Delivering Environmental Presence through Procedural Virtual Environments

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Abstract

While designing and evaluating virtual reality applications, the user's sense of presence plays a crucial role. Although the exact definition of presence is elusive its necessary conditions will include the presentation of sensory cues that are consistent with the internal models that humans have acquired of the world in which they exist. This paper deals with one of the many theories for presence that have been proposed, the notion of environmental presence. This theory states that presence depends on the effectiveness of the coupling of perceptions and action between the user and the (virtual) environment, which directly refers to the ecological view of perceptual veridicality. We believe that environmental presence is based on the consistency and coherence between the properties of the virtual world and those the user expects. In order to investigate this notion we propose a dynamic application that is capable of producing an unlimited number of authentic, procedural, virtual environments. Because of their dynamics such environments can produce a great number of possible and evolving reciprocal interactions. We propose an experiment to investigate how these interactions might increase a users feeling that the virtual environment seems real and thus try to understand how procedural virtual environments can contribute to the delivery of presence in virtual reality. We will in particular use this approach in the context of mixed reality interactions for social presence.

Keywords--- **procedural virtual environment, presence, environmental presence**.

1. Introduction

Presence is intuitively defined as a user's subjective sensation of "being there" and represents the largest body of psychological research on virtual experiences [1, 2]. Considered relevant for the design and the evaluation of virtual reality applications and other interactive media, the study of presence has an intrinsic heuristic value that can possibly shed light on conscious processes [3]. Among different definitions of presence, one theory distinguishes between "subjective personal presence", "environmental presence" and "social presence" [4]. For the current context the notion of environmental presence, which has been defined as the "extent to which the environment itself appears to know that you are here and reacts to you" is relevant. From a cognitive view this makes sense, since the human mind has evolved for generating an adaptive interaction with the world. According to ecological psychology [5] an individual perceives the world not in terms of objective, abstract features, but directly in terms of spaces of possible actions, that is, of affordances [6]. The definition of presence as a "successfully supported action in the environment," therefore directly refers to the ecological view of perceptual veridicality and avoids the need for a subjective sense of presence by suggesting that the effectiveness of the coupling of perceptions and action between the user and the (virtual) environment defines presence [7]. In what way however can affordances be visualized in a virtual environment thus what kind of cues are needed in order for a user to perceive them and use them to interact with the virtual environment? We follow the hypothesis that the ecological validity of environments is closely coupled to the expectations of the human observer with respect to their experience in the world. This is consistent with statistical theories of perception such as those proposed by objective function based models of perception [8]. Hence, we redefine environmental presence as the consistency and coherence between the properties of the virtual world and those the user expects. We present a set of integrated tools that facilitate the construction of dynamic, and thus procedural virtual systems that satisfy this requirement. Procedural virtual environments can not only produce continuous, novel stimuli, but also allow user-specific environmental interactions, thus the creation of user-specific affordances. The evaluation of these interactions may help to us understand how procedural virtual environments can contribute to the delivery of presence in virtual and mixed reality.

2. Procedural Virtual Environment

In our daily life, we are exposed to multi-modal sensory stimulation. While we can see, hear, smell and touch all components that make the world, these never stand still but continuously evolve, changing their appearance. Obvious components are for instance the changing position of the sun, which represents the advancing of time, weather changes or the rapid growth and distribution of the flora and fauna that surrounds us. Additionally, we are constantly involved in reciprocal interactions with our environment, giving us the opportunity to alter and adapt it to our needs. In order to perceive presence in an environment, we therefore rely on different kinds of cues: sensory stimulation from the environment, changes in the environment and interactivity with the environment [9]. We want to understand how to deliver this kind of environmental presence and therefore have developed an application that is capable of producing ongoing, evolving sensory stimulation and thus the dynamic creation of new affordances. Since all stimuli are presented in a virtual environment, their timeline e.g. length of sun cycle, growth of vegetation and occurrences can be altered online and may further be used to measure how exact virtual stimuli have to imitate their real world counterparts to convey a feeling of presence. Like in real world ecological systems the actions of users can also influence these parameters. The destruction or redistribution of flora may lead to the alteration of the weather that in response may change the topography. This could again lead to a redistribution of the environments flora and fauna resulting in a dynamic change of its appearance caused by the interaction with its users. We believe that with this greater number of possible reciprocal interactions between a virtual application and its users we can increase the feeling that the virtual environment seems real and strengthen the believe that one can have an effect on the environment. This requires that virtual environments should be fully dynamic i.e. procedural. While similar environments already exist [10, 11] they do not allow online alterations of single parameters that affect the whole application and are to complex for the use in scientific experiments. Based on the 3D game engine Torque (TGE) [12] we therefore propose such a procedural, virtual environment that constantly changes its appearance by altering its topography, weather, time and flora. The environment mimics familiar, real world experiences since the unfamiliar and unknown tends to make humans feel out of place i.e. anxious [9]. It however also includes novelty to pique a visitors attention and curiosity and challenge him to explore, learn and master, thereby heightening his feeling of immersion and presence [9]. In the following sections we will concentrate on the different procedural technologies we have used to create this application and how their combination helps to investigate the notion of environmental presence.

2.1. The Effect of varying Topography

In order to keep the application interesting we want to constantly change the virtual environments' initial topography. Creating a topography that is similar to real world environments however bears some problems e.g. only using noise for the simulation of real world terrains creates topographies that are statistically homogeneous and isotropic. These however are not properties of real terrain. We therefore used a terrain generation algorithm that uses Voronoi diagrams to

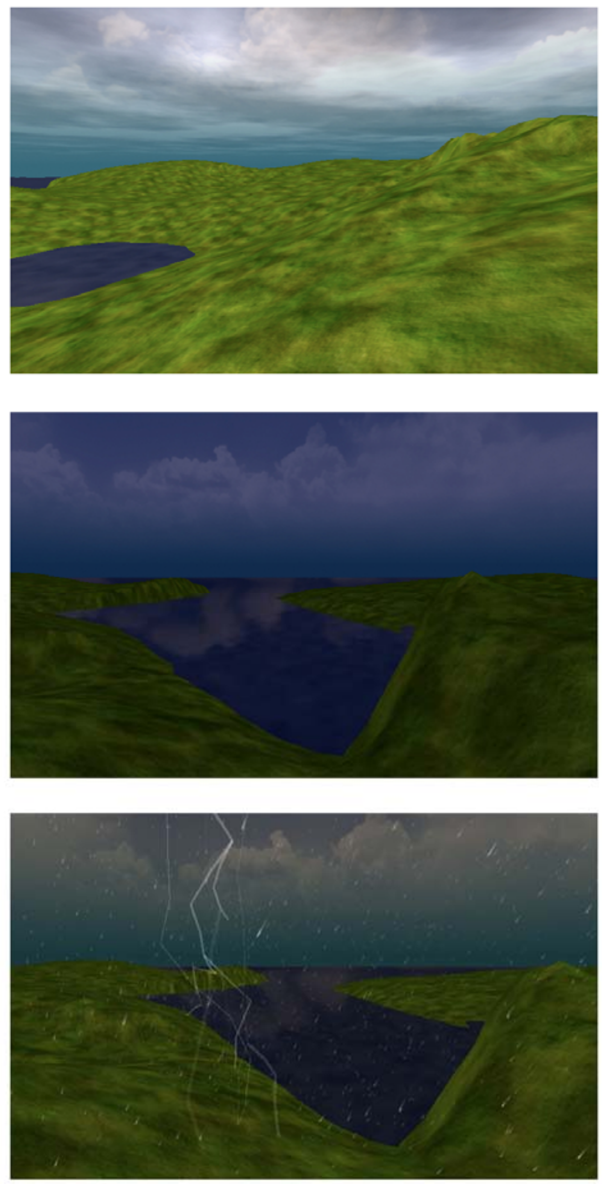

Fig. 1: Example terrains illustrating topology, weather and time difference. Terrain topology, weather and time can be controlled at runtime.

break this monotony and control the major characteristics of the landscape [13]. Optimized erosion algorithms and perturbation filters further give the terrain a more realistic look [13]. This technique together with the creation of procedural textures allows us to create an unlimited number of different, real world resembling virtual environments (Fig. 1).

2.2. Using Procedural Weather & Time

Time represents an important factor in our daily life. It has an influence on our behaviour and simultaneously affects

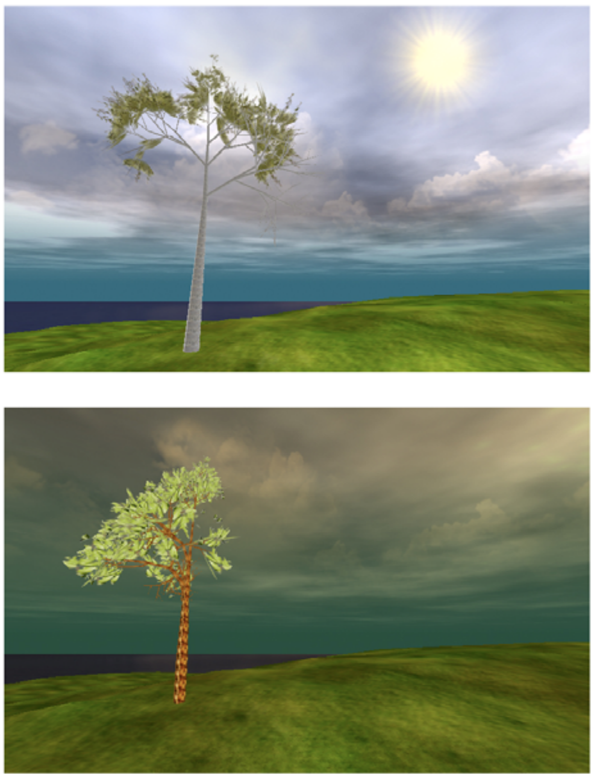

Fig. 2: Two example trees illustrating the strength of using L-Systems to render flora. Trees can be customized at runtime allowing growth simulation. Genetic algorithms will further create a wide diversity of species.

emotional states [14, 15]. By procedurally and visibly advancing time in a virtual environment, similar conditions may be induced. This helps to create customizable environments that amongst others can have sedative or arousing effects (Fig. 1). In our application time is represented through the momentary position of the sun (Fig. 1). We use elevation and azimuth values to change the suns position over time. This allows us to set the current time of day and create day-night cycles.

Weather changes can further have an effect on our behaviour. While some people might prefer sunny and clear environments, other people might like it more when it's raining (Fig. 1). Our application simulates changes in weather using a basic pressure system. A drop in pressure first causes the formation of clouds that can be followed by rain and thunderstorms. The dynamic weather system and the representation of time using the sun position thus help in creating inimitable, user specific environments.

2.3. Growing Plants using L-Systems

A common approach to model growth processes of plant development is done using Lindenmayer Systems i.e. L-Systems [16, 17]. The basic idea behind L-systems, is to define complex objects by successively replacing parts of a simple object using a set of rewriting rules or productions. This rewriting is carried out recursively and thus leads to self-similarity yielding fractal-like forms. By increasing or decreasing the recursion level of an L-System, one can slowly grow plant models and other natural-looking organic forms. Rewriting rules can furthermore easily be altered to obtain a wide range of different plant models. Since growing plants contribute to the overall appearance of biological environments, they should also be abundant in their congeneric virtual counterparts. All plants in our application are modeled using L-Systems [16]. This allows us to emit the feeling of both apparent and subliminal variability. Plants can be grown and altered online contributing to the procedural appearance of their virtual environment.

Conclusion

After having reviewed definitions of environmental presence, we have redefined this notion as the consistency and coherence between the properties of the virtual world and those the user expects. According to this theory, a virtual environment should provide a consistent coupling between itself and the perceptions and actions of its users. In order to investigate environmental presence, an application therefore needs to be capable of dynamically producing ongoing, evolving sensory stimuli that are consistent with stimulations one would perceive in the real world and that allow reciprocal interactions. Through the combination of the proposed technologies that resemble components also perceived in real world environments i.e. varying topography, time, weather and procedural flora we have created a virtual reality application that is capable of producing an unlimited number of user specific, procedural, easily customizable, interactive virtual environments. These environments are capable of constantly producing new stimuli and interaction scenarios. While this paper deals with the combination of different procedural technologies that may assist to intensify a users presence in virtual and mixed reality, their impact and effectiveness will have to be evaluated using an experimental setup. This experiment will be conducted using two different virtual environments. While environment A is totally static thus it does not have any kind of dynamics, environment B follows the guidelines presented in this paper. Subjects participating in the experiment will be divided into two groups. Group one will perform a challenging task in environment A. Group two will perform the same task in environment B. We assume that group two will perform better compared to group one resulting from a stronger apperception of presence in the procedural environment then in its static counterpart. This and similar experiments will eventually give us an idea of how and to what extend procedural virtual environments might contribute to the investigation and conveyance of presence.

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