Display System for Advertising Image with Scent and Psychological Effect

Keisuke Tomono[1], Hiroki Wakatsuki[2], Shigeki Kumazawa[2], and Akira Tomono[2]

[1] Department of Chemistry/Engineering Science, Wartburg College
100 Wartburg Blud, Waverly Iowa 50677-0903, USA
[2] Department of Information Media Technology, School of Information and Telecommunication Engineering, Tokai University
2-3-23 Takanawa, Minato-ku, Tokyo 108-8619 Japan
tomono@keyaki.cc.u-tokai.ac.jp

Abstract. We propose a new method in which scents are ejected through the display screen in the direction of a viewer in order to enhance the reality of the visual images. A thin LED display panel filled with tiny pores was made for this experiment, and an air control system using a blower was placed behind the screen. We proved that the direction of airflow was controlled and scents properly travelled through the pores to the front side of the screen. Moreover, the effectiveness to an advertising field of this system was estimated by simulating an actual situation in which various advertisements are around using the immersive VR System. The subjects' eye movements and impressions, when they look at the scented advertisements while walking, were analyzed.

Keywords: Display, Scent, Digital signage, Multi-Media, Advertisement.

1 Introduction

Because the technology of making a large and thin display screen has advanced in recent years, as for the graphic display device, the restriction of the installation location has decreased. It is possible to hang or integrate it with the wall. When this technology is used as digital signage, the advertisement has large flexibility, compared with the signboard that uses the photograph [1]. However, the digital signage should improve its cost-effectiveness because it is expensive. For instance, the ability to catch the eye and urge a passer-by to stop in front of the signboard is necessary.

The scent emitting systems to attract passers-by have been greatly developed, and these systems have started to be applied to various advertisements in places such as supermarkets and restaurants [2], [3]. From a merchandising prospect, these systems are expected to attract the passer-by to the place, which sells the product that relates to the scent and improve the desire to purchase it. Therefore, a highly effective advertising advantage can be expected by the addition of the scent corresponding to the product advertised on the digital signage. However, a conventional olfactory display only provides scents not accompanied by visuals. Therefore, when the product are introduced using the image, it is necessary to allocate an olfactory display near the graphic display device. Moreover, a conventional system has the problem of taking up too much space in the installation.

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In this paper, in order to solve the problems above, a new display system called the KANSEI Multi-Media Display (KMMD) that can present the visuals and scents with one device is proposed [4], [5]. To verify this concept, the display device that the air passed from the hole installed between the pixels of the thin display panel was made for trial purposes, and the characteristics of the air flow and scent presentation to the viewer were evaluated. Next, a psychological effect of the advertisements with scents, based on the concept of the scented digital signage, was evaluated by an experiment using subjects. Since it is difficult to evaluate it in the environment, where the digital signage is actually set up, it was evaluated in a virtual town that was created by using an immersive Virtual Reality (VR) system.

2 Related Works

The large display system that uses an LED for the pixel is often used in digital signage. In case that the screen size is 3×2m, and the resolution is 752×528 pixels to which the television image of NTSC standard can be displayed, the pixel pitch is about 4mm [6]. Regarding the display system using an Organic LED (OLED) as pixels [7], the large size one which was 3456×2471 mm (width × height) and had 1152×640 pixels with 3mm of pixel pitch, which has a function of High Definition Television (HDTV) was introduced from Mitsubishi Electric Corporation in CEATEC Japan in 2009. Thus, it is thought that a practical enough resolution is obtained for the pixel-pitch of 3~4mm in the digital signage of the width of about 3m usually seen in a town. However, as for the display device, the research that discharges the air or scent through the hole installed on the screen doesn't exist.

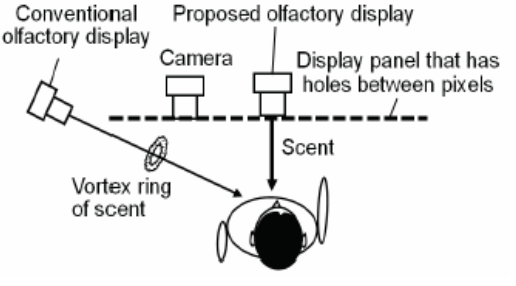

Fig. 1. Concept of the KMMD

As for the unwearable olfactory display, the air cannon type was developed [8]. This system is able to emit air-rings through air cannons from a short distance away from a viewer. However, there is still not much research regarding the emission of scents through holes in the screen.

3 KANSEI Multi-Media Display (KMMD)

In order to synchronously present a visual and a scent, the most efficient way to advertise is to emit a scent to a viewer's nose. Therefore, a scent emitting device using an air cannon has been developed [[9]. By detecting the position of one's nose with an image processor and discharging an air ring with a scent to their direction, the scent can be presented in a particular place at a particular time. However, as Figure 1 shows, because it is necessary to emit a scent from the side of the screen, if the screen is large, it is difficult to carry an air ring with a scent for a long distance.

On the other hand, the KMMD has the following feature. A thin display panel that has many tiny holes between pixels is used. A video camera and scents-emitting device are placed behind the display panel, and the scents are emitted through the holes in the screen to a person who is detected by the monitor camera. Since the distance between the olfactory display system and the person is relatively short, the system has the advantage of presenting a scent from an area near the displayed object toward the viewer with certainty. Therefore, the presence is obtained as if the scent drifted from the product displayed on the screen.

3.1 Prototype of LED Display That Air Passes through

If the hole installed on the screen is easily recognized, one's mental image associated with the objects on the screen is destroyed, and the quality of the image might be decreased as a result. Then in order to understand an appropriate size of the holes which can be installed in the display panel with 3 to 4 mm of pixel pitch, the thin type LED display panel was ordered for this experiment. The pixel pitch of this panel corresponds to the resolution of the digital signage with image quality of standard television level described in Chapter 2. This prototype LED display is used to clarify the mechanism of emitting gas to a particular direction. Since the whole experiment is just to confirm our principle, a compact size of a display was designed to present simple diagrams and for a user to be able to clearly read scripts such as Kanji, the alphabet, and numbers.

We used a 1.6 mm thickness of a FR-4 epoxy-glass which is 300mmW×200mmH. 2.4 mmφ diameter holes were created at intervals of 4 mm in the spaces between the pixels in the display area. The LEDs were mounted at 4 mm intervals. The area of the holes accounts for 28 percent of the display screen. On the top of the board, a compact CCD camera was mounted in the 2.4 mmφ hole. Scents were ejected toward the viewer who was monitored by the camera.

3.2 Display Characteristic

Figure 2 shows a prototypical display which was made for this experiment. Picture (A) is the face and screen side. Picture (B) is the back. The color of the board on the face is a pale gray color. The brightness of the LEDs is controlled in 10 stages. On the screen of the display, sentences in Japanese or English are described and run from right to left, and the size of each character that composes the sentences is 50 to 60 mm. In order to evaluate the visibility of the words, a questionnaire was given to each subject and their answers were totalized to a sum. By changing the brightness of the

LED pixels, the subjects were asked about the visibility of the objects on the screen. They had to choose between one of five choices ranging from "not really able to read," to "clearly able to read" and "comfortably able to read." The average from the seven subjects is shown in Figure 3. These people were also asked if they recognized the holes on the screen and, if so, the subjects were then asked if these holes interfered with the readability of the screen. A summary is shown in Figure 4.

Before the experiment began, our main concern was whether or not the subject could recognize the holes on the screen, because the LED pixels had the potential to illuminate the holes around the LED pixels themselves. However, the holes were not always recognized by the viewers during the experiment in the dark room. It is understood that this was because the LED pixels were mostly illuminated from the front and not from the sides. Another reason is because the human ocular system tends not to perceive objects that are near shining objects.

Since the display panel which was created for this experiment was small, complex and large visual images were not displayed on the screen. If the screen size is enlarged to a width of about 3m, it seems that the standard television quality can be achieved because the source pitch is 4mm.

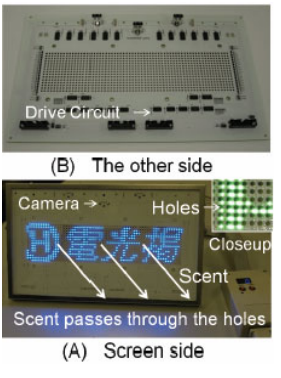

Fig. 2. Display with many holes

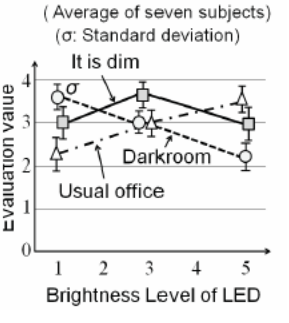

Fig. 3. Readability of displayed characters

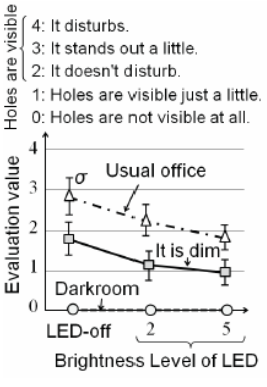

Fig. 4. Visibility of holes

4 Olfactory Display System Behind the Screen

4.1 Air Discharge Mechanism Design

KMMD uses an air control system which was placed behind the thin display with tiny holes to change the air pressure as shown in Figure 5. The control system was composed of an air compression mechanism, an air controller box, and an air duct. Compressed air was carried to the air controller box by the air duct. The air controller box was tightly attached to a specific position on the back of the screen. Therefore, the pressurized air in the box was smoothly emitted through the porous screen. By putting scents into the box, vaporized scents were discharged with the airflow. The

blades were installed in the air controller. We thought that the air passed through in various directions through the holes on the screen by changing the angle of the blades because the display panel had a thin design.

4.2 Airflow Control Experiment

We experimentally verified the flow control of air. The measurement conditions and the summary are shown in Figure 6. The eleven blades were adjusted to a specific angle to the display, and a distance was set between the display and each subject. The wind velocities directed horizontally to the display were analyzed using the Hot Wire Anemometer, RoHS, DT-8880. The subjects' reactions to each wind velocity were evaluated through answers to a questionnaire.

Picture (A) from Figure 6 shows the average velocity for ten seconds when adjusting the blades to 30 degrees to the display as an example, with a distance of 30 cm between the display and each subject. It is understood that the direction of the air flow changes by rotating the blades.

By changing the output of the blower, the airflow could be gradually adjusted between a gentle and heavy breeze at any distance up to 60 cm from the display. Since the strength and the direction of the airflow could be controlled, it will be possible to use it for not only presenting scents but also presenting the current of air like the wind to the skin, if a large-scale screen is made in the future.

4.3 Scent Emitting Experiment

A porous material (a cotton ball) was soaked in essential oil, such as vanilla and was placed into the air controller box where the oil was vaporized. The vaporized scents were discharged through the porous holes with either a gentle or weak breeze. As shown in Figure 6, changing the direction of the airflow made subjects feel the strongest scents in that area where the wind velocity was the strongest. This occurs because the scents were more concentrated in that area. This result could be applied to the situations of scent emissions coming from areas near the visuals on the screen.

5 Psychological Evaluation of Digital Signage with Scent

In a psychological examination of the advertisement using a scent, the eye catching effects were first examined. Next, the effects of scent presentation on one's memories were examined. In this experiment, a simulation experiment was also conducted using the immersive VR System, HoloStage™ made by the Christie company, because there were a lot of restrictions to the experiment in an actual passageway.

5.1 Eye Catching Effects of Advertising Image with Scent

Experimental Method. Figure 7(a) shows the virtual town used for the experiment. The scale of the VR space is equal to a real space, and the length of the passage is about 20m. Five digital signages were placed in a line on the left wall, and objects of the person type and the ornament, etc. were set up at the right of the passage. The digital signages for a cafe, roast meat, fruit, pizza, and flowers were queued up from

this side sequentially on the left wall. The contents for each digital signage used animation. The digital signages with the scent were evaluated in two kinds of patterns. In the experiment for pattern A , when a roast meat shop's signboard or a flower shop's signboard appears, the roast meat scent or the rose scent were presented respectively. In the experiment for pattern B, when a cafe's signboard or a fruits shop's signboard appear, the coffee or apple scent were presented respectively.

Figure 7(b) shows the appearance of the experiment. The procedure of the experiment is as follows. The subject advanced in the passage by the feeling to take the moving sidewalk, because the experimenter drew the VR space forward by the walking rate. The time to pass over the passage was about 40 seconds. The eye movement data of this time were accumulated, and the gaze of the objects were analyzed. The scent were presented not to be noticed from the back of the subject for about 5-7 seconds with a scent spreader when the subject approached the digital signage of the target. The subject obtained the sense of which the scent drifts from the passage while walking. The gaze objects when the scent was presented or not were compared. The subjects were questioned about their impression after the experiment ended.

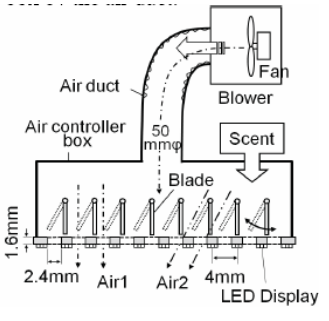

Fig. 5. Air and scent discharge mechanism

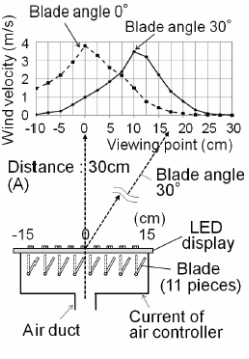

Fig. 6. Experimental results that control the air flow direction

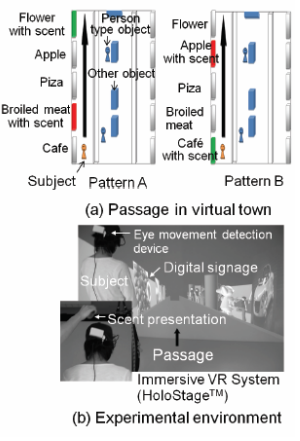

Fig. 7. An experiment of the eye catching property

Results. Figure 8 shows one example of the gaze detection result. The vertical axis are the objects that exists in the passage, the belt of a horizontal axis is time to gaze at each object. It was understood that the subjects gazed at the signboard with a scent at a high frequency compared to without the scent in both pattern A and B. Figure 9 shows the relation between the kind of the signboard and the average gaze time of ten of the subjects. The signboards that presented the scent were gazed at for a long time. Also, all subjects answered that he or she looked for the signboard when the scent was felt, and were interested in it. Thus, it was understood that the sense of smell was stimulated by presenting the scent and the digital signages with scents were considered strongly.

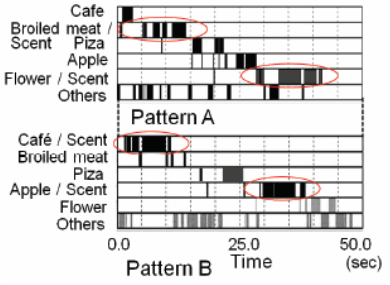

Fig. 8. An example of the change of the gazed target

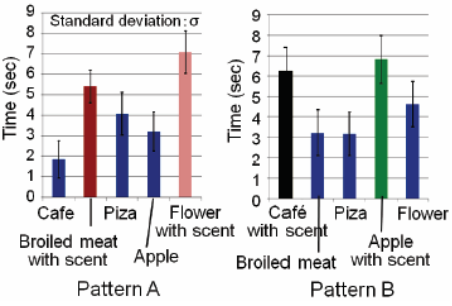

Fig. 9. Average gaze time of 10 subjects

5.2 Memory Promoting Effects of Image with Scent

A lot of clues for recollection are enumerated as for storage by combining different symbols. Then, the advantages to the memory of the image with the scent was investigated. Moreover, to explain the results objectively, the biological reactions when memorizing and recollecting them were examined.

Experimental Method

1. Method of memorization

One image was presented from 15 kinds of flower images on the screen of 120 inches one after another. The tasks of generating a mental image to the object and memorizing it were given to the subjects. One image was presented for 15 seconds. When the image was switched, a 30 second rest was taken to stabilize their feelings. Here, the scents added three images among 15. The scent was presented under one's nose by strength to which the kind was understood.

Figure 10 shows the appearance of the experiment. The sensors of Near Infra-Red Spectroscopy (NIRS) that measured the changes in the brain hemoglobin concentration were attached to the right and left sides of the subjects' frontal lobes. This NIRS was made by Hamamatsu Photonics (Multi-Fiber Adapter (MFA) for NIRO-200). Also, a biological sensor, Polymate 2 (TEAC Corporation), was used to analyze the skin conductance. A pair of active biological electrodes to analyze skin conductance were attached to two fingers of each subject's left hand.

2. Method of testing recollection

After memorizing 15 images, the rest was taken for about five minutes, then, the test images were presented one after another from 25 images that contained all of the 15 images used for memory, and when the same kind of image as the memorized image was recognized, the subject was instructed to push the button. Here, the subject was directed to push the button when it was possible to confirm it firmly, because it was not a test of speed. Since the purpose was to examine the relationship between the

depth of the processing level of memorizing the image with the scent and the result of recollection, in the recognizing task, the scent was not used. Also, the test image of the composition was different from the image that had been used when the subject was memorizing the images even if they were the same kind of flower image.

Each image was presented for ten seconds, and when the image was switched, they took a 30 second break. The subjects consisted of ten seniors. The correct answer rate and reaction time from the image presentation of the answer were examined.

Results. Figure 11 (left side) shows the reaction time comparison from the image presentation to the answer on the presence of the scent condition. It is understood that the judgment is early in the image with scent. Also, Figure 11 (right side) shows the correct answer rate in the recollection test. The image with the scent is recollected accurately. In the questionnaire after the examination, the following answers were obtained as an impression. "As for the image with the scent, the scent strongly leaves an impression.", "When memorizing it, the scent that had been smelt before was recalled, and the scene that related to the scent was useful for the memory." It is understood that the image with a scent strongly remains in the impression, and is effective for recalling the objects. We may assume that subjects perceive the object more consciously by recalling their past experience.

Figure 12 shows an example of the measurement result of the haemoglobin in the brain. In comparison with no scents, the concentration of the oxidized-hemoglobin increased while the deoxidized-hemoglobin decreased after being presented by scents. The results of presuming the revitalization of the brain on the scent presentation from the measurement were obtained from two or more subjects.

Figure 13 shows an example of measuring the skin conductance. When the image was presented, the skin conductances were the same as normal circumstances or rose more than normal circumstances in all ten subjects, regardless of the presence of the scent. When the rising values of each skin conductance had been compared, the image with the scent rose more than when there was no scent for eight subjects in ten subjects. It can be considered that the images with a scent cause the tension and the excitement easily as the results.

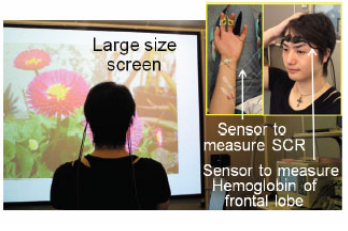

Fig. 10. Experimental environment to evaluate the psychological effect

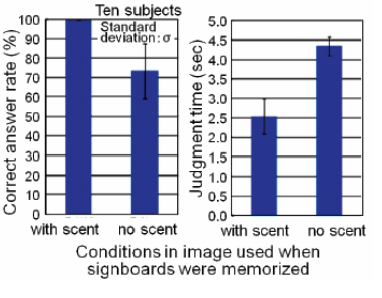

Fig. 11. Experimental results of recalling signboard presented ahead

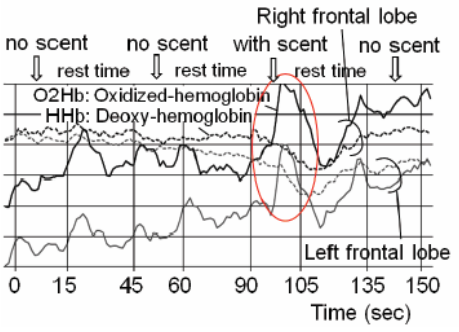

Fig. 12. Experimental results that show brain activity by scent presentation

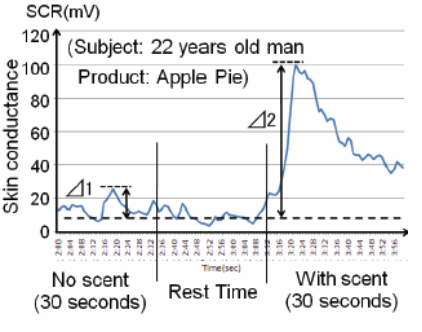

Fig. 13. Skin conductance changes by scent presentation

6 Conclusion

We made the KMMD that emit the scent through the screen for trial purposes, and examined the possibility of the scented digital signage by using the simulation. The conclusions in this experiment were as follows:

1. Three-colored LED pixels were separated by 4 mm spaces on a circuit board with a thickness of about 1.6 mm, and holes which were 2.4 mmφ in diameter were made in the spaces. The holes are considered not to degrade the quality of the visuals.
2. By tightly attaching an air controller box to the back of the LED panel, the direction of the airflow was controlled. Also, by putting scented essential oil in the box, the system was able to more naturally present the scents to the viewer.
3. The effect of the improvement to catch the eye with the image emitting a scent was shown through the simulation experiment using the Immersive VR System.
4. Presenting visuals with corresponding scents makes the viewers generate the mental image easily, and remain in their memory easily.

Though the KMMD made for trial purposes in this study was small in size, if it is possible to make it in a large-scale size, and emit the scent from the vicinity of the displayed object, one may feel as if actual scents come from the object. In the field of advertising, which uses devices such as digital signage, the display screen is used to increase a person's desire to buy the product. We want to use the KMMD also for other various fields such as virtual reality simulations and sensory games in the future.

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