Abstract

Multi-legged robots have received much attention due to their better mobility and terrain adaptability characteristics, while moving on natural terrains. The minimization of energy consumption plays a key role in the locomotion of an autonomous multi-legged robot. In the present thesis, a systematic analytical approach has been developed to study the kinematics and dynamics along with energy efficiency and stability of a realistic six-legged robot, negotiating straight-forward, crab and turning motions.

Besides a detailed kinematics analysis, two approaches, namely minimization of norm of feet forces (approach I) and minimization of norm of joint torques (approach II) have been developed to estimate optimal distributions of feet forces during the straight-forward, crab and turning motions of the above robot. Approach II provides more energy efficient distribution of feet forces compared to approach I. The effects of walking parameters like velocity, stroke, duty factor etc. have been studied on energy consumption and stability margin for the said motions. For a particular velocity, specific energy consumption is seen to decrease with the lower values of stroke and higher values of duty factor. Moreover, in order to minimize energy consumption, the velocity should be as high as possible for a particular duty factor. However, as velocity increases, the maximum reachable duty factor becomes restricted due to dynamic constraints of the joint actuators. The study related to the effects of stroke and duty factors on the minimum value of Normalized Energy Stability Margin (NESM) over a locomotion cycle indicates that the minimum value of NESM increases with the duty factor for a particular stroke.

Soft computing-based approaches, namely back-propagation algorithm-tuned multiple adaptive neuro-fuzzy inference systems; genetic algorithm-tuned multiple adaptive neuro-fuzzy inference systems; genetic algorithm-tuned coactive neuro-fuzzy inference systems and genetic algorithm-tuned back-propagation neural networks, have been developed to predict specific energy consumption and NESM in straight, crab and turning motions of the said robot. The genetic algorithm-tuned multiple adaptive neuro-fuzzy inference system has performed better than other three approaches for predicting both the outputs. The models, thus developed, might be useful to designers to predict the outputs for a set of input parameters, beforehand.

Keywords: Six-legged robot, Straight-forward gait, Crab gait, Turning gait, Kinematics, Dynamics, Energy consumption analysis, Stability margin, Adaptive Neuro-Fuzzy Inference Systems, Neural Network, Genetic Algorithm.