Model Order Reduction Using Modified Component Mode Synthesis Method

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1. ABSTRACT

Model Order Reduction (MOR) techniques are widely used in reducing the computational time associated with simulating high-dimensional models, enabling faster analysis and optimization processes [1]. The projection-based methods are generally used for MOR of dynamical systems [1] [2]. In these methods, the governing equations in the high dimensional space are projected onto a lower dimensional subspace using a transformation matrix which consists of projection bases. Component Mode Synthesis (CMS) is one such method of MOR that is popularly used to obtain the solution of linear dynamical systems. In the CMS modal bases and bases obtained using static condensation are used as projection bases [2]. The static condensation does not consider the inertia effects while computing transformation bases which affects the overall accuracy of the solution. We proposed a modified CMS (MCMS) method based on the highly efficient method developed by Qiu Wei Yang, Xi Peng [3]. In addition to the ease of computing the transformation matrix with the help of a recurrence formula, the method also considers the dynamic nature of the model. The method is more efficient than both CMS and the efficient method mentioned in [3]. A spring-mass model is used to verify the proposed method.

2. RESULTS & HIGHLIGHTS OF IMPORTANT POINTS

A spring-mass system is considered to test the accuracy of the proposed method and compare it with CMS and the highly efficient method. The system has 10 Degrees of Freedom (DoF) (see Fig. 1). Here, j=10

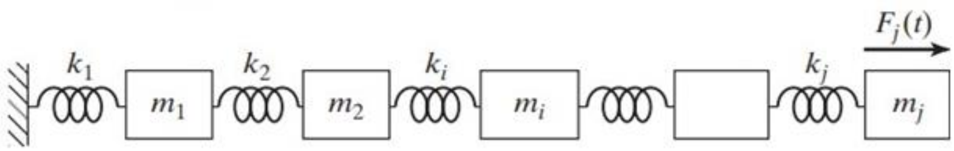

Fig.1 10 DOF spring mass systems

All mass elements have equal mass of 2 kg and each spring has a stiffness of 10 N/m. A sinusoidal force (F(t)=10sin(10t)) was applied at the last mass element. The response of the full order model was obtained by using the Backward Euler method. Further, we developed a reduced order model using the CMS method by considering two eigenmodes and two master DOFs. The resulting reduced system of equations is solved using the Backward Euler method. Next, a modified CMS method is implemented using two eigenmodes and two master DOF by employing a highly efficient method developed in [3]. The computational performance in the form of accuracy and computational efficiency of a modified CMS method is compared with conventional CMS method, highly efficient method [3] and full order solution. The response and error of the 4th mass element is shown in Fig.2 and Fig.3 respectively. It can be seen that the proposed modified CMS method shows better accuracy than the conventional CMS and highly efficient method [3]. The performance of the proposed method will be tested for the large systems discretized using finite element methods in the next step.

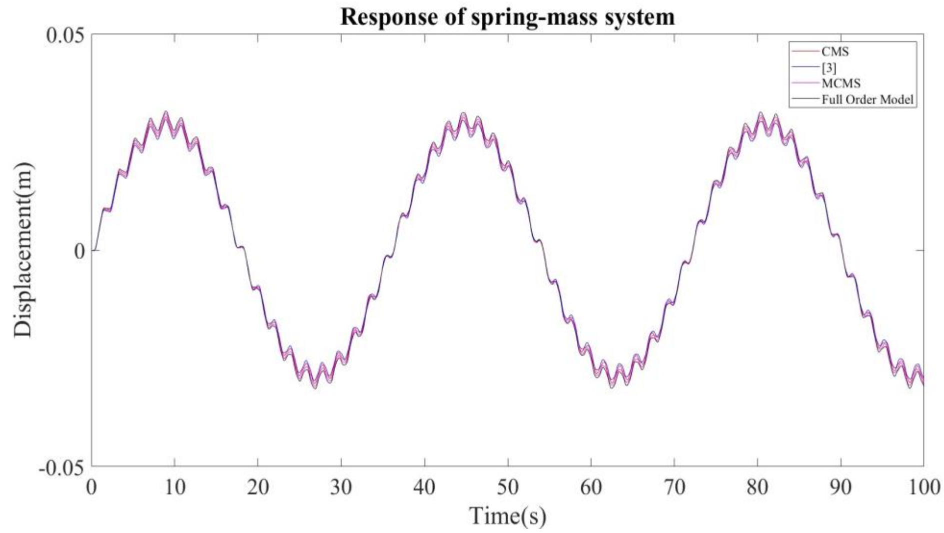

Fig.2 Comparison of displacement time history

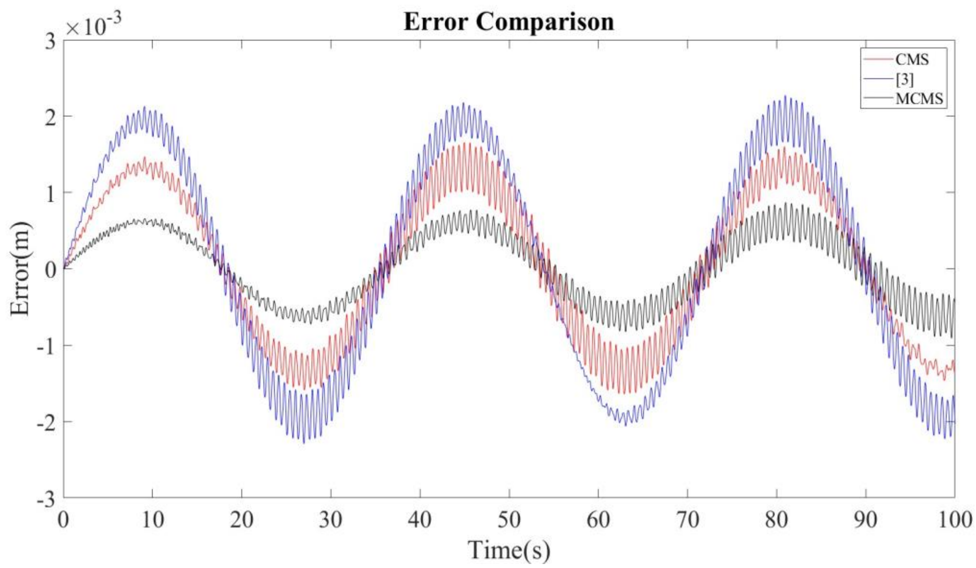

Fig.3 Error between solution obtained using MOR method and full order method.

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