AUTODYN & ROBOTTRAN - Computer Programmes

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AUTODYN

Abstract

This contribution presents the main features of the AUTODYN programme. This programme based on d'Alembert Potential Power Principle, permits to derive the equations of motion of any mechanical system which can be represented by a set of interconnected rigid bodies. In particular, it has important applications in the fields of robotics and vehicle dynamics. The variables of the system are the generalized variables describing the relative motion of the various joints of the system. A joints' library including surface rolling interconnections (rail-wheel joint) is available. Constraints can be considered and in particular those resulting from loops of bodies are automatically generated. The Lagrange multipliers technique permits to derive the complete set of equations of motion; a system reduction via the elimination of these multipliers and a coordinate partitioning method is available. The obtained programme can be used as a sub-routine for any desired application such as numerical integration, stability analysis, control design, numerical linearization, eigenvalues determination.

Introduction

The mechanical system under consideration is assumed to be represented by a multibody system composed of interconnected rigid bodies. These bodies will be characterized by their mass distribution parameters and by geometrical quantities which permit to localize their various interconnections. These connections are defined as joints and may have up to six degrees of freedom.

Joints can be represented by mechanical devices such as springs, dampers, hinges, universal joints or have more sophisticated representations such as sliding or rolling between surfaces. Relative motion can take place in the joints and interactions are produced. The variables describing the relative motions in the joints will be used as generalized variables (even if other variables can be used as outputs of the programme). The joint forces and torques can either be unknown constraint quantities or can be described by dynamical relations (describing functions) between the various joint variables.
A library of predefined joints with their variables and describing functions is available; the user is only asked to specify the actual values of the corresponding parameters.

Graph Description

The kinematical description of the system is greatly simplified when the graph of this system is defined \[1\]. A tree structure is always used; for system with loops of bodies, a cutting procedure is determined and an augmented tree structure is defined.

In order to simplify the introduction of the system data, conventions on the numbering of bodies and joints and on the localization of loop cuts are introduced. For this procedure, graph matrices have been abandoned in favour of the more readily usable notion of filiation \[2][3\]. This notion simply expresses that a given joint connects two neighbouring bodies.

First of all a reference body is defined and the index 0 is associated with this body which is assumed to be fixed with respect to inertial space and is the common ancestor of all the bodies of the system.

For chain and tree structures, the graph numbering is then very simple. All the bodies (considered as descendants) will be numbered according to a filiation order in the chain or in the tree; the joints are then given the number of the body they precede in this order. It is clear that for tree structures, this procedure favours certain branches of the system.

If the same procedure is applied to systems which include loops of bodies, it will soon appear that a given body is the direct ancestor of two (or more) bodies which have common descendants (see figure 1). This indicates that this body is at the origin of a loop. Conventionally, this body will then be separated in two parts, the original body which keeps all its physical properties and a fictitious loop closure body which only retains kinematical properties and permits to define an augmented tree structure. Once the cutting procedure is completed $M_L$ independant loops have been indentified and $M_L$ closure bodies have been added as terminal bodies of the corresponding augmented tree.

It can be of interest to define a main body of the system. The index 1 is then as-