Initial Project Overview

SOC10101 Honours Project (40 Credits)

Title of Project: Cloth Simulation

Overview of Project Content and Milestones

In games development, well-constructed cloth physics can be vital in adding to a game's realism. This project will be about implementing extended position-based dynamics (XPBD) within a physics framework to simulate cloth. XPBD is an extension to a well-known technique called position-based dynamics (PBD). PBD uses position constraints to iteratively solve the positions of particles within a simulation. XPBD improves upon the accuracy and stiffness problems of the method by having the stiffness depend on the number of iterations. It can also improve upon the positional errors by shortening the time step.

This simulation will be used to analyse and evaluate different configurations of cloth, to discuss the effectiveness and value of this simulating technique.

In terms of milestones, the first goal will be the literature review, discussing areas such as: cloth simulation for film, real-time cloth simulation and other techniques, e.g., motion capture.
The next milestone will be implementing the original position-based dynamics within a physics simulation framework. Next, the extended position-based dynamics will be implemented. This implementation will then be used for analysis, potentially with different cloth materials and configs to see where this technique is best suited for, and where it falls short.

If these milestones end up being simpler than initially thought, there is room to explore CPU vs GPU simulations using this technique.

The Main Deliverable(s):

The main deliverable is an implementation of extended position-based dynamics within a physics framework. The current plan is to use C++ as it is very common in physics due to its great performance and potential for optimisation. The framework will most likely be Unity, which is C#, but mainly for its visualisations, the actual physics simulation code will be in C++. This will be done by compiling the C++ code to a .dll file, then used by Unity.

The Target Audience for the Deliverable(s):

The target audience would be game developers and game/physics engine developers, as it hopefully will be useful to them in testing.

The Work to be Undertaken:

Firstly, cloth simulation in various fields will be investigated and discussed within the literature review. The main bulk of the work will be implementing XPBD within a chosen framework. It will then be used to analyse things such as performance, realism etc. The simulation can also be evaluated against other implementations to compare findings.

Additional Information / Knowledge Required:

For this project, I will need to improve my current knowledge of programming physics simulations. I have previously worked on a mass-spring cloth simulation in a previous module: Physics-based

animations. The knowledge gained in this module will be helpful in understanding further methods and techniques in the field.

Also, as the framework will most likely be new software to me, I will need to experiment and get to grips with that, to successfully implement this project.

Information Sources that Provide a Context for the Project:

For this project, there is a lot of information related to the topic in papers published by Matthias Müller, as he is one of the co-authors of both PBD and XPBD.

References

Macklin, M. (2016, September 15). *XPBD (submission video)*. Retrieved from Youtube: https://www.youtube.com/watch?v=jrvJFzrF3kg

Matthias Müller, B. H. (2006). Position Based Dynamics. *Virtual Reality Interactions and Physical Simulations (VRIPhys) 2006*.

Miles Macklin, M. M. (2016). XPBD: Position-Based Simulation of Compliant Constrained Dynamics. *MiG '16: Motion In Games* (pp. 49-54). Burlingame California: ACM.

Müller, M. (2023). *Publications*. Retrieved from Matthias Research: https://matthias-research.github.io/pages/publications/publications.html

The Importance of the Project:

As most 3D games in the field use some sort of cloth physics, this project is very relevant to modern games development today, and since performance is a vital aspect of game development, every bit of optimisation with these techniques can be instrumental in helping a game succeed.

As for the novelty aspect, while it is true there are many different implementations of XPBD online, I plan to test a wide range of simulations with different configurations to see how each aspect affects the overall performance. For example, a 50 by 50 cloth with just bending constraints vs a 500 by 500. Hopefully with these experiments, I can conclude what has the most impact on simulations.

The Key Challenge(s) to be Overcome:

I anticipate the main challenge to be properly understanding the maths involved in XPBD, while also being able to program the expected behaviour in C++, I will most likely have to devote a lot of time to this. Another challenge will be how to efficiently use the chosen framework, in terms of visualising the cloth simulation.