Modeling of Insect's Legs by Inverse Kinematics Analysis

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Abstract

This paper describes an inverse kinematics anlalyses for the real leg movement in cricket. An experiment was set up to study the locomotion of the cricket walking on a treadmill. The motion was then recorded by high speed video. The kinematics data were extracted each frame to analyze by the inverse kinematics to solve for the simplified joint parameters for the insect's legs movement.

1. Introduction

1.1. Biological Studies

In general, crickets have three pairs of legs attached to the thorax. Each leg has four main segments: the coxa, trochanter, femur, and tibia as shown in Figure 1.

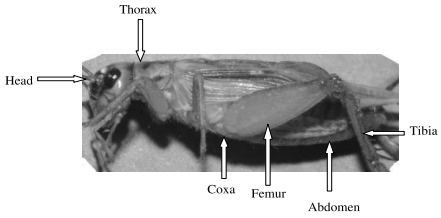

Figure 1: General structure of a cricket

Structurally, insects are usually long and bilaterally symmetric; the left and the right sides of the body are identical. Insects have six legs, which they use to stand in sprawled postures. The sprawled legs are able to absorb the sideways motion and help keep the center of mass over the legs for stability.

1.2. Methodology

An experiment was set up to study the locomotion of the cricket walking on a treadmill. The observation and measurement of the legs and body movement was done by using high speed video shooting 250 frames per second.

2. Leg Model

For the simplicity, the front and middle legs of the cricket were modeled with two segments (femur and tibia) and three DOF, two at the body-femur joint and one at the femur-tibia joint. Using inverse kinematics, the three joint angles of this simplified cricket leg can be solved.

3. Foot Trajectories Results

The foot trajectories are constructed by transforming the digitized data into the body fixed reference frame. The result is plotted as if the animal's body was fixed with its legs freely moving. The " foot" is defined as the end of the tibia.

4. Joint Angles Results

The joint angles results obtaned by solving the inverse kinematics by using the foot trajectories.

5. Discussion

The model of the cricket legs was further simplified for the purpose of simplifying the design of a robot inspired by cricket. The inverse kinematics method was used to determine joint angle data to fit these three degrees of freedom leg models using the foot trajectory data. The results show that the front and middle legs make use of all three joints to follow the animals foot trajectories. The rear leg only needs its coxa-femur and femur-tibia joints.