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Demonstration: 3-Hand Manipulation of Virtual Objects

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Abstract

This demonstration introduces a new 3D interaction technique called “3-Hand Manipulation”, for multi-user collaborative manipulation of 3D objects. This technique relies on the use of three manipulation points that can be used simultaneously by three different “hands” of two or three users. The three translation motions of the manipulation points fully determine the resulting 6 DOF motion of an object. We describe the graphical representations of the 3-Hand Manipulation and an illustration of its use by two or three users on an insertion task.

Categories and Subject Descriptors (according to ACM CCS): H.5.1 [Information Interfaces and Presentation (e.g. HCI)]: Multimedia Information Systems—Artificial, augmented, and virtual realities; I.3.6 [Computer Graphics]: Methodology and Techniques—Interaction techniques

1. Introduction

Object manipulation is one of the most fundamental tasks of 3D interaction in Virtual Reality (VR) [BKLP04], and the collaborative manipulation of virtual objects by multiple users is a very promising area for Collaborative Virtual Environments (CVE) [BGRP01]. In such virtual collaborative tasks, all the users should participate naturally and efficiently to the motion applied to the object manipulated in the VE. Due to the complexity of current VR interfaces, no universal collaborative solution has already been proposed to naturally apply a motion to a co-manipulated object. Interaction metaphors that are usually used for single-user 3D interactions have to be adapted for collaborative 3D virtual manipulations.

2. Related Work

Some 3D interaction techniques have been proposed for manipulating virtual objects with the two hands of a single user [HPPK98], but only a few of them such as “grab-and-carry”, “grab-and-twirl” and “trackball” techniques [CFH97] allow users to position and rotate at the same time virtual objects. These techniques have two main restrictions: they are not very representative of real world interactions, and they cannot be used to simulate real interactions with big or heavy

objects that a user cannot manipulate alone. Several approaches combine two users’ movements to obtain virtual object’s final movements [RSJ02] [RHWF06], but none of them is ideal. Indeed, the intersection technique is the more relevant when the two users have to perform a similar action, whilst the average technique is preferred when users have to perform different tasks. The SkeweR technique lets multiple users grab simultaneously any part of a virtual object [DLT06] through “crushing points”. A problem remains for determining the rotation along the axis determined by the two crushing points. Another kind of collaborative manipulation consists in splitting the task DOF among users [PBF02]. In this case, the number of DOF that each user can access and control is limited: one user controls rotations while the other one controls translations. This can be compared to the Two-Hand “trackball” technique.

3. The 3-Hand Manipulation Technique

We propose a new 3D interaction technique for 6 DOF multi-user collaborative manipulation of 3D objects, which enables the determination of virtual object position and orientation through only positions of three non-aligned manipulation points on the surface of this object. These manipulation points can be used naturally, in a realistic way, by three different “hands” of two or three users.



Figure 1: 3-Hand Manipulation of a virtual hood by two users.

3.1. Manipulation and Graphical Feedback

Hands are represented by pointers. When a hand is close enough to the object to manipulate, ray-casting from the hand gives an intersection point with the object. This point is called a *manipulation point*. If a user starts a manipulation, a virtual ball is added to display the location of the manipulation point. In addition, a rubber band is added between the virtual ball and the hand to avoid any ambiguity concerning its owner and to display the distance between the hand and the manipulation point. This rubber band is elastic and its color varies according to the distance between the hand and the manipulation point. It uses a green-red code: farther a hand is from its associated manipulation point, the more the rubber band becomes red. With such a feedback, users' hands are expected to remain close to their manipulation point to avoid instabilities during the manipulation.

3.2. Computation of Manipulated Object Motion

The manipulated object motion can be computed in different ways using input motions of the three users' hands. One solution consists of making the manipulation points stay as close as possible to the hands. The positions of the three hands define a first triangle, the positions of the three manipulation points define a second triangle. The idea is to make these two triangles match as accurately as possible. Another solution for implementation is to use three "point-to-point" constraints of a physics engine like Bullet or PhysX. A constraint is dynamically added between a hand and a manipulation point. Here, if the two triangles defined by the hands and by the manipulation points do not keep the same shape, there can be some small inconsistencies for the roll angle. In both cases, the use of a colored rubber band can help users to keep their hands close to the manipulation points.

4. Use-Case

The 3-Hand Manipulation technique is used for a 3-hand manipulation task as illustrated by figure 1. Two or three people manipulate simultaneously a virtual hood to place it on a support. This hood has holes that users must align with the support. This task is consistent with a possible real one: a hood is a big and heavy object that a user cannot manipulate alone. Physics and collisions in the virtual environments are implemented using the Bullet physics engine. Hands are manipulating objects through Bullet constraints.

5. Conclusion

"3-Hand Manipulation" is a new 3D interaction technique for multi-user collaborative manipulation of 3D objects. This technique relies on the use of three manipulation points that can be used simultaneously by three different "hands" of two or three users. The three translation motions of the manipulation points fully determine the resulting 6 DOF motion of the manipulated object. The considered task consists of assembling the hood on a support. User feedback suggests that the technique is suitable for collaborative manipulation, and further work is now necessary to evaluate and compare our approach to other existing techniques involving many users.

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