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MASTER THESIS

Fast Rigid Body Simulation with Contact and Constraint for Prediction

Problem description:

When designing control strategies for the constrained robotic systems with dynamic environments, a difficulty is on the fact that consequences of current control actions appear in the future. Especially, intermittent rigid contacts and hard constraints enforce the systems to meet unexpected discontinuity that may degrade the control performance or even damage the systems and the environment. Briefly speaking, there are two approaches to take count of this problem. The first approach is to measure the current distance to the expected contacts or constraints by using additional sensors, then to modify the control action for reactive behaviors that properly smoothen discontinuity on the acceptable level. The second approach is to predict the expected contacts or constraints by using mathematical models of the systems and the environment, then to find the optimal control actions for the whole operation time. The first method called greedy control can be implemented as on-line algorithms and handle the dynamic environment, but becomes hard to consider optimality of the control action. While, the second method can find global or local optimal control actions, but, normally it suffers from complexity of the problems and requires a lot of time to solve them numerically, so it's implemented as off-line algorithms and hard to be used in the dynamic environments. An alternative is to use a receding horizon for the prediction that is comparatively short such that on-line implementation becomes possible [1], then a fast algorithm for the rigid body simulation which is much faster than the real world is strongly needed. This thesis focuses on boosting up the speed of the existing algorithms for the rigid body simulation such as [2][3]. The main issue is to find an algorithm that can compromise between various performance criteria of the simulation such as speed, accuracy, robustness, size, etc.

Tasks:

- Literature study for the rigid body simulation with contact and constraint
- Development of fast algorithms for the rigid body simulation
- Implementation of proposed methods for the 7-DOFs manipulator using C++

Bibliography:

[1] Camacho, Eduardo F and Alba, Carlos Bordons, *Model Predictive Control*, Springer, 2013
[2] Roy Featherstone, *Rigid Body Dynamics Algorithms*, 2008
[3] Jan Bender, Kenny Erleben, and Jeff Trinkle, Interactive Simulation of Rigid Body Dynamics in Computer Graphics, In *Computer Graphics Forum*, 2014

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