

# An Unencumbering, Localized Olfactory Display

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## ABSTRACT

Olfaction is considered to be an important sensory modality in next-generation virtual reality (VR) systems. We currently focus on spatiotemporal control of odor, rather than capturing and synthesizing odor itself. If we simply diffused the odor into the atmosphere, it would be difficult to clean it away in a short time. Several olfactory displays that inject the scented air under the nose through tubes have been proposed to realize spatiotemporal control of olfaction, but they require the user to wear something on one's face. Here, we propose an unencumbering olfactory display, by conveying a clump of scented air from a certain remote place to the user's nose. To implement this concept, we used an "air cannon" that generates toroidal vortices of the scented air. We conducted a preliminary experiment to examine the possibility of this method's ability to display scent to a restricted space. The result shows that we could successfully display incense to the target user.

## Keywords

Olfactory display, virtual reality, air cannon

## INTRODUCTION

VR systems have been developed to cover visual, auditory, and haptic sensations, so it is a natural progression to apply olfaction. Although olfactory displays for VR are still at a beginning stage, researchers have already started to explore the possibility of olfactory displays [1, 2].

Hirose et al. [3] have developed several head-mounted type olfactory displays. In these display systems, scented air was sent to the nose through a tube. However, it could be much more useful if users do not need to block their faces with any devices, or to trail cumbersome tubes.

The technical challenge in our research is to restrict the scent emersion to a specified local space, while the scented air is launched from some remote position: scent can be perceived only in a limited range of space at a certain time.

By localizing the scent, we can display different smells to multiple users. Also, we can significantly reduce the amount of (often expensive) odorant compared with just diffusing the scent into an entire room, as the volume of the air with odorant is so small. The system can thus be relatively cost-effective. In addition, this small clump of scented air can easily dissipate in a short time, which enables us to wield short-term control of the olfactory effect.

## SYSTEM DESIGN

The entire system is composed of a head/face tracker, scent generator, and an air clump launcher, and a scent generator, as shown in Figure 1. First, we have to detect the position of the user's nose. For this purpose, we can apply existing vision-based face tracking techniques.

Next, how to transfer the clump of scented air from a remote place to the nose through free space is the key to realize the system. Now let us focus on an important part of the system, the "air clump launcher". We propose to use an "air cannon" for this purpose. An air cannon (also known as a vortex cannon) is a chamber with a round aperture, and it is very popular in science demonstrations for children. The simplest way to make an air cannon is to use a cardboard box, cutting out a hole and sealing the seams with packing tape. If we fill the box with smoke and push it gently, a smoke ring is observed to move smoothly at the speed of approximately 1 meter per second. This ring demonstrates a

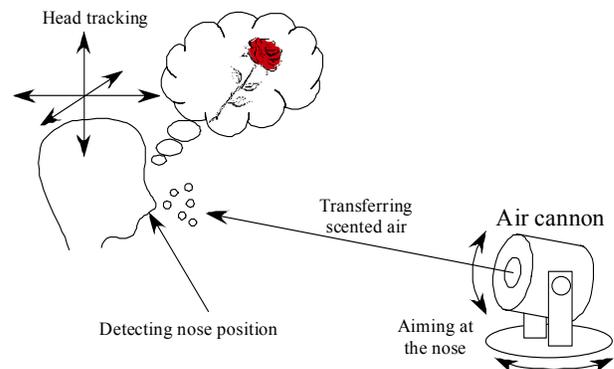


Figure 1: Concept of unencumbering, localized olfactory display.

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**Figure 2: A smoke ring launched from the air cannon.**

toroidal vortex generated by the air cannon, and it shows that the vortex can carry particles that exist around the aperture when the air cannon launches the air. The schematic of a toroidal vortex is shown in Figure 2. It is not necessary for the scent generator to fill the chamber with scented air: it only has to spray the scent just before the air cannon launches a clump of air. Thus we can send a different scent with each launch and cover multiple users with a single air cannon.

The platform on which the air cannon is mounted will be controlled to aim at the user's nose (to be done). Two degrees-of-freedom angles (azimuth and elevation) are controlled to determine the direction of the air cannon. A part of the prototype system is shown in Figure 3.

#### PRELIMINARY EXPERIMENT

We conducted an experiment to examine how stably an air cannon can provide scent to the user from a remote place, and if it is possible to display scent separately to different users. We filled the air cannon with the smoke of a SENKO (Japanese incense stick) to observe the aspect of launched vortices, as well as to use it as a kind of odorant.

Two subjects were asked to sit on chairs side-by-side, and the air cannon was placed on a tripod 120 cm from the subjects. The distance between the noses of the two subjects was 50 cm. Subjects were asked to close their eyes during the experiment and to raise their hands if they could detect the smell. The air cannon was set to aim at the two subjects and at other places in random order each time it launched a smoke ring.

There were 59 trials in total; including 11 miss hits (smoke rings were not stable enough to reach the subjects). Among the successful hits, in 9 trials the air cannon aimed at non-subject targets; therefore, the number of hits to either of the subjects was 39. The successful smell detection rate was 72% for total (28 out of 39). There was no trial in which either subject reported the smell when the smoke hit a different target, including the point between the two subjects. Among the successful hits to the face, the smoke reached the forehead in 8 trials, and of these the subject reported the smell only 1 time. If we exclude these cases, the successful detection ratio raises up to 87% (27 out of 31). These re-



**Figure 3: A prototype system.**

sults showed that the proposed method has the potential to stably display scent to a particular user.

#### CONCLUSIONS

We proposed a novel configuration of an olfactory display that does not require users to put anything on the face and that localizes the effective space of the displayed scent. The technical key to realize this concept is to transfer a clump of scented air from a remote place to the nose, and we confirmed that this is possible by using an air cannon.

Future works include precise theoretical analysis of a toroidal vortex for the optimal design of air cannons, the design of the scent generator/switcher to be mounted on the air cannon, and so on. We are going to solve these problems step-by-step to construct a transparent, easy-to-use olfactory display system.

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