EXECUTIVE SUMMARY

Design Problem

A one meter scale hexapod robot was developed last semester based on the ideas of Smart Composite Manufacturing (SCM), but the previous design does not have the appropriate stiffness to achieve high speed running. Therefore, the best way to solve this problem is to design a new elastic leg to optimize its weight, cost and ease of modification, with the goal of achieving the rapidly running function.

Customer Requirements and Engineering Specifications

There are seven customer requirements for the leg, which are the leg stiffness, low cost, ease of fabrication, ease of modification, light weight, ground clearance, and load bearing. Specifically, running fast and low cost are the most important requirements among them. According to customer requirements, we generated eight engineering specifications: leg stiffness needs to be in the range of 650 to 800N/m; leg should have a J-shaped stiffness curve; cost should be less than 10 dollars per leg; leg weight needs to be less than 350 grams; fabrication time from raw material is required to be less than 2 hours for a untrained student to finish it; assembly time needs to be less than 30 minutes; leg ground clearance needs to be bigger than 15 cm; the leg must be able to stand a 27 N vertical load.

Concept Generation and Selection

Four categories of eighteen concepts were generated based on background information from relevant papers, experience working in University of Michigan Solar Car Team and group discussion. The four categories are determined by the source of stiffness: solely extensional spring, three-bar linkage with extensional spring, torsional spring and the material itself. Six out of the eighteen concepts were selected and then compared by using the Pugh Chart Method. We graded each concept by its performance on all the engineering specifications. Then we combined the top two concepts and further modified the concept base on instructor's suggestions. The final concept was then generated. It is a structural compliance leg, which is bent from a single sheet metal. It also has a dual-function mechanism to project the main leg body from failure. Details of the concept are included in Chosen Concept section.

Fabrication Plan

A detailed fabrication plan was developed for untrained people who want to fabricate the leg. Some fabrication tools such as a sheet metal punch, a sheet metal bending machine, and a template are prepared for fast fabrication.

Prototype Validation Tests

Prototype tests were conducted including stiffness tests, weight tests, ground clearance tests, fabrication and assembly time tests and cost evaluation. Test results shows that the leg has met all of the engineering specifications.

Conclusion and Recommendation

The overall leg design is successful. However, there are still some aspects that can be improved. Smaller screws and locking nuts may be used; a better protection mechanism is needed. We also recommend that installing the leg to the real robot to see the performance of the leg.