Towards a sensory delineation of microclimatic urban ambiances in virtual reality

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Toinon VIGIER[1], Guillaume MOREAU[1], Daniel SIRET[1], Laurent LESCOP[2]

1. CERMA, UMR CNRS 1563 Urban and Architectural Ambiances, Graduate School of Architecture of Nantes, France
2. GERSA, Graduate School of Architecture of Nantes, France

Abstract. *Virtual reality has been proved to be a good tool to communicate visual urban ambiances thanks to immersion and interaction. Our work consists in extending this use for a multisensory delineation and assessment of cities. We focus on the microclimatic ambiances and we discuss two approaches for their representation: the physical stimuli simulation and an evocative audio-visual world relied on perception knowledge and artistic practices.*

Keywords: urban ambiances, sensory representation, virtual reality

Introduction

This paper discusses the ability of virtual reality (VR) to delineate multisensory features of urban ambiances. VR offers an alternative to a purely scientific visualization of urban physical phenomena and makes it possible the consideration of the spatiotemporal features of ambiances. Virtual representation of ambiances relies on two main questions: which entities, objects, phenomena should be represented to suggest the ambiance of a place? Which mediums are the most appropriate?

Urban ambiances are complex. Augoyard (1998) defines them as the meeting between the build spatial structure with the physical signals (light, sound, heat, wind, smells…) interacting with human-beings through the action, the perception and the social and cultural representations. To put back human-being at the heart of this issue, we focus on the effects of ambiances. Indeed, thinking about effects allows to start with the perceptual and sensory results to then highlight the phenomena that are responsible of them. First, we will expose the advantage of using VR to reproduce effects of ambiances. Then, we will focus on the microclimatic ambiances and propose various solutions to suggest this kind of effects.

Suggesting sensory effects with VR

Why VR?

For about 30 years, computer graphics images have been used in architecture and urban planning. Using animation and 3D offers to designers a new understanding of their proposals. VR, thanks to its additional capacities of immersion and interaction, allows a dynamic and subjective assessment of the urban landscape, as shown by Bishop & Rohrmann (2003), Tahrani & Moreau (2008) or Drettakis *et al.* (2007).

Although applications have been more focused on visual representation, VR seems adequate to a multisensory evaluation. In spite of an undeniable technical progress, an exact realism that relies on the strict reproduction of physical phenomena is not achieved. It is thus necessary to adapt the representation to the objective of the VR application: the suggestion of effects of ambiances.

Realism and effects

Basically, three types of realism are defined for computer graphics images: physical realism, photo-realism and functional realism (Ferwerda, 2003). Chalmers *et al.* (2008) propose a new VR concept more adequate to our application: the "there-reality" which goal is to bring the same perceptual response than in reality. This idea is also developed by Morie *et al.* (2002, 2005) through the Sensory Environments Evaluation project. Here, the authors prefer the term of "feel-realism". They extend the concept of Gibson's affordance to define the "emotional affordances" which are all the emotional possibilities offered by the virtual environment. We may apply this methodology by trying to delineate all the effects of ambiances that the virtual world should render. Then, thanks to knowledge in perception and in cognition, *in situ* experiences and observations, we may define and simulate the emergent elements of effects.

We are now going to focus on the microclimatic ambiances to exemplify the use of VR in tangible way.

Multisensory representation of microclimatic ambiances

The target study of microclimatic ambiances makes it possible to take into account various multisensory effects in a more tangible way. Moreover, we can note that urban models (3D GIS, urban walkthrough for the landscape evaluation) are often represented within ideal climatic conditions and thus the landscape analysis is biased (Steinicke *et al.*, 2008). The representation of microclimatic ambiances consists both to add a climatic and meteorological context to the 3D model (wind, temperature, sunshine or rainfall), but also to suggest transition and dynamic effects like wind effects, sunshine variations, shrinking effect in a small street in summer, and so on. Two different approaches to suggest these effects can be considered.

Reproduction of the sensory stimuli

The first approach is to reproduce the physical stimuli of microclimatic ambiances (wind, heat but also sunshine and sound). A localized sound system makes it possible to simulate the wind sound effects (Houtkamp *et al.,* 2008) but also to increase the presence feeling of users. About sunshine, besides paying particular attention on shading computation in the 3D model, some installations to add *virtual shadows* have been implemented (Naemura *et al*., 2002). The felt heat transitions are often determined by sun radiation. They could be simulated with directional radiant panels. These equipments are already used in VR but have not been perceptually evaluated (Kulkarni *et al.*, 2007). Wind is one of the most significant microclimatic aspects. Various devices have been developed and studied to simulate wind stimuli (Moon & Kim, 2004, figure 1a; Kosaka *et al.*, 2007; Kulkarni *et al.*, 2007, figures 1b and 1c). The main drawbacks of these installations are sonic and visual intrusions, biases compared with reality. Moreover all these solutions are designed for an immersive room and are hardly transportable.

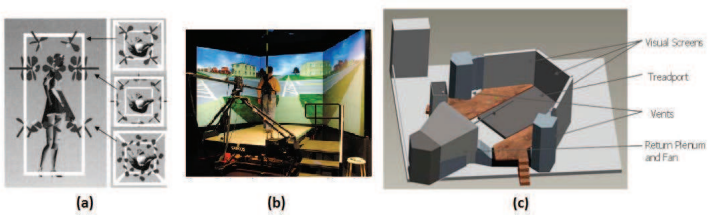

Figure 1. Examples of wind devices

Augmented and evocative audio-visual representations

Perception is not the translation of stimuli through detectors but a much more complex cognitive process resulting from direct and indirect sensations, sensory interactions, inferences, cultural and social marks, previous experience, physical state and state of mind. Thus, each microclimatic effect should be analyzed to bring out its visual and sound components. Two main solutions may be considered: augmenting visual and sound components of one effect; or using visual and sound elements which are not the effective causes of the expected effect, but which are capable to give the same feeling (sensory metaphors).

Besides knowledge about perception, we can also rely on artistic practices (paintings, movies, comic strips, video games) that have developed visual and sonic languages to represent sensory effects causing complex sensations, perceptions or emotions.

Let's consider some audio-visual representations for temperature and wind. Various light and color effects may evoke a season and consequently give an indication of global temperature (figures 2 and 3). Post-processing methods may be used to modify saturation or value of colors. Moreover, we can draw our inspiration from cartoons studios and propose colors palette corresponding to seasonal light ambiances. In addition, we can use the depth of field which varies according to heat.

Figure 2. *Les meules* (Monet, 1890-1891), visual evocation of spring, summer, autumn and winter

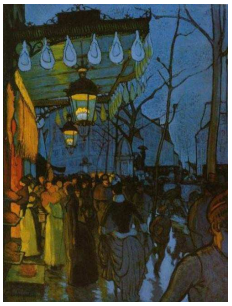

Figure 3. *Avenue de Clichy, soir 5 heures* (Anquetin, 1887). The painter observes the scene through a blue tinted glass to render the atmosphere of an autumn evening in Paris (Chalumeau, 2000)

Pedestrians are particularly sensitive to temperature transitions. These effects may be represented with shape buildings distortions and visual adaptation. For instance, to suggest a pleasant coolness in a shaded street in a hot summer day, we can distort visual environment by moving outwardly the base and inwardly the top of buildings, in order to exaggerate sun visor and shadows. In the same way, to evoke an oppressive heat while arriving in a big sunny place, we can exaggerate brightness and dazzle. For wind sensation, our suggestion would be to use effects on vegetation or characters (often used in comic strips) and sounds. For instance, to evoke a pleasant breeze in summer, we may compute and display a light

movement in tree leaves and in hair characters. And, to simulate a strong wind, we can add annoying whistling. We may use the Beaufort scale that is based upon links between visual, sonic and sensory wind effects and wind speed. For instance, a wind of 2-3 m/s corresponds to a *wind felt on exposed skin. Leaves rustle and wind vanes begin to move*.
Our future work will consist in validating these proposals. We will set up fans and radiant panels in an immersive device. And on another hand, we will implement visual and sound effects on the open source VR platformOpenSpace3D (www.openspace3d.com). We will evaluate and compare both using different urban scenes and ambiances.

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Authors

Toinon Vigier is a graduate computer engineer from École Centrale de Nantes, France. After completing a master's degree in architectural and urban ambiances, she is a PhD candidate at CERMA laboratory on the theme of virtual ambiances. She also benefits from a partnership with the society I-maginer (www.i-maginer.fr), specialist in 3D modeling. G. Moreau, D. Siret and L. Lescop are her supervisors.