

A Multimodal Locomotion User Interface for Immersive Geospatial Information Systems

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Abstract. In this paper we present a new multimodal locomotion user interface that enables users to travel through 3D environments displayed in geospatial information systems (GISs), e.g., Google Earth or Microsoft Virtual Earth. When using the proposed interface the geospatial data can be explored immersively using stereoscopic visualization on a head-mounted display (HMD). When using certain tracking approaches the entire body can be tracked in order to support natural traveling by real walking. Moreover, intuitive devices are provided for both-handed interaction such as gestures to complete the navigation process. We introduce the setup as well as associated interaction concepts.

1 INTRODUCTION

The main Exploration and visualization of geospatial data is of major importance for many areas, e.g., building evaluation, urban planning, terrain exploration.

Hence, various web-based GISs, e.g., Google Earth or Microsoft Virtual Earth, are available and on the rise. These products allow users from different domains to gain new perspectives on 3D geospatial data. For such geospatial applications (semi-)immersive VR systems have proven to provide enormous potential – these environments give a realistic impression of complex datasets and allow to virtually intrude into them (Dodge et al. 1998). Usually the immersion is supported by stereoscopic projection or immersive displays. However, most web-based GI applications do not support stereoscopy and interaction in immersive VEs natively – although different plug-ins are available. In order to further increase the realism when exploring geospatial environments, it is essential to permit users at least to apply exploration paradigms that are similar to those used in the real world; or even better to provide more sophisticated approaches to overcome drawbacks and restrictions involved in the real world (Whitton et al. 2005). The most natural and intuitive way to get from place to place is to walk as a pe-

destrian. Consequently, it is important to allow users to perform real walking in immersive VEs (Whitton et al. 2005). This can be done by tracking the user's movements, in particular the gaits. Actually, VEs usually exceed the dimensions of the real environment in which motion can be tracked. To meet this challenge various locomotion interfaces have been proposed, e.g. treadmills or step-in devices (Ishii et al. 2002). However, the most natural way to map the walking metaphor is to support real walking.

2 MULTIMODAL LOCOMOTION SETUP

HMDs are the standard display devices for immersive VR systems. These devices consist of two LCDs mounted in front of the user's eyes giving a stereoscopic impression when the images on the LCDs show slightly different scenes (see Figure 1). Usually, orientation and acceleration sensors are attached to the HMDs measuring a change of the user's head orientation. HMDs are not featured with position trackers providing the user's absolute or relative position in terms of a tracking coordinate system. But optical tracking systems, for example, allow reconstructing the position of certain trackable markers. Due to line-of-sight restrictions, these systems are constrained to laboratory environments, where accuracy errors can be reduced below 1mm. We use a stereo-based optical tracking system setup, where the tracking volume is about $10\text{m} \times 5\text{m} \times 3\text{m}$ and thus the user can move within this area. When both cameras capture markers which are attached to the user, e.g., attached to the head, hands, and feet, this information is applied in the virtual world: the head position is mapped to the position of the virtual camera, transformations of the real hands and feet are mapped to the user's virtual avatar allowing the user to see her virtual extremities.

Since the interaction volume is restricted to an area usually smaller than the virtual world through which users travel, further locomotion strategies have to be applied in order to realize navigation within the entire VE. For this purpose we exploit the Nintendo Wii remote in combination with the nunchuk supporting both-handed interaction allowing simple gestures (see Figure 1). We associate control stick movements on the nunchuk to accelerated movements along the ground plane, and the control pad buttons on the remote controller are mapped to height changes, or motions along the view axis providing fly-to-view-direction approaches. Furthermore, the buttons can be used to configure several settings as described in Section 3.

3 LOCOMOTION USER INTERFACE

We have developed an interscopic user interface framework (Steinicke et al. 2007) that allows capturing 3D content of any graphics applications based on OpenGL or DirectX, e.g., Google Earth or Microsoft Virtual Earth. The 3D content can be modified and processed arbitrarily, e.g., the scene can be rendered twice for stereoscopy. Moreover, we can manipulate certain parameters of the virtual camera with respect to the tracked user's inputs.

These manipulations are generic in terms of their universal usability across different 3D graphics applications and are independent of their ordinary user interface. For instance, Google Earth neither natively supports stereoscopic projection on an HMD nor interaction via optical tracking systems respectively a Wii controller (although third-party plug-ins are available), but using our framework provides full control about the world displayed in Google Earth. In order to enable appropriate VR-based scene exploration, the application's coordinate system and the tracking coordinate system must be calibrated. When a change of the user's position is tracked, the application's virtual camera is moved with respect to the changed position, i.e. when the user moves straight ahead, left, right, or backwards the camera is moved accordingly. When the user looks around, the virtual camera is rotated in an analogous way providing a look-around capability. Small distances or height changes can be realized by walking or head movements, larger distances can be implemented via the Wii controller as described in Section 2.

When mapping the movements of the user to camera motion different strategies may be applied. The movements can be mapped using a one-to-one mapping, i.e., if the user moves one meter in the tracking coordinate system, this movement is mapped to a motion of one meter in the corresponding direction of the scene camera. In order to allow the user to explore a larger region by using walking or head movements only, this mapping can be scaled. We have tested certain factors up to a value of 15, which still gives the user a good mechanism to explore geospatial data in particular when the objects to be explored are far away. The scaling factor can be configured manually using certain buttons on the Wii controller. Using a scaled relation of motion for a longer period results in an adaptation of the mapping by the user. Hence, also larger scaling values might be appropriate; moreover, the user can access them and sense them as accustomed mappings (Freundschuh et al. 1997).



Figure 1: (left) Multimodal locomotion setup consisting of HMD, optical tracking system, and Wii. The projection wall illustrates the user's view. (right) Photograph of the same building.

Figure 1 (left) illustrates the described proceeding. The user wears HMD and perceives a detailed model of the castle of Münster. Figure 1 (right) shows a real image of the same scene. The user can explore the castle using multimodal approaches: turning the head, walking around by feet, or moving via the Wii controller in combination with the nunchuk. If a corresponding mapping is applied, the user is able to virtually walk around the virtual castle, although the tracking volume is restricted to a clearly smaller region.

4 DISCUSSION

In this paper we have presented a multimodal locomotion interface for immersive 3D geospatial information systems. The approach combines walking with both-handed interaction using different mapping strategies. The setup has been tested with different application scenarios in the context of web-based geospatial graphics services. Since walking has been revealed as most intuitive navigation concept, further locomotion and mapping strategies will be developed that increase the area, which is comfortably reachable by real walking.

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