Conceptual Design and Simulation of a Multibody Passive-Legged Crawling Vehicle

by

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(Abstract)

Rugged terrains, including much of the earth's surface, other planets, and many man-made structures, are inaccessible to wheeled and tracked vehicles. This has inspired research into legged vehicles. Prior to the research described here, virtually all legged vehicle designs relied on the concept of mounting actuated leg-type mechanisms onto a single rigid frame or chassis. This dissertation research explores and advances a novel vehicle concept that uses passive legs attached to an actuated multibody structure. This new vehicle moves only its actuated body trunk to achieve locomotion; thus moving in a manner similar to that used by insect larvae known as caterpillars. The passive-legged design is termed a "crawling" vehicle, to differentiate it from "walking" vehicles, which have powered legs.

A conceptual design for the proposed vehicle was developed using insights from observations of caterpillar specimen geometry, gaits, leg trajectories, and ranges of motion. The flexible, segmented body of the robot is realized using a series of actuated truss-like mechanisms, resulting in a configuration similar to the body structure of caterpillars.

A computer simulation was developed to verify the concept and to assist in creating future designs. This simulation includes a parametric model of the robot structure, an efficient kinematics model, a motion programming method based on six-dimensional parametric cubic trajectories, static stability analysis, actuator velocity and acceleration analysis, wire-frame animations, and rendering, thus providing synthesis and analysis tools for this new class of vehicle.

Results of this work show that by using properly designed Stewart-Gough platform mechanisms for the vehicle multibody structure, a range of motion very similar to that of caterpillars is achievable. Simulation tests showed that imitating the caterpillars' primary gait (or stepping sequence) yields superior speed and efficiency, with little reduction of stability, when compared to a simpler, more obvious gait.

With proper controls, this crawling vehicle will, like its biological counterpart, be intrinsically stable and have excellent maneuverability over rough terrain. The crawling vehicle is shown to be a viable legged locomotion system that may prove to have superior rough terrain mobility to all previous types of man-made land vehicles.

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My graduate work at Virginia Tech has been a long, arduous process, interrupted by esoteric software bugs, two major computer hardware failures, some entrepreneurial efforts, and a patent attempt. It stands to reason that when researching and writing a dissertation over a period of years, there would be a rather long list of people who would have significantly helped or encouraged the author during the work. Such has been the case for me.

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