Abstract

Dynamics plays crucial role in the design and simulation of multi-body systems such as automobiles, haptic interfaces, robots, etc. Whereas inverse dynamics is useful for design, forward dynamics helps in simulating systems under various controller paradigms even though they are not actually made. In this thesis, focus is on haptics and dynamic formulations. In haptics, a contemporary issue is to achieve stable impact with stiff virtual walls, e.g., metal-metal contact in a virtual-CAD assembly, interaction with bones in a virtual surgery, etc. These walls are modelled as having certain stiffness and damping parameters. Conventional controllers in impedance based haptic interfaces typically use uniform sampling rates for both position and velocity loops to realize stiffness and damping, respectively. In this, higher sampling rate improves the stiffness range but simultaneously degrades the damping range on account of poor velocity estimation. Hence, a dual-rate sampling scheme is proposed in this thesis in which the position and velocity loops of the conventional controller are decoupled in order to achieve higher stiffness and larger range of damping.

Further, stability analysis and simulation of such systems require efficient and accurate dynamics algorithms. Inaccurate and inefficient algorithms leads to misleading stability results and unrealistic simulation behaviour. Recursive dynamics algorithms have proven to be efficient in the past for both open and closed-loop multi-body systems. Since the haptic device developed in this research is a closed-loop multi-body system, an efficient dynamics algorithm is proposed here for these systems. The concept of the