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Design and Implementation of a Multibody Code Oriented to HIL Simulation

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ABSTRACT

The instruments, which are based on the “Hardware in the Loop” (HIL) approach, always need a performant mathematical model, allowing real-time simulations. The development of a dedicated code, which is oriented to the application, and a real-time kernel are often the most efficient solution. However thanks to the improvement of performances of the modern personal computer and to the real-time kernel optimisation, today it is possible to develop a generic multibody software with high efficiency. This solution eliminates inevitable errors in writing equations and it also allows outsiders of mechanical ambient to build efficient dynamic models.

In this work the chosen formulation to describe the dynamic equations is based on natural coordinates, which have been already used with success in finite elements simulations. This method allows, through constant and linear matrices, to define in an easy way the dynamic of the system. However, the disadvantage is to increase the degrees of freedom. The result is a simple formulation with a high number of equations to integrate. The high matrices sparsity warrants a rapid integration.

The data structure of the software, which is based on object oriented programming, guarantees high computational performances. In this case it is optimised, reducing all the needed resources and allocating them at the beginning of the simulation. Moreover a data structure dedicated to the matrix, of which the sparsity is exploited, permits a quick holding of the data access and the solution of the related algebra.

The used language (C++) is a standard instrument with consolidated and optimised libraries and it also permitts to generates a code which can be used on different platforms.

The code objects are the typical elements of a Multi-Body system (bodies, markers, constant and variable forces, springs and damper, constraints etc . . .). Since the objective of this code is the simulation of vehicles dynamic (cars , motorcycles , working machines, etc. . .), it has been introduced a modelization of the contact between the tire and the road surface, based on the Pacejka’s Magic Formula.

The data structure of the classes has been implemented to facilitate the introduction of new Multi-Body components. Therefore, by using the Derived Classes, the Inheritance and the Polymorphism, it can be

easy to add new types of constrains, markers, forces, springs and damper with non-linear characteristics, etc....

Many considerations were made on the stability of the integration of the differential equations, preferring solutions which are based on direct and implicit integration methods rather than ones based on stabilisation of constrain equations. Thanks to this choice the reduction of the integration step is surely a needed target to guarantee accurate solutions.

The analysis of the performances has been managed comparing the results of a dedicated model in Matlab (Real-Time Workshop) and the ones of a well-established commercial software for multibody simulations (Adams). The simulations have been made on the same computer platform.

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