An orthogonal hybrid function approach to reduced order modeling in Continuous time domain

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Abstract — This research paper interacts with a new method for reduction of model with higher order continuous time approach into lower order continuous time model. Reduction of the model is done with improvement using hybrid function Approximation method. By this method, the obtained low order model retains properties of the higher order system like stability and it reduces computational time also. This proposed method demonstrated with the model of numerical example considered.

Index Terms — Continuous system, Hybrid function, routh technique, numerical examples, MOR

I. Introduction

Reducing-order models are frequently requisite in the investigation and blend of Large-order complex systems. The Pade approximation procedure has been effectively used to discover lower-order approximants of larger-order systems. This technique has the negative aspect that reduce low order form may be unsteady although the actual system is steady. Several methods [1-2] are on hand for arriving at firm reduce-order Pade technique [3]. This process involves additional computation which may direct to computational problems for especially order systems when higher.

The new format for ruling stable small-order alike of comparatively larger-order systems, as given is computationally effortless to program and theoretically simple. We can employ a situate of sample-and-hold functions and the triangular function of right hand side set to figure a fresh set of function, which we given name a 'hybrid function' To identify a hybrid domain function (HF) set, we convey

the (i+1)-th component $H_i(t)$ of the m-set hybrid function $H_{(m)}(t)$ as

$$H_i(t) = a_i S_i(t) + b_i T2_i(t) \qquad (1.1)$$

where, i = 0, 1, 2... (m-1), a_i and b_i are scaling constants, $0 \le t < T$, S_i and $T2_i$ are the (i+1)-th part sample-and-hold function in addition to right hand side triangular function. For ease, in the subsequent, we write T instead of T2. The above equation (1.1) can now be uttered as

$$H_i(t) = a_i S_i(t) + b_i T_i(t) \qquad (1.2)$$

Let us currently illustrate in which way a function f(t) is expressed via a situate of hybrid functions. Hybrid function place always come up by means of a piecewise linear explanation [4].

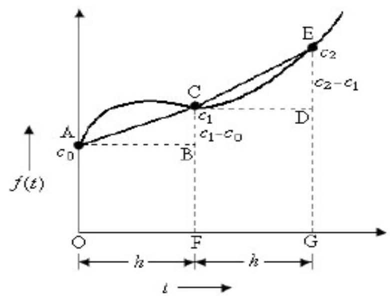

Fig.1.Function Approximation through hybrid

n Figure 1, the function f(t) is section at three halfway points (case interval h) A, C as well as E correspondingly with analogous sample values c_0, c_1 and c_2. Now, f(t) can be approximated in a piecewise approach of linear way by the two straight lines AC and CE, which are the side of two nearby trapeziums. The trapezium of ACFO might be careful to be a blend of the SHF block ABFO, and the triangular block ACB. Alike is the casing for the second trapezium CEGF. Therefore, in favor of the first trapezium the hybrid function demonstration may be on paper as the blend of SHF and TF as

$H_0(t) = c_0 S_0(t) + (c_1 - c_0)T_0(t)$

Then the whole function f(t) may be represent as[4]

$f(t) = H_0(t) + H_1(t)$

$= \{c_0 S_0(t) + (c_1 - c_0)T_0(t)\} + \{c_1 S_1(t) + (c_2 - c_1)T_1(t)\}$

$= \{c_0 S_0(t) + c_1 S_1(t)\} + \{(c_1 - c_0)T_0(t) + (c_2 - c_1)T_1(t)\}$

$= C^T S_{(2)}(t) + D^T T_{(2)}(t) \qquad (1.3)$

Where, $[c0 \quad c1] = C^T$ and $[(c_1 - c_0) \; (c_2 - c_1)] = D^T$

II. Problem formulation

Let, Given a higher order continuous time steady system of order n that is expressed by the S-transfer function—

$$G(S) = \frac{a_1 + a_2 s^2 + a_3 s^3 + \cdots + a_m s^m}{b_1 + b_2 s^2 + b_3 s^3 + \cdots + b_n s^n} \qquad \text{Where, } n>m$$

The idea is to locate a reduced rth order model that has a transfer function(r<n)

$$R(s) = \frac{c_1 + c_2 s^2 + c_3 s^3 + \cdots + c_r s^p}{d_1 + d_2 s^2 + d_3 s^3 + \cdots + d_r s^r}$$

Where ,r >p

III. New move toward for reduced order Modeling:

Let the high-order transfer function G(s) be prearranged by $G(S) = \frac{a_1 + a_2 s^2 + a_3 s^3 + \cdots + a_m s^m}{b_1 + b_2 s^2 + b_3 s^3 + \cdots + b_n s^n}$

Step1: Now believe the numeration polynomial & now approximate the numerator polynomial using hybrid function approximation technique and get the reduced numerator like-

$$c_1 + c_2 s^2 + c_3 s^3 + \cdots + c_r s^p$$

Step 2: Now regard as the denominator's polynomial & now approximate the denominator's polynomial using hybrid function approximation technique and get the reduced denominator like-

$$d_1 + d_2 s^2 + d_3 s^3 + \cdots + d_r s^r$$

Step 3: Now, by using the latest numerator & denominator polynomial form the reduced order model with newly approximated system

$$R(s)=\frac{c_1+c_2s^2+c_3s^3+\cdots.+c_r\,s^p}{d_1+d_2s^2+d_3s^3+\cdots.+d_r\,s^r}$$

Step 4: lastly we will check the newly modeled system stability and compare it with the actual system.

IV. Results obtained from simulation:

Example1: This is in use as of Chuang5 and is specified by Transfer function:

$$G1(s)=\frac{8\,s^2+6\,s+2}{s^3+4\,s^2+5\,s+2} \quad (4.1)$$

Now by using hybrid function approximation technique this 3rd order scheme has been reduced the 2nd order system as given below

Reduced 2nd order Transfer function:

$$R1(s)=\frac{2\,s+4.64}{2\,s^2+3.168\,s+4.704} \quad (4.2)$$

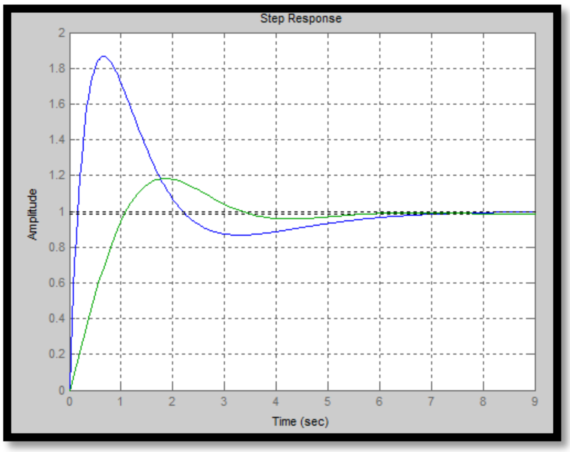

Figure.2: Step Responses of G1(s) & R1(s)

- Steady-state –error comparison

Approximation Technique	Original system steady state error	Reduced system steady state error
Pade Approximation	0.0066	0.0045
Hybrid function Approximation	0.0066	0.0093

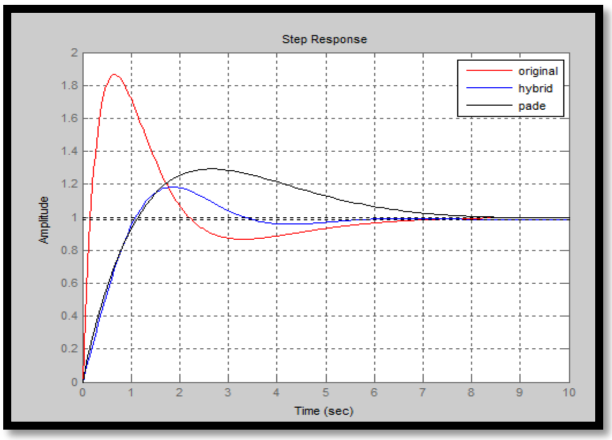

Figure.3 Comparisons of original system with reduced lower order systems by various approximations

Conclusion

A innovative method for stable system with lower order of Pade equivalent is projected here. This technique does not dictate huge computation of actual system. It is computationally proficient and gives a distinctive stable model of reduced order. Though in this case the steady state error has been increased but still it gives a computationally easier solution among the other reduction methods.

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