**Massey-Sain algorithm for inverting a discrete state space model.**

To implement Internal Model Control it is necessary to create both a model of the plant and an inverse of that model. The plant model is provided from [ANDY’S EWTEC PAPER] in the form of a state-space model. Creating a robust inverse of this model is a task for this project.

One potential approach is to convert the state-space system into a system of transfer functions. In this case the inverse is simply the reciprocal of the transfer function. This method is complicated by the fact that the plant is a 6x6 MIMO system. Generating corresponding transfer functions using inbuilt MATLAB methods results in 36 very high order transfer functions. Problems with this include:

* Over-fitting to the model
* Improper after being inverted, requiring a filter to be realisable.
* Only practical to consider a maximum of 6 transfer functions, ignoring cross terms. (2 in practice).

The Massey-Sain algorithm is an alternate method for creating a real-time inverse of a state space system. First it is necessary to convert the continuous time state-space model to a discrete time model. This is achieved using the ‘c2d’ function in MATLAB. Using discrete time also prevents any errors caused by the numerical methods of the Simulink solver.

First it is necessary to test whether or not the system is invertible. All discrete-time state space systems are of the form:

Where x is the state vector; y is the output vector; u is the input vector; A is the state matrix; B is the input matrix; C is the output matrix; D is the disturbance matrix.

For our system there is no disturbance input and so D is the zero matrix. It will not be shown in further equations.

Paraphrasing from Sundaram:

“A system has an inverse with delay if can be uniquely determined from y (and perhaps )”

So, we need to find the lowest possible value of . It is possible to express later time-steps in terms of the current time step via substitution.

Substituting equation [1]:

This can be iterated for arbitrarily large timesteps. It can also be represented in a matrix format:

GOTO Latex file.