

# Multibody system transfer matrix method: The past, the present, and the future

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## Abstract

The multibody system transfer matrix method (MSTMM), a novel dynamics approach developed during the past three decades, has several advantages compared to conventional dynamics methods. Some of these advantages include avoiding global dynamics equations with a system inertia matrix, utilizing low-order matrices independent of system degree of freedom, high computational speed, and simplicity of computer implementation. MSTMM has been widely used in computer modeling, simulations, and performance evaluation of approximately 150 different complex mechanical systems. In this paper, the following aspects regarding MSTMM are reviewed: basic theory, algorithms, simulation and design software, and applications. Future research directions and generalization to more applications in various fields of science, technology, and engineering are discussed.

## KEYWORDS

multibody system dynamics, multibody system transfer matrix method, transfer matrix, transfer equation, automatic assembly theorem, reduced multibody system transfer matrix method, theory, software, applications, acoustic system, electrical power system, fluid system

## 1 | INTRODUCTION

Modern science, technology, and engineering have been developed to an advanced stage of analyzing and solving the problems of research object in terms of its modeling, simulation, design, manufacturing, testing, evaluation, and use from the whole –system-dynamics viewpoint, to obtain ideal engineering products with desired performance. One of the highest levels of their development is to establish accurate mathematical model for system dynamics and solve it efficiently and numerically, so as to predict and evaluate the system performance accurately and quickly. While mechanical systems are considered in this paper as examples, it will be shown that the introduced method is also effective for many other physics applications, including electrical systems, acoustic systems, and so forth. Many mechanical systems can be represented using a multibody system dynamics model<sup>1–5</sup> which

is composed of objects, either considered as bodies or hinges. Bodies refer to inertia elements, including rigid bodies, flexible bodies, lumped masses, and so forth. Hinges are used to describe the interaction between bodies, including ideal ball-and-socket, pin, and translational hinges, springs and dampers, and so forth. Two common problems are encountered when using conventional multibody system dynamics approaches for complex systems: establishing a mathematical model described by global dynamics equations with a generalized system inertia matrix and their fast numerical solution.<sup>6–8</sup> This is because of the large dimension of the inertia matrix when algebraic constraint equations are absent or the large dimension of the combined inertia matrix and constraint Jacobian in the case of differential-algebraic equations. Their inversion or LU factorization leads to significant deterioration of the computational efficiency. This can be a disadvantage, particularly if fast simulations are required for design

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# Science Matrix Past Present And Future

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