

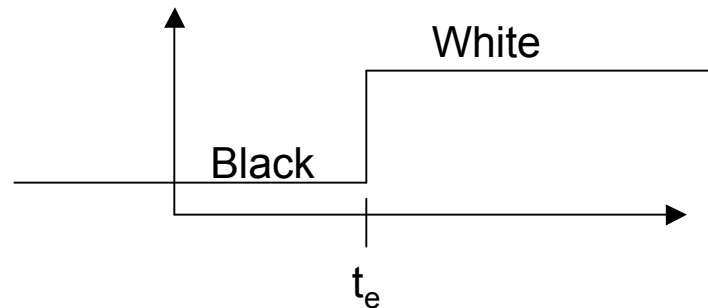
Matched Filtering: Finding Stuff in Images

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Pattern Matching

Goal: find the location of a “pattern” in an overall signal

- Finding edges in images (or other features such as eyes, cars, tanks, ...)

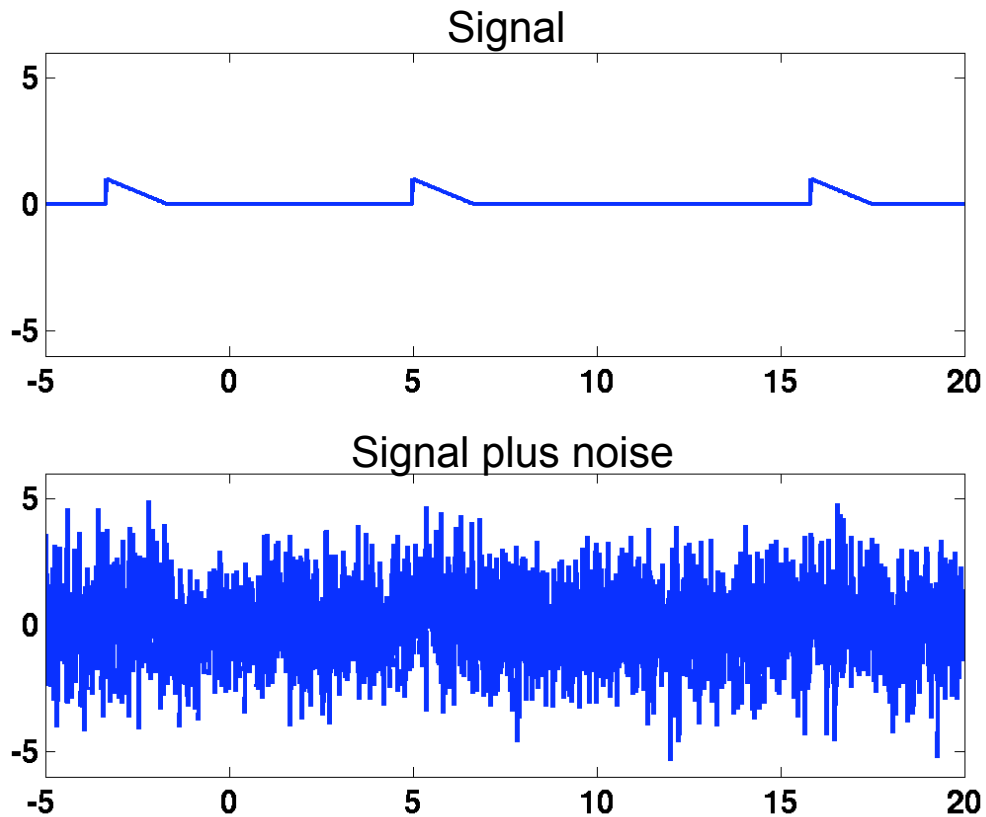


- Finding pulses in a communication signal



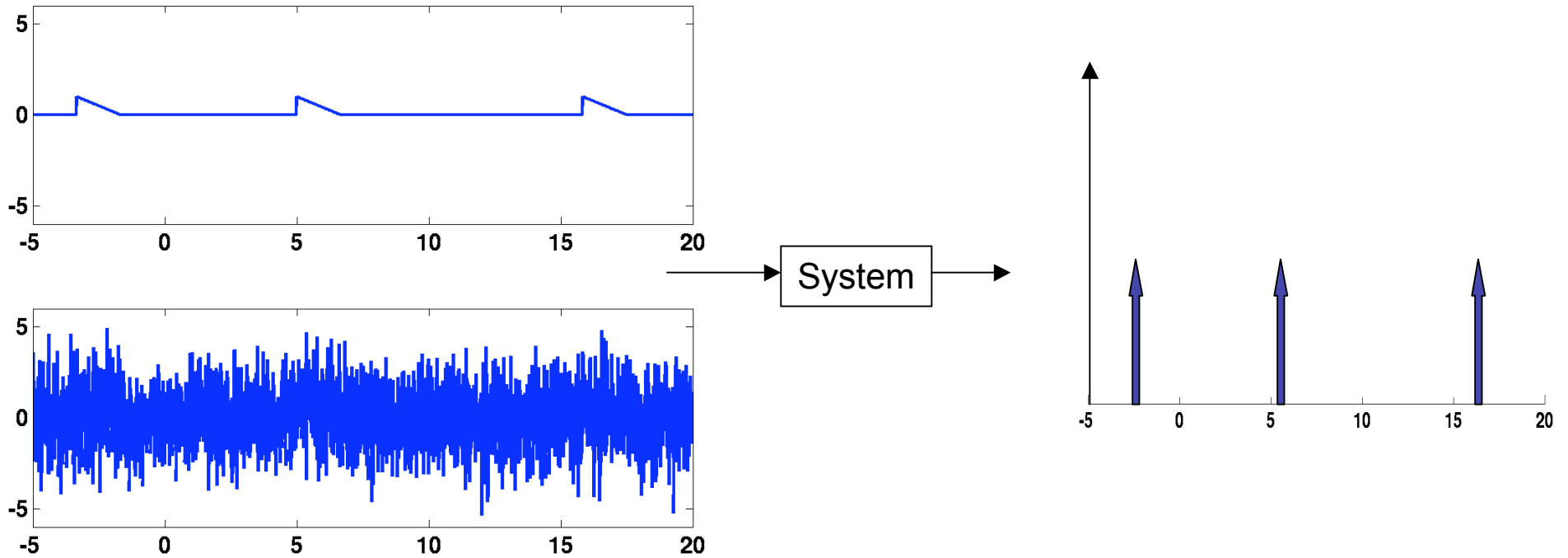
- Processing radar returns to find distance to objects

More on Pattern Matching



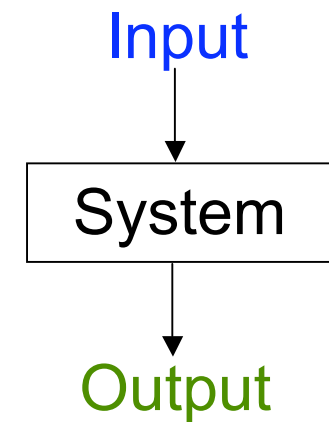
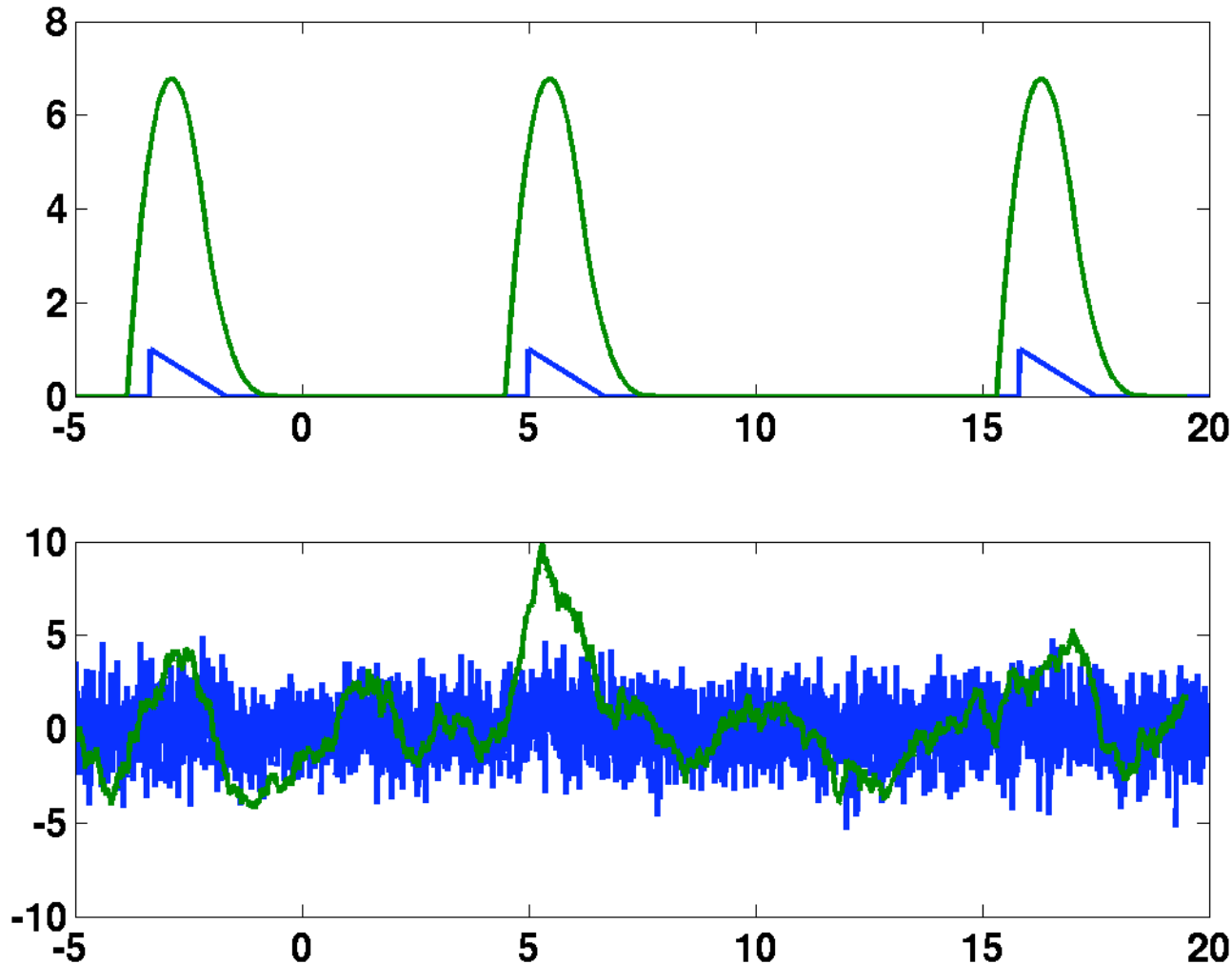
- Not too hard to do if the signal is clean
- A bit more challenging when there is noise (as is commonly the case)

Ideal system



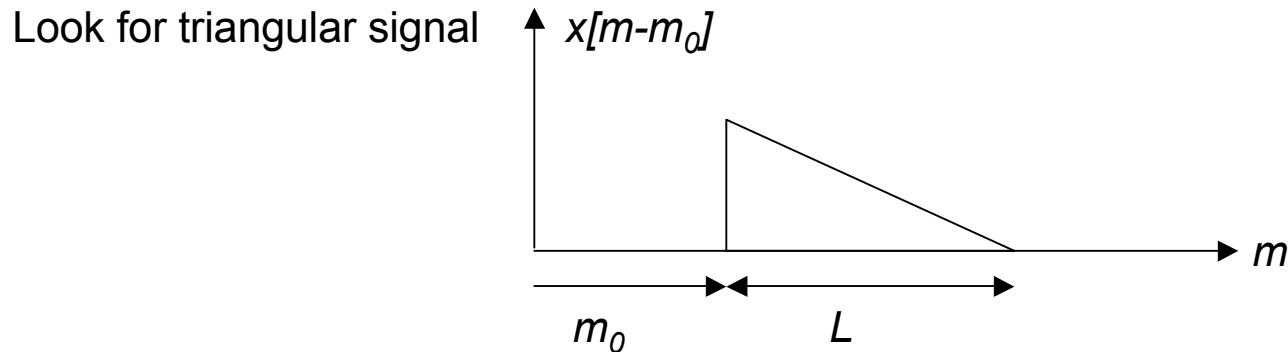
Put in either signal and get out “impulses” at the locations of the pulses

Real system

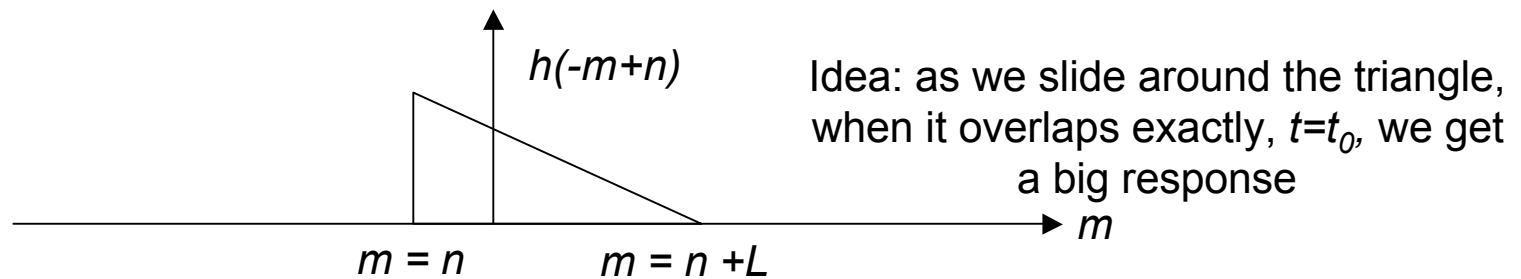
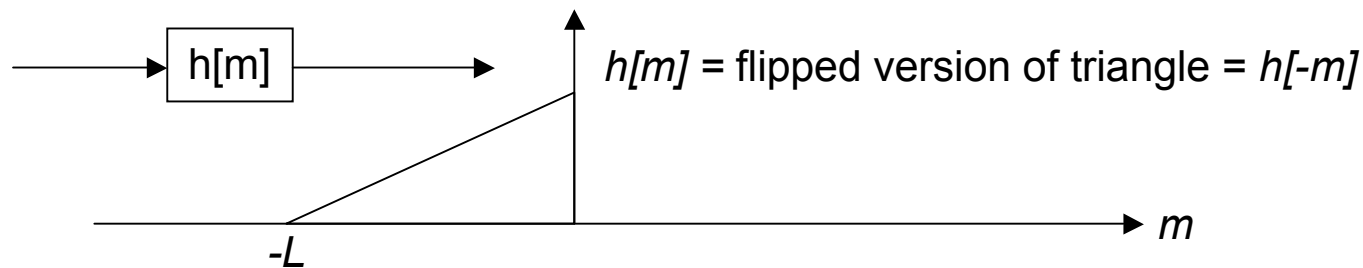


Can find pulse locations by looking for local maxima of output

Implemented using convolution

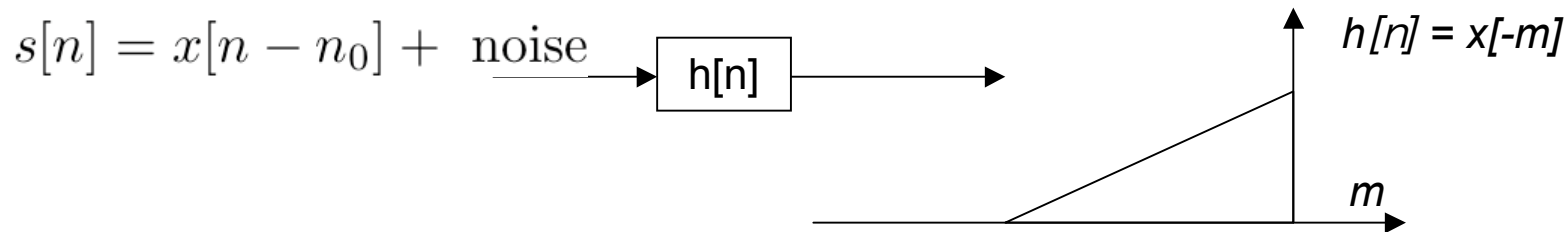


Use LTI system with triangular impulse response



The Mathematics

Use LTI system with impulse response matched to x



$$y[l] = \sum_m h[l - m]s[m] \quad h[m] = x[-m]$$

$$= \sum_m x[-(l - m)]s[m]$$

$$= \sum_m x[m - l]s[m] \quad n = -l$$

$$y[n] = \sum_m x[m + n]s[m] \quad \text{Cross correlation of } x \text{ and } s$$

Lots of really nice properties and important uses



Image Processing Version

- Same idea as in 1D case with two changes:
 - We use 2D convolution, `conv2` in Matlab, rather than 1D
 - If we want to find an object, $s[m,n]$, the filter we use has an h function given by $h[m,n] = s[-m,-n]$.
 - In this case we call s a template.
- See Matlab code