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A Predictive algorithm

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Abstract

A generalized algorithm that permit to predict the input of a system that acts as simple de-convolution process.

Keywords: Mathematical algorithms; Filter algorithms; De-convolution

Introduction

This is a work I did in 1993, but I never published it. Let us consider a generic stable linear system where the initial state is 0:

$u(s)=G(s)\cdot y(s)$; $\qquad s=\sigma+j\omega$

Where u is the output signal (the measured signal) and y the non-note input signal. In many cases it's impossible to achieve a computational method to reverse and solve the equation:

$$y(s)=\frac{u(s)}{G(s)}$$

because in many system, G($j\omega$) behaves as a low pass filter when ω is a big number and so u/G behaves as 0/0; in this case the computational method becomes very difficult.

We can consider a different recursive approach see Figure 1, the input signal $y(t)$, the output signal $u(t)$ and a re-transformation of the output signal $G\times u(t)$, we can think to re input to the system the output signal.

Now, consider the signal:

$\Delta=u-G\cdot u$

Next, the following sequence

$$H_0=u+\Delta=u+u-G\cdot u=u+(1-G).u$$
$$H_1=H_0+u-G\cdot H_0=(1-G)\cdot H_0+u$$
$$H_2=H_1+u-G\cdot H_1=(1-G)\,H_1+u$$
$$\ldots$$
$$H_n=(1-G)\cdot H_{n-1}+u$$

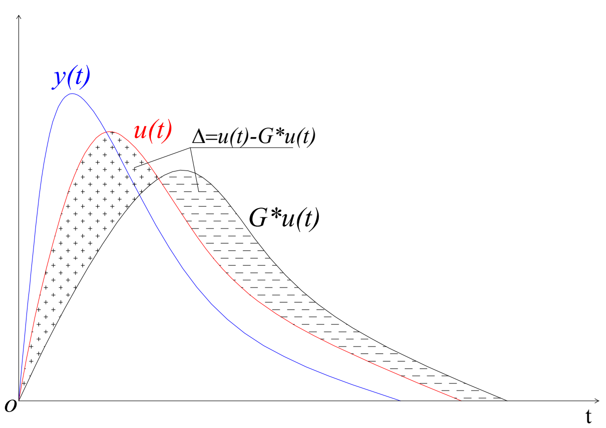

Figure 1

We demonstrate now that $H_n \to y$ when $n \to \infty$, if G is under some conditions. We can see this process as a generic de-convolution algorithm.

In fact

$$H_2=(1-G)\cdot H_1+u=(1-G)^2\cdot H_0+(1-G)\cdot u+u$$
$$\ldots$$
$$H_n=(1-G)^n\cdot H_0+\left(\left((1-G)\right)^{n-1}+(1-G)^{n-2}+\ldots 1\right)\cdot u$$

i.e.

$$H_n=(1-G)^n\cdot\left(u+(1-G)\cdot u\right)+u\cdot\sum_{k=0}^{n-1}(1-G)^K$$

$$H_n=u\cdot\sum_{k=0}^{n+1}(1-G)^k$$

remember that;

$u=G\cdot y$

so

$$H_n=G\cdot y\cdot\sum_{k=0}^{n+1}(1-G)^k$$

Let now consider the following fraction

$$H_n/y=G\cdot\sum_{k=0}^{n+1}(1-G)^k\cdot$$

The condition for the convergence is |1-G|<1 for every σ where G is stable and for every $j\omega$; this is not a great limitation, we will see this problem above.

So the limit

$$\lim_{n\to\infty}H_n/y=G\cdot\frac{1}{1-1+G}=1$$

Means exactly as

$$\lim_{n\to\infty}H_n=y$$

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May be a problem if the condition |1-G|< 1 for every σ where *G* is stable and for every *jω* is not satisfied.

Let us see now how we can bypass this problem, we can modify a little the system, and measure *u′* instead of *u*:

$u' = k \cdot G \cdot y$

i.e.

$u' = G' \cdot y$

where *k* is a real constant, and $G' = k \cdot G$.

Now we can postulate that there is a *k* for witch |1-G′|<1 for every σ+jω as above and apply the process, in this case we have:

$$H_n = (1 - G') \cdot \mathrm{H}_{n-1} + u'$$

and

$$H_n = u' \cdot \sum_{k=0}^{n+1} (1 - G')^K$$

we remember again that

$u' = G' \cdot y$

so

$$H_n / y = G' \cdot \sum_{k=0}^{n+1} (1 - G')^K$$

and again

$$\lim_{n \to \infty} H_n / y = G' \cdot \frac{1}{1 - 1 + G'} = 1$$

i.e. again

$$\lim_{n \to \infty} H_n = y$$

So the problem |1-*G*|<1 for every σ+jω as above scan be resolved.

The algorithm can be extended to linear multi dimensions systems. For non-linear systems the problem is a bit more complex but, if we can have a good model of the system and of the non-linearity, may be that the method converges again.

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