Summary

Jumping as a method of locomotion is advantageous in several ways, especially in rough terrain where rolling or walking might be difficult. Our research is inspired by the jumping spider family, where spiders have many times their body length, allowing them to pounce on prey traversing great distances relative to their size. They do so by contracting muscles in their upper body (ephalothorax), decreasing the volume of blood there and forcing it into the legs, causing an increase in pressure in the extremities. This pressure increase rapidly extends the spiders’ legs, catapulting them into the air. The primary focus of ArachnaBot is to mimic this sequence of events, so that we may gain a better understanding of the biomechanics involved, and in the future apply this understanding to make better and more versatile robots.

Motivation and Design

Pressure buildup in the robot’s legs is created by compressing a bladder of fluid located at the top of the leg. Pressure is applied at the joint itself via a hollow channel running through the leg. This requires the connections and the joint itself to be hermetically sealed (by O-rings or adhesive). The joint is a simple hinge joint, covered in a non-stretchable sleeve to take advantage of the maximum force application. Bending of the joint is accomplished by a small cable tendon, mechanical tensioning mechanisms, a rigid segmented joint, remote air supply, and forces acting on the joint, assuming a constant pressure application.

Results and Future Directions

In order to launch a 30 g, 5 cm tall robot twice its height into the air, we calculated a pressure application of 60 kPa, resulting in a force of 2 N on the bottom joint. The deforming force from the latch must therefore match this force.

Ongoing investigations are being done into the sleeve design and the joint membrane seal. Ideally, we will use a soft membrane made of silicone bonded with a loose fabric weave, requiring careful mold design and casting. Mylar sleeves have been tested, but there are difficulties with the durability of the material. We are still looking into the design of the mechanical actuator to squeeze fluid into the legs. A separate actuator will be placed in the body of the spider to bend the legs; currently we are evaluating a solenoid design. The biggest challenge still to overcome is scaling down the size and weight of the robot. We are exploring novel fabrication methods towards this goal.

Methods and Analysis

We have developed a model using Conservation of Energy analysis on a single leg to determine the amount of pressure required to jump. Multiple latch designs were tested using a single-point load cell to determine the amount of force needed to demate the latch. The dynamic motion is simulated in MATLAB, using a differential algebraic equation (DAE) method, resulting in ten equations which track the motion of the center of mass of the body as well as the forces applied to the base of the leg and forces acting on the joint, assuming a constant pressure application.

Acknowledgements

Andy Bruna, for his immeasurably useful Dynamic and Kinematic assistance. Robert Shepherd and Kevin W. O’Brien, for graciously allowing us the use of their 3D printer, and Joe Kellner, for his help in the Maker Shop.

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