

Lab 2 Report

Convolution and LTI System

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1. 1D Convolution for an Image

Original Lena



Figure 1. Original Lena after imshow()

Row-conv Lena



Figure 2. Row convolution Lena

The image is more blurry by columns for sure, but it is hard to tell whether everything is shifted towards up or down.

Col-conv Lena



Figure 3. Column convolution Lena

The image is more blurry by columns for sure, but it is hard to tell whether everything is shifted towards left or right.

Row-conv-Col-conv Lena



Figure 4. Row Convolution and Column Convolution Lena

The image is more blurry, and it seems like the image is shifting to the bottom-right corner. It is the combination of the previous two results.

2. Zero-Input and Zero-State Responses

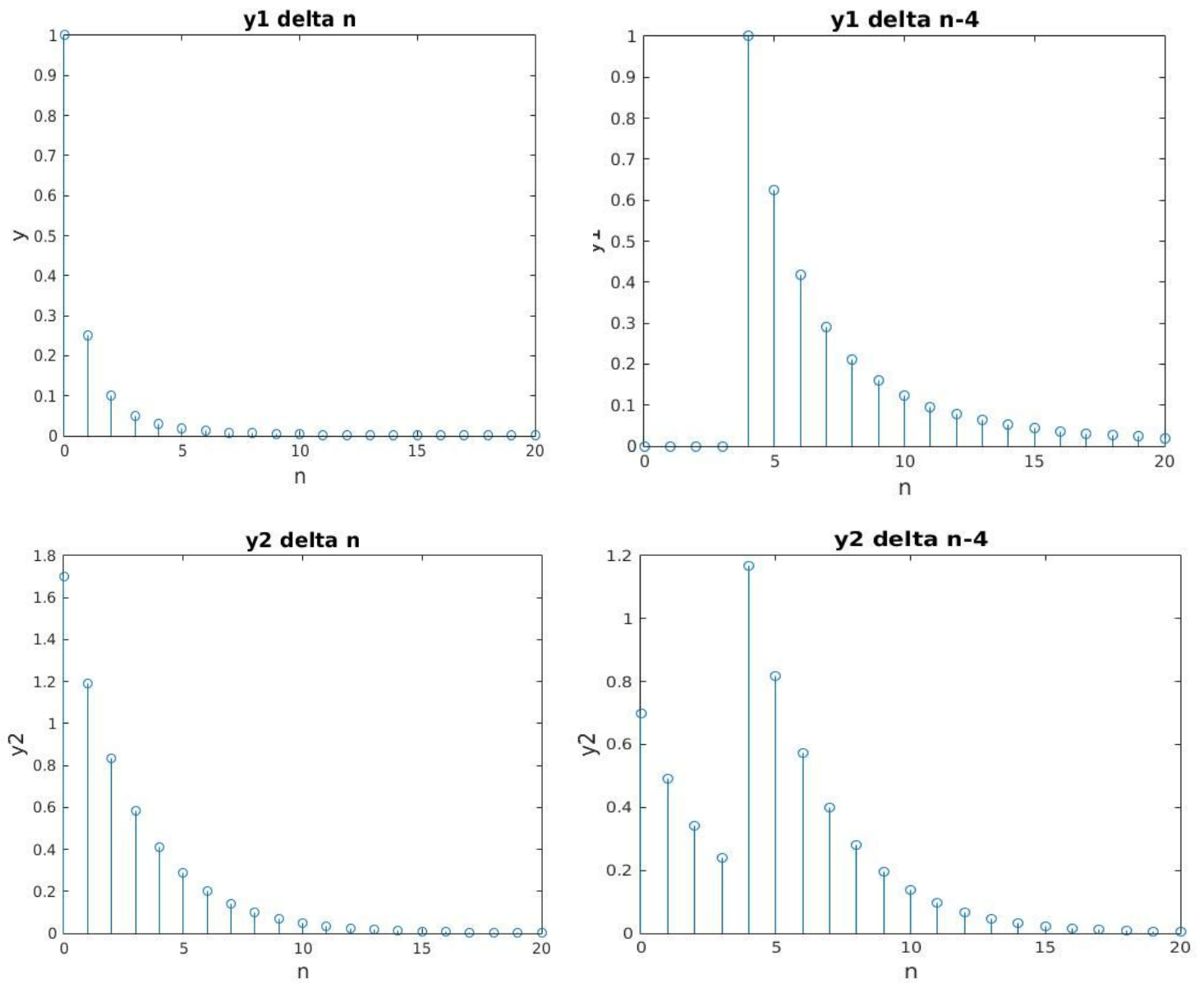


Figure 5. Top-left y1 part(a), Top-right y1 part(b), Bottom-left y2 part(a), Bottom-right y2 part(b)

part(a) comment: y1 is decreasing much faster than y2. Neither of them has obvious zero-input response.

part(b) comment: Both decreasing about the speed, but y1 has a zero-input response of 0 for $n < 4$, and y2 has a non-zero input response for $n < 4$.

3. Bitcoin Analysis

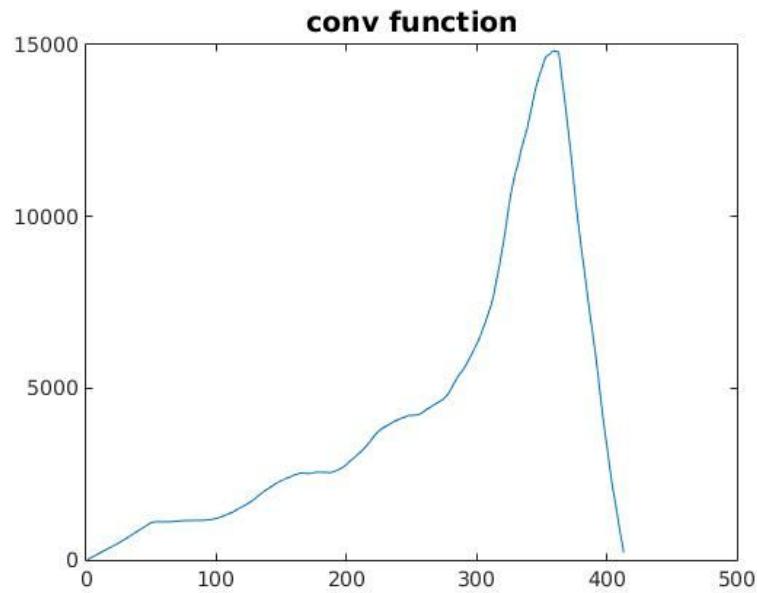


Figure 6. Convolve with a ones vector of 51 length, which verifies my result

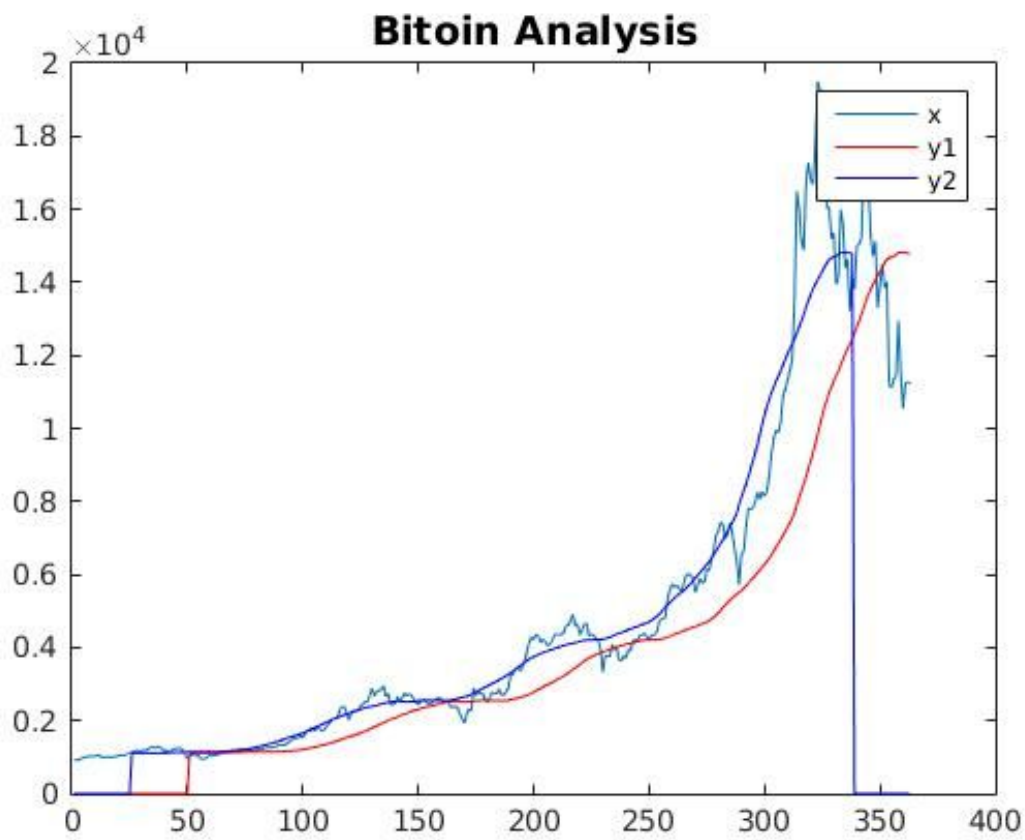
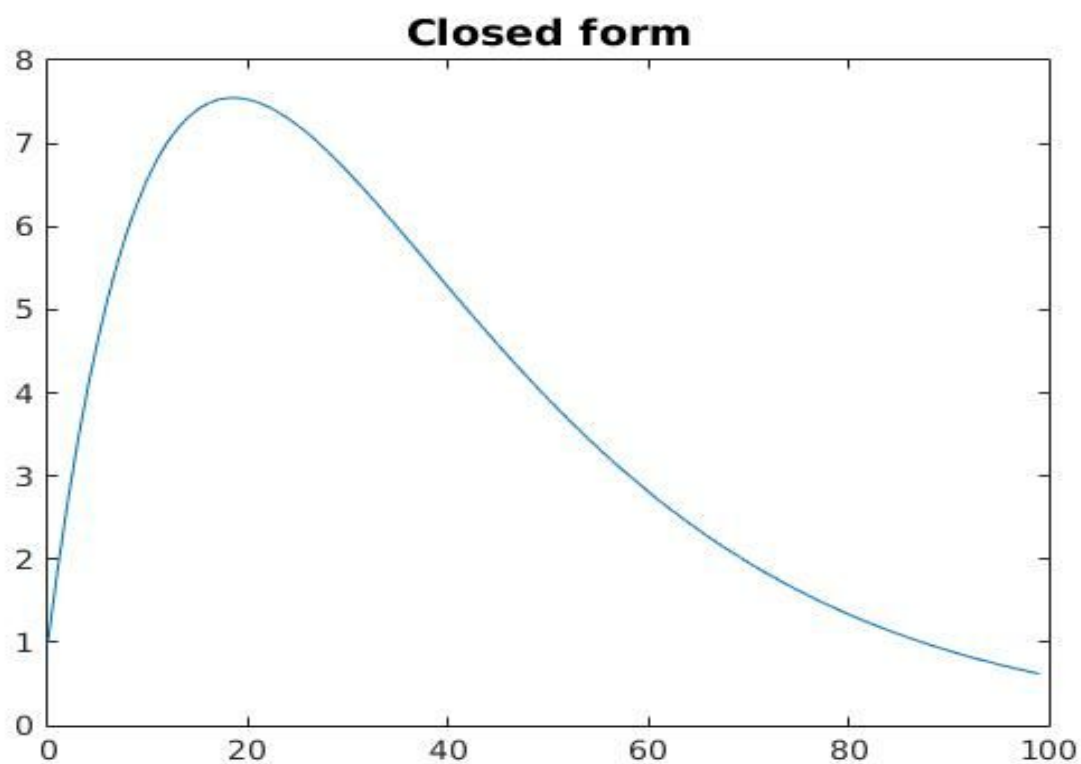


Figure 7. Bitcoin Analysis sequence

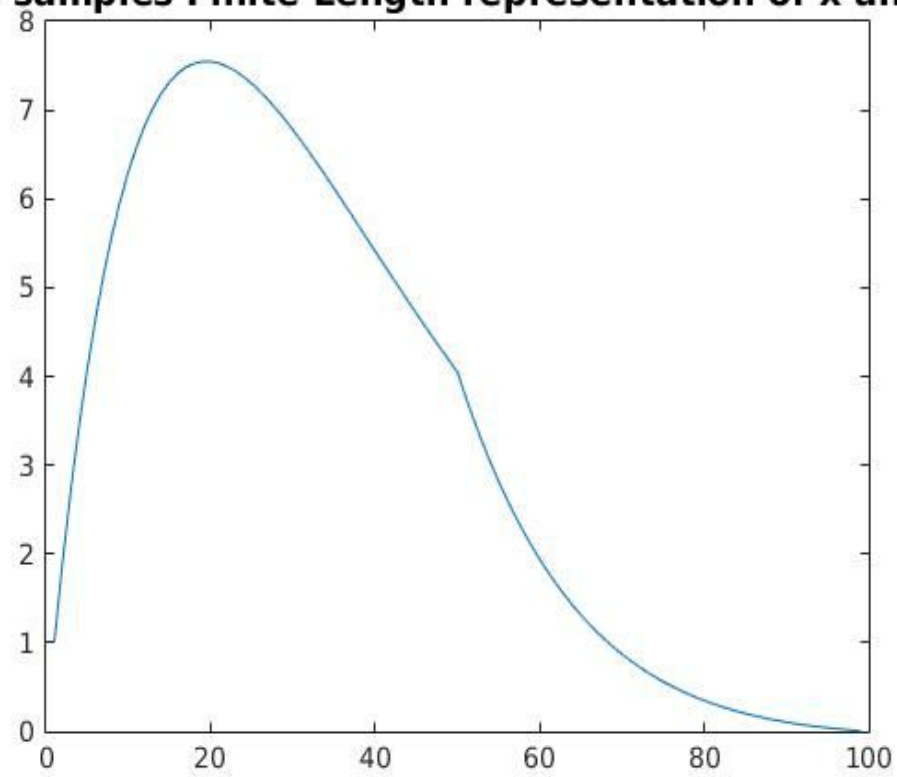
Comment: The results from two convolution seem to be identical. They are just shifted by 25.

4. Analytical Expression and Finite Length Representation of a Convolution

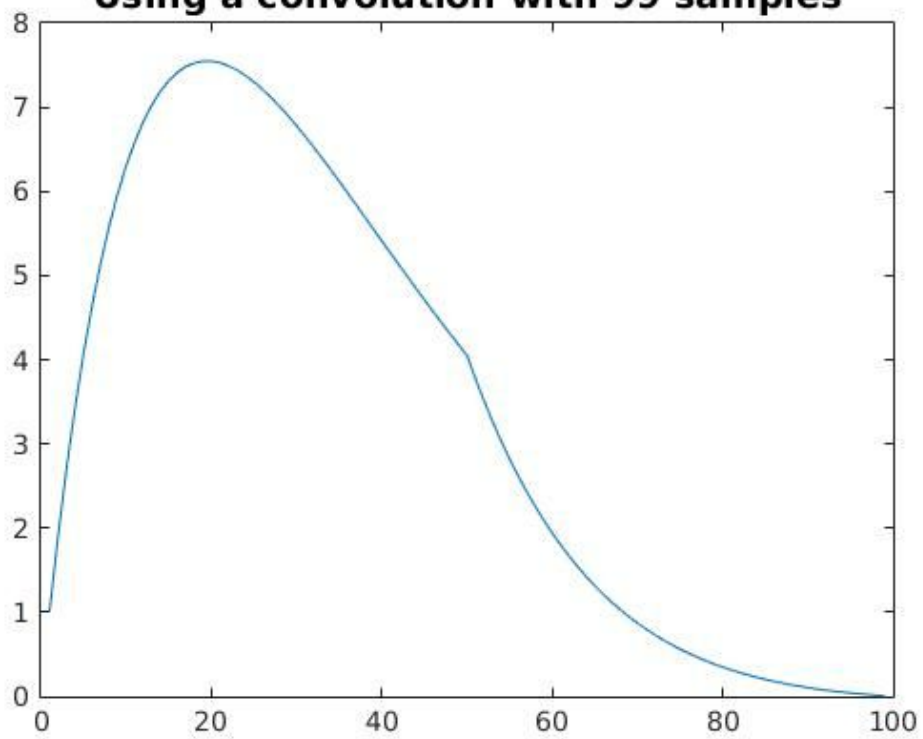
$$\begin{aligned} & \sum_{k=-\infty}^{\infty} 0.95^k u[k] 0.95^{n-k} u[n-k] \\ &= \sum_{k=-\infty}^{\infty} 0.95^n u[k] u[n-k] \\ &= \sum_{k=0}^n 0.95^n \\ &= 0.95^n (n+1) \end{aligned}$$



50 samples Finite Length representation of x and h

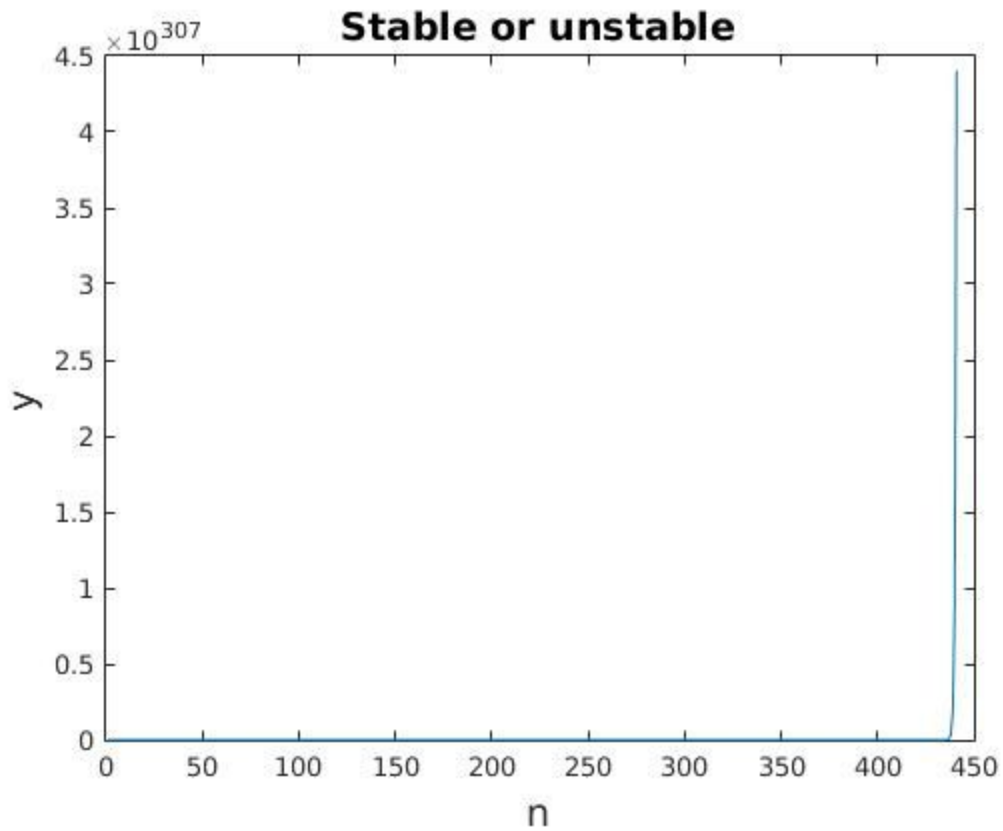


Using a convolution with 99 samples



Comment: both part b and part c look similar to that of part a. However part c should come closer to part a. Since part a is using an infinite length sequences, and part c we are using more samples from the two sequences.

5. Stable or Unstable?

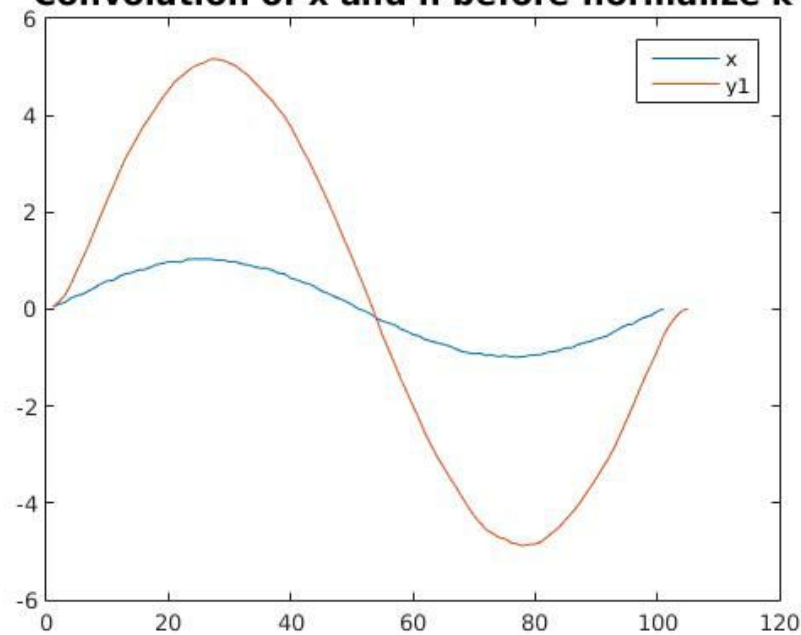


Comment: The system is unstable.

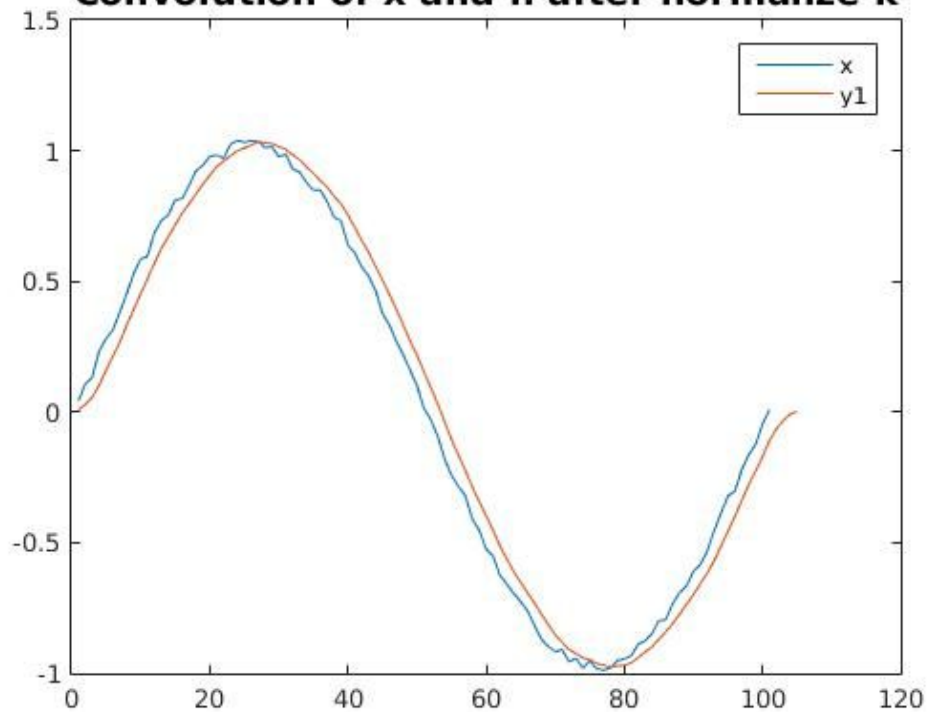
6. Convolution Sum

$$y[n] = \sum_k x[k] * h[n-k] = \sum_k x[k] * \sum_n h[n-k] = \sum_k x[k] * \sum_n h[n]$$
$$y[n] = AxAh$$

Convolution of x and h before normalize k



Convolution of x and h after normalize k



Comment: Because $h(n)$ is normalized, therefore $y[n]$ has the magnitude very much like the $x[n]$ because $h[n]$ is acting like moving average filter.

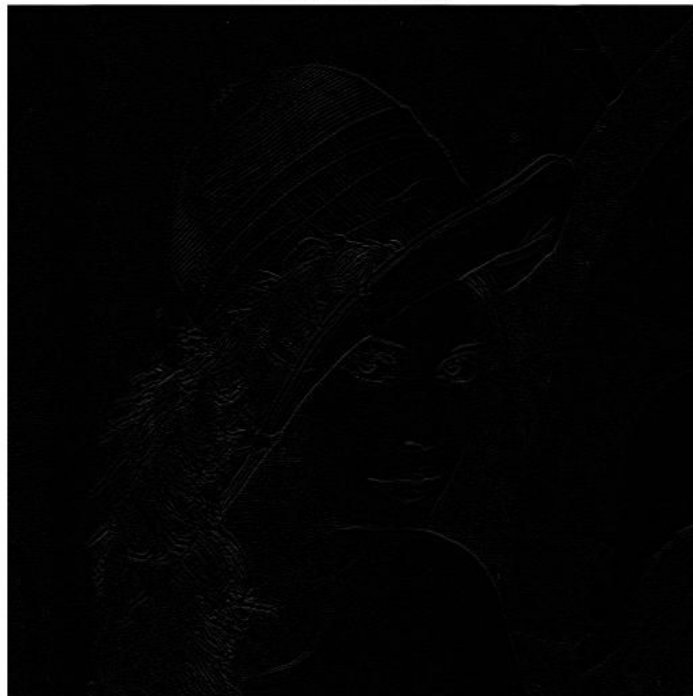
7. Edge Detector for an Image

$$H[x] = \text{delta}[n+1] - 2\text{delta}[n] + \text{delta}[n-1]$$

Row-conv Lena



Col-conv Lena



Part b: For row-by-row, vertical lines are emphasized.

Part c: For col-by-col, horizontal lines are emphasized.