3D Model Annotation from Multiple Viewpoints for Croquet

Rieko Kadobayashi
National Institute of Information
and Communications Technology, Japan
rieko@nict.go.jp

Julian Lombardi
Office of Information Technology
Duke University, USA
julian@duke.edu

Mark P. McCahill
Office of Information Technology
University of Minnesota, USA
mpm@umn.edu

Howard Stearns
Division of Information Technology
The University of Wisconsin-Madison, USA
hstearns@wisc.edu

Katsumi Tanaka
National Institute of Information
and Communications Technology, Japan
Graduate School of Informatics
Kyoto University, Japan
tanaka@dl.kuis.kyoto-u.ac.jp

Alan Kay
Viewpoints Research Institute, California, USA
Adjunct Professor at UCLA, California, USA
alan.kay@squeakland.org

Abstract

This paper explores ways by which multiple authors can annotate 3D models from multiple viewpoints in a 3D collaborative environment, with particular reference to the environment provided by Croquet. We deal with two types of viewpoint: the conceptual viewpoint and the physical viewpoint. Our approach is to exploit the portal, which is a notable feature of Croquet, in order to achieve our goal. We can assume that a physical viewpoint is expressed by the position and orientation of a portal. To provide a method for annotation based on the conceptual viewpoint, we developed a new portal called an "interactor." The design and our preliminary implementation are discussed.

1. Introduction

This paper explores ways by which multiple authors can annotate 3D models from multiple viewpoints in a 3D collaborative environment, with particular reference to the environment provided by Croquet [9]. Croquet, written in Squeak [2], is a combination of open-source software and peer-to-peer network architecture providing an infrastructure for synchronous real-time problem solving within shared simulations. Croquet supports collaborative creation, viewing, and interaction with and sharing of remote objects via a peer-to-peer network of diverse user hardware.

As an ad-hoc multi-user network, Croquet is similar to the web in that users have the ability to create and modify a "home world" and create links to any other such world. In Croquet, these worlds are 3D virtual worlds. Users or groups with appropriate sharing privileges can visit and work inside other Croquet worlds on the Internet. Croquet's connections between worlds via spatial "portals" are an analog of web page hyperlinks. Users may put as many portals as they want in a world. The portals can be located in different places, and users can visit different parts of the world from the different portals.

A portal is represented as a square window and it has its own position and direction in a 3D world. When users look through the portal, they can see other worlds. A user's view of the other world beyond the portal changes slightly as they change position (See Figure 1.) It is hence regarded as a see-through anchor.

We deal with two types of viewpoint; conceptual ones such as those concerning ecology and technology, and physical ones, i.e. places from which you can see something. As 3D models and 3D spaces are three-dimensional, they can be annotated based on a 3D physical viewpoint as well as on a conceptual viewpoint.

Our approach is to exploit the portal that features in Croquet in order to achieve our goal. We can assume that a physical viewpoint is expressed by the position and orien-

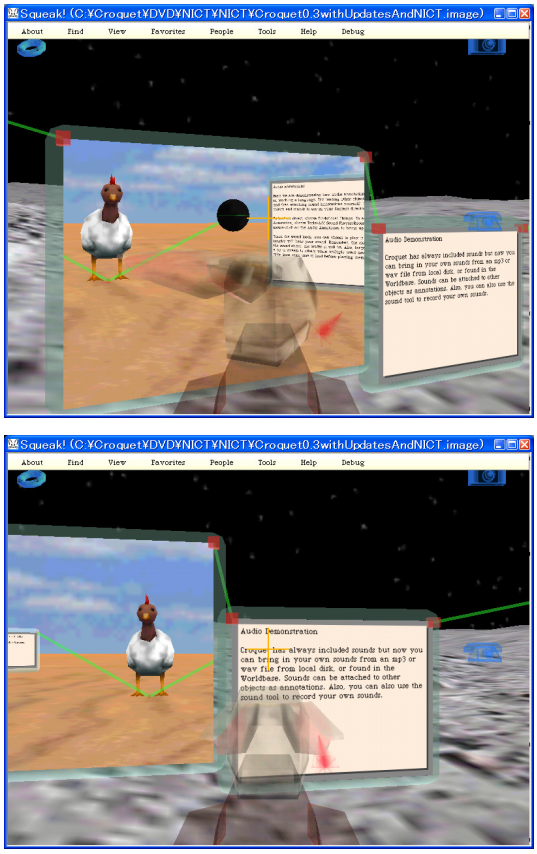

Figure 1. A user represented as a rabbit avatar is looking at another world through a portal. The view of the world beyond the portal changes according to the user's position.

tation of a portal. As mentioned above, a world can have multiple portals which invite users to explore different parts of the world. This means a portal represents the physical viewpoint of the user who put the portal in the world.

To provide a method for annotation based on conceptual viewpoint, we enhanced the ability of the portal. This new type of portal is called an "interactor." It allows users to add annotations to objects and to control the view of annotations. The annotation is visible only in the interactor through which it was made. Individual users can have their own interactor, or several users working in a group or team can share an interactor. The interactors can be moved around, and viewing through both simultaneously allows you to view annotations from both sets of authors.

Many collaborative annotation systems have been proposed. For example, "Annotea" is an annotation mechanism for the Web [6] and "3D Blog" is a blog system that allows users to annotate 3D content such as 3D models of buildings and to read these annotations in a blog [5].

The advantages of our system are summarized as follows: it allows users to annotate 3D models in a 3D collaborative environment, it allows users to communicate with others synchronously, it provides users with several ways to add annotations.

The framework for authoring 3D spaces and user interfaces for Croquet has also been developed. These issues are discussed in separate papers [7, 10].

2. Basic Annotation Function

We have developed basic conventions by which annotations can be created independent of the form of media. We allow objects to become annotations even if the object was not originally designed with this in mind. This is important so that we can provide the richest possible set of tools for expressing comments and annotations. Of course, users can make a new annotation object using such a text input interface.

Annotations may be represented as a connector, a line connecting two objects, or they may be a marker, displayed as a thumbtack denoting some hidden content that can be made visible when triggered by a user action within a filter [4] as shown in Figure 2.

3. Viewpoint-based Annotation

3.1. Physical Viewpoint

When a user wants to annotate a 3D model based on physical viewpoint, this is achieved by putting a portal in an appropriate place and orientation in a world. As a portal is a see-through anchor, a user can view the other world without following the hyperlink. If multiple portals are in different locations in a world, users obtain different views of the world depending on the portal used.

Portals can be annotated and thus a 3D world or a view of a 3D world through a portal can also be annotated. This means that viewpoints themselves can also be annotated, as portals can be regarded as viewpoints. Figure 3 shows an example of an annotated portal.

3.2. Conceptual Viewpoint

An interactor, an enhanced portal, allows users to add annotations to 3D objects based on conceptual viewpoints. The annotation is visible only in the interactor through which it was made (see Figure 4). Individual users can have their own interactors and hence can annotate 3D models based on their own viewpoints. A user may have several interactors so that the annotations can be categorized based

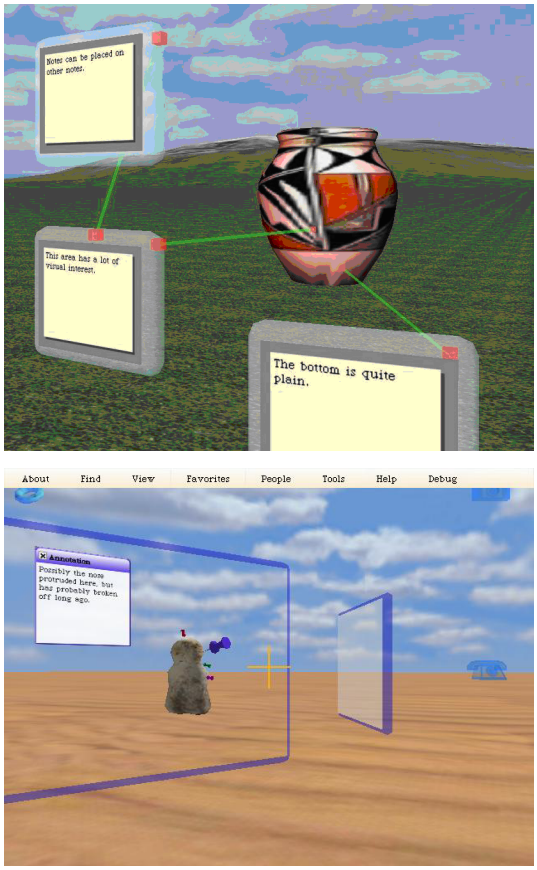

Figure 2. Pottery artifact with annotations. Annotation objects can be annotated (top). Annotations represented as thumbtacks are visible through a filter (bottom).

on viewpoints. On the other hand, several users working in a group or team can share an interactor while at the same time sharing the same viewpoint.

The interactors can be moved around, and viewing through both simultaneously allows you to view annotations from both sets of authors (see Figure 5). For example, suppose there is a 3D model of a historical building and experts with diverse backgrounds wish to discuss the preservation of the building. Some of the experts may annotate the model from the historical point of view, and others may annotate from the economic point of view. By overlapping these points of view, the differences and similarities between the experts' thoughts would become clearer. This is to say "join of viewpoint" and provides users with a very easy and intuitive way to manage the viewpoint of annotations. This is similar to a function provided by '3D Magic Lens' [11]. When multiple lenses are overlayed, different information is displayed through the lenses.

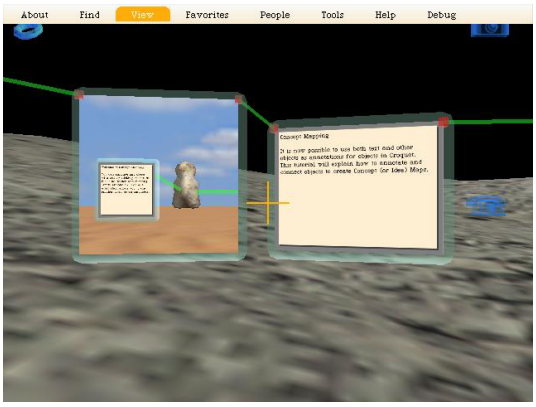

Figure 3. Annotated portal.

You can also walk through an interactor, which then responds as though you have the interactor surface stretched over your "camera" lens. this allows multiple users to use the same interactor in different places, and may be more natural than standing in front of a "viewing screen" (see Figure 6). You can return to normal by walking through the interactor again.

In one sense, ordinary portals present a physical viewpoint on a given 3D space, showing all that is in geometrically visible from the portal's perspective. An interactor, however, presents a conceptual viewpoint on a given 3D space. One can think of this as showing the same physical view with annotations added, or one can think of this as a different 3D space that shares the same physical elements, yet which also has other (e.g., annotation) elements shown.

4. Related Work

Annotea is a web-based system for sharing annotation of Web documents. It is closely similar to our system in the sense that it supports annotation sharing among distributed users and it treats annotation as external content to the original documents. What sets apart our system from Annotea is that our system supports annotating 3D space and/or 3D objects such as 3D computer graphics models of buildings, furnitures and every operation of annotation, i.e. creating, browsing, searching, and filtering annotation can be done collaboratively in a shared 3D virtual world. Furthermore, our system allows users to annotate from both conceptual viewpoint and physical viewpoint while Annotea does not.

In computer graphics domain, a portal was originally introduced as a rendering technique, specifically a technique for hidden line removal [3]. Airey et al. [1] used portals for rendering architectual scenes. Portals were used to connect physically adjacent cells in these works.

A significant change in the role of portals was introduced

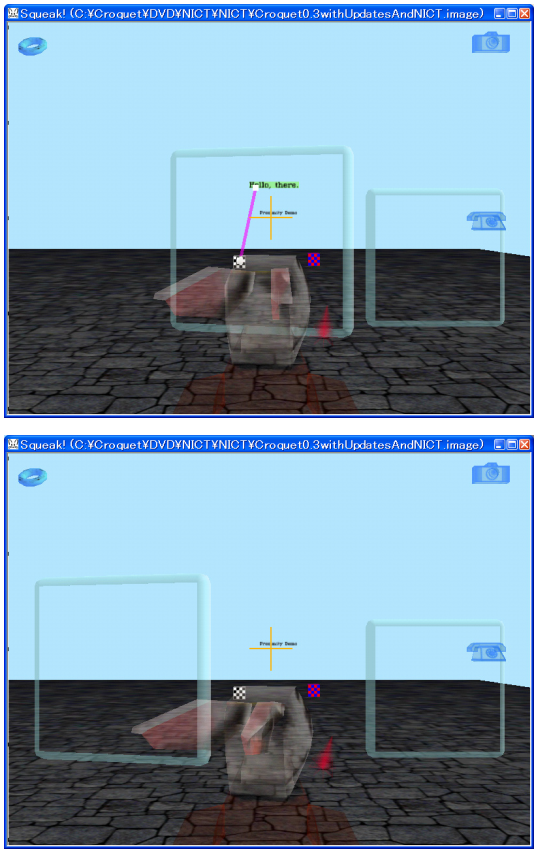

Figure 4. Interactor. An annotation is visible only in the interactor through which it was made.

by SEAMS [8]. As the name implies, SEAM (Spatially Extended Anchor Mechanism) is an expantion of anchor mechanism in World Wide Web to 3D virtual worlds. That is SEAMS, which correspond to portals, connect 3D worlds even if the worlds are not adjacent to each other. In other words, users can move from one world to another by teleportation. This is done by anchor and link mechanism as with WWW. A SEAM acts as see-through anchor, users can see other worlds through SEAMS before they enter the other worlds. In terms of portals, SEAMS is very similar to Croquet which we used as a base for our annotation system.

Our annotation system further extended the role of portals. Portals are used to express viewpoints both conceptually and physically. Moreover an interactor, an enhanced portal, has a similar function to '3D Magic Lens' as described in Section 3.2.

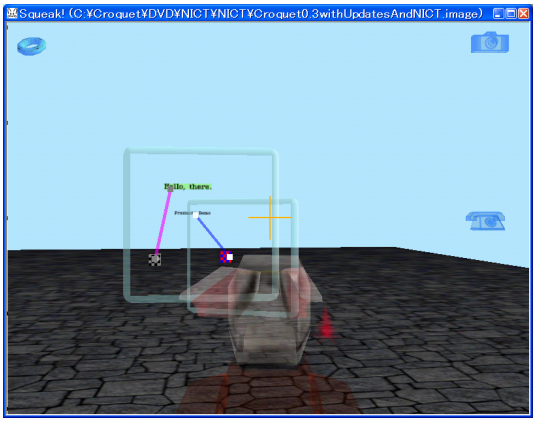

Figure 5. Annotations made through different interactors can be visible when these interactors are overlapped.

5. Conclusion

We have introduced our prototype system on collaborative annotation based on viewpoint in 3D virtual environments. First we discussed the types of viewpoint: conceptual viewpoint and physical viewpoint. In 3D collaborative environments, the physical viewpoint is especially important and thus should be supported.

So far, we have discussed how to annotate 3D objects based on viewpoint. We should also consider how to use viewpoint to search for annotations and objects. Portals represent physical viewpoints by showing different views of a world. In other words, there are annotations and objects that are not shown from a particular portal. We believe the viewpoint-based search is essential to 3D collaborative environments, and our next step is to design a system combining these two elements.

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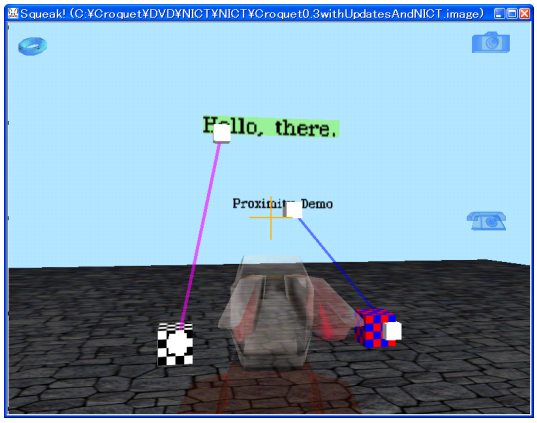

Figure 6. Users can view annotations after walking through interactors.

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