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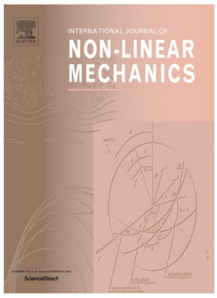

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On impulsive isoenergetic control in systems with gyroscopic forces

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Abstract

We consider the problem of transfer of a Lagrangian system with gyroscopic forces to a given state in the configuration space by means of an impulsive isoenergetic control. This type of control can change instantly the direction of the generalized velocity, but preserve the total energy of the system. We present sufficient conditions for global controllability by a finite number of impulsive switchings, and some results related to the estimation of this number.

Keywords: impulsive control, gyroscopic forces, Finsler metric, Lagrange system, possible motion area

1. Main results

It is a well-known fact that discontinuities and various types of switching play an important role in the study of control systems. For instance, from the Pontryagin principle, we often obtain piecewise constant optimal controls [1]. Also, for topological reasons, it is often impossible to globally stabilize a system by means of continuous control [2, 3] and one has to consider less regular control functions in order to solve this problem [4]. Control systems with impulsive switchings provide another important example of discontinuous dynamics. One can find detailed exposition of the recent developments in the theory of impulsive differential equations, impulsive control and so-called hybrid systems in [5, 6, 7, 8, 9, 10, 11]. Impulsive control can be applied to a wide range of mechanical systems including nonholonomic ones (see, for instance, [12]). However, one of the most useful application of this type of control design can be found in the classical problem of a spacecraft manoeuvring [13, 14, 15]. The problem is to change the orbiting trajectory of a spacecraft by means of a single or multiple thrust impulses. Note, that it may be important — due to the fuel limitation — to minimize the number of thrusts during the transfer from one orbit to another. The results of our paper are also related to the problem of impulsive control of a mechanical system and to the problem of estimation of the required number of impulsive switchings.

To be more precise, consider a mechanical system with the following Lagrangian function

$$L = L_2 + L_1 + L_0 = \frac{1}{2}A(q)\dot{q}\cdot\dot{q} + a(q)\cdot\dot{q} + V(q), \quad q \in M. \tag{1}$$

Here M is a smooth manifold and q denotes the local coordinates on M. Suppose that L_2 is a positive definite quadratic form, L_1 is defined by a 1-form on TM. Below, we assume