Types of filters

Suppose we have a data set x_i, with $i = 1$ to N, and we want to filter it to produce a smoother data set y_i. Broadly speaking, we could consider two different families of filters.

- Finite impulse response (FIR) filters use only values of x. Thus the filter consists of a set of coefficients a_j with $j = 1$ to M, and we convolve x with a to produce y.
- Infinite impulse response (IIR) filters use values of x as well as prior estimates of y. Thus $y_i = \sum_{j=0}^{m} b_j y_{i+j} + \sum_{j=0}^{M} a_j x_{i+j}$. It is applied iteratively.

In Matlab, the coefficients a are referred to as the numerator, and the coefficients b are the denominator.

In practice, IIR filters can produce sharper frequency cut-offs at smaller order (i.e. smaller values of m or M) than FIR filters, but they run the risk of being unstable, hard to design, and hard to implement.

Commonly, we use a Parks-McClellan filer design algorithm to set up a filter that removes unwanted frequencies but retains others.

Some filters are not strictly filters in the sense that they do not involve convolving a set of filter coefficients with data. A LOESS filter ("locally weighted scatterplot smoothing") uses a least-squares fit to a subset of the data. It can produce a smooth curve, with different functional forms for different segments of data. Such an approach can be computationally intense but manageable with modern computer resources, and it has been used extensively for applications such as processing satellite altimetry in the coastal domain.