

# delay space stepping strategy

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last modified 2017-02-06

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Linear stepping is more expensive than it needs to be.

Want to capture the dynamic range of the data as quickly as possible.

Typically have exponential decay dynamics (perhaps multi-exponential)... we can capitalize on this. We want to take high resolution data at early delays and low resolution data at late delays.

Of course, we don't want to throw away any information we would otherwise be entitled to.

Conceptually we want to 'linearize' the data, so that each subsequent delay step accounts for the same change in signal.

Signal goes exponentially...

$$S = e^{-\frac{t}{\tau}} \quad (1)$$

$$\log(S) = -\frac{t}{\tau} \quad (2)$$

$$t = -\tau \log(S) \quad (3)$$

So to step linearly in  $t$ , my step size has to go as  $-\tau \log(S)$ .

We want to go linearly in signal, meaning that we want to divide  $S$  into even sections. If  $S$  goes from 0 to 1 and we choose to acquire  $N$  points,

$$t_n = -\tau \log\left(\frac{n}{N}\right). \quad (4)$$

Note that  $t_n$  starts at long times and approaches zero delay. So the first  $t_1$  is the smallest signal and  $t_N$  is the largest.

Now we can start to consider realistic cases, like where  $\tau$  is not quite known and where some other longer dynamics persist (manifested as a static offset). Since these values are not separable in a general system, I'll keep  $S$  normalized between 0 and 1.

$$S = (1 - c) e^{-\frac{t}{\tau_{\text{actual}}}} + c \quad (5)$$

$$S_n = (1 - c) e^{-\frac{-\tau_{\text{step}} \log\left(\frac{n}{N}\right)}{\tau_{\text{actual}}}} + c \quad (6)$$

$$S_n = (1 - c) e^{-\frac{\tau_{\text{step}} \log\left(\frac{N}{n}\right)}{\tau_{\text{actual}}}} + c \quad (7)$$

$$S_n = (1 - c) \left(\frac{N}{n}\right)^{-\frac{\tau_{\text{step}}}{\tau_{\text{actual}}}} + c \quad (8)$$

$$S_n = (1 - c) \left(\frac{n}{N}\right)^{\frac{\tau_{\text{step}}}{\tau_{\text{actual}}}} + c \quad (9)$$

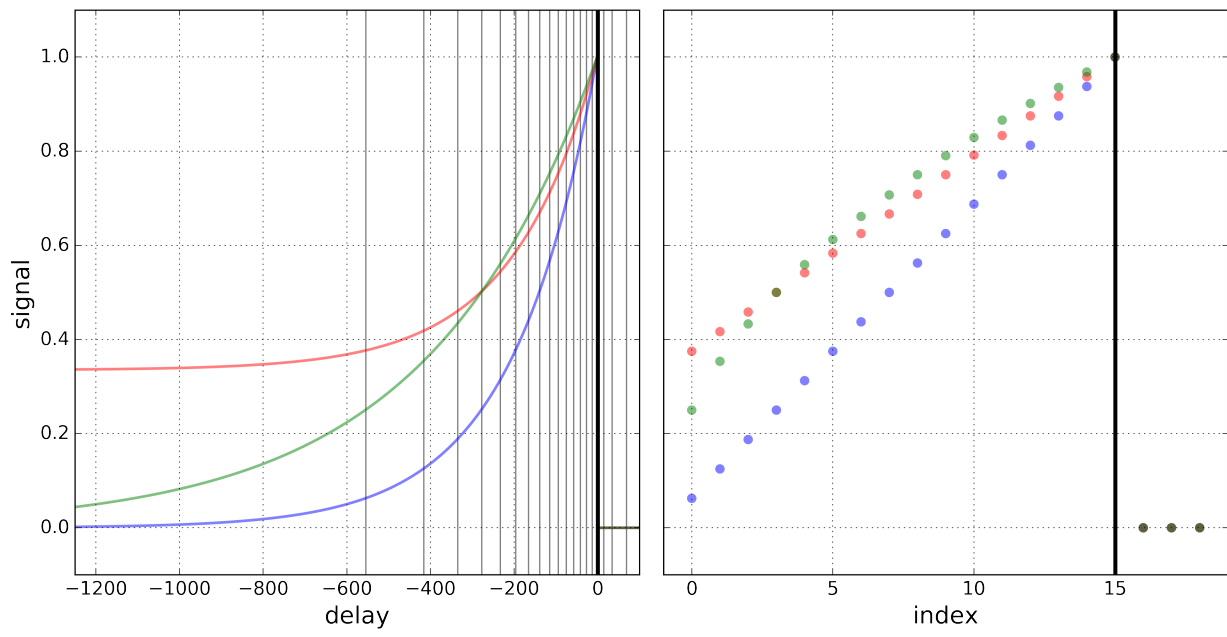


Figure 1: