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Comparative study on different model reduction techniques in MIMO systems

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Large physical systems usually result in complex high-order dynamic models. Numerical simulations of dynamical systems are routinely used for studying complex physical phenomena. However, for very high-order systems the storage and computational requirements of such simulations may increase to unmanageable levels. One option is to use parallel computing to reduce the computational burden, which is expensive and also depends on the parallelizability of the simulations. Additionally, almost all the modern control design philosophies such as LQG, H_2 and H_∞ result in controllers of the same size as that of the plant. Due to these reasons the reduction of the model is important. In this process it is essential to derive the reduced model so as to capture the important properties of the original system. Eliminating certain states while having a reasonable representation of the original system is known as model reduction. The central idea of the model reduction is to find a reduced order model G_r of order r of the original system G_n of order n $(r \ll n)$ such that the infinity norm of their difference $\|G_n(j\omega) - G_r(j\omega)\|_\infty$ is sufficiently small.

In this paper, three different model reduction methods were compared. Methods of interest, *Direct Truncation* (DT), *Balanced Truncation* (BT), and *Moment Matching* applied to a MIMO system. Using the above mentioned approaches the closed-loop system was reduced to a 6-states model such that it retained the essential properties of the original system. From the frequency response and the time-domain responses, it was observed that the BT was able to capture the critical modes of the system better than the moment matching through *Arnoldi* decomposition. Since the BT approach uses the *Lyapunov equations* for obtaining the controllability and observability gramians, it is limited to a moderate order system. As the dimension increases the BT breaks downs. In such conditions the moment matching approach is preferred over the BT method. The future work will be on finding the most appropriate moment matching technique when very large systems with dense state matrix are involved and the BT fails to solve the Lyapunov equations.