Proposal of Spider Web Simulation

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***Abstract*—This study explores the deformation of elastic materials from a bionics perspective, with a focus on the deformation of spider silk upon impact by a flying insect. Through simulations, we want to replicate and analyze the deformation characteristics of both single and combination of multiple spider silk threads under impact conditions, modeling the response of spider silk to external forces. By understanding these interactions, we hope to learn the mechanical properties of spider silk and contribute to the design of elastic materials.**

I. Introduction

With the rapid development of technology, the application of elastic materials in various fields is becoming increasingly widespread and has become one of the hot directions in science research due to their unique advantages including high dynamic bending elasticity, stretchability and high mechanical strength [1]. Elastic materials, with their excellent features have shown great potential for applications in multiple different fields, such as aerospace, medical devices and bionic robots.

In recent years, the development of bionics has further inspired the innovation of elastic materials. By drawing inspiration from the unique structure and function of biomimetic material, scientists continuously design high-performance elastic materials. These materials not only enable complex deformation, but also maintain excellent mechanical properties under impact and extreme conditions, providing a new approach for engineering applications [2]. Therefore, research on the performance of elastic materials in biomimetic scenarios has become an important topic in the field of materials science and engineering.

In this project, the goal is on studying the deformation of spider silk. Due to the unique mechanical properties and excellent energy absorption ability of spider silk. Spider silk not only has high strength and ductility, but also exhibits excellent impact resistance in complex dynamic environments, providing an ideal model for the design of high-performance elastic materials.[3]

This study focuses on the deformation behavior of spider silk when flying insects collide with it from a biomimetic perspective. Through computer simulation, we first studied the deformation characteristics of a single spider silk under impact conditions, and then extended to the response of multiple spider silk combinations. By simulating and analyzing the deformation characteristics of spider silk and spider silk combinations under impact conditions, we hope to learn the mechanical properties of spider silk and contribute to the design of elastic materials.

II. Plan

The spider silk can be seen as a rod, so our team decided to start the simulation with a single rod in two dimensions and increase the complexity gradually. In all simulations, the fly will be represented by a continuous force. The result of the first simulation should show the deformation and movement of a single rod. After simulating the single rod in two dimensions, our team wants to improve the current simulation into three dimensions in the second simulation. The result of this part should show the same result as the first simulation except in three dimensions. For the final simulation, the simulation object is a combination of multiple rods, which is a designed web. The web contains some grids and it has six-fold rotational symmetry. The result of the final simulation should show the bounce reaction and deformation of the designed web.

III. Restriction

To reduce the complexity, our team designed some restrictions of the simulation. Young's modulus of spider silk ranges from 1.5 to 12 gigapascals, and our team chooses 5 gigapascals in general [3]. Moreover, the diameter of the silk ranges from 0.2mm to 1mm, and our team decided to use its average which is 0.6mm [4]. Besides, the adhesive force of spider silk is not considered in this project.

In the first and second simulations, the two ends of the rod are fixed, whereas in the final simulation, only the outer ends are fixed. Moreover, the applied force is perpendicular to the rod and the center of the web.

IV. Milestone

In the first week, our team is required to do the single rod simulation.
In the second week, our team is required to do the single rod simulation in 3-D.
For the rest of the weeks, our team should assemble the rod into a web, and do the web simulation.

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