# Contributions to the model order reduction of large-scale dynamical systems

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The accurate mathematical modeling of natural and man-made processes leads to models of high complexity. The simulation, analysis, control, design and implementation of the systems of high orders are difficult and costly if at all possible. To cope with these problems, suitable methods for model order reduction are required. Over the past few decades, there has been increasing interest in the methods which reduce the order of dynamical systems while preserving the input-output behavior and important features [1]-[3].

The model reduction techniques can be divided into two broad categories: singular value decomposition (SVD) based methods and the moment matching based techniques. The SVD-based methods have a guaranteed upper bound for the approximation error and they usually preserve the stability of the original model in the reduction process. The moment matching based methods are usually more efficient computationally, but they have no guaranteed error bound. The stability of the reduced order model is not guaranteed when these methods apply [1]-[3].

The balanced model reduction introduced in [4] is one of the most common model reduction schemes. To apply balanced truncation, the system is first represented in a basis where the states which are difficult to reach are simultaneously difficult to observe. This is achieved by simultaneously diagonalizing the controllability and the observability gramians, which are solutions to the controllability and the observability Lyapunov equations. Then, the reduced model is obtained by truncating the states which have this property. Balanced model reduction method is modified and developed from different viewpoints [1]-[12]. The time-interval balanced truncation is among the methods which improves the accuracy of the ordinary balanced truncation [5], [6], [10]. The frequency-interval balanced truncation is another well-known method which improves the accuracy of the ordinary balanced truncation [5], [7]-[9], [13]. In both classes of techniques which improve the accuracy of the ordinary balanced reduction gramian plays a key role. The gramians are matrices with the embedded controllability and observability information. The controllability and observability gramians were first introduced in [14] and [15] and more recently in [4]. It is well-known that the controllability gramian shows the level of controllability. Similarly, the observability gramian contains information of the level of observability for a system. Apart from the well-known application of gramians in model reduction, they have been extended and have been used in applications such as control configuration selection [16]-[22].

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