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DISCUSSION ON THE MODELLING FIDELITY LEVELS IN FLEXIBLE SYSTEM DYNAMICS

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ABSTRACT

The development of simulation tools for the dynamic behaviour of articulated flexible multi-body systems is becoming a challenge for the industrial software providers since the industry is more and more interested in a solution for such problems [1]. In order to accurately analyse an articulated system during its movement, the model must include not only the classical mechanical parts but also the other components which allow and guide the motion, i.e. joints, motors, sensors, actuators and control systems. The resulting mechatronic model can therefore describe the true physical non linear dynamic behaviour of a machine in working conditions, which interacts dynamically with its controllers [2]. The virtual prototype is a model of a real system, which allows a very deep study of its behaviour, that would be possible on a physical prototype only adopting very complex and expensive instrumentation systems able to measure robot motion and deformation during experiments. The mechatronic model should be used to e.g. reproduce reliably static stiffness tests and tool tip impact tests, to evaluate the dynamic compliance at the tool, to execute specific trajectories and to estimate the machine precision, and to tune the gains of the control devices.

The development of accurate flexible mechanism and mechatronic models should rely on computational tools able to simulate different levels of fidelity, from the base component up to the full mechanism, including flexibility and possible non linear characteristics for the components and for the kinematic joints. The SAMCEF finite element code [3] includes all those computational capabilities. Recently this solution procedure has been used for proposing a first model of a robot [4] in the frame of a European project called RAPOLAC [5].

In this paper the minimum level of fidelity needed for an accurate representation of a flexible system is discussed (Figure 1). Around a Master Model (library of parts) including interchangeable components with different levels of fidelity it is possible to define specific minimum fidelity models. Depending on the computational goal, components of different fidelity can be interchanged, leading to the definition of e.g. a low fidelity model including only rigid components or a minimum fidelity model including flexibility with a Super Element approach [6]. When contact and related damage (e.g. initiated at the joints) must be studied, the Super Element technique is no

longer valid, since contact implies a change of boundary conditions, and damage suggests a non linear material behaviour. Thanks to its FEM based approach [7,8] SAMCEF is able to consider flexible components made of a full FE model, therefore solving non linear advanced analyses marginalizing the use of most of the other available industrial solutions. All those modelling levels will be compared and discussed in the field of robotics (minimum fidelity levels, mixing Super Element and full FE, contact, plasticity, CPU times, …).

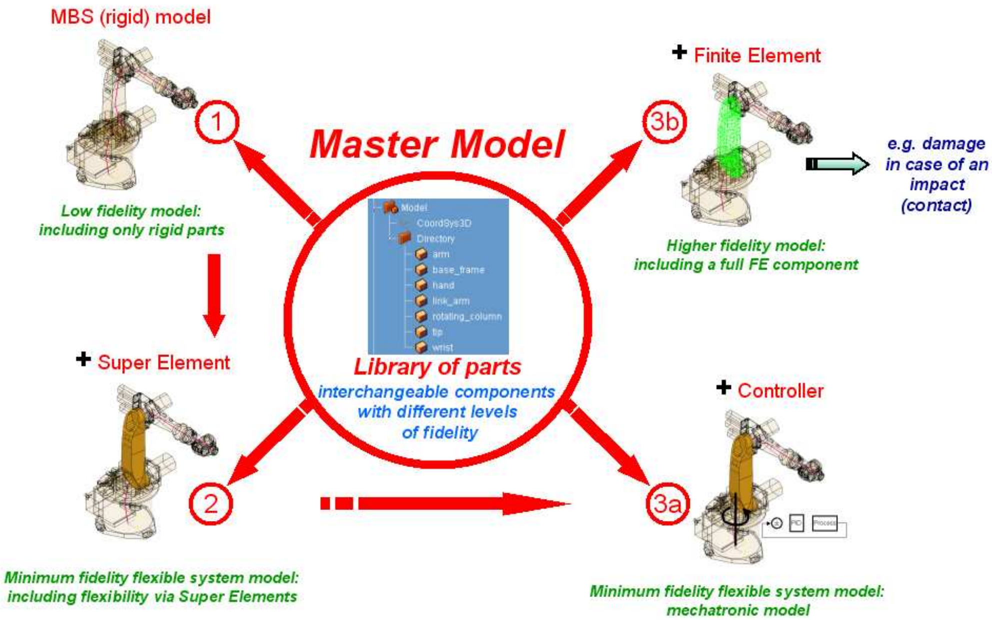

Figure 1. The Master Model of a flexible system:
different minimum fidelity levels for different needs

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