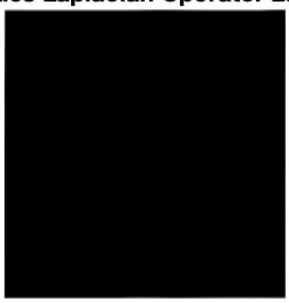
Polarcities Laplacian Operator Layer = 1

Polarcities Laplacian Operator Layer = 2

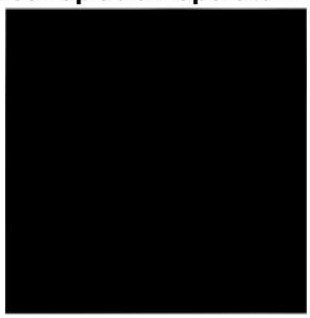
Polarcities Laplacian Operator Layer = 3



Polarcities Laplacian Operator Layer = 4

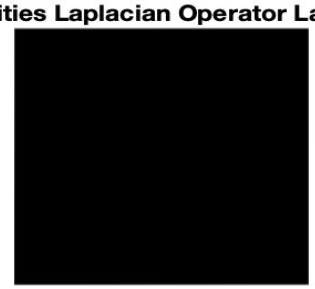


Polarcities Laplacian Operator Layer = 5



Polarcities Laplacian Operator Layer = 6

Polarcities Laplacian Operator Layer = 7



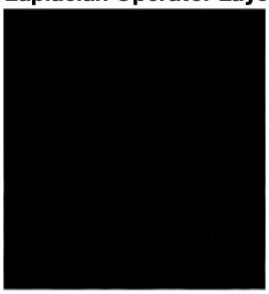
Polarcities Laplacian Operator Layer = 8

Text Laplacian Operator Layer = 0

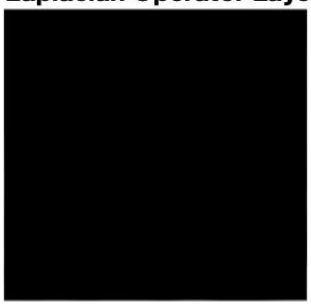
Text Laplacian Operator Layer = 1

Text Laplacian Operator Layer = 2

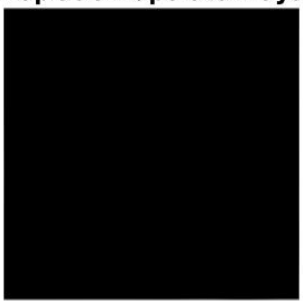
Text Laplacian Operator Layer = 3



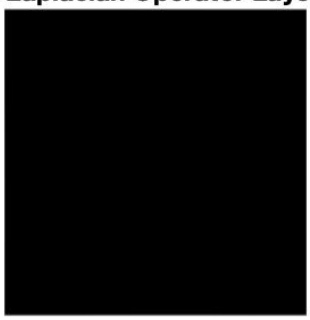
Text Laplacian Operator Layer = 4



Text Laplacian Operator Layer = 5

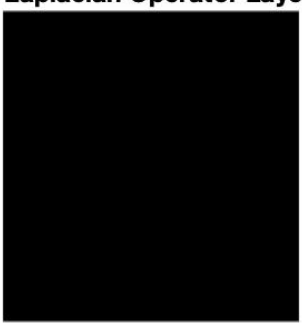


Text Laplacian Operator Layer = 6



Text Laplacian Operator Layer = 7

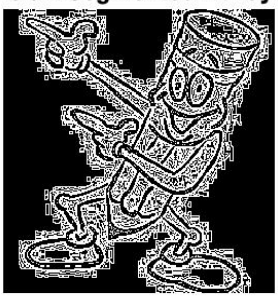
Text Laplacian Operator Layer = 8



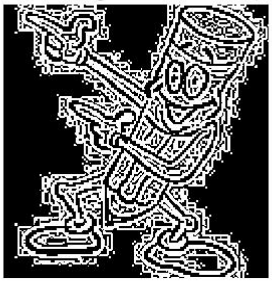
- Step 2: Segment the second order derivative image by assigning value to 1 to all pixels of magnitude greater than 0 and value 0 to all pixels of magnitude less than or equal to zero.

Cartoon

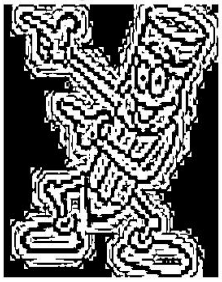
CARTOON Segmented At Layer = 0



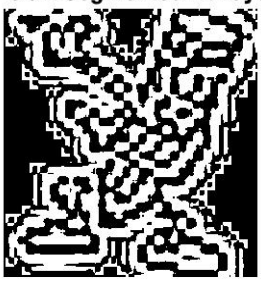
CARTOON Segmented At Layer = 1



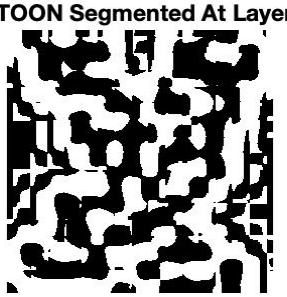
CARTOON Segmented At Layer = 2



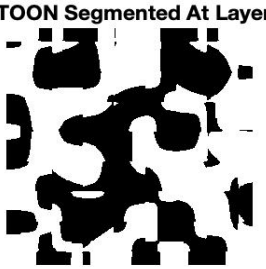
CARTOON Segmented At Layer = 3



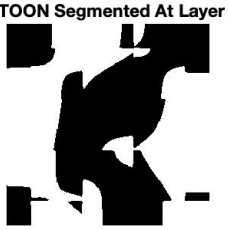
CARTOON Segmented At Layer = 4



CARTOON Segmented At Layer = 5

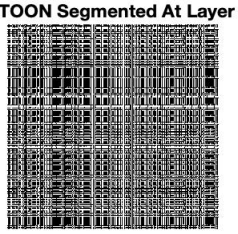


CARTOON Segmented At Layer = 6



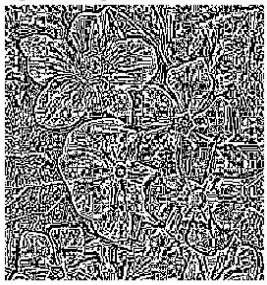
CARTOON Segmented At Layer = 7

CARTOON Segmented At Layer = 8

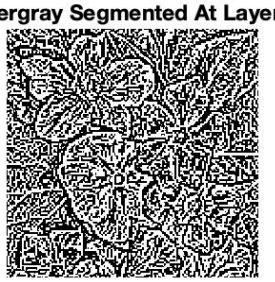


Flower

Flowergray Segmented At Layer = 0

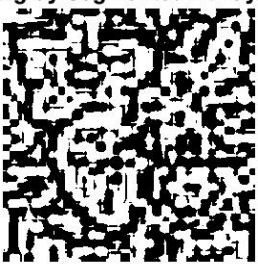


Flowergray Segmented At Layer = 1

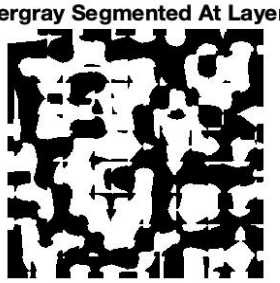


Flowergray Segmented At Layer = 2

Flowergray Segmented At Layer = 3

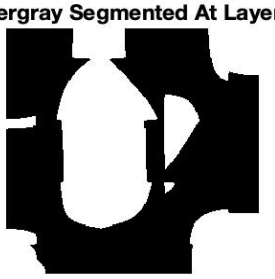


Flowergray Segmented At Layer = 4



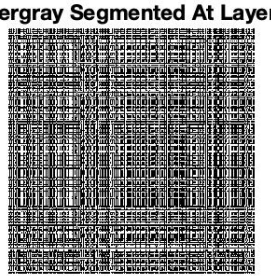
Flowergray Segmented At Layer = 5

Flowergray Segmented At Layer = 6



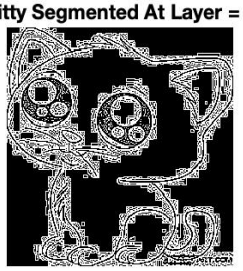
Flowergray Segmented At Layer = 7

Flowergray Segmented At Layer = 8

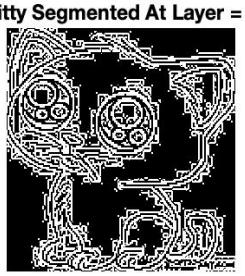


Kitty

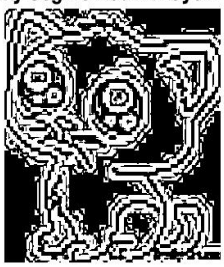
Kitty Segmented At Layer = 0



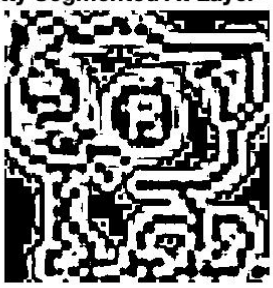
Kitty Segmented At Layer = 1



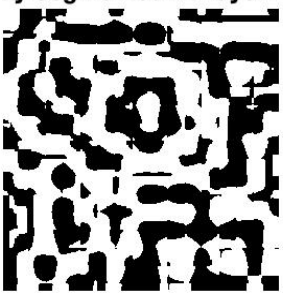
Kitty Segmented At Layer = 2



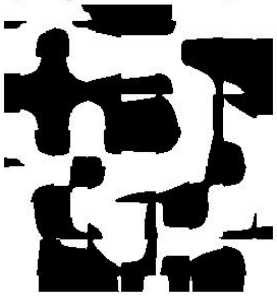
Kitty Segmented At Layer = 3



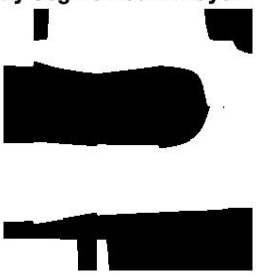
Kitty Segmented At Layer = 4



Kitty Segmented At Layer = 5

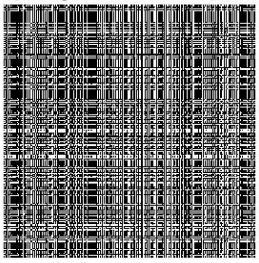


Kitty Segmented At Layer = 6



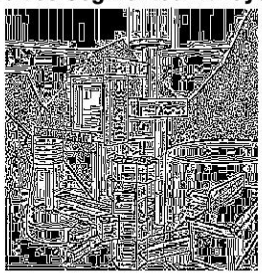
Kitty Segmented At Layer = 7

Kitty Segmented At Layer = 8

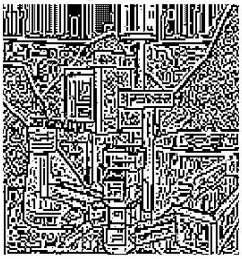


Polarcities

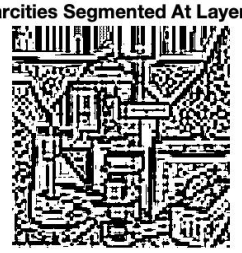
Polarcities Segmented At Layer = 0



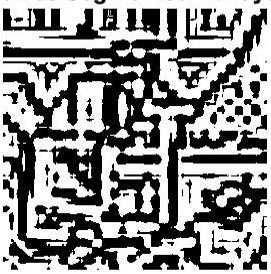
Polarcities Segmented At Layer = 1



Polarcities Segmented At Layer = 2

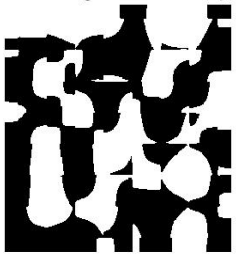


Polarcities Segmented At Layer = 3

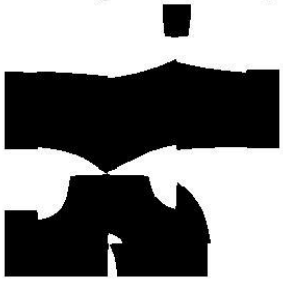


Polarcities Segmented At Layer = 4

Polarcities Segmented At Layer = 5

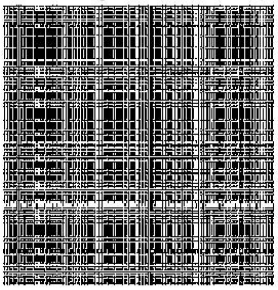


Polarcities Segmented At Layer = 6



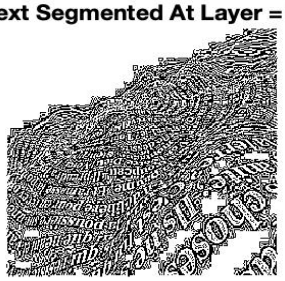
Polarcities Segmented At Layer = 7

Polarcities Segmented At Layer = 8



Text

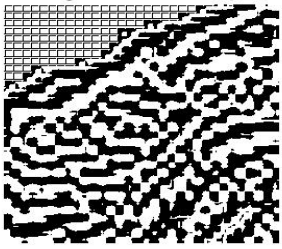
Text Segmented At Layer = 0



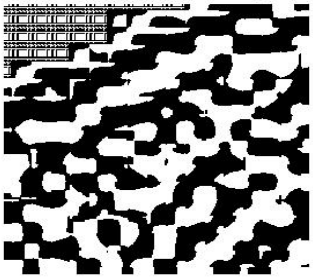
Text Segmented At Layer = 1

Text Segmented At Layer = 2

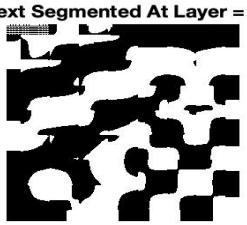
Text Segmented At Layer = 3



Text Segmented At Layer = 4



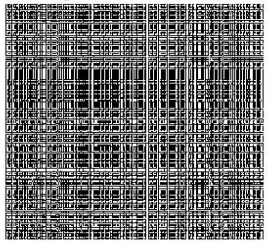
Text Segmented At Layer = 5



Text Segmented At Layer = 6

Text Segmented At Layer = 7

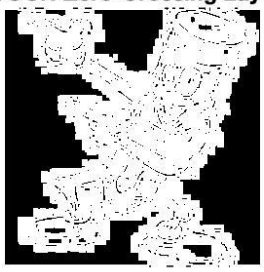
Text Segmented At Layer = 8



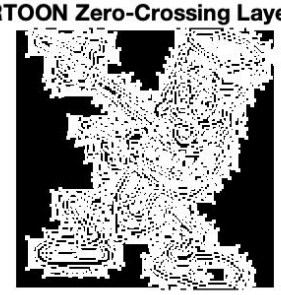
Step 3: Detect the zero crossing in the segmented image. This is done by tagging any pixel which has at least one neighbor who is of different value than the pixel itself.

Cartoon

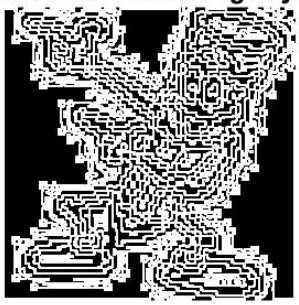
CARTOON Zero-Crossing Layer = 0



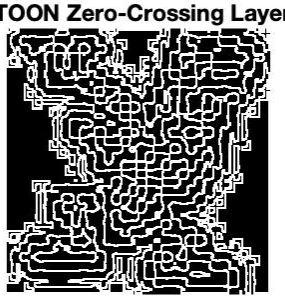
CARTOON Zero-Crossing Layer = 1



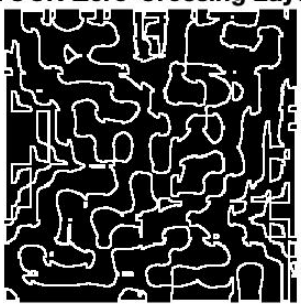
CARTOON Zero-Crossing Layer = 2



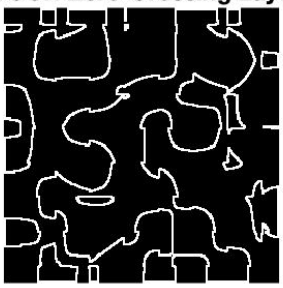
CARTOON Zero-Crossing Layer = 3



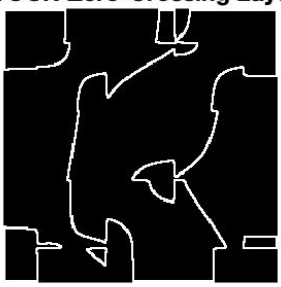
CARTOON Zero-Crossing Layer = 4



CARTOON Zero-Crossing Layer = 5

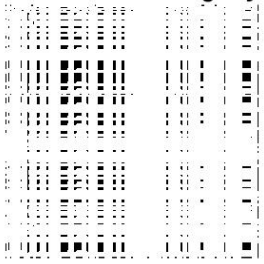


CARTOON Zero-Crossing Layer = 6



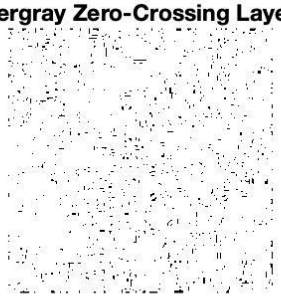
CARTOON Zero-Crossing Layer = 7

CARTOON Zero-Crossing Layer = 8

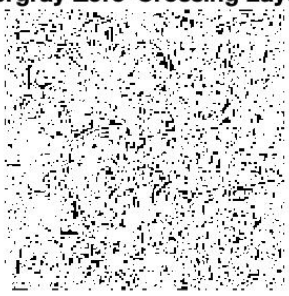


Flower

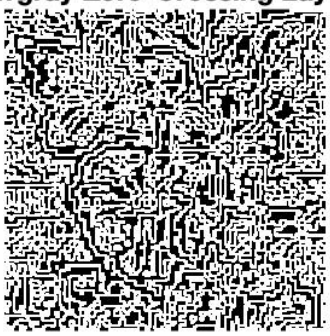
Flowergray Zero-Crossing Layer = 0



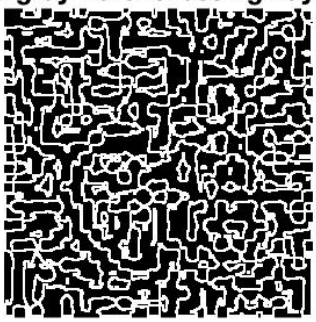
Flowergray Zero-Crossing Layer = 1



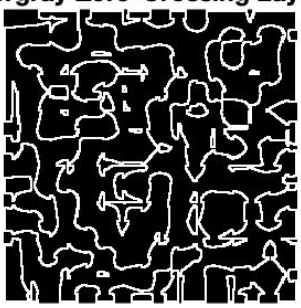
Flowergray Zero-Crossing Layer = 2



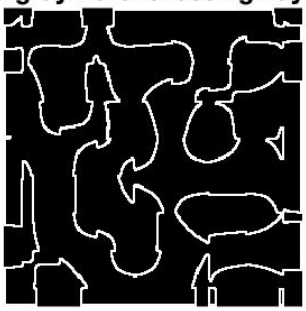
Flowergray Zero-Crossing Layer = 3



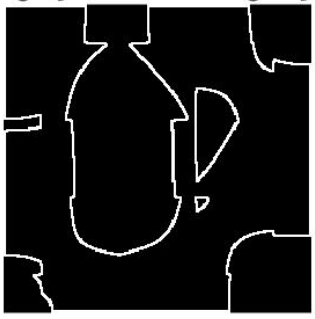
Flowergray Zero-Crossing Layer = 4



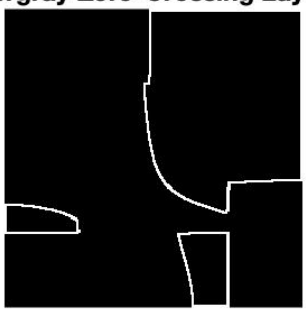
Flowergray Zero-Crossing Layer = 5



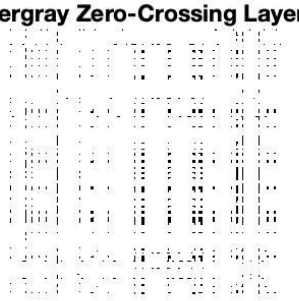
Flowergray Zero-Crossing Layer = 6



Flowergray Zero-Crossing Layer = 7

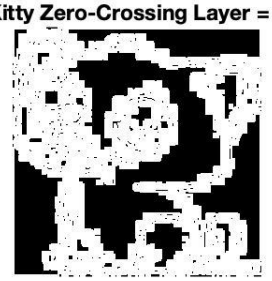


Flowergray Zero-Crossing Layer = 8

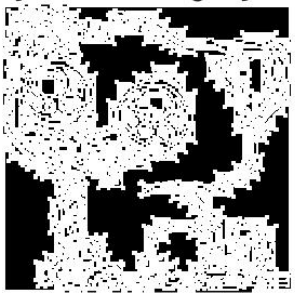


Kitty

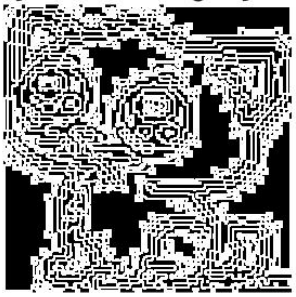
Kitty Zero-Crossing Layer = 0



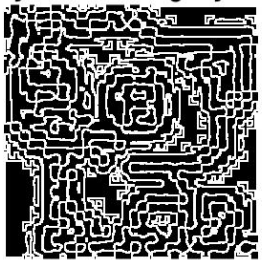
Kitty Zero-Crossing Layer = 1



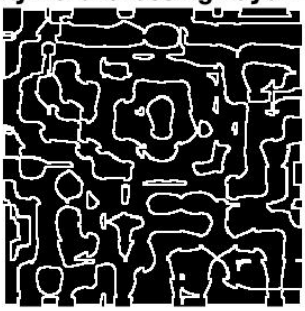
Kitty Zero-Crossing Layer = 2



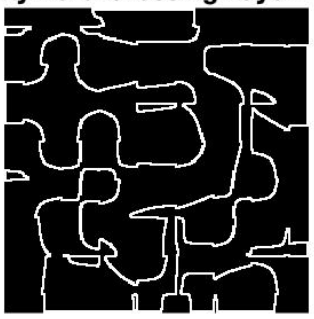
Kitty Zero-Crossing Layer = 3



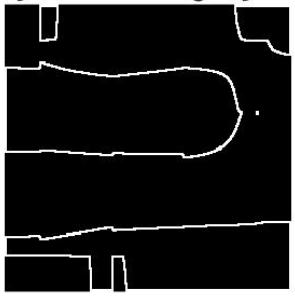
Kitty Zero-Crossing Layer = 4



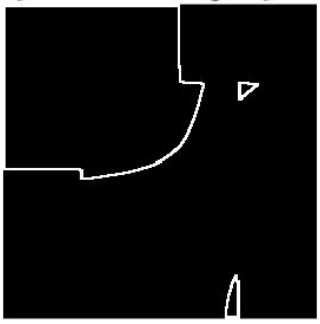
Kitty Zero-Crossing Layer = 5



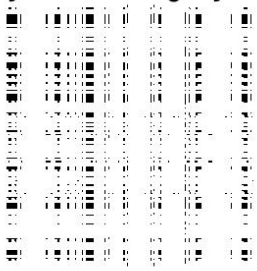
Kitty Zero-Crossing Layer = 6



Kitty Zero-Crossing Layer = 7



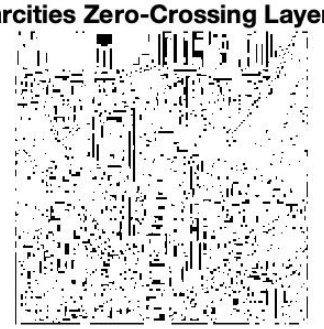
Kitty Zero-Crossing Layer = 8



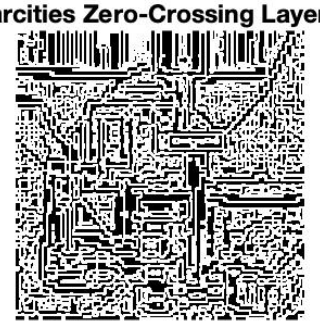
Polarcities

Polarcities Zero-Crossing Layer = 0

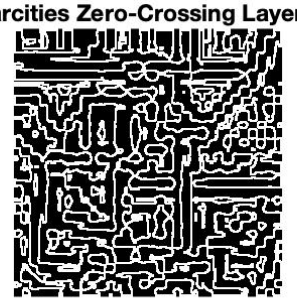
Polarcities Zero-Crossing Layer = 1



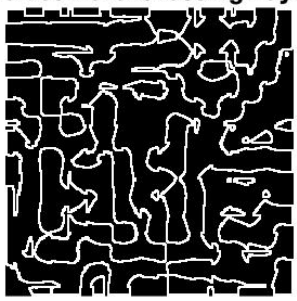
Polarcities Zero-Crossing Layer = 2



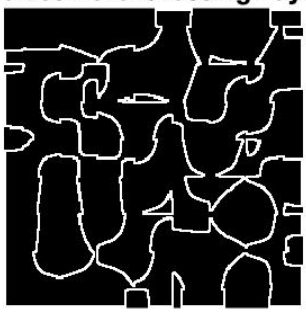
Polarcities Zero-Crossing Layer = 3



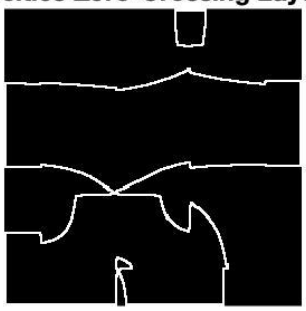
Polarcities Zero-Crossing Layer = 4



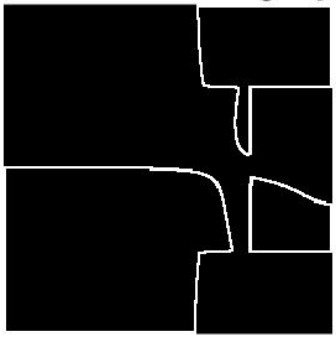
Polarcities Zero-Crossing Layer = 5



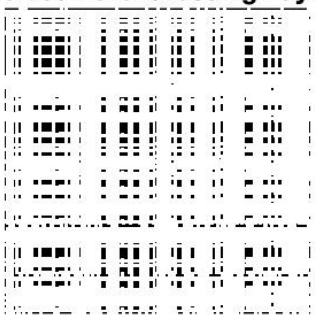
Polarcities Zero-Crossing Layer =



Polarcities Zero-Crossing Layer = 7

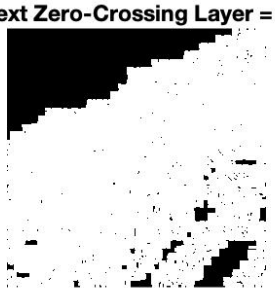


Polarcities Zero-Crossing Layer = 8



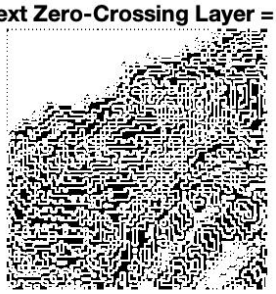
Text

Text Zero-Crossing Layer = 0

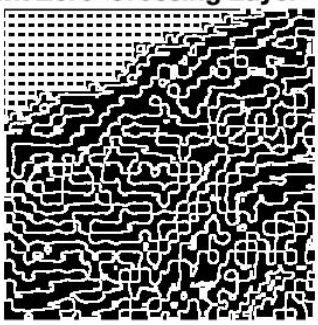


Text Zero-Crossing Layer = 1

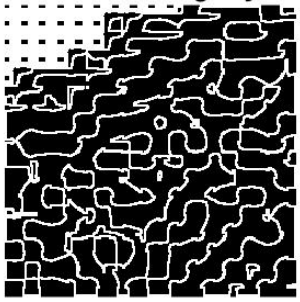
Text Zero-Crossing Layer = 2



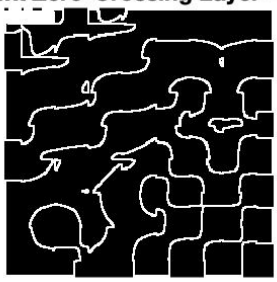
Text Zero-Crossing Layer = 3



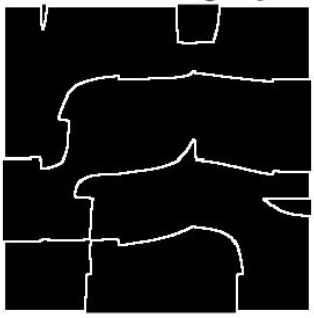
Text Zero-Crossing Layer = 4



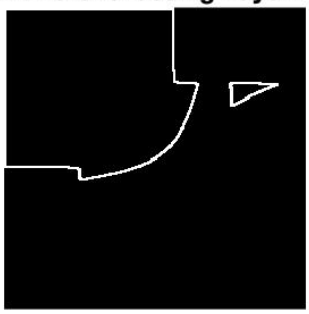
Text Zero-Crossing Layer = 5



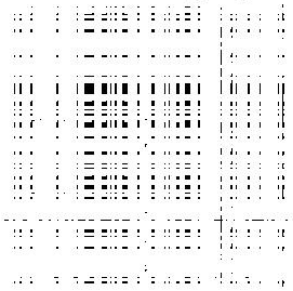
Text Zero-Crossing Layer = 6



Text Zero-Crossing Layer = 7

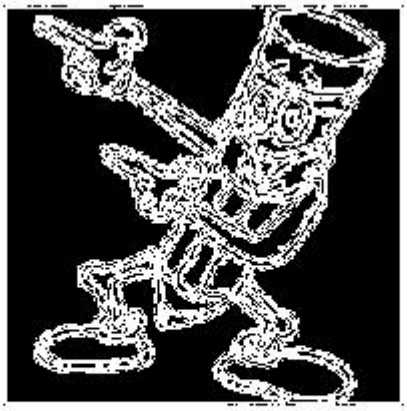


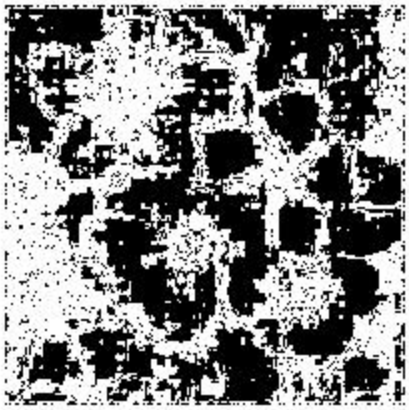
Text Zero-Crossing Layer = 8



- Step 4: Examine the pixels surrounding the zero crossing pixels in the second order derivative image. Calculate the local variance and mark it as an edge pixel if this value is greater than a certain threshold.

    - We note here that the below images are all from layer 1 of the Gaussian Pyramid along with a specific custom threshold values for the variance.
    - We also note that the results are very sensitive to different variance threshold value, because images contain different amount of noise. For example, the *cartoon* and the *kitty* pictures both required similarly high threshold, because they had relatively low amount of noise. However, images like the *flowergray*, *polarcities*, and *text* required varying threshold values that were lower to differentiate textures of the garden, the rooftop, and the special text-effects of the images, respectively.





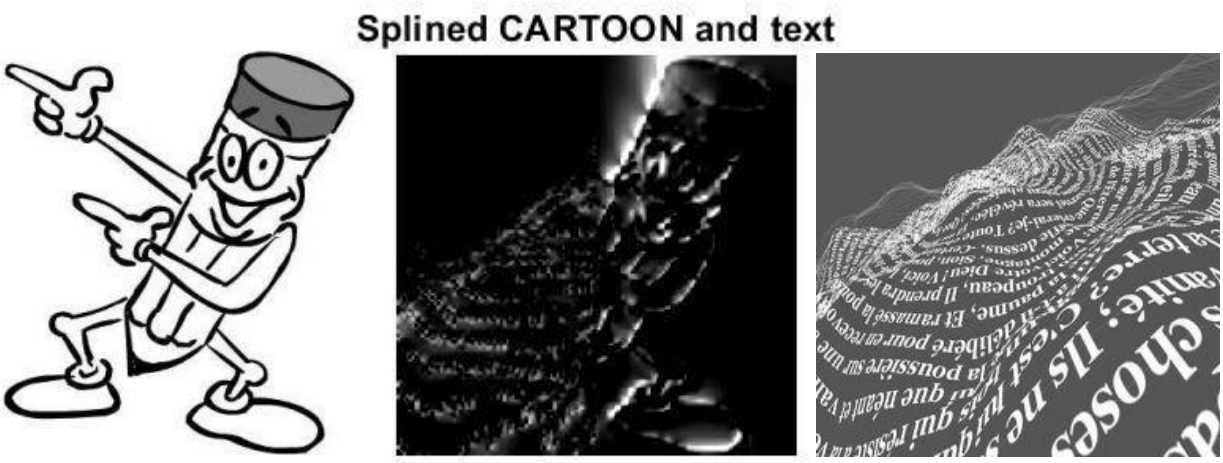
Multi-Resolution Spline

- Choose 3 pairs of images from the gallery. Show the original images, your mask and the final result in your PDF file

Mask Filter

Splined CARTOON and kitty

Splined flowergray and CARTOON



- Note that the order of the splines matter. When the cartoon was splined in reverse order, the side of the picture that the cartoon appeared also changed.

Contributions

- This assignment has been completed by Aaron and Sakshi. Part #1, #2, and #5 was done by Aaron. Part #0 and Part#3 was done by Sakshi. At the end of completing the individual parts, we got the partner to give insights and critique the codes and the respective outputs. It helped us correct many parts in the code as well and encourage discussions.