Chapter 7

Olfactory Display Using Solenoid Valves and Fluid Dynamics Simulation

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ABSTRACT

Olfaction is now becoming available in Multiple Sensorial Media because of recent progress of an olfactory display. One of the important functions of the olfactory display is to blend multiple of odor components to create a variety of odors. We have developed the olfactory display to blend up to 32 odor components using solenoid valves. High-speed switching of a solenoid valve enables us to blend many odors instantaneously at any recipe even if the solenoid valve has only two states such as ON and OFF. Since it is compact and is easy to use, it has been so far used to demonstrate a movie, an animation and a game with scents. However, a contents developer must manually adjust its concentration sequence because the concentration varies from place to place. The manually determined concentration sequence is not accurate and, moreover, it takes much time to make the plausible concentration sequence manually. Thus, it is adequate to calculate the concentration sequence using CFD (Computational Fluid Dynamics) simulation in the virtual environment. Since the spread of odor in spatial domain is very complicated, the isotropic diffusion from the odor source is not valid. Since the simulated odor distribution resembles the distribution actually measured in the real room, CFD simulation enables us to reproduce the spatial variation in the odor intensity that the user would experience in the real world. Most of the users successfully perceived the intended change in the odor intensity when they watched the scented movie, in which they approached an odor source hindered by an obstacle. Presentation of the spatial odor distribution to the users was tried, and encouraging results were obtained.

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INTRODUCTION

Since the technology of presenting visual and auditory information is matured, people then want to have haptic interface to obtain the feeling of touch. The haptic interface has been so far studied and it can be used to some extent in virtual reality. Thus, the next technology of presenting sensory information should be related to the olfaction.

Olfactory display is a gadget to present smells. Nowadays it is quite easy to deal with visual and auditory information in a computer. We can acquire much visual and auditory information through Internet. However, sensory information except these senses also gives us different sensation. For example, when we see delicious food on TV, its smell is indispensable for reproducing much reality.

Sensing is another important aspect to realize artificial sense in virtual reality. We have studied an odor sensing system using multiple sensors with different characteristics and pattern recognition technique (Nakamoto, and Moriizumi, 1988). Although there have been many reports about the artificial sensor called the electronic nose (Pearce et al., 2003; Persaud, and Dodd, 1982), it has been studied separately from the olfactory display.

Thus, we proposed an odor recorder, which reproduces smell as well as records it (Nakamoto et al., 2001; Nakamoto, 2005). The composition of several odor components is determined so that a sensor array output pattern of blended odor can be identical to that of the target odor in an odor recorder. It was successful to replicate several fruit flavors using this gadget (Somboon et al., 2007a). Moreover, we recently demonstrated the experiment on teleolfaction (Nakamoto et al., 2008a), where sensed smell is reproduced at the remote site. Although a broad variety of application is feasible, we focus on olfactory display in this study.

There have been several works on the olfactory display even if the number of reports related to olfactory display is small. An olfactometer has been used for many years to give a human an olfactory stimulus so that human sense of smell or EEG (Electroencephalogram) induced by olfactory stimulus could be studied (Kendal-Reed et al., 1998). However, the olfactometer is large and complex. Although a commercially available diffuser is simple, the smell cannot be changed quickly because the cartridge should be exchanged (www.scentair.com). Although another PC-controlled scent diffuser that could present several smells was proposed, it has no blending function (Messager, 2002).

Although they are useful in certain situations, one of the most important functions of an olfactory display is to present a variety of smells. A variety of smells can be generated when the function of blending is introduced. An important point is, however, what kinds of odor components should be prepared for blending.

Buck and Axel reported the multigene family of G-protein-coupled ORs (olfactory receptors) in 1991 and, then, the molecular biology of olfaction rapidly progressed [11]. However, primary smells (Amoore, 1970) are not known, unlike the primary colors in vision. In this situation, a device for blending as many odor components as possible is indispensable to cover a wider range of smells.

Even if primary smells have so far not been found, it is still important to blend smells because the blending process is currently essential in creating new smells, particularly in the flavor and fragrance industry.

In addition to novel scent creation in the flavor and fragrance industry, a variety of olfactory display applications are feasible, such as a smell-presenting device in, for example, an odor recorder, a movie with scents, games, exhibitions, on-line shopping, restaurants, educational tools, medical-diagnostic tools, museums and art. In particular, a product with scent indispensable for evaluating its quality should be presented using an olfactory display in various situations.

Recently, we exhibited a cooking game with scents at several places in collaboration with artists, and 300-400 people experienced this game.
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