Physics-based Hand Grasping Animation

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March 3, 2023

1 Proposal

For my hand grasping animation I decided to implement it as a particle system. I am creating the hand by placing several particles in the formation of the hand and attaching springs between each of the points to ensure that the shape of the hand is maintained. The springs will also be used to control the general movement of the hand. The central palm particle will be only one with force moving towards the object, so the springs will create a hierarchy of movement leading up through the fingers. This also applies when the fingers go to wrap around the object, only the particle at the base of the finger will have forces applied to it. Each particle of the hand will be drawn with a sphere to give the hand more volume. The object itself will also by a particle within the system, as for now, the object being grabbed is a sphere. The palm particle will move towards the object and when it collides with it, forces applied to the object and back into the hand will cause the hand to stop its forward motion. The finger particles will then wrap around the object until they collide in the same way, and once enough particles have collided, both friction forces to keep it in place, and upwards force the fight gravity acting on both the hand and the object will be applied, carry the object upwards. The friction forces will be based on Coulomb's friction model [1]. The particle system is using the forward Euler integration. Currently I have a simple version of the hand representation in particles to make the implementation of collision and movement easier to handle. The hand moves in the direction of the object, but not actually towards the object, again just to get other parts implemented first. Collision has been finished, and the forces causing the hand particle to push into the object, receive that same force back, causing the particles to stop has also been finished. In terms of evaluation, I plan to parametrization different parts of the project and create a few test cases. These parameterizations will include different locations, sizes, and weights of the object. Whether these test cases pass or fail will be based on qualitative visual analysis done by myself. More specifically, does the hand collide properly, do the fingers move and collide properly, and does the hand move without dropping the object.

2 Related Work

The most common implementation in hand grasping animations or simulations is using motion capture data. This motion capture data can be used in two different ways; real time capturing of data, versus pre-calculation grasping configurations. For the real time capturing, the hand models are tracked and controlled by the user [1] and does not require prerecorded data [2]. The other method starts with prerecorded hand movement data and uses different methods to determine stable grasp configurations and realistic motions. These methods include "*machine learning and particle swarm optimization*" [3], and "*data driven synthesis algorithms*" [4]. Grasping simulations are not only used for games and animations but can also be used for assembly and disassembly operations. Virtual assembly is a field that benefits from continued application of

hand grasping simulations by creating "*more intuitive, natural and immersive feelings for users*" [5]. Hand grasping animations can also be used for the improvement of task learning and automation in assembly and disassembly [6].

3 Plan

The biggest change that occurred with this project was deciding to change what application the project would be done in. Originally, I planned to do it in Unity, but after changing the system to implement a particle system, I decided to use the base code as I was already familiar with it. My first milestone was to get the movement of the hand finished. This is partially done, with a simple version of it completed, but I still plan to implement springs within the hand, as well as add the parameterization which will make the hand move towards wherever the object is, as opposed to the direction of the object as it does now. I also need to add more particles to the hand and get the movement of the fingers finished. The next milestone was collision, which is completed and working for the current sphere object. The last milestone from the original proposal is implementation of the forces. Currently, the forces causing the hand particles to stop once they have collided with the object. The remaining work needed for the forces is implementing the friction forces from the hand to the object to keep it within the grasp of the hand, and any movement forces after the object is firmly grasped. A new milestone is the adding of parameterizations, as mentioned before, to test different aspects of the project. Parameterizations such as size, weight, and location of the object. All that is left to do would be writing and finishing the final report and presentation before the due date.

4 References

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