Gestural Interface for Specification of Material Properties in Virtual Reality

Project Proposal

Lawson Fulton Vismay Modi Christine Murad

Abstract

The creation of compelling virtual reality environments necessitates worlds that are not just static, but respond to users presence in realistic ways. Physical simulation of materials enables this type of experience. However, the process of choosing appropriate material parameters for simulation remains an arduous process for artists. In this project proposal, we describe a method for the intuitive gestural specification of deformable material simulation parameters in virtual reality.

1 Introduction

Physical simulation of virtual objects is a broad field that includes rigid bodies, fluids, cloth, deformable objects, and more. In this project we will restrict our focus primarily to the simulation of elastic deformable bodies. This class of materials can represent many objects we encounter on a daily basis, such as organic matter, while remaining complex enough to pose a significant challenge when specifying material parameters.

2 Previous Work

2.1 Artist Directed Simulation

Much of the previous work on artist directed physics simulation has been aimed at producing simulations that act within the constraints of artist provided keyframes [4], guiding simulations to match example poses [3], or editing the results of a previous simulation [2]. However, little work has been done on an intuitive way of specifying the underlying material parameters such as stiffness and damping.

2.2 Specification of Material Parameters

One very flexible approach is editing of a stress-strain curve to specify arbitrary non-linear materials [5]. However, this method does not provide an intuitive sense of what behaviour will result from a given curve.

3 Proposed Method

We propose the use of gestural interaction to specify material parameters of an elastic deformable body. Physical parameters that we are interested in exploring include, the young's modulus, and the damping, for both isotropic, and anisotropic materials.

3.2 Gestures

There are many possibilities to explore in terms of which gestures to use, and how to map them to material parameters. Our high-level vision is to map deformations of a hand held proxy object to the material parameters of a deformable object out in the world. That is, we will attempt to infer the user's intent through a combination of controller input displacement, velocity, acceleration, oscillatory behaviour, etc. This data can then be mapped directly to some material parameters through an explicitly designed function. A more sophisticated approach is to optimize over a range of possible parameter choices and choose those that best imitate the indicated motion. Due to computational limitations, this option may be infeasible for real time applications.

3.2 Hardware and Software

We will work with the stock HTC Vive VR platform. We chose this platform since it provides dual controller input, which will be the main mode of interaction with the virtual materials. For the software environment, we will use Unity, since we have previous experience developing for that environment.

3.2.1 Physics Simulation

One of the constraints of using Unity for development is that we will need to implement our physics simulations in either Javascript or C#. We've chosen to use C# because it allows us to use several powerful linear algebra libraries and solvers. As a reference we can use the BEPU C# physics simulation repository. Additionally, a number of linear algebra and numerical computation methods have been implemented in math.Net. Finally, AlgLib is a commercial strength numerical analysis library with a very good implementation of the limited memory BFGS solver.

References

[1] Wen Tang and Tao Ruan Wan. 2012. Simulation of deformable solids in interactive virtual reality applications. In Proceedings of the 18th ACM symposium on Virtual reality software and technology (VRST '12). ACM, New York, NY, USA, 77-84. DOI: https://doi.org/10.1145/2407336.2407351

[2] Jernej Barbič, Funshing Sin, Eitan Grinspun. Interactive Editing of Deformable Simulations, ACM Transactions on Graphics 31(4) (SIGGRAPH 2012), Aug 2012.

[3] Sebastian Martin, Bernhard Thomaszewski, Eitan Grinspun, and Markus Gross. 2011. Example-based elastic materials. In ACM SIGGRAPH 2011 papers (SIGGRAPH '11), Hugues Hoppe (Ed.). ACM, New York, NY, USA, Article 72, 8 pages. DOI: https://doi.org/10.1145/1964921.1964967

[4] Ryo Kondo, Takashi Kanai, and Ken-ichi Anjyo. 2005. Directable animation of elastic objects. In Proceedings of the 2005 ACM SIGGRAPH/Eurographics symposium on Computer animation (SCA '05). ACM, New York, NY, USA, 127-134. DOI: https://doi.org/10.1145/1073368.1073385

[5] Hongyi Xu, Funshing Sin, Yufeng Zhu, and Jernej Barbič. 2015. Nonlinear material design using principal stretches. ACM Trans. Graph. 34, 4, Article 75 (July 2015), 11 pages. DOI: https://doi.org/10.1145/2766917