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PARALLEL COMPUTING OF THE MULTIBODY SYSTEMS OF LARGE DIMENSIONS

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ABSTRACT

The parallel processing is main path for growth computer efficiency. At current work is presented the solving of the equations of the multibody systems dynamics via parallel computing. The parallel processing is realized at software FRUND and used for simulated some mechanical systems.

One of the major problems of multibody systems dynamics is large dimensions. The method of the divided of differential algebraic equations into weak dependence parts is investigated. The standard form of ones equations are

$$\begin{cases} \mathbf{M}\ddot{\mathbf{x}} - \mathbf{D}^{\mathrm{T}}\mathbf{p} = \mathbf{f}(\dot{\mathbf{x}}, \mathbf{x}, t), \\ \mathbf{D}\ddot{\mathbf{x}} = \mathbf{h}(\dot{\mathbf{x}}, \mathbf{x}). \end{cases} \quad (1)$$

Here, $\mathbf{x}$ is the n-dimensional vector of unknowns, $\mathbf{M}$ is the constant coefficient matrix of the second derivatives, $\mathbf{f}(\dot{\mathbf{x}}, \mathbf{x}, t)$ is the vector function composed of the right-hand sides of the differential equations, $\mathbf{D}$ is the $k \times n$ matrix of the variable coefficients in the constraints (where k is the number of constraints), $\mathbf{h}(\dot{\mathbf{x}}, \mathbf{x})$ is the right-hand side vector of constraints, and $\mathbf{p}$ is the vector of Lagrange multipliers.

The numerical integration of (1) is performed much more efficiently if the constraint matrix $\mathbf{D}$ is block diagonal. Moreover, the block diagonal form of the matrix $\mathbf{D}$ makes possible parallel computing the system (1). Therefore, we examine the problem of partitioning $\mathbf{D}$ into independent blocks so as to ensure the prescribed accuracy in the solution to system (1). Suppose that a portion of constraints in system (1) is represented in compliance form. Then, system (1) with a block diagonal constraint matrix can be written as

$$\begin{cases} \mathbf{M}\ddot{\mathbf{x}} - \mathbf{D}_f^T\mathbf{p}_f + \mathbf{D}_b^T\boldsymbol{\alpha}_{cb}\mathbf{D}_b = 0 \\ \mathbf{D}_f\ddot{\mathbf{x}} = \mathbf{h}_f(\dot{\mathbf{x}}, \mathbf{x}), \end{cases} \quad (2)$$

Here, $\mathbf{D}_f = \begin{pmatrix} 0 & \mathbf{D}_2 \\ \mathbf{D}_1 & 0 \end{pmatrix}$ is the block diagonal constraint matrix, the vector $\mathbf{p}_f$ is composed of the Lagrange multipliers corresponding to the constraints with the matrix $\mathbf{D}_f$, $\mathbf{h}_f(\dot{\mathbf{x}},\mathbf{x})$ is the right-hand side vector of constraints in the partitioned system, $\mathbf{D}_b$ is the matrix of the boundary entries in the constraints, and $\boldsymbol{\alpha}_{cb}$ is the matrix of conservative coefficients for the boundary constraints. Note, that the system (2) have precise numerical solution and permit simple parallel processing with data interchange at every iteration.

The parallel numerical integration (2) was realized at software FRUND. The programming technique based on creating separable executable module for every subsystem of (2). The software algorithm makes possible the subdivision system (1) on arbitrary number of the parts. The parallel modules may be runs at computers with single or multiprocessors. For example are presented the tested simulation results of the systems from the some thousands bodies. The software can be used for parallel solution inverse and forward dynamics models at problem of synthesis of the control motion of multidimensional spatial machines – fig. 1.

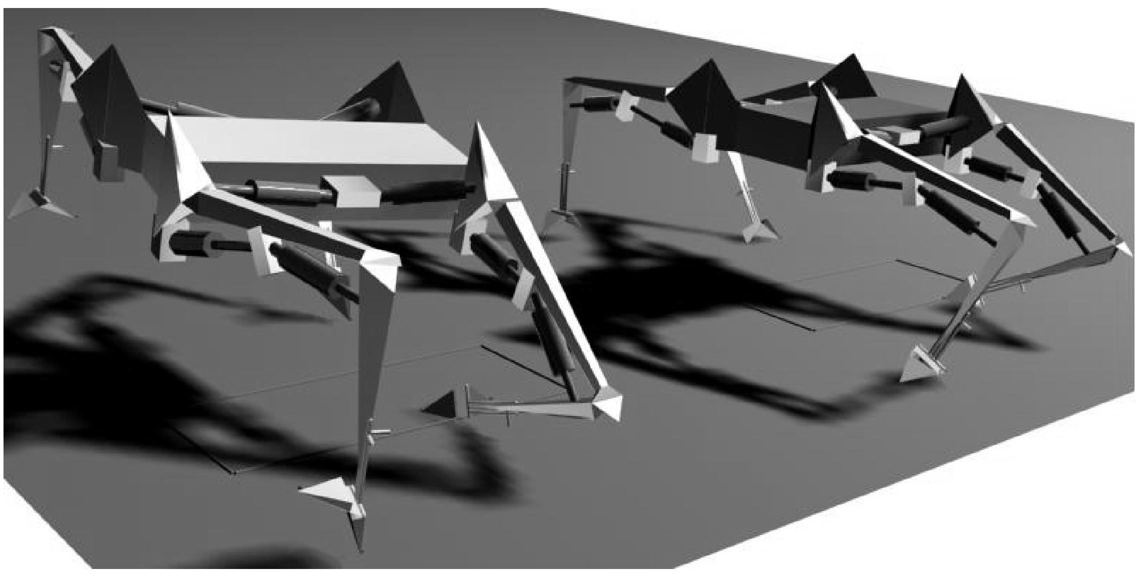

Figure 1. The parallel solution the inverse (right) and forward (left) dynamic problem.

The paper presents implementations of the portioning method and program realization for parallel computing large scale multibody systems. Proposed technique can be used at multiprocessor systems or at the grid based parallel computing.

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