

FRictional IMPACT ANALYSIS OF CONSTRAINED MULTIBODY MECHANICAL SYSTEMS

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ABSTRACT

Analysis of the impact problem in the presence of any tangential component of impact velocity requires a friction model capable of correct detection of the impact modes such as sliding, sticking, and reverse sliding. A survey of literature has shown that studies on the impact analysis of constrained multibody systems have either been limited to the direct impact type with only a normal component of impact velocity (no frictional effect) or the ones that include friction have shown energy gains in the results due to the inherent problem in the use of Newton's hypothesis. This work presents a formulation for the analysis of impact problems with friction in constrained multibody mechanical systems. The formulation is presented for both the open and closed-loop multibody systems. The formulation recognizes the correct mode of impact, i.e., sliding, sticking, and reverse sliding. The Poisson's hypothesis is used for the definition of the coefficient of restitution, and thus the energy gains inherent with the use of Newton's hypothesis are avoided. The formulation is developed by using a canonical form of the system equations of motion using joint coordinates and joint momenta. The use of canonical formulation is a natural way of balancing the momenta for impact problems. The joint coordinates reduce the equations of motion to a minimal set, and eliminate the complications arising from the kinematic constraint equations. The canonical form of equations is solved for the change in joint momenta using Routh's graphical method. The velocity jumps are then calculated balancing the accumulated momenta of the system during the impact process. The impact cases are classified based on the pre-impact positions and velocities, and mass properties of the impacting systems. Analytical expressions for normal and tangential impulse are derived for each impact case. The classical problem of impact of a falling rod with the ground (a single object impact) is solved with the developed formulation, and the results are compared and verified by the solution from other studies. Two other impact problems, one in an open-loop system, and the other in a closed-loop system, are also solved. The results obtained for both the problems confirm that the energy gain in impact analysis of constrained multibody systems can be avoided, by considering the correct mode of impact and, using Poisson's instead of Newton's hypothesis.