

Physics-based Hand Gripping Simulation

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1 Proposal

The project that I am proposing is a simulation of a human hand, using real world physics and forces, picking up objects. During the simulation, the hand will move over to the object, tighten the grip around the object and then apply the appropriate amount of force based on the real world force needed to pick up corresponding objects. My plan is for the system to have different incremental steps and customization. Starting with simple objects, such as cylinders and spheres, the hand will then try to pick them up acting against gravity. If that works, the hand will then try to move the objects while maintaining its grip. If all of that works, then I can add more intricate objects, such as fruits or more non-uniform shapes, for the hand to try and move, as well as try different sized hands and more complicated movements, like shaking or rotating the hand. In terms of the motion of the hand and the fingers around the objects, I plan on using inverse kinematics [1], which will then direct where the force needs to be applied. I will be using implicit integration for the collision due to its greater stability [2]. Based on the structure on how I plan to implement this project, plan b is scaling back on some of the additive features. As stated before, I plan to try and get the hand to pick up various types of objects, so in the event of problems, I would focus my time on less varied objects, or just one simple object should it come to that.

2 Related Work

Collision is a key part of this project, so even through Volino and Magnenat Thalmann's paper [2] is on cloth collision, the basic ideas of collision could still be gained from it. Also, since I want the collision to be very realistic, a complicated collision process such as cloth being taken and simplified to hand collision was something I thought would be insightful. In terms of other hand gripping simulation, research into this idea has been going on for a long time, and various developments have been discovered and added on through the years. Thalmann and Mas Sanso [1] in 1994 discussed the system being able to determine how to grip and object, such as "*a pinch when the object is too small to be grasped by more than two fingers or to use a two-handed grasp when the object is too large*". More reason studies, however, have more of a focus of using motion capture data in order to build their gripping animation on top of realistic hand motion [3] [4] [5].

3 Plan

For this project I intended to Unity for my implementation because, as Kiran and Young stated in their paper, it allows me to use Unity's graphics engine to render 3D objects [3], so I can focus on the animation side. The resource that I will need for this project are simply different 3D models, starting with a human hand model and basic 3D shapes like cylinders and spheres, and then as stated before, more complicated models if there is success in the earlier parts of the

project. Before any work on the actual animation, for the first week I will do some initial research into the real world physics that I will be trying to simulate, as well as research and reading associated papers about the animation mechanics I will be implementing in the coming weeks. I have broken down the project into four major areas of difference and plan on working on those incrementally throughout the weeks. For week two I will work on the movement of the hand, making sure it looks and feels correct. Week three I will work on the collision between the hand and object, as well as start the basic application of the forces. In week four I will simply continue working of the force physics. During week five I will write the interim report and update my future plans if necessary. Week six I will hopefully finish the force physics and start testing more varied movements and test with the gravity more. By week seven I plan on finishing the working demo of the project. And in week eight I will write the final report. The biggest difficulty I foresee in this project is getting the collision of the hands and the objects correct to such a level that is does not mess with the forces that are going to be applied. The force of the hand needs to be applied directly to the surface of the objects, so if the collision is not near perfect, for example if the hand goes into the object or is too far away, the force being applied will not work properly, but will also not simulate the real world.

4 References

- [1] R. Mas Sanso and D. Thalmann, "A Hand Control and Automatic Grasping System for Synthetic Actors," *Computer Graphics Forum*, vol. 13, no. 3, pp. 167-177, 1994.
- [2] P. Volino and N. Magnenat Thalmann, "Implementing fast cloth simulation with collision response," IEEE, Geneva, 2000.
- [3] K. Nasim and Y. J. Kihm, "Physics-based Interactive Virtual Grasping," *HCIK '16: Proceesings of HCI Korea*, pp. 114-120, 2016.
- [4] N. S. Pollard and V. B. Zordan, "Physically based grasping control from example," *SCA '05: Proceedings of the 2005 ACM SIGGRAPH/Eurographics symposium on Computer animation*, pp. 311-318, 2005.
- [5] W. Zhao, J. Zhang, J. Min and J. Chai, "Robust realtime physics-based motion control for human grasping," *ACM Transactions on Graphics*, vol. 32, no. 6, pp. 1-12, 2013.