3D Arrow: a Virtual Pointer for Immersive Sculpting

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ABSTRACT

Interaction inside virtual reality applications begins usually with simple selection tasks that can be achieved with moderate degrees of performances. More complex operations like modeling or sculpting inside an immersive environment raises however increased needs for precise 3D selections and visual feedback. In a modeling context any 3D location must be targetable, even ones that are outside of initial reach or not graphically represented. Common interaction techniques in virtual reality do not fullfill these goals without switching between different tools.

We present an extensive and precise selection technique called the 3D arrow, used for moving and sculpting inside an immersive terrain modeling application. Composed of a graphic mouse-like pointer constrained inside a workspace defined by the region of space at arm's reach, the 3D arrow allow the users to seamlessly reach and target any position of space within the same interaction paradigm and to rotate the view around the pointer. The graphic appearance of the pointer is carefully designed to help users estimate its global and local position in the terrain scenery.

Index Terms: Virtual reality, Selection technique, Navigation technique

1 INTRODUCTION

Modeling inside a virtual environment is a very complex yet challenging task. Most virtual reality (VR) setups offer one stereoscopic view of the 3D scene inside which the user has to sequentially navigate, select and manipulate objects.

The application context of this work is the modeling of large complex terrains presented in [3] by depositing and sculpting different types of rock and matter in an immersive VR configuration. The terrain model is based on a voxelized space where the user can sculpt real 3D geologic structures like overhangs, arches and caves. In a typical editing scenario of our terrain modeling application the user draws with a simple 3D brush tool that deposits a ball of rock at the pointed position. By moving the hand in space the user can continuously draw curves of rock. The opposite editing function removes rock and can be applied for instance to gradually dig a cave inside a mountain.

The primary requirements to begin sculpting is to achieve the efficient selection of any 3D positions inside the modeling space; this means a fast and even more importantly very precise selection technique. This simple task in the real world is still a difficult objective in a 3D virtual environment. First and foremost the movement of selection need to be correctly planned. Depth has been widely recognized as a difficult dimension to estimate for VR users, even with a stereoscopic view. Then the selection technique should provide an efficient mechanism to move to, turn around and point at targets at all kind of ranges in the field of view, in dense or scarcely populated scenes.

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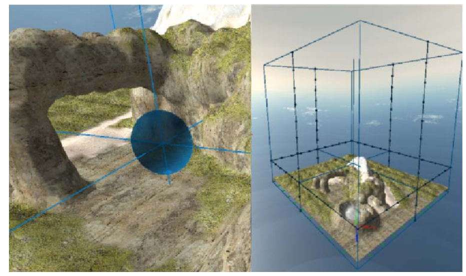

Figure 1: Close-up and panoramic view of the 3D arrow pointer in the terrain modeling application

The two most popular selection techniques in VR are the virtual ray[1] and the virtual hand metaphors[2] and their derivatives. The former is very well suited to the selection of objects but can not point out invisible, not yet materialized 3D position and was therefore rejected. On the other hand the virtual hand metaphor is appropriate for this kind of selection as long the pointed 3D positions are not too far away and not beyond arm's reach. For most techniques derived from the virtual hand the pointing task becomes less precise and more difficult the further the target.

Instead of combining two unrelated interaction techniques and asking users to constantly switch between selection and navigation, we chose to design a new type of pointer based on the virtual hand paradigm and which embeds the navigation process. Camera location in our immersive context is fundamentally related to the modeling gesture. The authors emphasize that the unique stereoscopic view found in most virtual reality configurations increases the problem of perception and camera management during the modeling work.

2 3D ARROW

The interactive and immersive modeling of terrains in a voxelized 3D space requires the user to quickly and precisely point at any 3D coordinates of the virtual world. The design goals behind the 3D arrow are twofold. First we want a technique which brings a clear perception of the 3D position that is pointed at, globally and relative to the scene that is edited. Since the user is immersed in the terrain application in a very big virtual world, the pointing technique should help to target any position in the field of view whether near or far away albeit beyond arm's reach.

2.1 Spatial perception of the arrow

Like previous selection techniques in VR, the 3D arrow is an avatar of the hand in the virtual scene. We have designed the pointer in our technique to be the intersection of three long crossing lines. The location of the cross on the vertical line is a good indicator of the height of our pointer above the terrain. For the two horizontal lines to provide the same service, the whole modeling space is displayed

Figure 2: The proximity sphere gives strong visual clues of the distance to the surface.

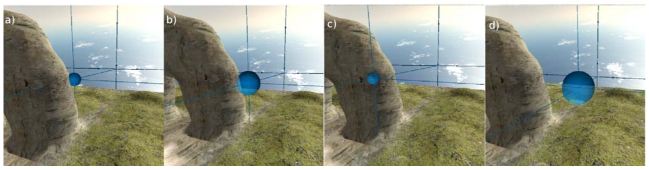

Figure 3: The visual feedback provided by the proximity sphere and the axes help to understand the spatial position of the pointer without ambiguity

as a wireframe cube (figure 1). The crossing lines may also provide additional depth clues when alternatively covering or being hidden behind mountains or other drawn elements (figure 3).

For local positionning and the sculpting operation one of the most important visual information to provide is the distance of the pointer to the nearest shape. We designed around the pointer a so-called *proximity sphere*. The radius of this transparent sphere is the minimal distance to the nearest object. A maximal value is chosen to not let the sphere growths too much when the pointer is far from any shape. The sphere radius, unlike a single line between two points, can be estimated equally well from any viewpoint. The visual impression is that a soap bubble is absorbed by the terrain when the pointer moves from distance to a point on the surface (figure 2). The radius falls from a maximum value to zero when exactly on the surface, so it becomes trivial to decide when to stop the hand's movement.

The pointer must be visible at all times even if the cross enters rock layers as we want the 3D arrow to support editing tools that removes matter, for instance to dig tunnels or caves. We handle occlusion each time the pointer is masked by drawing a cylindric region around the view axis twice: transparently and in wireframe.

2.2 User control of the arrow

The pointer is controlled in our implementation by a flystick hold in the user's hand. Two complementary modes have been designed to control the movements of the 3D arrow: a direct and inertia mode.

In direct mode, the 3D arrow pointer acts like a mouse arrow. The pointer moves with a 1 to 1 ratio when grasped and stays static in the scene otherwise. The advantages are threefold: first it becomes possible to let the user rest inbetween or during manipulations independently from the pointer's position. Secondly the user is allowed to adopt a new strategy and try to reach very small targets in several approach stages, correcting bit-by-bit the arrow's position, since one does not lose the proximal positions already achieved and is not required to be focused all along in one unique difficult trajectory. Finally the user can reach regions outside arm's reach by incrementally moving the avatar of the hand.

The inertia mode was added to quickly cover the large distances found in the terrains' sceneries. Moving the arrow step by step with grasp and release sequences is repetitive, tiring and slow. We propose to let the user throw the 3D arrow in any direction with a grasp and release movement and if the button is released while the hand is still moving, the arrow keeps its velocity.

2.3 Scrolling workspace and orientation

In a typical immersive modeling scenario, the user has to constantly adjust the distance and orientation to the part of the scene he wants to work on, move towards or away and orbit around a specific point of interest while operating a modeling operation. Switching between different interaction modes or tools is cumbersome and disrupts the sequence of modeling actions.

To work in the most comfortable conditions with the 3D arrow, at arm's reach and in front of the user, our pointer should never leave a predefined workspace. We set the shape of this region to be a cubic volume to roughly match the borders of our two-screens VR configuration. The whole scene is scrolled when the 3D arrow hits the invisible borders. The role of our scrolling workspace is to transparently follow the moves of the 3D arrow pointer, dragging the view without changing the speed or direction of the pointer in any way.

Both the direct and inertia control modes of the arrow can drag the workspace. In the direct mode the user can finish a started modeling movements that would otherwise leave the field of view without any worry. The point of view is simply dragged by the extension of the arms against the walls of the workspace. As the arrow ends its movement in the virtual scene the workspace and the user's point of view are shifted to keep the arrow inside the workspace.

In the inertia control mode the user can throw the arrow in any direction and the preserved velocity keep pushing the pointer against the invisible walls of the workspace, consequently dragging the point of view with it. Without any fatigue the user can thus travel over large distances.

Finally the user can freely orbit around the arrow at any time without losing its current spatial location. This behaviour is especially crucial to correctly assess volumes in a single view environment and to navigate.

3 CONCLUSION

We have designed a new pointer for immersive sculpting to help the selection of 3D locations at any kind of range, visible or not. A scrolling workspace metaphor allows users to always interact at arm's reach through direct manipulation and to smoothly and automatically adjust the camera's location for selection's gestures that end outside the workspace. Special care has been taken about the spatial perception of the 3D arrow.

We have conducted a first experimentation to evaluate the performances and comfort of users with the 3D arrow in two identified scenarios: traveling over long distances and sculpting large shapes. Results demonstrated that the 3D arrow is a valid technique to quickly travel to distant parts of the scene that are already in the field of view. Turning was not involved in the evaluation process however and should be further analyzed before concluding about the 3D arrow as a full-fledged navigation technique. The automatic management of the camera position in the 3D arrow technique helped greatly the achievement time of sculpting gestures that requires several repositioning of the point of view. More importantly this gain was not hindered by a loss of accuracy.

REFERENCES

[1] M. R. Mine. Virtual environment interaction techniques. Technical report, Chapel Hill, NC, USA, 1995.

[2] M. R. Mine, F. P. Brooks, Jr., and C. H. Sequin. Moving objects in space: exploiting proprioception in virtual-environment interaction. In *SIGGRAPH '97: Proceedings of the 24th annual conference on Computer graphics and interactive techniques*, pages 19–26, New York, NY, USA, 1997. ACM Press/Addison-Wesley Publishing Co.

[3] A. Peytavie, E. Galin, S. Merillou, and J. Grosjean. Arches: a Framework for Modeling Complex Terrains. *Computer Graphics Forum (Proceedings of Eurographics)*, 28(2):457–467, 2009.