

Basic Application of FIR Filtering in Digital Processing Systems

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Background

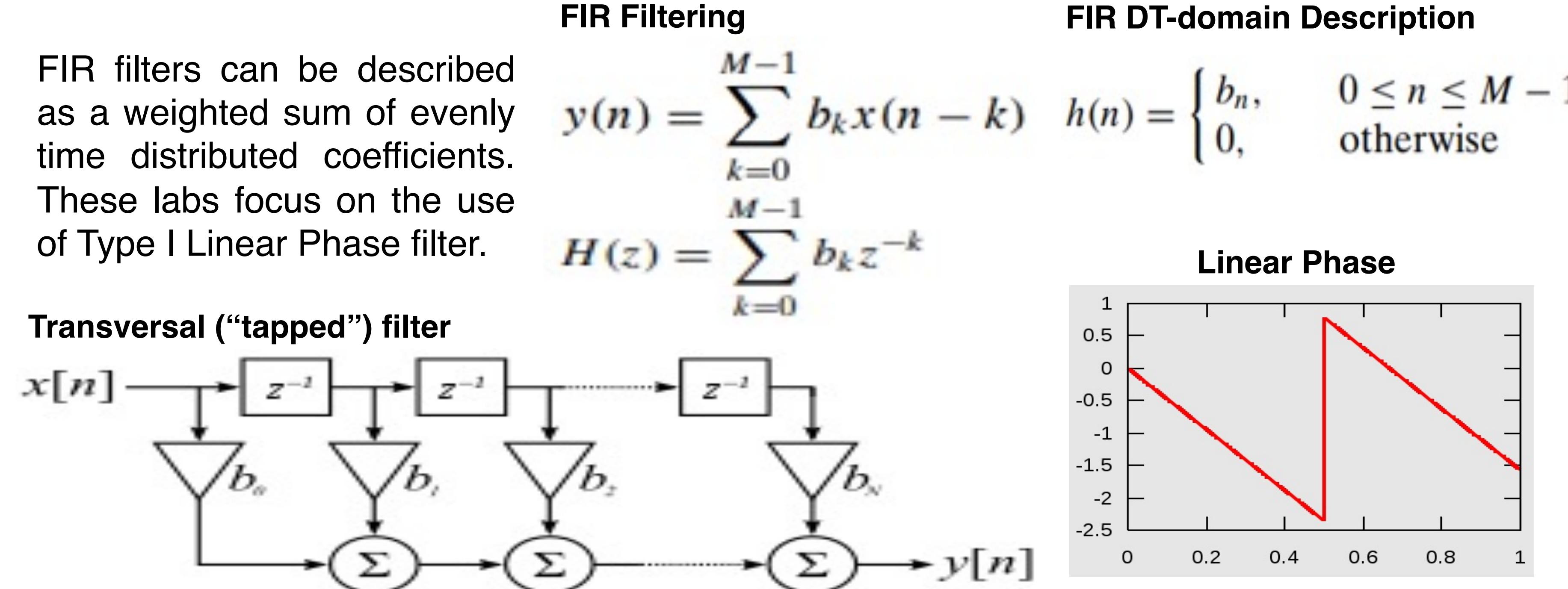
A large component of DSP is audio and image processing. Within this area, computationally efficient FIR filters play a key role in applications such as edge detection, noise reduction, and smoothing.

In this project, we demonstrate edge detection with bar code readers, adding echoes to sound files, and recovering a noisy 2D signal.

Introduction

FIR filters can be described as a weighted sum of evenly time distributed coefficients. These labs focus on the use of Type I Linear Phase filter.

Transversal (“tapped”) filter



Method: Echo/Reverb

To achieve echoes (“ghosts”) and reverb (cascaded echoes), the output is a weighted sum of the present input with a past input sample.

$$y[n] = \frac{1}{1+\alpha} w[n] + \frac{\alpha}{1+\alpha} w[n-P]$$

A time delay is represented as an integer number of samples determined by the sampling frequency.

$$P = \text{Time Delay} * F_s$$

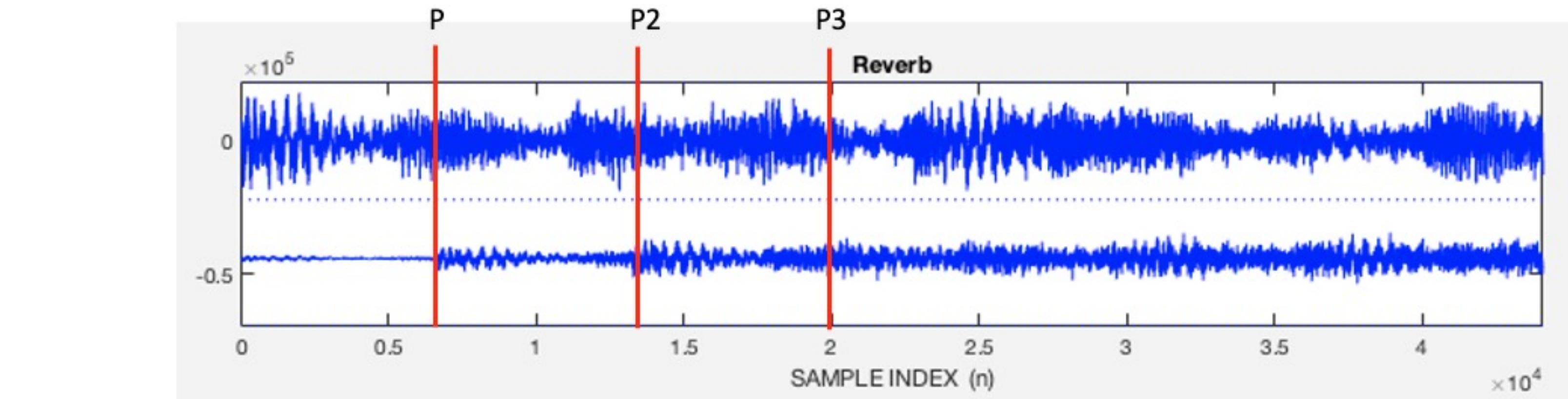
Results

Barcode Edge Detection

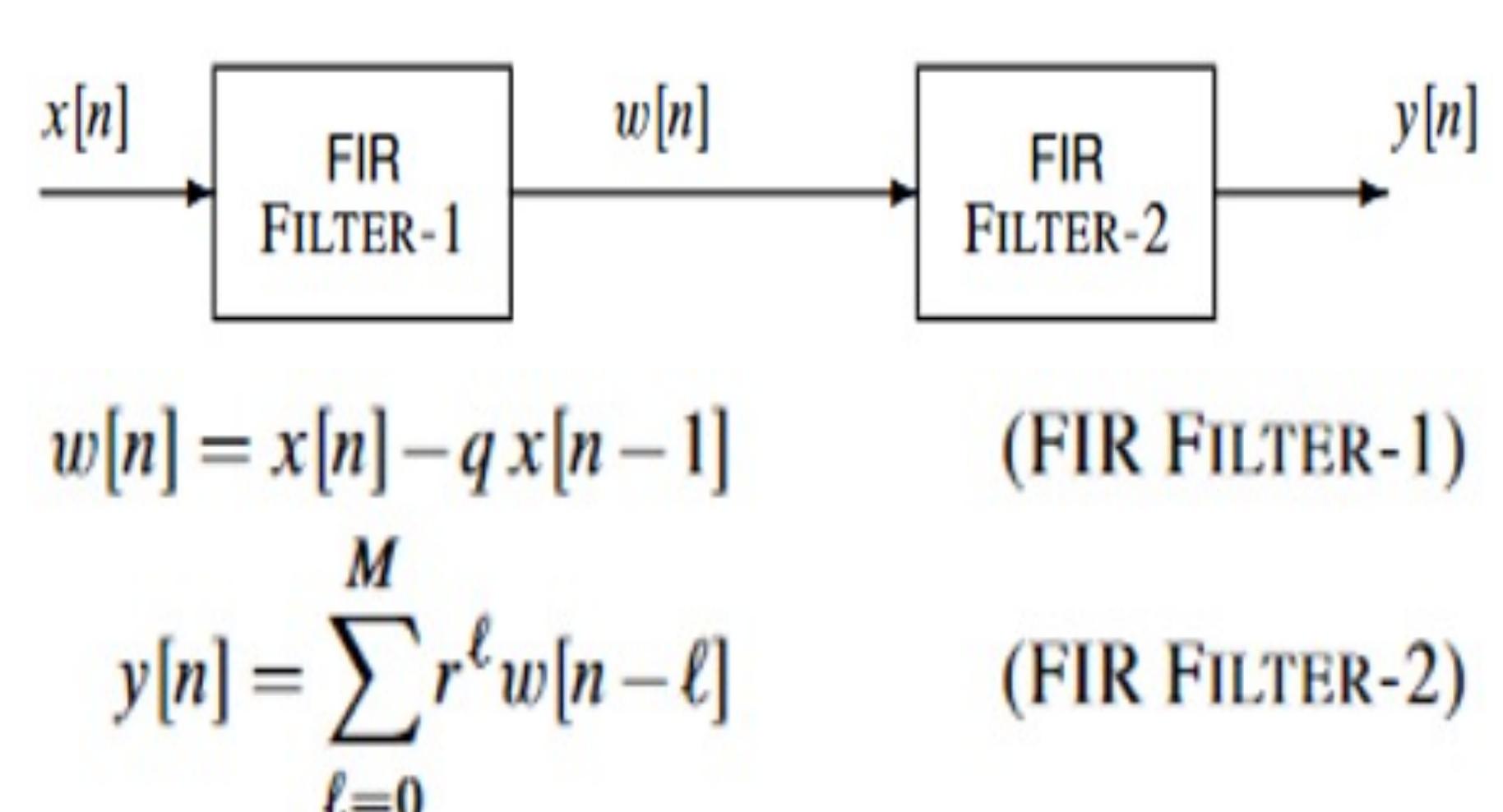


The ordered widths of the bars can be fed to a decoder. The decoder will return a 12-digit code.

Audio Echoing and Reverb

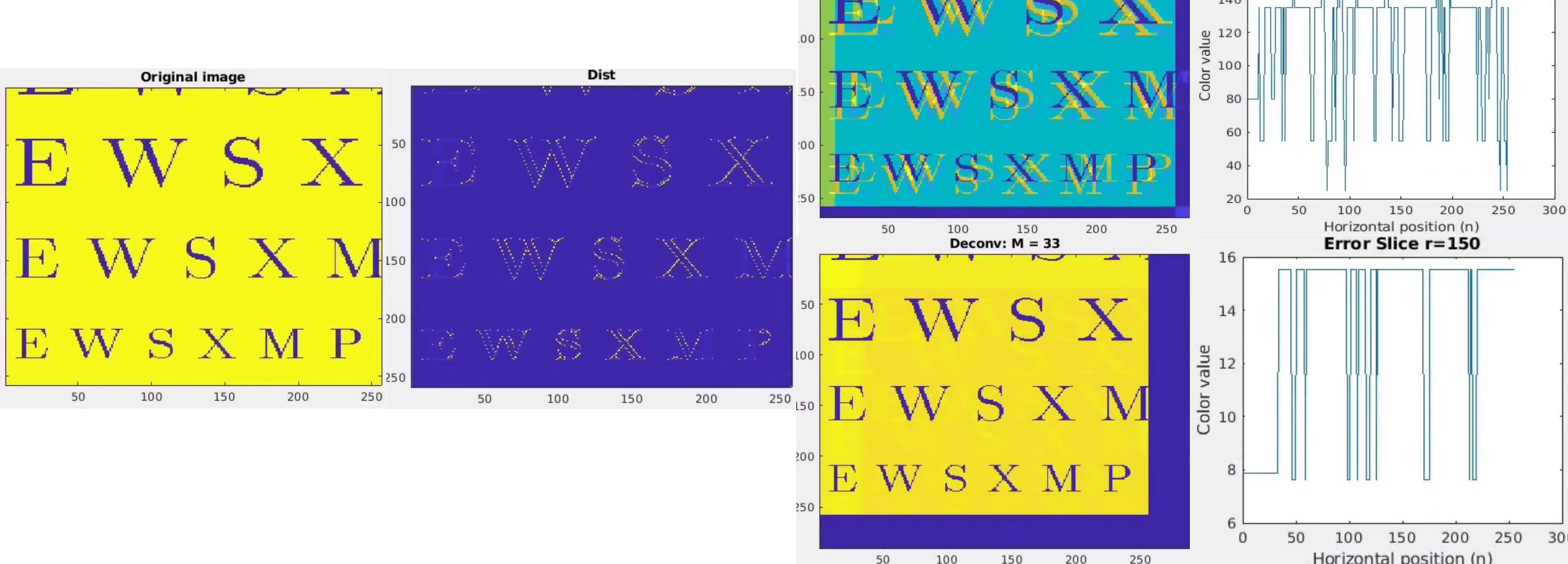


Method: Deconvolution (Cascaded Filters)



The cascade of Filter-1 (HP) and Filter-2 (LP) results in an approximate restoration (unity gain) of an input signal.

Image Alteration and Ghosting

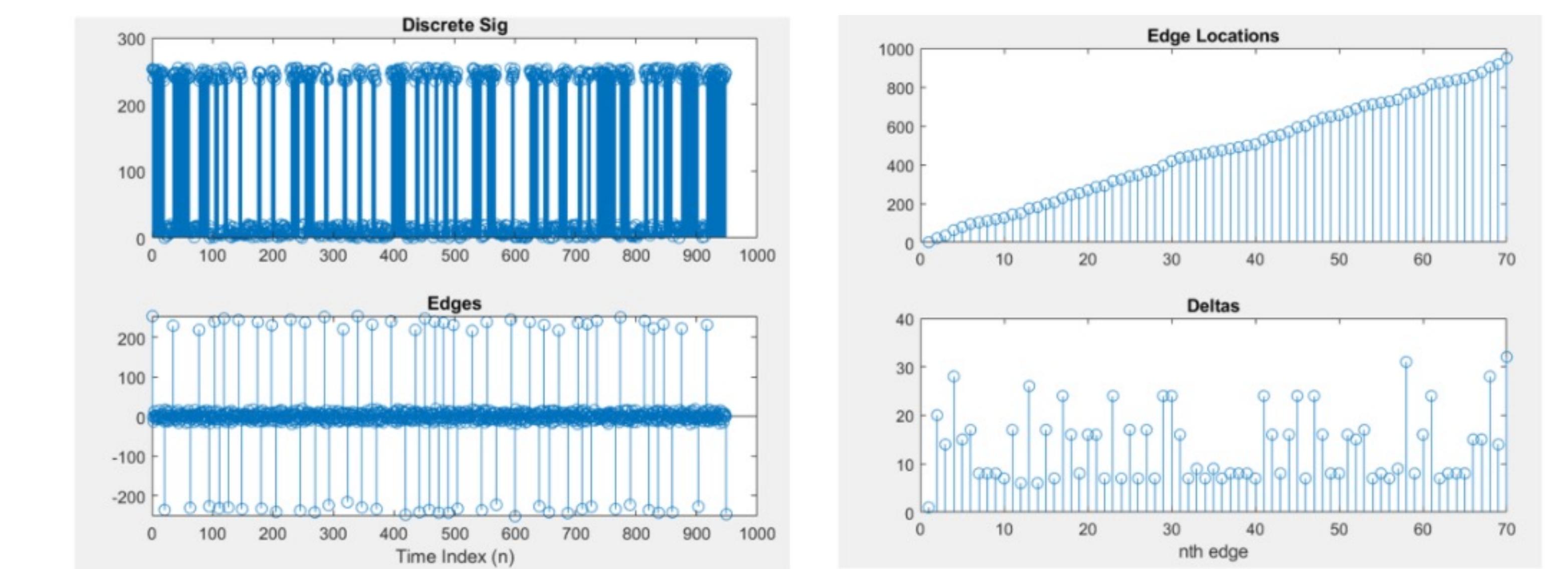


Method: Edge detection

An edge detector is as simple as convolving a signal with a [1 -1] Vector. Applications for an edge detector vary greatly but include bar code reading.



It begins by taking a perpendicular slice anywhere across the barcode. Convolving this with our detection vector, the edges can be found. The sign of the edge indicates the color (black or white) of the proceeding bar. The coded information is in the width of the bars.



Summary

The applications of FIR filters are clearly shown here to extend across discipline and dimension. The weight and ordering of FIR filter coefficients can be leveraged to obtain many desirable system characteristics.

References

J. Proakis and D. Manolakis, *Digital signal processing*, 4th ed. Upper Saddle River, NJ: Pearson Education, 2007, pp. 577-766.

Acknowledgement

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