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Optical Sight Metaphor for Virtual Environments

Andrei Sherstyuk *
Telehealth Research Institute
University of Hawaii

Jarrell Pair †
Institute for Creative Technologies
University of Southern California

Anton Treskunov ‡
Institute for Creative Technologies
University of Southern California

ABSTRACT

Optical sight is a new metaphor for selecting distant objects or precisely pointing at close objects in virtual environments. Optical sight combines ray-casting, hand based camera control, and variable zoom into one virtual instrument that can be easily implemented for a variety of Virtual, Mixed, and Augmented Reality systems. The optical sight can be modified into a wide family of tools for viewing and selecting objects. Optical sight scales well from desktop environments to fully immersive systems.

Keywords: Object selection, vision aid virtual tools, ray-casting.

Index Terms: H.5.1 [Information Systems]: Information Interfaces and Presentation—Artificial, augmented, and virtual realities H.5.2 [Information Systems]: Information Interfaces and Presentation—User Interfaces Input devices and strategies

1 INTRODUCTION

Object selection is a fundamental task for all systems where virtuality is involved. Dozens of methods and metaphors have been implemented for object selection and manipulation, including a 'virtual hand', a 'world-in-miniature' and a magical 'voodoo doll' (see a short survey of the most popular techniques in [1]). More methods and designs are described in [2] and their numbers are constantly growing.

Techniques based upon the 'virtual hand' metaphor became classic in the field of user interface (UI) design. The virtual hand is used to manipulate objects, steer travel direction, specify targets and perform application-specific tasks. The virtual hand metaphor has been applied for object selection by direct touching [3], extended touching [4] and, in conjunction with various forms of ray-casting, by pointing at the object [5, 6, 7]. As discussed in [6], noise and imprecision of tracking along with the instability of the user's hands make it difficult and sometimes impossible to select distant or small objects reliably. Unassisted pointing with 'bare-hands' may become a prolonged, laborious task, leading to fatigue, errors, and frustration. Also, with unassisted pointing it is problematic to select occluded or partially occluded objects. However, the simplicity and low computational cost of ray-casting makes direct pointing very attractive for building user interfaces.

A variety of techniques were proposed to improve the usability of methods based on ray-casting. The *Flashlight* metaphor by [5] reduces the need for pin-point precision in selecting objects by replacing thin rays with conic volumes. The aperture technique [6] employs cones of variable sizes, which allows users to close in on the object of interest by narrowing the cone. However, the entire object of interest must be initially covered by the pointing cone. This requirement may become problematic in situations where the object and the viewer are in close proximity. A collection of techniques described in [7] take advantage of reducing the selection problem to a 2D case. These methods use traditional ray-casting with a combination of intuitive hand positions that help aim probing rays.

In our work, the *optical sight* metaphor is introduced which complements existing methods for selecting objects that demand virtual hand and ray-casting techniques. Optical sight eliminates the problem of selecting small or distant objects by using variable camera zoom. Hand and head stabilization reduces the jitter problem. Furthermore, the optical sight metaphor provides an intuitive and flexible context for the implementation of a variety of view-enhancing interface devices.

2 OPTICAL SIGHT METAPHOR

In its basic form, an optical sight is a combination of a variable camera zoom, hand-controlled direction of view, and pin-point ray-casting. As the name implies, the optical sight is primarily intended for selecting objects by shooting, which is accomplished by firing probe rays from the eye-point in the look direction. Optical sight is a direct descendant of the family of pointing techniques that involve aiming which were described earlier. The focus of this work is to make pointing and selection easier. Therefore, we do not compare it to view enhancing virtual interfaces, such as the 3D MagicLens [10], X-Ray vision [11], and the zoom tool [8].

- *Basic model*: As in the real optical sight, the view follows the direction of the pointing hand. Zoom is fixed with head and hand tracking data unfiltered.
- *Improved model*: Zoom is variable. Hands and head tracking are stabilized by oversampling the raw data from a tracking system. The number of sub-samples varies to compensate for jitter that increases with the zoom level.
- An optional *crosshair* slides over the image plane providing an additional input stream for confirming selections. Note that the look direction and the head orientation are decoupled. While the hand is controlling the view (i.e., defines the look direction), the head rotation controls the position of the crosshair on the viewing plane (i.e., serves as a pointing device). Selection of an object is made when the object is placed at the center of the view and overlayed by the crosshair, in other worlds, is being pointed at both by the hand and the head.
- An optional *head light projector* may be attached to the optical sight in poor virtual lighting conditions and a *night vision device* may be used in virtual scenarios when users need to conceal their position.

In the models described above, the optical sight is attached to a pointing hand, which makes it more suitable for target-oriented activities. Alternatively, the optical sight may be controlled by head orientation. In this case, it behaves similar to a real world viewing device such as a binoculars, or a telescope. These devices are well suited to exploration tasks.

*e-mail: andreis@hawaii.edu
†e-mail: pair@ict.usc.edu
‡e-mail: treskunov@ict.usc.edu

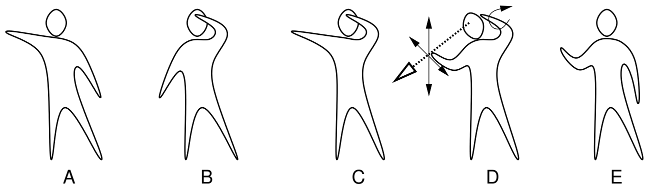

Figure 1: How to operate an optical sight. ”Point-at” pose (A) along with a ”take a good look” pose (B) form the command pose to start the optical sight mode (C). Once the optical sight is engaged, the extended arm can relax (D). To return to normal view, the left hand is dropped (E).

3 Implementation

The optical sight was implemented as part of the immersive system for training triage skills *VR-Triage*, which is currently under development at the University of Hawaii School of Medicine. The user interface is based on human poses and specified by the position and orientation of the user’s hands and head. Hands and head are tracked with an extended range Flock of Birds motion tracking system. The following rules describe the command interface.

The optical sight mode is initiated by extending the dominant hand at 75% of the arm’s length or more (”pointing at something” pose, see Figure 1, A). The other hand must be placed above the eyebrows, palm down (”take a good look” pose in Figure 1, B). Upon detection of this combination, the command language interpreter turns the optical sight on.

In this mode, the dominant hand serves as a pointer. The selecting rays are fired from the eye-point through the center of the viewing frame continuously, with a half second frequency. In the non-immersive version of *VR-Triage*, the rays are fired using a mouse click. To make it easier for users and to minimize fatigue, the requirement to hold a pointing arm extended is dropped once the optical sight mode is initiated (Figure 1, D). While the dominant hand is driving the direction of view, the other hand controls zoom. By shifting it left and right in front of the camera, the user increases and decreases the level of magnification. This replicates the ‘wide-telephoto’ slider adjustment used in many camcorders. In this case, the slider is the hand moving along the X coordinate in the user’s eye space, remaining in a 50 cm-proximity from the eye in the Z direction. Alternatively, the camera zoom may be intuitively controlled by using the axial rotation of the non-dominant hand. Here, pronation increases and supination decreases magnification. This method of zoom control is depicted in Figure 1, D.

To return to the normal view, the user must move his or her hand away from the ‘zoom slider’ zone.

In *VR-Triage*, the optical sight is used for traveling towards distant objects. Target-based travel allows one to traverse long distances without continuous steering, which minimizes fatigue. Figure 2 shows snapshots from the training zone of *VR-Triage*, which is also used for testing various UI techniques. A view only *virtual binoculars* mode was also implemented.

To conclude this section, we reiterate that the look direction does not need to be dependent on the orientation of the head. This position only implementation allows us to use the same interface for immersive environments with either 3 DOF or 6 DOF tracking devices. For desktop monitor based implementations, it allows us to use a mouse interface. Consequently, the optical sight is fully functional in both immersive and non-immersive virtual environment applications.

4 Discussion and Future Work

In this section, we discuss additional benefits and possible extensions of the presented technique.

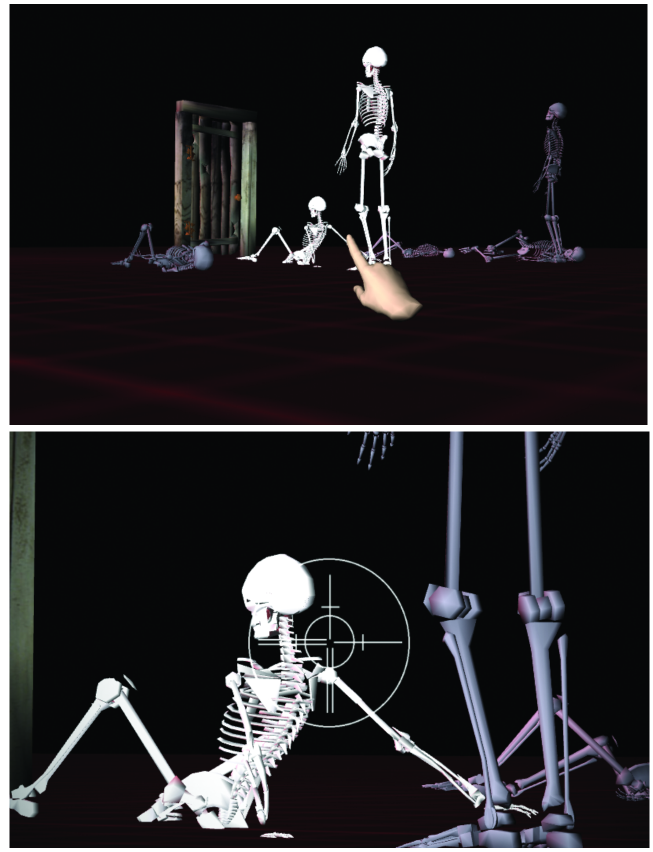

Figure 2: Selecting travel destination during travel technique practice in *VR-Triage*. Intended travel destination: sitting character. Top: normal view, multiple target selections (highlighted). Bottom: optical sight view with 4x magnification.

4.1 Mixed and Augmented Reality Applications

Optical sight was initially tested in a purely virtual environment. However, the optical sight metaphor has potential for applications in which both reality and virtuality coexist. For instance, the *Flatworld* system developed at the Institute for Creative Technologies at the University of Southern California [9] makes use of real props in conjunction with rear-projected screens displaying virtual content. In one *Flatworld* application, a real room is augmented with large virtual windows showing street scenes in a foreign country. The 3D content is very detailed and dynamic. Virtual lighting is controlled to present both day and night scenarios. Users are expected to survey the scene and react appropriately when needed to events in the environment. Simulated virtual binoculars and night vision devices based on the optical sight metaphor could play a significant role in this system. In cases when trainees are expected to return fire, the optical sight can also play a role. A basic *Flatworld* mixed reality system is shown in Figure 3.

In real life, optical sights, binoculars, and other view enhancing devices bring distant objects closer without making them more available for active interaction. In our discussion of the optical sight, it should be noted that it is very important that virtual interfaces match the user’s functionality expectations. In other words, a pair of virtual binoculars must do exactly the same job as real ones. When this requirement is satisfied, incorporating interface tools such as these to virtual environments will enhance rather than distract from the user’s sense of presence and engagement.

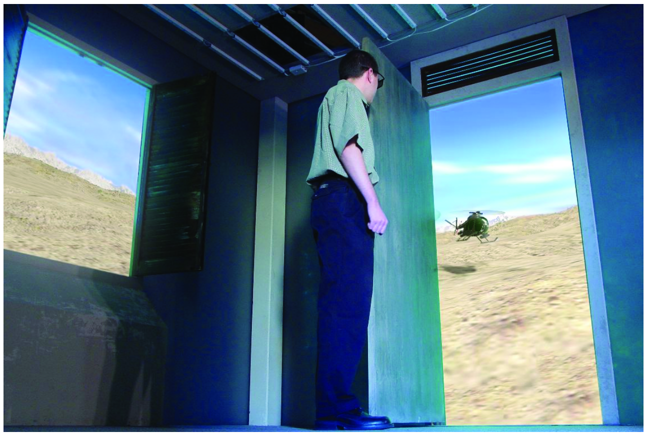

Figure 3: Here, a virtual desert scene projected on two screens is merged with the real room environment's prop window and doorframe. In this setting, a pair of binoculars could be useful for surveying the scene. View magnification on the screen could be triggered when the user picks up a pair of tracked, real binoculars, looks through them, and views the scene presented via the mixed reality 'window'.

4.2 X-Ray Vision

X-ray vision can be implemented by enabling transparency on rendered objects that are hit by the pointing rays. Traversal must stop when opacity reaches a certain threshold. By adjusting the value of this threshold the viewer can effectively modulate the level of x-ray vision. This feature addresses the problem of finding and selecting occluded objects.

4.3 Natural LOD control

Another application of the optical sight is to use it as a level of detail trigger. The action of changing view zoom level could be used to switch between 3D models of low and high geometric complexity, bypassing more computationally expensive methods of geometric and visual blending.

Allowing users to observe remote parts of the scene with the same level of visual detail removes the need to stage scenario events in the immediate vicinity of the user. This feature makes the entire immersive experience more natural and more effective in training applications.

4.4 Precise Pointing at Small and Occluded Objects with the Optical Sight

In many VR systems, bounding volumes of various types are used for ray-object intersection tests. These tests are required for object selection. When high precision pointing is necessary, it is necessary to go beyond simple ray-sphere or ray-box intersections. Instead, the ray must be tested with all of the target object's polygons. There are a variety of methods for organizing geometry to accelerate ray-object intersection tests. We argue that there may be no need for these tests when using the optical sight, as the number of probing rays required for successful selection is determined primarily by human reaction time and is likely to be in the range of few rays per second.

Interestingly, increasing pointing precision for the optical sight may lead to unwanted results. Consider the characters shown in Figure 2. Polygon-level precision will result in many misses in the rib-cage area when probing rays pass between the ribs. In this case, bounding boxes are more suitable.

Considering these issues, view magnification coupled with x-ray vision may provide an optimal solution for selecting distant, small, and occluded objects with the optical sight.

4.5 User Evaluation

In our future work we plan to conduct a user study for the optical sight metaphor. In this study, the optical sight implementations mentioned in section 3 would be evaluated against comparable, established interface techniques. Additional calibration will help to find comfortable positions for zoom controls and zoom range.

5 Conclusions

We have described the design and implementation of the optical sight, a new metaphor for viewing and selecting objects in virtual scenes. We believe that this technique along with its variations will become a useful addition to existing interfaces and will hopefully encourage the development of new ones.

6 Acknoledgements

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