Abstract

Quadrupeds robots can move on uneven and rough terrain where mobile robots cannot venture. Although bipeds have more capabilities, they are inherently unstable and difficult to control. Most quadrupeds today are built with a rigid spine. In nature, however, all quadruped have a flexible spine, and it provides better agility and more efficiency in motion. This thesis deals with the study of the development of a method to develop a flexible spine for Quadruped robots. At first, we explore the idea of discretizing a continuous beam into multiple rigid and flexible body element. The flexible elements are considered to be linear torsional spring on a rotary joint (R). We developed a simple algebraic formulation to discretize a continuous beam in any desired number of rigid and flexible elements.We show that, for small deflection, this method covers all types of boundary condition generated in a beam formulation. Next, we exploit the idea of transforming the continuous structure into a rigid-flexible structure to generate spine-like structure for quadruped robot. We use ideas from structural optimization to produce a shape of the articulated structure that can support the desired load while providing the needed flexibility. The objective function used in the optimization represents the rigidity of the structure, and the constraints contained the flexibility desired. A gradient-based optimization method is used to obtain various structures under similar constraints for different endpoint flexibility. Additionally, we analyze the response time of the structure. It is shown that the desired response time can be obtained by introducing damping in various parts of the structure. Again a gradient-based optimization is used to obtain the damping in the structure to achieve the desired response time.

In the second part, we deal with the development of quadruped robots with the rigid and flexible spine. The CAD models of the robots created and simulated in the physics engine. Once validated, the segments and modules of the robots are manufactured and assembled with the servo motors. The controllers and power source are added afterward completing the design. The robots are both controlled with coupled nonlinear oscillator without any feedback. By controlling the coupling, we generated various gaits in the robots such as trot, bound and canter. In the simulation result, we found the velocity of the flexible spine quadruped is higher than a rigid spine quadruped for a bounding gait. In this part, we also describe the use of the optimal spine in the development of the quadruped and problems experienced while executing it in real life.