Int j simul model 16 (2017) 1, 176-186
ISSN 1726-4529 Original scientific paper

NONHOLONOMIC MOTION PLANNING USING TRIGONOMETRIC SWITCH INPUTS

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Abstract
In this paper we present a local motion planning law called trigonometric switch inputs which can steer the chained form system to the final positions, at least locally, around the initial positions. This method steers the system step by step instead of steering all states in one step. The advantages of trigonometric switch inputs law are that the motion trajectories are quite smooth and have less oscillation and lower computational costs, all of which is beneficial for the application of the time scale transformation technique and improvement of motion efficiency of the system. A two-wheeled mobile robot system is steered by this new motion planning law to illustrate the practical application. Finally, simulations with the time scale transformation technique and experiments with the mobile robot verify the feasibility and effectiveness of trigonometric switch inputs law.
(Received, processed and accepted by the Chinese Representative Office.)

Key Words: Chained Form Conversion, Motion Planning, Trigonometric Switch Input, Nonholonomic System, Time Scale Transformation

1. INTRODUCTION

Nonholonomic motion planning designs an appropriate bounded input planning path to steer the system from an initial position to a desired position over a finite period of time. In recent years, there have been many works involving nonholonomic motion planning. Motion planning of a chained form system in particular has become an important research field because chained form conversion provides powerful tools to steer a class of nonholonomic systems. Furthermore, motion planning for some nonholonomic systems requires high computational costs in dealing with complicated kinematic equations that cannot be converted into chained form, as in reference [1]. In reference [2], a set of sufficient conditions for conversion into chained form were given. Reference [3] addresses the chained form conversion of a car with passive trailers. Two different controllable joint manipulators were designed and controlled based on chained form conversion in references [4-6].

The chained form system is easily integrated and can be steered by existing motion planning laws. Actually, many practical nonholonomic systems, including wheeled mobile robots, can be converted into a chained form system through coordinate transformation and input feedback transformation. Many useful motion planning laws have been proposed. Murray and Sastry introduced a sinusoidal input control law based on optimal control theory for a chained form system [7]. Each state can move to the final value step by step utilizing the periodicity of sinusoidal function. Tilbury and Murray make a detailed discussion about over-parameter sinusoidal, piecewise constant and time polynomial inputs law for motion planning of a chained form system in [8], Sekhavat and Laumond in [9], respectively. Nakamura et al. proposed an optimal three-point trailer system and applied time polynomial inputs and sinusoidal input laws to steer the new mechanism [10]. Measurement and control system for underactuated manipulator is described in [11]. The polynomial input control for an under actuated manipulator was studied in [12]. Chelouah et al. demonstrated the effectiveness of the digital control method through two classic examples: the car with one trailer and the hopping robot [13]. Li et al. presented a switch control method by use of bang-bang inputs to