Nonlinear Dynamics and Systems Theory, **19** (3) (2019) 362–371

Analysis of the Model Reduction Using Singular Perturbation Approximation on Unstable and Non-Minimal Discrete-Time Linear Systems and Its Applications

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Received: August 9, 2018; Revised: June 19, 2019

Abstract: In the natural phenomena, many systems are unstable and non-minimal. Moreover, the systems in the universe often have large order. Therefore, we need to simplify the order of the system without any significant errors. Simplification of this system can be done using the reduction of the model. Model reduction can only be done on the stable and minimal system. Thus, we need a model reduction for unstable and non-minimal systems. There are many model reduction methods in the literature, for example, a balanced truncation method and a singular perturbation approximation. In this work, we propose a method to reduce unstable and non-minimal systems by using the singular perturbation approximation (SPA). First, we decompose the unstable system into a stable subsystem and an unstable subsystem. Then, if the stable subsystem is non-minimal, we apply the minimization process to obtain a stable subsystem that is minimal. Next, we apply the singular perturbation approximation to the stable and minimal subsystem to obtain a reduced subsystem. Finally, we obtain a total reduced model by combining the unstable subsystem and the reduced subsystem. Then we apply the method to shallow water equations. Based on the simulation results, frequency response of the original system and the reduced minimal system using the SPA method has similarity in low frequency, but in high frequency the value tends to be different. Furthermore, the error bound of the SPA and the balanced truncation method is almost the same.

Keywords: *model reduction; singular perturbation approximation; unstable systems; non-minimal systems.*

Mathematics Subject Classification (2010): 78M34.

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