CS775 Paper Abstract : Soft Body Locomotion

Mayank Meghwanshi (110050012), Shivam H Prasad (110050041)

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1 Introduction

We would work on physics-based system to simulate and control the locomotion of soft body characters without skeletons.[1][Siggraph 2012]

Motivation of the work comes from wide variety of animals that have no skeleton. Some examples of such creatures are slugs, starfish, earthworms, octopus and jellyfish. Many animated character move in such flexible manner that they seem to be boneless. The animation principle of *squash-and-stretch* can be seen with soft body characters.

2 Problem Scope

This paper uses finite element method to represent tetrahedral mesh of soft body characters. The shape is controlled using muscle fibres of different types namely, *longitudinal muscles* (controls size and bending of body), *radical muscles* (controls volume preservation property) and *helical muscles* (controls twist of soft body characters).

For movement of body this paper uses controls such as moving point on character body, changing center of mass or angular momentum, and maintaining balance.

Using these controllers new muscle fibre lengths are determined, and for each point of contact any motion such as sliding or lifting is also determined. Results over all muscle fibres and point of contacts when aggregated enable a soft body character to perform various kinds of movements such as walking, jumping, crawling, rolling and balancing.

3 Solution

3.1 Soft Body Simulation

Finite Element Simulation. A soft body creature is represented as a tetrahedral mesh and is simulated using a modified co-rotational linear FEM. The state of creature is computed through integration of dynamic motion equations.

FEM is a numerical method to solve integrals by computing quotients of differences at finite mesh points.

Muscle Modelling. Muscle fibres are modelled as polygonal curves with a small number of segments. Based on their arrangement muscles are categorized in three bundles - *longitudinal*, *radial* and *helical*. Each muscle segment is modelled as spring with a fixed stiffness coefficient. Any deformation in muscle may influence many FEM elements.

3.2 Locomotion Control

To create functional locomotion a control algorithm is used to compute the appropriate muscle contractions. This involves formulating an optimisation problem which gives us desired muscle deformation that satisfies physics constraints.

Control mechanisms to formulate objective function:

Momentum Control. This is needed for balancing and enabling movement of character. Linear momentum relative to base is very effective balancing strategy. Angular momentum also plays a crucial role in balancing of soft body characters.

Base Control. For maintaining balance and volume preservation changing the size of contact area is an effective technique. By squashing and stretching its entire body, a soft body creature can adjust its base area at will to maintain balance.

Position and Velocity. Controlling position and velocity is important for regulating motion of soft body character.

References

[1] Jie Tan, Greg Turk, and C. Karen Liu. Soft body locomotion. *ACM Trans. Graph.*, 31(4):26:1–26:11, July 2012.