SIGNALS AND SYSTEMS

PROJECT REPORT

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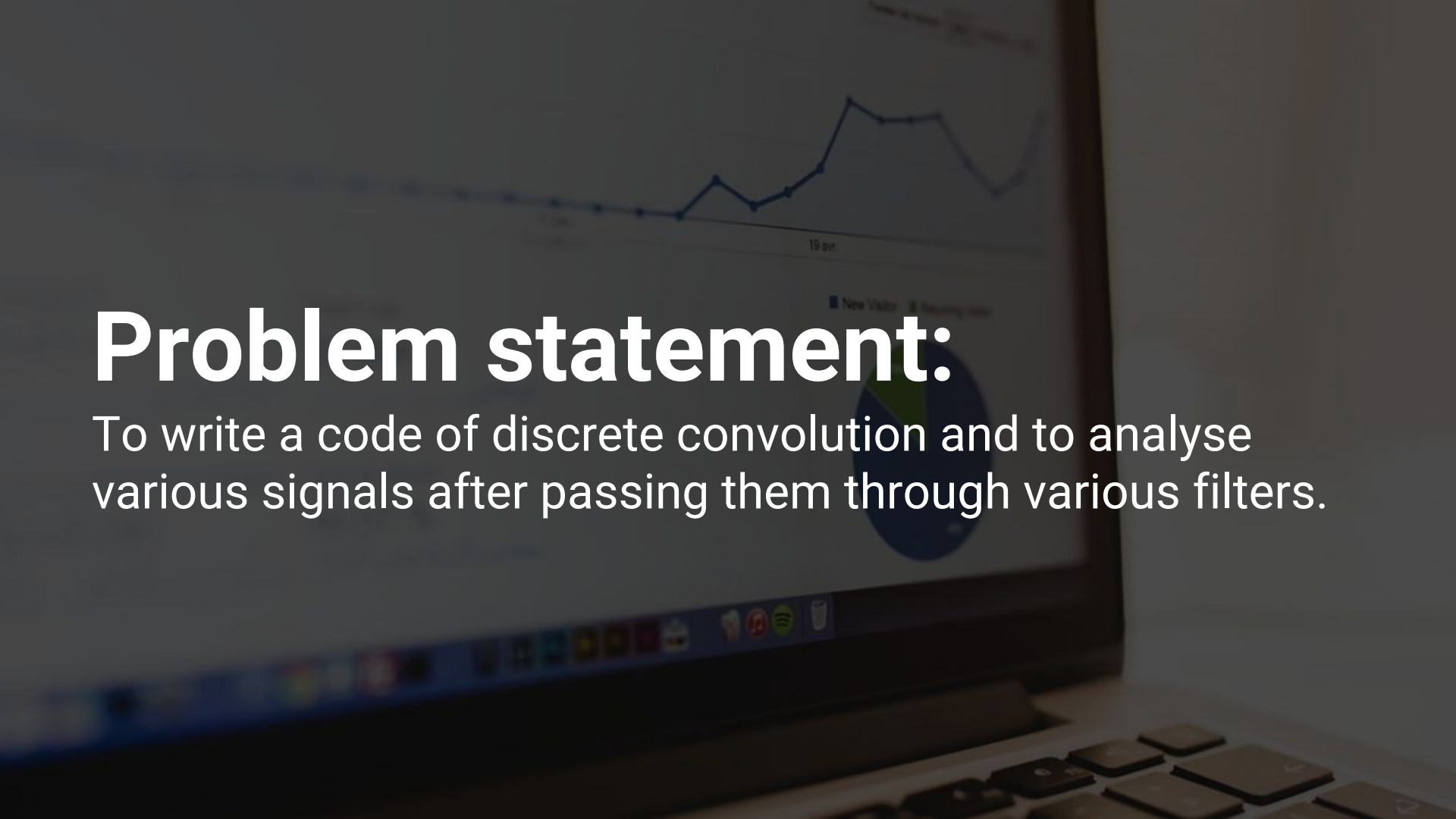


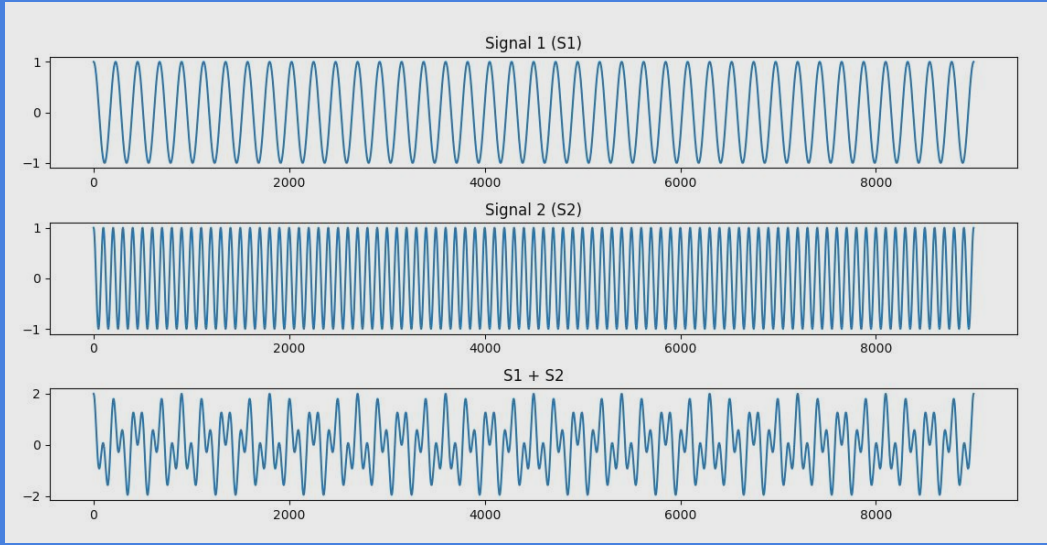
Problem statement:

To write a code of discrete convolution and to analyse various signals after passing them through various filters.

The overview

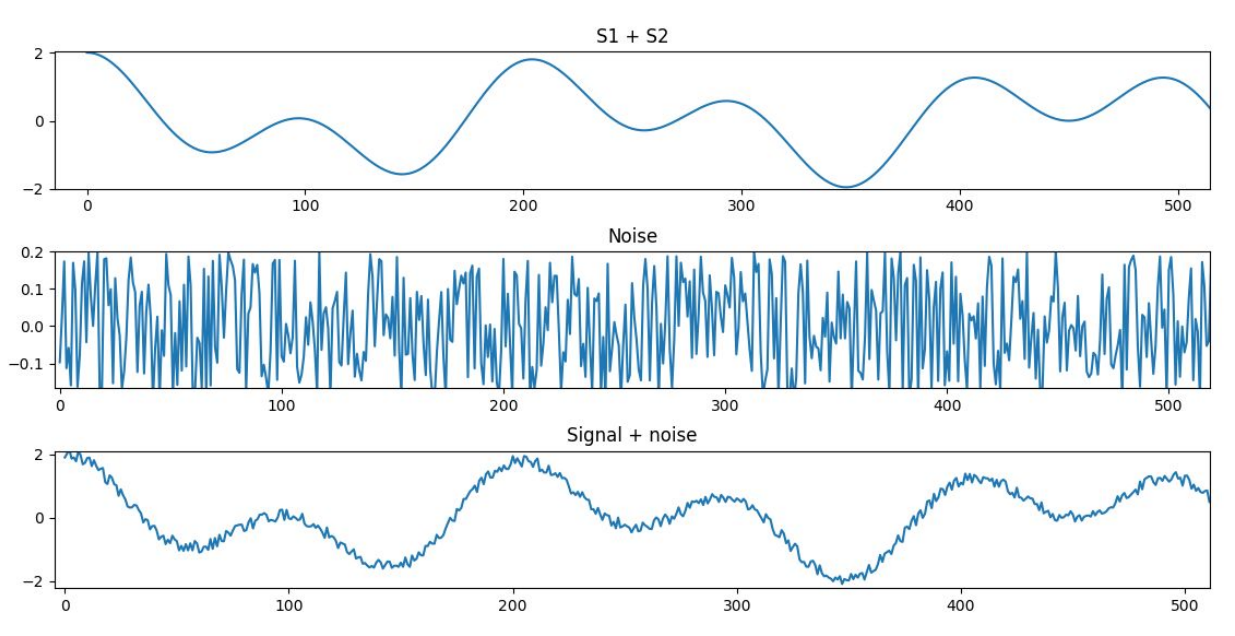
Use of python programming language and wrote the code of one dimensional and two dimensional convolution.
Codes for box, triangular filters.
Representation of sinusoidal waves, noise, voice signals and image signals as mathematical objects, ie. arrays and matrices.
Obtaining the output of convolution of the signals with filters given.
Varying various parameters and observing the output.
Implemented sharpening, sobel, filters for images (additional).

Sinusoidal waves

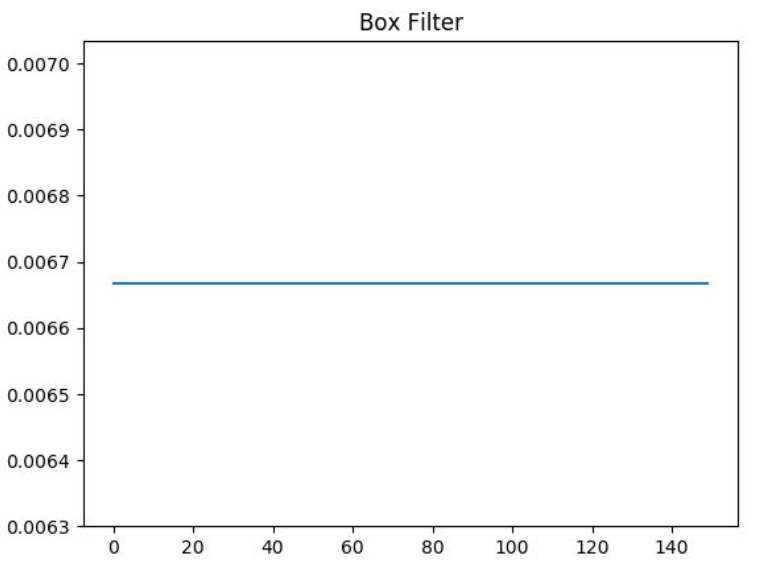


Adding noise

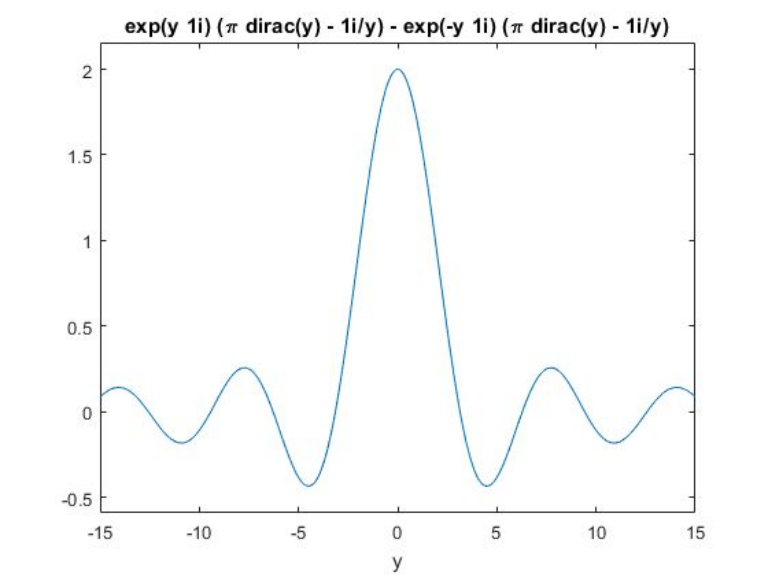
Using sigma = 0.2



Box filter

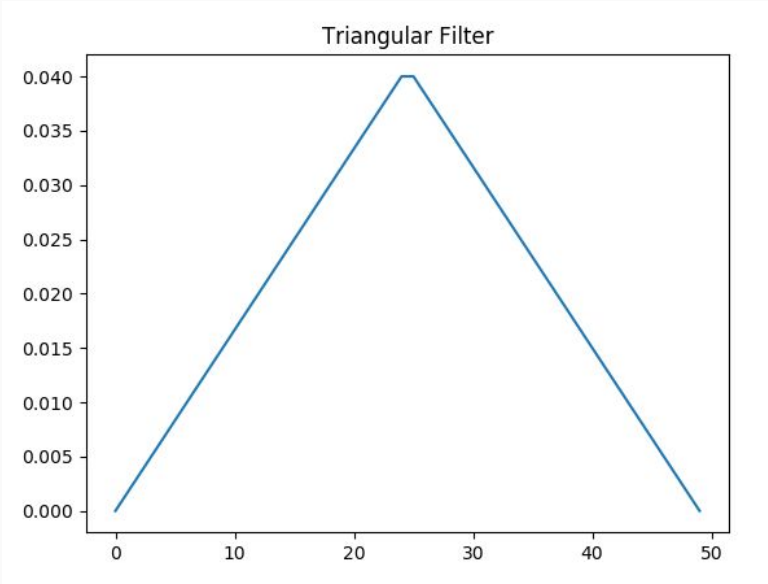


Time domain plot

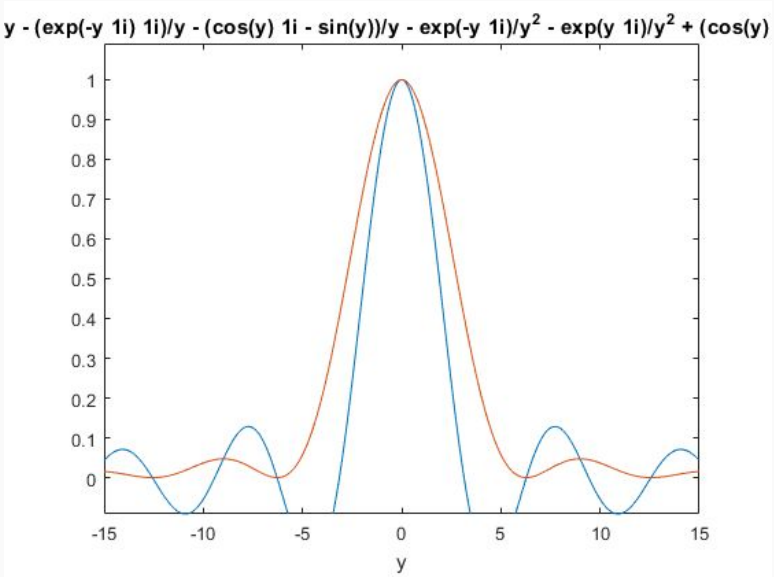


Frequency domain plot

Triangular filter

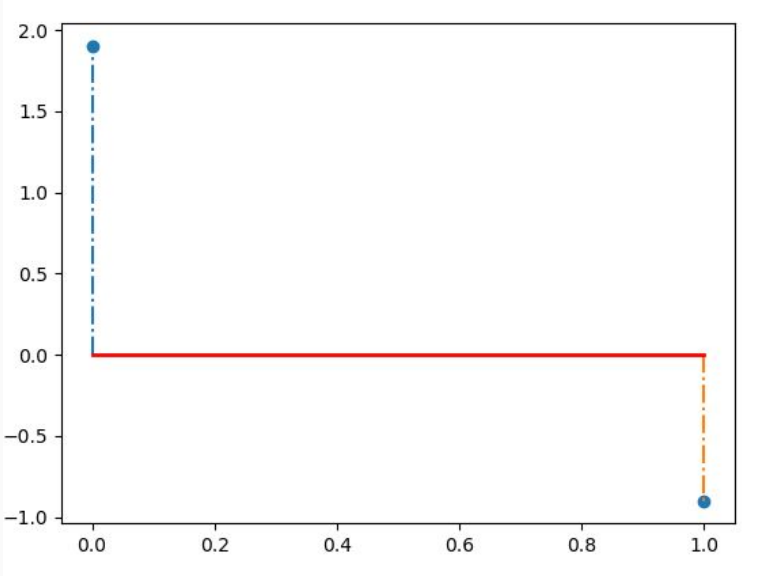


Time domain plot



Frequency domain plot (red colour)

Delta filter - (1 + p).□(n) - p.□(n-1)

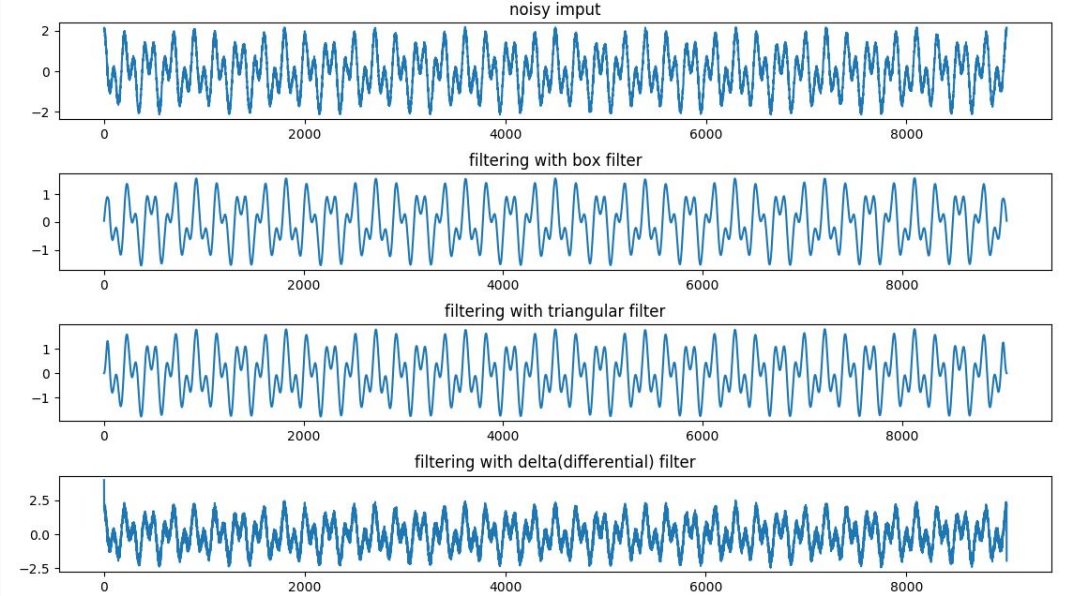


Fourier transform of delta functions is a constant thus it doesn’t affect the frequency of output signal.

All three filters are used together. Value of M used was 50 and that of p was 0.9

Observations:

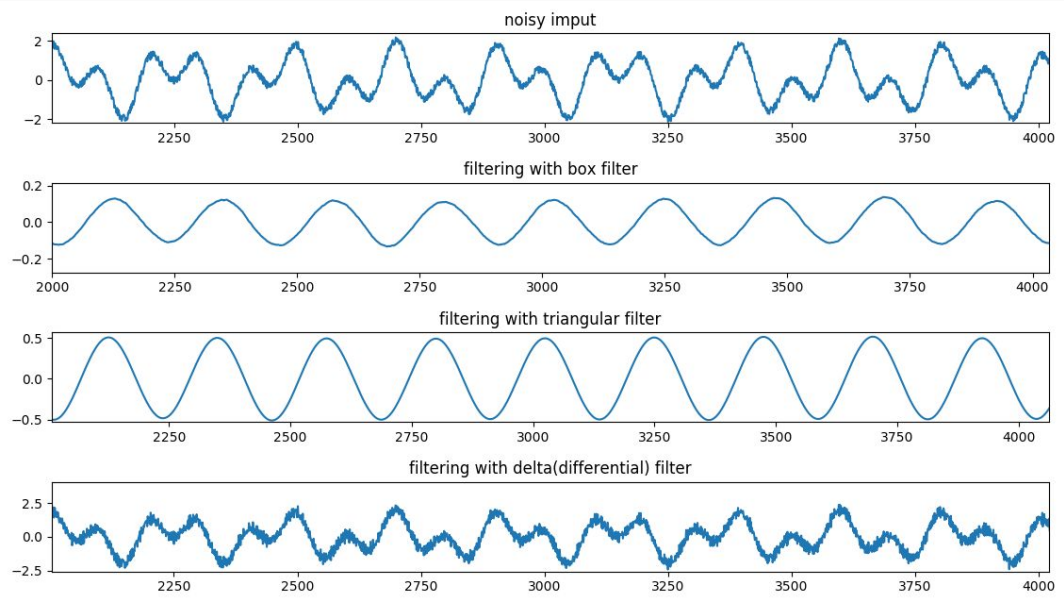
- Lower frequencies were prominent:
  - Higher frequencies absent
  - Filter is a low pass filter
- Overall amplitude reduced:
  - Because of reduction in frequency components
- Noise almost completely removed
  - Noise has higher frequencies than than the signal
- Time shift of signal was observed
  - The filter delays the output
- Edge effects
  - Edge appeared to be less stable



All three filters are used together. Value of M used was 200 and that of p was 0.5

Observations:

- Lower frequencies were more prominent:
  - Compared to the previous plot, where M was 50, in this case, even the higher frequency signal among the two signals has been filtered out.
  - This can be explained by the fact that as the width of the filter increases, the width of its fourier transform decreases, hence it allows even lower frequencies

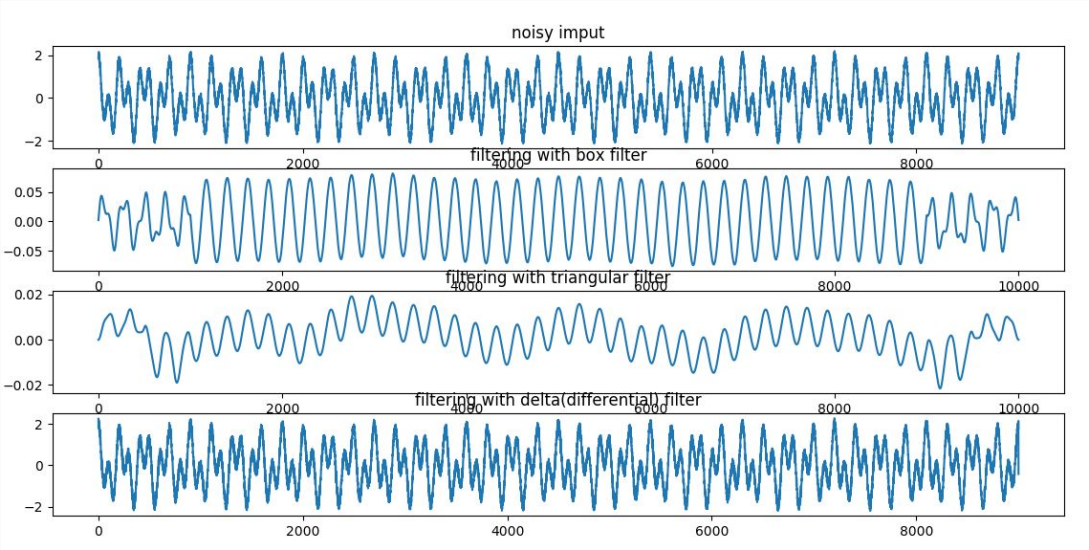


All three filters are used together. Value of M used was 200 and that of p was 0.5

All three filters are used together. Value of M used was 1000 and that of p was 0.2

Observations:

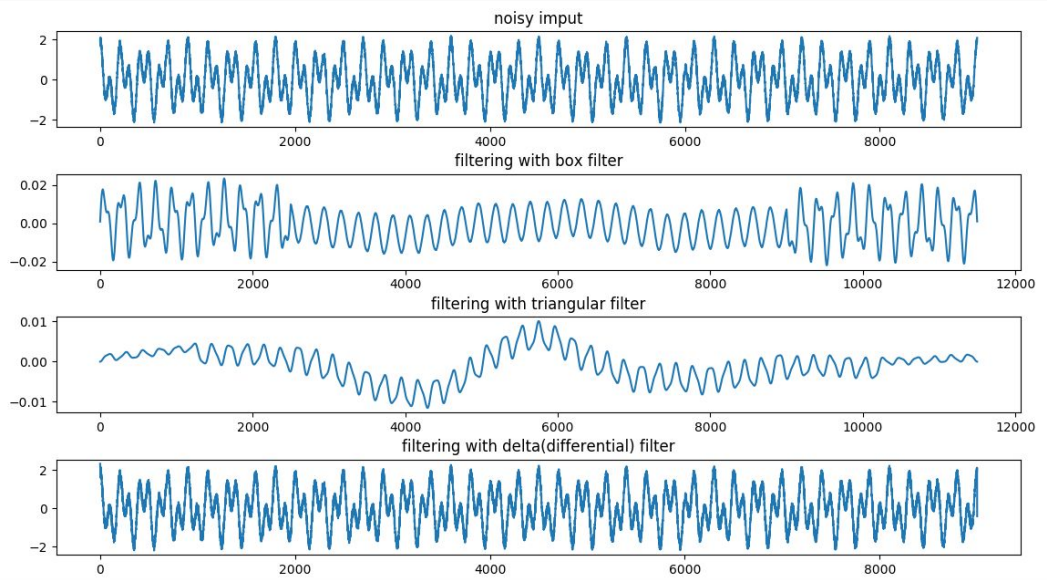
- As the filter width increases even more, it starts allowing even lower frequencies
  - As can be seen in the third plot, another much lower frequency has, come in.
  - However, we have been unable to come up with a reasonable explanation for it



All three filters are used together. Value of M used was 2000 and that of p was 0.2

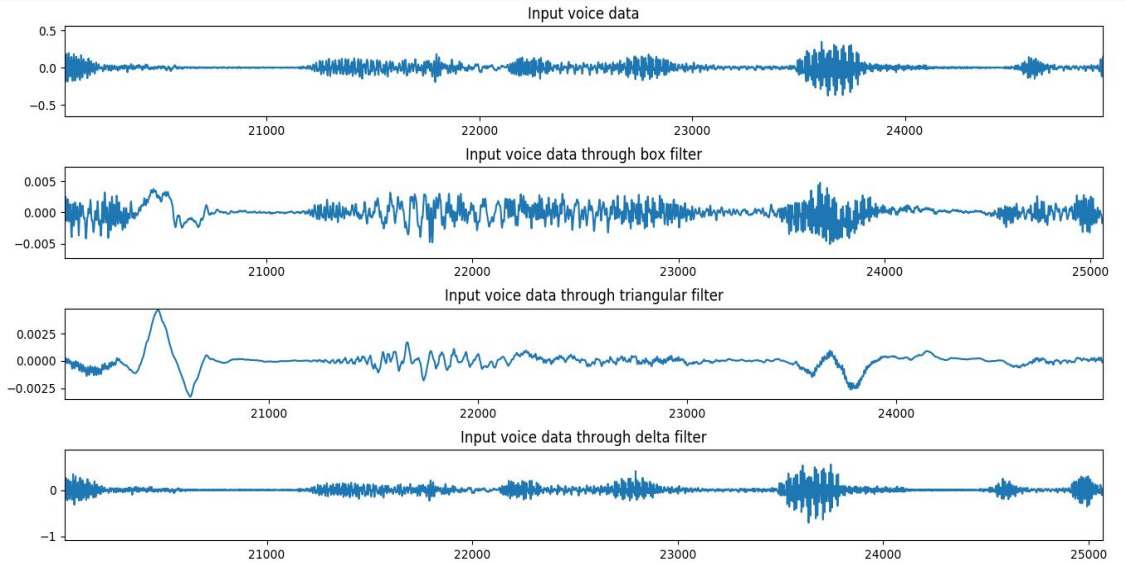
Observations:

- As mentioned in the previous, slide, an extra wave of a much smaller frequency is observed, and its frequency gets smaller as we increase the filter size



Voice signal

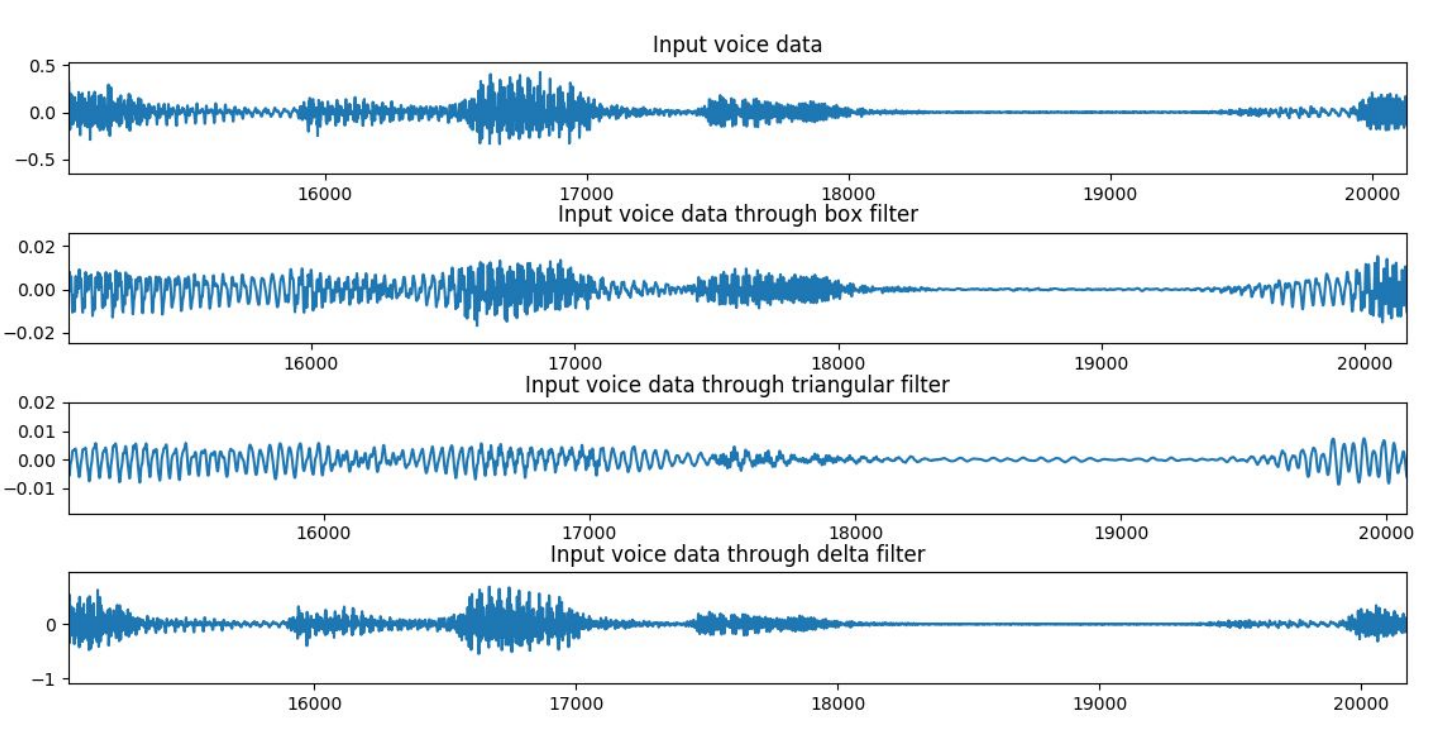
All three filters are used together. Value of M used was 150 and that of p was 0.9



Observations:

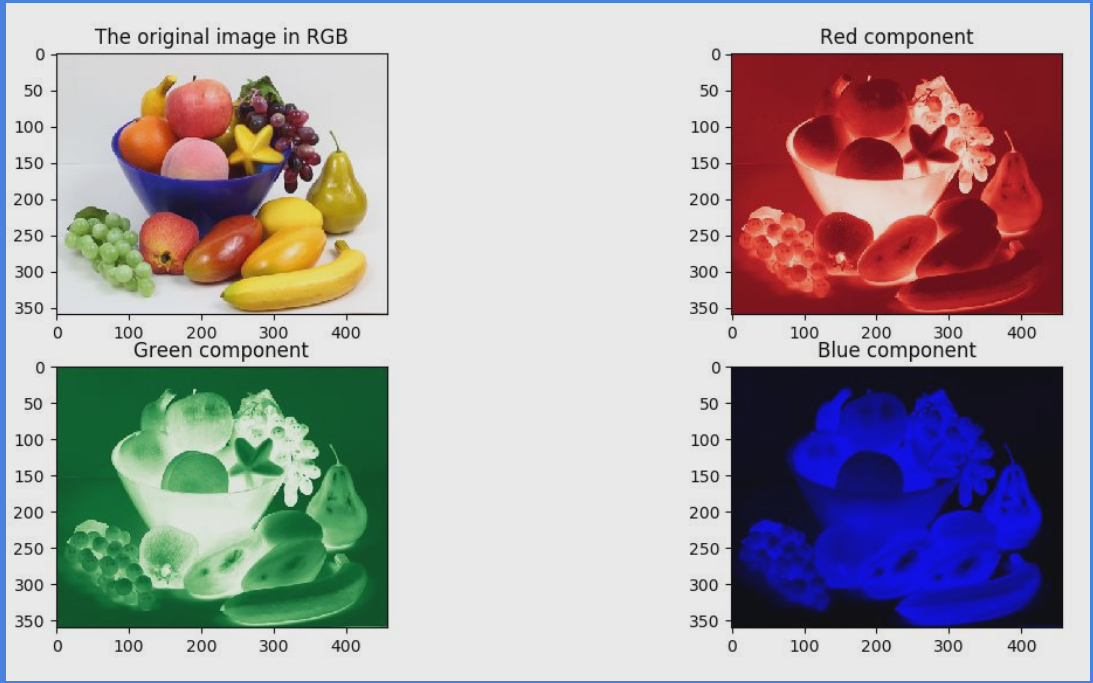
- Change in the quality of signal:
  - Box and triangular filters reduce frequency component while the delta filter doesn't
- Higher frequencies were lost:
  - Box and triangular filters are low pass filter while the delta filter doesn't affect the curve with respect to frequency. (This can be explained by the fact that the fourier transform of the delta function is constant
- Overall amplitude reduced:
  - Because of reduction in frequency components
- Noise almost reduced by first two filters
  - Noise has higher frequencies

All three filters are used together. Value of M used was 50 and that of p was 0.5



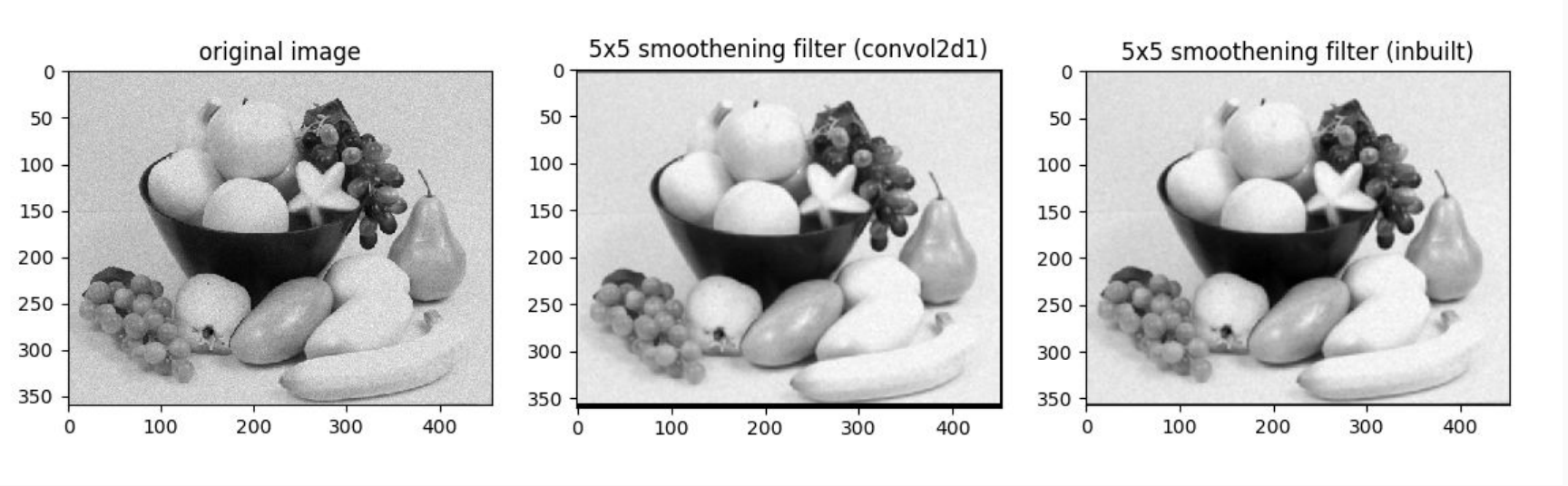
The output from box filter was exceptionally noise free!

Image file


The original image in RGB
Red component
Green component
Blue component
0
50
100
150
200
250
300
350
0
100
200
300
400

Smoothing filter (5x5 kernel)

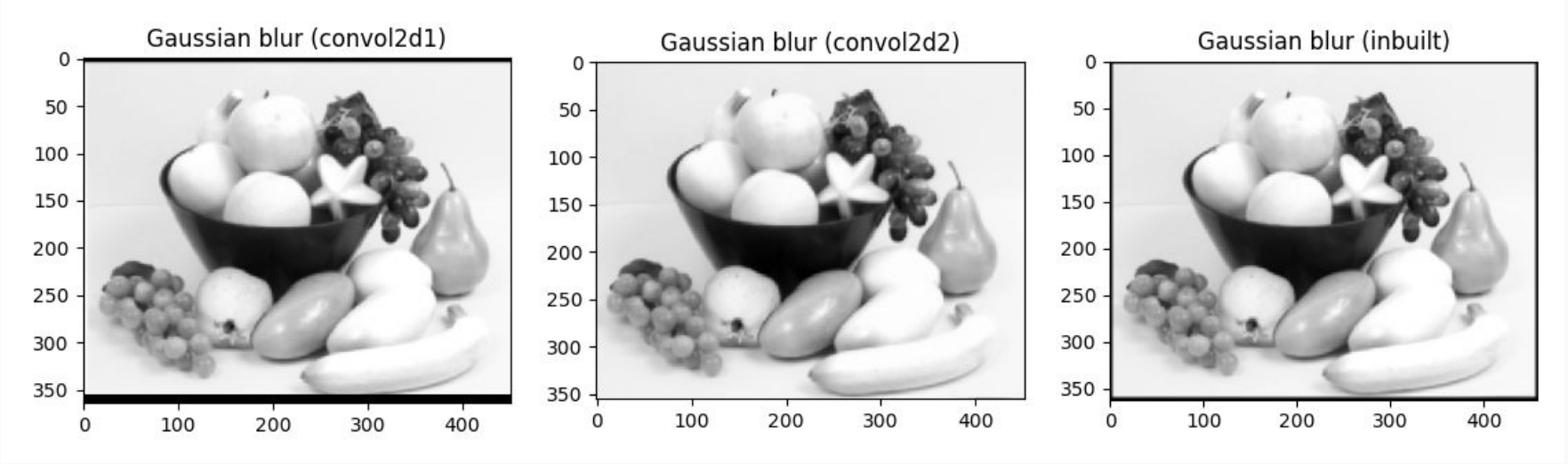
Similar to box filter, in 2-d



Used only R-component(grayscaled) of the filter, can be done for all three to get complete image. We used two different approaches for convolution and made a comparison with the inbuilt one.

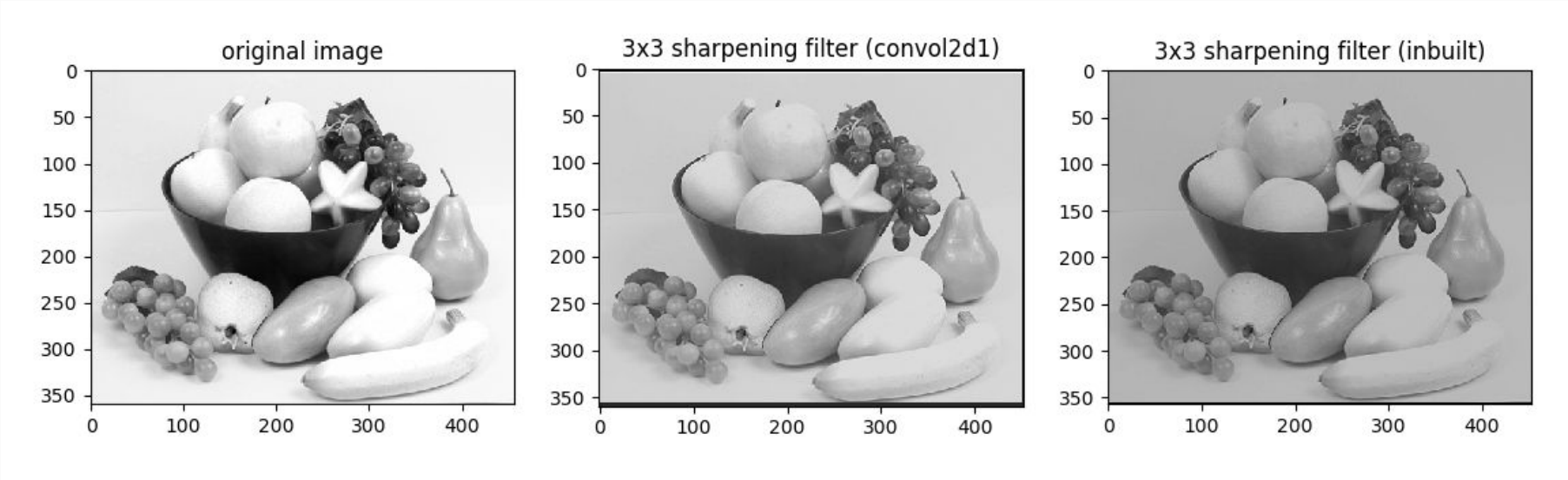
Gaussian blurring filter (5x5 kernel)

Similar to triangular filter, in 2-d



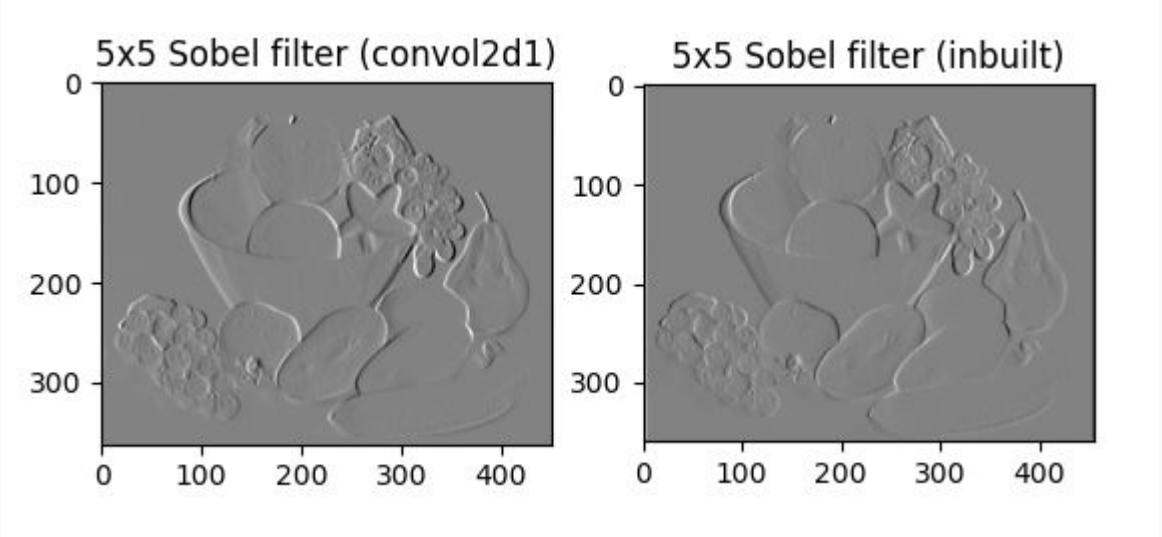
Used only R-component(grayscaled) of the filter, can be done for all three to get complete image. We used two different approaches for convolution and made a comparison with the inbuilt one.

Sharpening filter



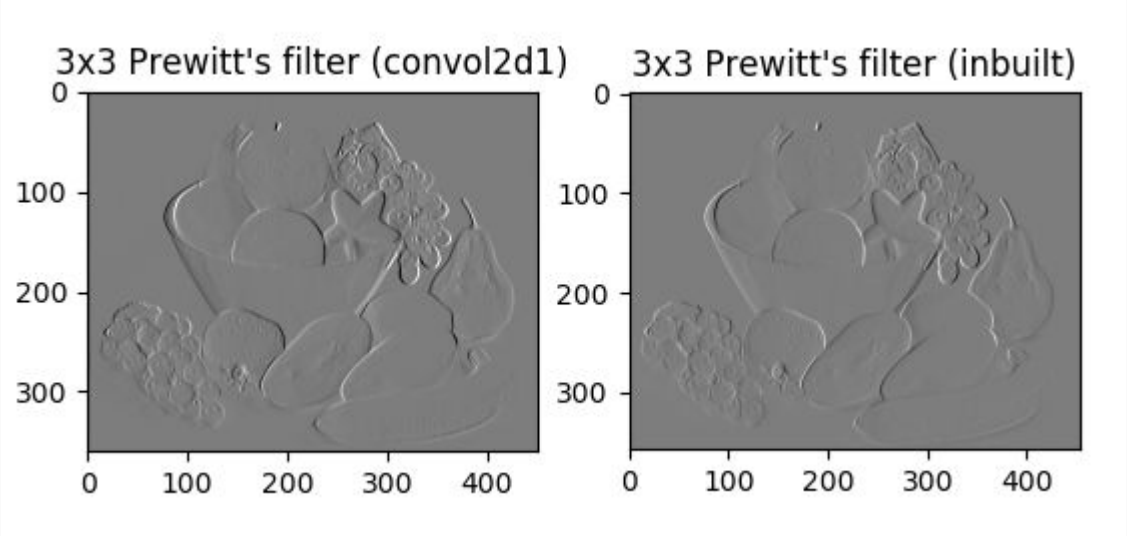
Used only R-component(grayscaled) of the filter, can be done for all three to get complete image. We have made a comparison with the inbuilt one.

Sobel filter



This filter detects vertical edges, we have made a comparison with the inbuilt one. Embossing might be different because of different way of implementation

Prewitt’s filter



This filter detects vertical edges, we have made a comparison with the inbuilt one. Embossing might be different because of different way of implementation

END