Nonlinear Dynamics and Systems Theory, **15** (1) (2015) 73–89

Constrained Motion of Mechanical Systems and Tracking Control of Nonlinear Systems: Connections and Closed-form Results

Firdaus E. Udwadia [1*] and Harshavardhan Mylapilli [2]

[1] *Departments of Aerospace and Mechanical Engineering, Civil and Environmental Engineering, Mathematics, Systems Architecture Engineering, and Information and Operations Management, University of Southern California, Los Angeles, California, USA.*
[2] *Department of Aerospace and Mechanical Engineering, University of Southern California, Los Angeles, California, USA.*

Received: March 31, 2014; Revised: December 15, 2014

Abstract: This paper aims to expose the connections between the determination of the equations of motion of constrained systems and the problem of tracking control of nonlinear mechanical systems. The duality between the imposition of constraints on a mechanical system and the trajectory requirements for tracking control is exposed through the use of a simple example. It is shown that given a set of constraints, d'Alembert's principle corresponds to the problem of finding the optimal tracking control of a mechanical system for a specific control cost function that Nature seems to choose. Furthermore, the general equations for constrained motion of mechanical systems that do not obey d'Alembert's principle yield, through this duality, the entire set of continuous controllers that permit exact tracking of the trajectory requirements. The way Nature seems to handle the tracking control problem of highly nonlinear systems suggests ways in which we can develop new control methods that do not make any approximations and/or linearizations related to the nonlinear system dynamics, or its controllers. More general control costs are used and Nature's approach is thereby extended to general control problems.

Keywords: *nonlinear mechanical systems; constraints; tracking control; closed form controllers; d'Alembert's principle; nonideal constraints.*

Mathematics Subject Classification (2010): 93A10, 93A30.

* Corresponding author: mailto:fudwadia@usc.edu

© 2015 InforMath Publishing Group/1562-8353 (print)/1813-7385 (online)/http://e-ndst.kiev.ua 73