Three-Dimensional Smooth Trajectory Planning Using Realistic Simulation

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Abstract. This paper presents a method for planning three-dimensional walking patterns for biped robots in order to obtain stable smooth dynamic motion and also maximum velocity during walking. To determine the rotational trajectory for each actuator, there are some particular key points gained from natural human walking whose value is defined at the beginning, end and some intermediate or specific points of a motion cycle. The constraint equation of the motion between the key points will be then formulated in such a way to be compatible with geometrical constraints. This is first done in sagittal and then developed to lateral plane of motion. In order to reduce frequent switching due to discrete equations which is inevitable using coulomb dry friction law and also to have better similarity with the natural contact, a new contact model for dynamic simulation of foot ground interaction has been developed which makes the cyclic discrete equations continuous and can be better solved with ODE solvers. Finally, the advantages of the trajectory described are illustrated by simulation results.

1 Introduction

Today, humanoid robots have attracted the attention of many researchers all over the world and many studies have been focused on this subject. When biped robots are viewed as general dynamical mechanisms, there are several problems such as limited foot-ground interaction, discretely changing dynamics, naturally unstable dynamics and multi-variable dynamics, which make using distinctive methods inevitable in controlling them and in planning trajectory for them [1].

Planning walking pattern is one of the most challenging parts. Recording human walking data aided Zerrugh to investigate human walking pattern [2]. Tad McGeer [3] developed the idea of using gravity as a main source of generating natural dynamic walking in the sagittal plane and Kuo [4] developed the stable walking in lateral motion.

Huang and his team [5] planned the walking pattern for a planner biped robot by interpolating third order spline between some key points of motion cycle. In the present study, we used this method to fulfill the trajectory for sagittal motion while also considering energy consumption optimization as well as geometrical consistency.

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