Olfactory Display and Its Application

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ABSTRACT

An olfactory display is a device to present smells. We have studied multi-component olfactory display to generate a variety of smells since it can blend many ingredients at the specified recipe. Although several models have been studied, the recent model consists of multiple micro dispensers and a surface acoustic wave atomizer. Both desktop-type and wearable type olfactory displays were developed. We have a variety of the applications of olfactory displays in addition to movie with scents and animation with scents. A remarkable sensation, not given by vision and auditory sense, was obtained when we have olfactory stimulus. The applications of both desktop and wearable olfactory displays are described in this paper.

1 INTRODUCTION

Recently many people can enjoy virtual reality since it becomes more popular. However, the experience on sniffing smells in virtual environment is still rare although he/she experiences visual/auditory perception in most of cases. However, we often encounters the situation of sniffing smells in our daily life. Thus, olfactory stimulus is indispensable even in the virtual environment.

A gadget to give us olfactory stimuli in the virtual environment is called olfactory display [1, 2]. Several types of olfactory displays have been so far proposed. Yanagida et al proposed a scent delivery system using an air cannon [3]. Shinogi et al studied smelling screen where the smell confined to a certain area in the screen is generated [4]. Moreover, psychologists are interested in olfactory display.

We have studied multi-component olfactory display. A variety of smells can be generated since it can control the mixture composition of multiple ingredients. In this conference, the hardware of multi-component olfactory display is reviewed and then developed contents related to olfaction in the virtual environment are described.

2 Multi-component olfactory display

2.1 Methods to blend odors

There are several ways to realize multi-component olfactory display as is shown in Figs.1(a)-(d). First method is to use multiple mass flow controllers. The mixture composition of several ingredients is determined by the ratio of flow rates [5]. Although the flow rate can be precisely controlled by the mass flow controller, the system becomes bulky and expensive.

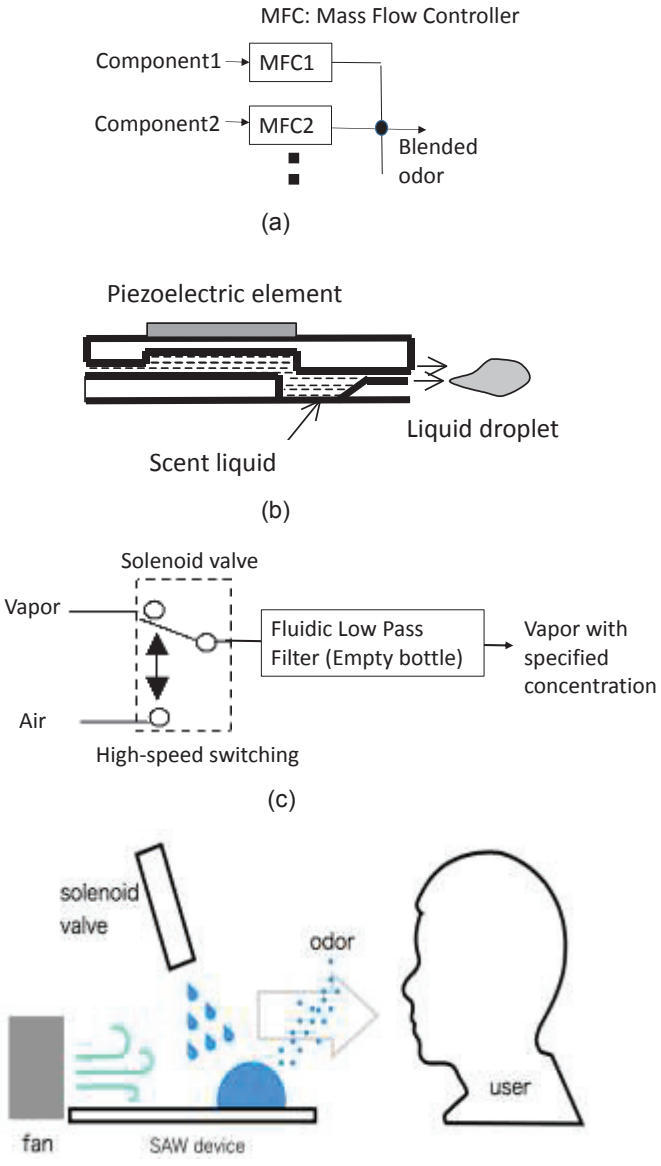

Fig.1 Principle of multi-component olfactory display. (a) Mass flow controller, (b) Inkjet device, (c) solenoid valve and (d) micro dispenser and SAW atomizer.

The second method is to use inkjet devices as is shown in Fig.1 (b) [6]. Several inkjet devices are used to spout liquid droplets. Although only tiny amount of the liquid is required, it often encounters the problem of bubbles and clogging.

The third method is to use solenoid valves in Fig.1 (c) [7]. Since solenoid valve works digitally, high speed switching of solenoid valve is used to express analog value of the ingredient concentration equivalent to frequency of ON state of solenoid valve. Although the behavior of the system is very stable, the problem of smell persistence occurs when low-volatile compounds are used.

The final method is to use micro dispenser combined with an ultrasonic device such as SAW (Surface Acoustic Wave) atomizer as is shown in Fig.1 (d) [8]. A micro dispenser made up of a solenoid valve spouts a liquid droplet onto the surface of SAW device, which atomizes the droplets. The mist goes to a human nose. It is effective to enhance the atomization power of SAW device by coating its surface with amorphous Teflon [9]. The following desktop and wearable olfactory displays are based upon the final method.

2.2 Desktop olfactory display

We have developed the olfactory display based upon the principle illustrated in Fig.1 (d). We used a micro pump to deliver liquid droplet into SAW atomizer before using a micro dispenser [10]. However, its amount of liquid droplet is unstable and it often encounter the clogging problem because of the weak power of the micro pump.

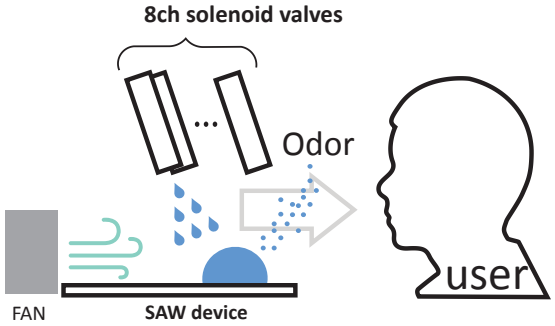

Fig.2 Multi-component olfactory display using micro dispensers and SAW atomizer.

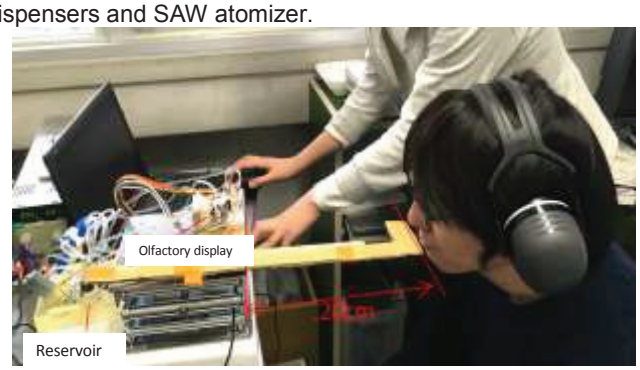

Fig.3 Scene of sensory test using olfactory display illustrated in Fig.2 [8] (copyright IEEE 2018).

Thus, we adopted the micro dispenser instead of the micro pump. Since its power is strong and back pressure control is not required, it is much better than inkjet device.

It is easy to extend the system to multi-component olfactory display as is shown in Fig.2. We set up the eight micro dispensers so that their droplets could be shot toward a single point. Then, we performed the sensory test to confirm the blending capability of this olfactory display. The scene of the sensory test is shown in Fig.3.

We performed the triangle test [11] to check whether people can discriminate between the scent blended by this device and the mixture in the liquid phase blended in advance. The bending capability of this device is confirmed if the discrimination between the two is not achieved.

In this experiment, two samples were chocolate and mint flavors. Fifteen participants were requested to discriminate between the scent blended by this device and chocolate-mint mixture blended in the liquid phase in advance. The result is shown in Table.1. The null hypothesis that the chocolate-mint flavor was the same as the scent blended in our device was accepted using the result in Table 1 when the level of significance was 5%. Thus, we can say that our proposed olfactory display can make the scent the same as that of the flavor manually blended in advance in the liquid phase.

Table 1 Result of discrimination between chocolate-mint flavor and scent blended in our device (Number of correct answers:4) [8] (Copyright IEEE 2018)

ID	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
1st time	1	1	1	1	1	0	0	0	0	0	0	0	0	0	0
2nd time	0	0	0	0	0	1	1	1	1	1	0	0	0	0	0
3rd time	0	0	0	0	0	0	0	0	0	0	1	1	1	1	1
Answer	2	1	2	2	2	1	3	3	1	1	3	3	2	2	3
Correctness	0	1	0	0	0	0	0	0	0	0	1	1	0	0	1

2.3 Wearable olfactory display

The principle of the desktop-type olfactory display is almost applicable to wearable one. The point different from the desktop one is that the scent is not shot toward a human nose but the scent flows just in front of the human nose. The self-collection of emitted odor inside the device is achieved to prevent the scent from spreading into the ambient air as is shown in Fig.4. Moreover, the photo of wearable olfactory display attached to HMD is shown in Fig.5.

The point of hardware development of wearable olfactory display was RF power amplifier to drive SAW atomizer. Since the frequency of our SAW device was very low (9.6MHz), there is no RF power amplifier module commercially available for that frequency range.

Thus, we developed the small-size 30W E-class RF power amplifier using discrete a transistor.

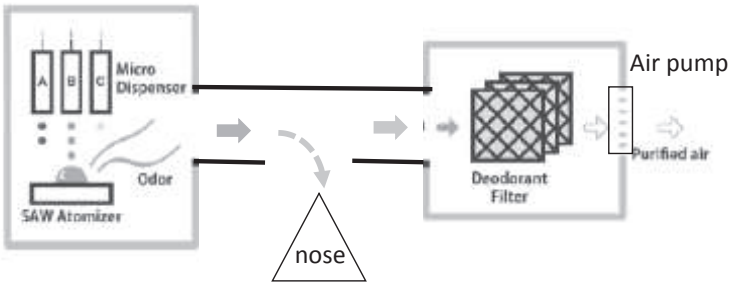

Fig.4 Concept of wearable olfactory display.

Fig.5 Photo of wearable olfactory display (white one) attached to HMD.

3 Content of olfactory display

We have so far developed the contents of olfactory display. First, we developed the movie with scents [12]. We used Japanese famous movie “Spirited away”. It was found that the contrast of pleasant smell with offensive one remarkably enhanced the user impression. Then, we have developed the cooking game with scents in collaboration with artists [13]. Ingredients are sequentially added until the curry is completed. This cooking game was demonstrated at many places and people enjoyed the game with scents very much. The desktop olfactory display using solenoid valves was used for the two contents above.

Next, we made the content of virtual ice cream shop [14]. Since many flavors such as vanilla, chocolate, coffee, strawberry etc were prepared, users can enjoy the scent of mixed flavor as if the ice cream were there. Moreover, virtual soda was demonstrated as is shown in Fig.6 [15]. The olfactory display using micro pumps and SAW atomizer was used here [16]. Although the user drank sugarless soda, she felt sweet due to the scent generated by the olfactory display.

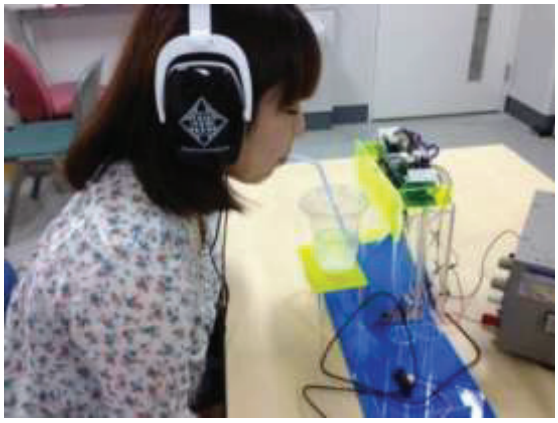

Fig.6 Demo of virtual soda.

Another content was aimed to have the feeling that a user passed by someone when the user sniff the smell as is shown in Fig.7 [17]. The user will soon pass by man with smell. The timing of generating smell is important for this purpose.

Fig.7 Scene that a user passes by man with smell.

Fig.8 Scene of cocktail maze.

The content of wearable olfactory display is called “Cocktail maze”. A user looks for cocktail bar through a maze as is shown in Fig.8. In the maze, there are pillars with the pictures of fruits such as orange and cassis and the user can penetrate them in the virtual environment [18, 19]. The user perceives the corresponding smell when he/she collides the pillar. When he/she reaches the

goal, i.e., cocktail bar, he/she sniffs the smell mixed with ones at pillars he/she has passed through. Many people can enjoy this game in the virtual environment because the game is very simple.

4 Conclusion

The hardware of olfactory display and its application has been reviewed. We have a variety of applications of the olfactory display if anyone can easily use it. The application is not limited to entertainment but disaster drill is also important application [20]. Moreover, study of odor components is important to extend the range of odor using limited number of ingredients [21, 22]. Another aspect is the combination of olfactory display with haptic device [23]. More people are expected to use an olfactory display in the future.

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