

# Abstract

Robotics systems are, in general, complex mechanisms. Modeling and simulations are useful tools for analyzing various parameters in order to predict the performances of these systems. Designers can easily predict the system's performances based on its input parameters. Hence, through modeling and simulations, designers can arrive at some feasible solutions for a given set of system parameters without carrying out any real experiment. Thus, there is a saving of time and materials resources. In this thesis, evolutionary algorithms, namely Genetic Algorithm (GA) and Particle Swarm Optimization (PSO) algorithm are used to solve the optimization problems related to two robotic systems. At first, an attempt is made to design and develop an optimal structure and controller for a 2-DOF serial manipulator tracking a given trajectory. Secondly, optimal gait planning problems of a 7-DOF biped robot have been tackled in both single and double support phases separately. These gait planning problems have been posed as multi-objective optimization ones and Pareto-optimal fronts of solutions have been obtained.

Although, an extensive study has been conducted on 2-DOF manipulator on various issues, a very limited work has been carried out on simultaneous design of structure and controller for efficiently tracking a given trajectory. The structural parameters and controller's non-linear gains are optimized using GA and PSO algorithm separately, so that the manipulator can trace a given trajectory accurately. Four approaches are developed. The approach designed based on a combination of neural network and PSO algorithm is found to perform better than the other approaches. This approach is highly adaptive in nature and filters out disturbances in achieving the objectives accurately. This good performance is due to its capability to carry out the local and global searches simultaneously.

Another robotic system, namely, a biped robot is investigated for gait planning, while moving through a staircase during the single and double support phases. It has become a challenge to researchers to completely understand various issues affecting the performance of a biped robot. One such issue is designing walking gaits for various terrains. The walking gait varies according to the terrains, such as flat, sloping, parallel, intersecting, irregular, uneven, rough, etc. In the present study, flat and parallel surfaces are considered for gait planning. For complete understanding of the gait walking cycle, biped robot's single and double support phases are considered for the staircase ascending and descending problems. During optimization, two conflicting objectives, namely power consumption and dynamic balance margin of the robot have been considered, and solved using the GA and PSO algorithm separately. Pareto-optimal fronts of solutions are obtained for both constrained and un-constrained optimization problems. The obtained Pareto-optimal fronts of solutions help the designer to select the appropriate ones depending on the requirement. Thus, it helps the designer to obtain a suitable design for the biped robot.

**Keywords:** Biped robots; Gait planning; Multi-objective optimization; Genetic algorithm; Particle swarm optimization; Single support phase; Double support phase.