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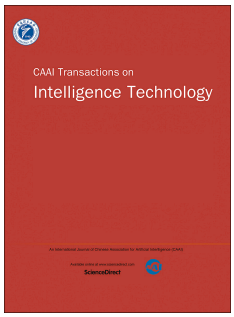

Trajectory planning for biped robot walking on uneven terrain—taking stepping as an example

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Trajectory planning for biped robot walking on uneven terrain—taking stepping as an example

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Abstract: According to the features of movements of humanoid robot, a control system for humanoid robot walking on uneven terrain is present. Constraints of stepping over stairs are analyzed and the trajectories of feet are calculated by intelligent computing methods. To overcome the shortcomings resulted from directly controlling the robot by neural network (NN) and fuzzy logic controller (FLC), a revised particle swarm optimization (PSO) algorithm is proposed to train the weights of NN and rules of FLC. Simulations and experiments on different control methods are achieved for a detailed comparison. The results show that using the proposed methods can obtain better control effect.

Key words: Humanoid robot, PSO, NN, FLC, motion planning

1. Introduction

In order to make humanoid robot able to "live" in the human being environment, it must be able to perform some complex motions. There are two methods to plan these complex motions: The first method is to first establish the appropriate model according to the type of movement, and then plan for the trajectory of motions. Usually, the trajectories of ankle and hip of the robot are assumed by parameter interpolation. Secondly, trajectories of other joints are deduced by geometric relationship. Finally, the optimal trajectories are confirmed by optimal algorithms according to the MAX of stability or MIN of energy consumed or similar strategies[1][2]. The second method is firstly to design an ideal trajectory of motion according to the stability or optimal targets. Then the movement of each joint will be calculated to match the ideal trajectory through inverse kinematics. Finally, during process of the real movement, the error between real trajectory and ideal trajectory will be adjusted[3].

It is worth to study of humanoid robot of integrating into society and serving in the home, and it is a very challenging subject. In face of all kinds of uncertain environment, for walking, robot might need to complete the task in various of complex environment regularly, as shown in Fig.1.

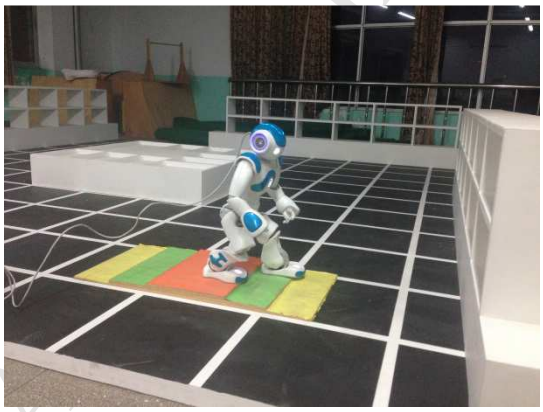

Fig. 1 Robot walks in complex environment

Walking on uneven terrain for humanoid robot is one of the complex motions. It involves in planning and controlling more than ten degrees of freedom of the robot, and this system is a high-dimensional nonlinear complex system. If traditional methods are used in this system, the optimized control effect is not very satisfactory. And especially when there are many more uncertain initial variables, it is easy to fall into local optimization, slow optimization and poor adaptive ability of the algorithm. Therefore, because almost all soft computing algorithms are highly versatile, and analyticity of objective function is not required, evolutionary algorithms and other soft computing techniques can be considered in order to control this system. Rahul used GA with fuzzy logic method to control biped robot walking, and obtain good results[4]. Based on soft computing Pandu designed a gait planner that keep the robot stable when it walked on slop[2].

PSO algorithm has proven to be very effective in solving complex optimization problems. However, as with other evolutionary algorithms, with PSO algorithm it is also easy to fall into local optimal solution. Maintaining the diversity of population and avoiding prematurely falling into local optimal solution is a direct way to improve the PSO. One way to improve the evolutionary algorithm is an idea based on multi-population[5], and it has achieved very good results solving practical problems[6][7]. In order to control the multi-robots formation, Seung-Mok used a coevolving particle swarm optimization(CCPSO) algorithm to optimize the model predictive control, and obtained good results[8]. Micael S.