Application of a Visual Perception Model in Virtual Reality

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1 Introduction

Visual perception is an important source of information for a human. It is directly related to vision although this relation is commonly not quantified but qualitatively well described. This research aims to establish a human visual perception model to analyse the perception process and thereby quantify its properties. Recognizing the relation between vision and perception, which are deterministic and probabilistic in nature, respectively, a probabilistic theory for perception is developed. From the theoretical results, the perception is defined in mathematical terms and based on this a perception model is devised in virtual reality for the verification of the theory.

2 Perception model

To start with the model development, consider the geometry seen in figure 1(left), where P represents the position of observation, looking at a plane with a distance l_o, where the vision in a particular direction is represented by θ.

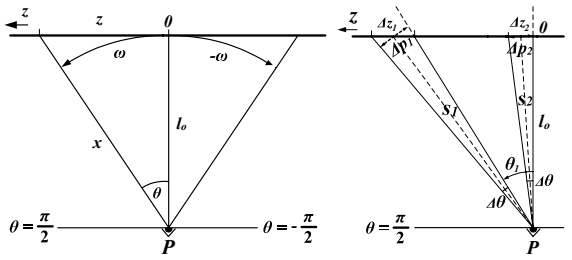

Figure 1: The geometry of visual perception from top view.

One can consider that the observer has a vision, which spans $-\pi/2$ and $\pi/2$ equally valid in all directions without any preference. The differential of vision is defined as the vision within the differential angle $d\theta$ around the angle θ so that the vision with respect to θ is uniformly distributed. Based on this, the visual attention is defined as the differential vision per unit angle θ at the angle θ, which is uniformly distributed with respect to θ. However, human perception is essentially comprehended with distance rather than θ, since visual attention per length diminishes with distance as this is represented in figure 1(right), where the length of vision Δz increases with the distance x. The differential perception is defined as the visual attention intensity within the differential angle $d\theta$ at the angle θ implying that it is a probability in the form of $f_\theta(\theta)d\theta$ or alternatively $f_x(x)dx$ where $f_\theta(\theta)$ and $f_x(x)$ are the probability density functions (pdf)s of θ and x respectively; $f_x(x)$ is given [Ciftcioglu et al. 2006]

$$f_x = \frac{4}{\pi}\frac{l_o}{x\sqrt{x^2-l_o^2}} \quad \left(l_o \le x \le l_o/\cos(\pi/4)\right)$$

so that for the sufficiently small constant interval Δx and Δz the perception becomes

$$\int_0^{\Delta x} f_x(x)\,dx \cong f_x(x)\,\Delta x \quad \text{and} \quad \int_0^{\Delta z} f_z(z)\,dz \cong f_z(z)\,\Delta z\,,$$

which imply that $f_x(x)$ and $f_z(z)$ are approximate representatives of perception of human indicating its variation with the distances x and z. The pdfs with respect to the distance x and z are shown in figure 2 [Ciftcioglu et al. 2006].

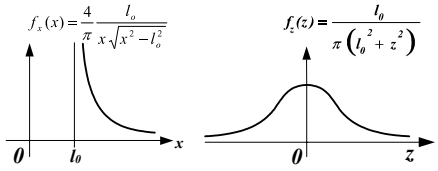

Figure 2: Sketch explaining the relative importance of the viewing direction for visual perception.

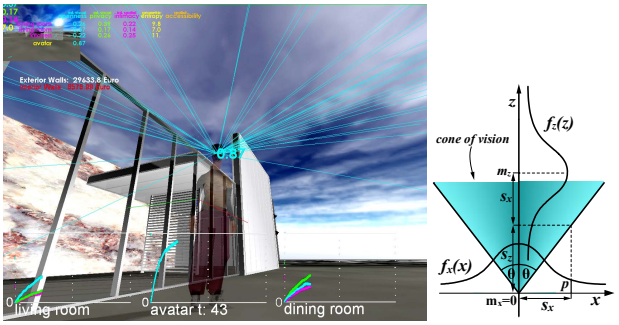

Figure 3: Implementation to virtual reality environment.

The visual perception experiments for the verification of the model are carried out in the virtual space by means of an avatar shown in figure 3(left). The avatar is equipped with a human like vision system, where the visual attention is modelled by the pdfs $f_x(x)$, $f_y(y)$, and $f_z(z)$ in 3D. In 2D, this is indicated in figure 3(right) on the zx plane.

3 Conclusion

The theory developed in this work, which defines perception in probabilistic terms, is verified by means of extensive computer experiments in virtual reality. Due to complexity a probabilistic approach for perception is appealing and the results have direct implications, which are confirmed with our common visual perception experiences.

References

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