Image Display System Using Bamboo-blind Type Screen that Can Discharge Smell

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Abstract: In order to promote the realistic sensations of visuals, a display system, in which smell along with air was discharged through screen to a viewer, was invented. A bamboo-blind screen where thin rods and spaces were arranged in the vertical direction was used. For the alley type screen, the visuals were displayed using projectors. Both airflow and scent generators were attached on the back of the screen. This work insinuated the following details; the direction of airflow was controlled by installing blades functions and smell was able to be directed and oozed toward expected locations. Also, if the screen was large enough and an animated series of visuals was presented, the alley type of display enabled to remain the high quality of visuals. Applications to digital signage and large-screen virtual game etc. can be expected.

1 INTRODUCTION

A new piece of technology called a multimodal interface, which is different from the conventional audio visual interface, has recently been developed for the purposes of clarifying human perceptual mechanisms, enhancing realistic sensation and many other reasons (Hirota et al., 2011; Onojima et al., 2011; Furuya et al., 2011). Because sense of smell is one of the senses that acts directly on memory and emotion, the multimedia with olfactory information added to audio and visual information is called KANSEI Multi-Media and the detection, regeneration, transmission and application of scent has been studied (Nakamoto et al.,2012). Furthermore, the breeze-feeling sense has also been focused on as a media that enhances realistic sensation, and the methods of presenting it and its psychological effects have also been researched (Yanagida, 2013; Ueoka et al., 2013). Sawada et al. proposed the interface that brought the new communication medium of "wind" into the bidirectional interaction between the virtual environment and the real environment by integrating the graphic presentation with the input and output of wind on a special screen (Sawada et al., 2008). Also, Matsuura et al. proposed the system that generated an airflow directed toward the user from a certain position on the screen by making the wind that rose from four fans collide on the screen (Matsukura et al., 2012).

The author et al. have been studying a system that collaboratively displays images and scents called KANSEI Multi-Media Display (KMMD) and its psychological effects for the purposes of applying it to digital signage and virtual reality. Thus far, the author et al. have proposed a display that can collaboratively present images and scents by using a special screen through which air can flow, and evaluated the enhancement of memory, the effect of visual attraction and realistic sensations caused by the images with scent (Tomono A., 2008; Tomono K., 2011; Tomono A., 2010).

In this field, in order to present scent in a way to be linked with image, it is necessary to block of scent near the nasal cavities, not spread the scent. This can effectively make users perceive the scent with only a small amount of scent, so that it is also possible to switch the scent in accordance with the image. To measure this purpose, various devices have been researched, such as: a device that confines the scent in a vortex ring and sends it to the users using an air gun (Yanagida et al., 2004), one that evaporates the scent and sprays it through a fine nozzle (Kim et al., 2011), and one that generates a weak airflow and discharges the scent to its users in a pulse-like way (Kadowaki, et. al, 2007). In order to

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generate scent and present it to users at a place separate from the device, certain measures to generate air current are needed, and in order to present the scent with the movement of the users, technology to control the direction of the airflow is required.

Therefore, the purpose of this research was to propose a KMMD that can discharge air and scent in a predetermined direction through a screen with small holes and gaps and verify the validity of the principle by a trial device. Firstly, the significance of the development of the KMMD was described and the experiment of controlling airflow using a bamboo blind-type screen and a blade mechanism was explained. The airflow velocities were measured at various observing places and the smell sensory properties were evaluated. Furthermore, the image quality projected on a bamboo blind-type screen was discussed.

2 INTEGRATED SYSTEM PRESENTING IMAGE, SCENT AND AIRFLOW

Fig. 1 shows the concept of the KMMD. As shown in Fig. 1 (a), generally in a conventional system presenting images together with scent, a scent generating device is installed near the display and both devices are controlled in accordance with the contents (Sakaino, 2008). However, the problem is that the available space to install a large scent generating device is constrained and it stands out, so that the operator cannot be concentrated in projecting image. In the case where the display is large-sized, if the scent generating device is installed near the display, the distance between the device and the users becomes too large, and it is difficult to control sending the scent to the users.

On the other hand, as shown in Fig. 1 (b), the KMMD has a screen with small holes and gaps and the devices generating airflow and scent are arranged behind the screen. This system has the following characteristics:

(1) The scent generating device does not stand out in order for this system to be less psychologically oppressive.
(2) Because the scent generating device can be installed anywhere behind the screen, it is possible to send scents and breezes from areas close to the users.
(3) Because the scent can be discharged from the place where the image is displayed, a collaborated expression of image and scent is possible.
(4) It is possible, in principle, to present the scent of the object on the screen which the users are viewing if a monitor camera is installed to detect the positions and gazes of users.

There are two structures as display devices, such as using a spontaneous light emission element (LED or EL) and using a projector screen (Tomono K, 2013). The latter one is explained here.

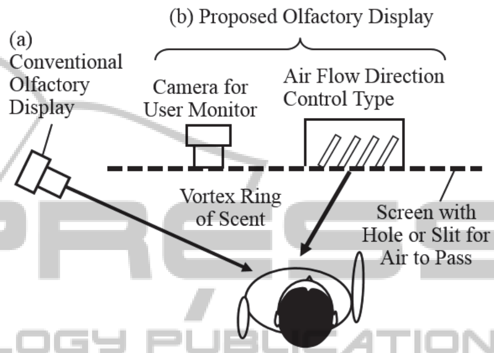


Figure 1: Concept of KMMD that collaboratively displays image, smell, and wind.

3 KMMD USING BAMBOO BLIND-TYPE SCREEN

Due to the screen through which the airflow passes and the airflow direction control mechanism, a trial device was produced in order to realize the concept of the KMMD in the previous chapter. Fig 2 shows the design specification and Fig. 3 shows the experiment system manufactured by way of trial.

3.1 Bamboo Blind-type Screen

In order to let the airflow pass easily in a transverse direction on the display screen, the screen consists of many elongated rod-shaped display parts piled up in a longitudinal direction so that the long axis becomes horizontal with gaps between the rods. The display parts can be structured by spontaneous light emission elements, such as LED and ED, being arranged in a row. However, in this paper, in order to easily confirm the principle, bamboo sticks painted with white paint were used as display parts. These sticks were arranged in a vertical direction and used as a projector screen. The specifications of the screen used in the experiment are shown in Fig. 3 (b). Fig. 3 (a) shows the bamboo blind-type screen before it was painted with white paint.

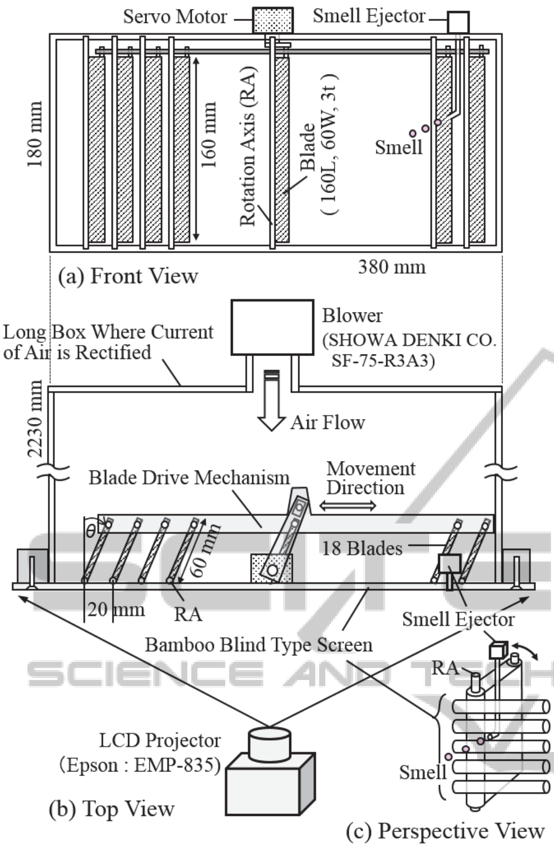


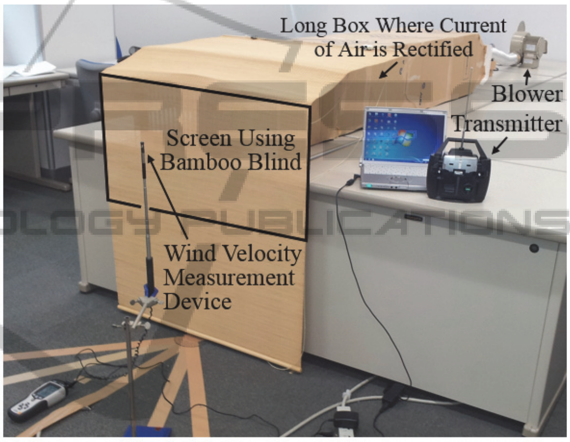
Figure 2: Design of KMMD using bamboo blind type screen.

3.2 Airflow Direction Control Mechanism Using Rotary Blades

As shown in Fig. 2, in order to control the direction of horizontal airflow, 18 blades (16 cm in length and 6 cm in width) were set in a vertical direction so that they were perpendicular to the gaps of the screen, and the rotation axes of blades were arranged so that they contacted the screen. It was expected that the airflow in the box would be discharged from the gaps in the predetermined direction when the plural blades rotated in a coordinated manner. A servo motor for radio control was used to rotate the blades.

In order to increase atmospheric pressure behind the screen, a box (380 cm in width, 180 cm in length and 223 cm in depth) was installed in a way that it surrounded the blade mechanism, and a blower (SHOWA DENKI CO.: SF-75-R3A3) was placed behind the box through a duct (10 cm in diameter). The maximum flow rate was 8m^3/min. and the maximum pressure was 0.55 kPa. The reason why the depth of the box for increasing atmospheric pressure was long is as follows: The diameter of the airflow outlet of the blower was small at 10 cm and the pressure at the time of airflow emission was not stable, so it was contrived to adjust the airflow while passing through the long box and make it even just before the blades. If it is possible to use a blower with a large airflow outlet in the future, that part will become more compact.

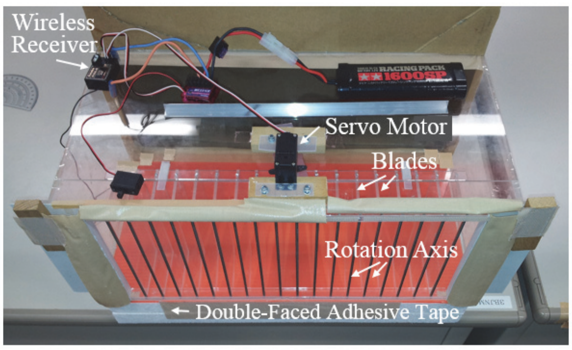
The bamboo blind-type screen was fixed at the front surface of the airflow direction control mechanism using a double-faced adhesive type, as shown in Fig. 3 (c). The scent was evaporated and arranged so that it could be discharged through the gaps of the bamboo blind-type screen as needed, using a collaborated air pump and nozzle.



(a) Bamboo Blind Screen is Mounted in Front of Air Flow System.

Screen Size	Horizontal 85cm	Vertical 64cm
Aspect Ratio	4	3
	Mean value	SD
Diameter of Rod	1.26	0.08
Gap Between Rods	0.87	0.14

(b) Specification of Bamboo Blind Screen



(c) Air Flow Direction Control Mechanism

Figure 3: Experimental system of KMMD using bamboo blind type screen.

3.3 Evaluation of Airflow Direction Characteristics

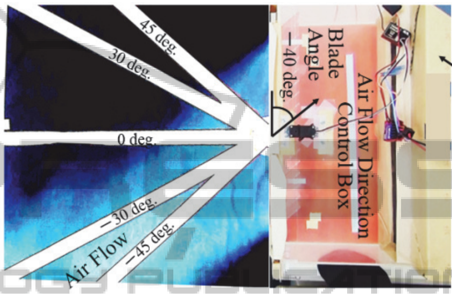
3.3.1 Experimental Method

Under the environment in Fig. 3, when the angle of the blades was varied within the range of 0 degrees to ± 45 degrees, the wind velocities at predetermined places were measured using a hot-wire anemometer (RoHS, DT-8880). The measurement locations were defined with angles and distances from the center of the screen as the first original point. Generally speaking, airflow is likely to change. Therefore, it was measured five times during approximately a 10-second period, and average wind velocities were obtained. Firstly, only the characteristics of the airflow direction control mechanism shown in Fig. 3 (c) were examined, and then the characteristics of when the bamboo blind-type screen was mounted were inspected.

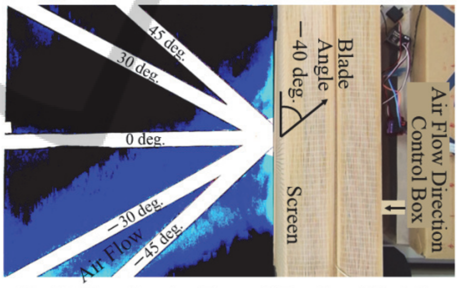
3.3.2 Experimental Results

Fig. 4 shows the changes of airflow when the angle of the blades was set at -40 degrees. A smoke-generating device (Stage Evolution's product: Smoke Stream JR) was installed at the air-intake of the blower and the airflow discharged from the screen was visualized and photographed, and the distribution of smoke was highlighted by image processing. As shown in Fig. 4 (a), in the case where the screen was dismantled, the air in the box was generally inflected in the direction of the blade angle and discharged. Fig. 4 (b) shows a case where the bamboo blind-type screen was installed. In that case, although the air was inflected the same as the (a) case, it can be observed that the discharging angle was slightly smaller than the blade angle. Therefore, displacement of the airflow direction caused by passing through a bamboo blind-type screen was obtained in detail.

Fig. 5 shows the conditions where the screen was installed. Fig. 5 (a) shows the results of the measurement of wind velocity made at each position with ●■▲ markers parallel to the screen (direction of x) as the second original points. These ●■▲show a 50 cm, 100 cm and 200 cm distance from the first original point. Fig. 5 (b) shows the velocity distribution of airflow when the blade angle θ was 0 degrees, Fig. 5 (c) and (b) show those when the blade angles θ were +30 degrees and -30 degrees, respectively, and Fig. 5 (e) and (f) show those when the blade angles θwere +45 degrees and –45 degrees, respectively. The larger the blade angle becomes, the more the position of the maximum wind velocity deviates from the original point. However, the amounts of deviation were not so large. For example, in the case where the angle of blade was 30 degrees, the position of the maximum wind velocity deviated 10 cm to the right (x direction) from the original point at 200 cm distance. In other words, it was an accidental error of approximately -11% of the blade angle (3.3 degrees/30 degrees) because the angle of airflow was 26.7 degrees. An accidental error occurred in the same way when the blade angle was negative.



(a) Air Flow Controlled With Blades



(b) Air Flow Passing Through Bamboo Blind Screen

Figure 4: Experimental results changing air flow direction with blade.

3.4 Characteristics of Scent Presentation

In order to examine whether it is possible to present a scent to the users at distant positions, an experiment of sensory evaluation was conducted under the situation in Fig. 3 (a), where subjects were placed in the position of (1) (0 degrees, 200 cm) and (2) (-45 degrees, 200 cm), as shown in Fig. 5 (a). Guerlian's Samsara Eau de toilette was used for the scent. A mouillette, which was immersed in the scent, was placed near the center of the bamboo blind-type screen, the blade angle was set at -45 degrees and airflow was sent for five seconds. Subjects were asked to respond to the questionnaire at four stages (1. No smell at all, 2. Some smell, 3. Can recognize the scent, and 4. Can strongly recognize the scent). Subjects were four university students with a normal sense of smell.

Fig. 6 shows the average scores of the questionnaire. It was clear that the subjects perceived the smell at the position of (1) and almost did not at the position of (2). Because the air flowed only in the direction of (1) from Fig. 5, the results could be assumed. However, it was clarified that scent can be selectively discharged to a given direction.

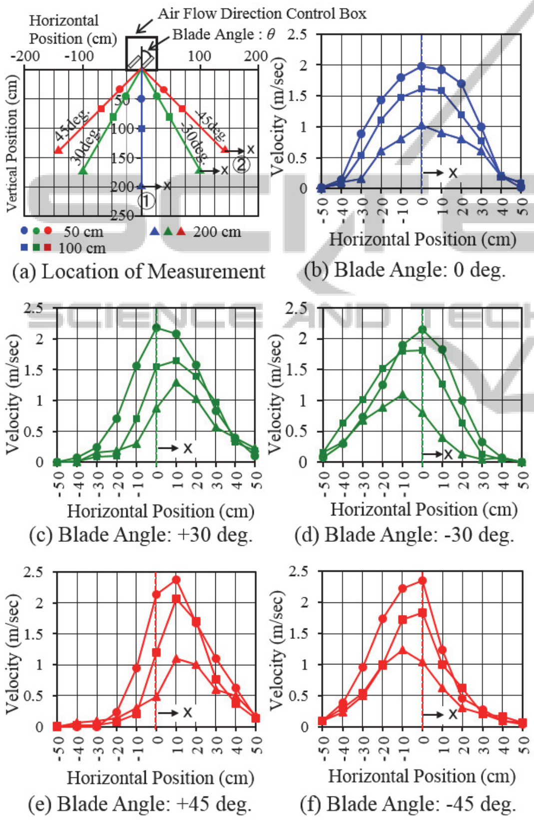


Figure 5: Velocity distribution of air flow that passes through bamboo blind type screen.

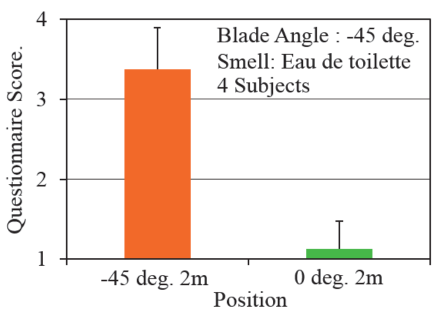


Figure 6: Difference of smell perception according to observation place.

3.5 Evaluation Experiment of Image Quality by Projection

In order to examine the degree of influence of the bamboo blind-type screen on the image quality, an experiment was conducted where the conventional projector screen (PS) and the bamboo blind-type screen (BS) described in 3.1 had images projected on them and the subjects subjectively evaluated them. Two images were subjected to evaluation: (i) Latin dance image as an image with a large amount of movement (rumba for three minutes) and (ii) The Sound of Music as a famous movie (the first 20 minutes was subtitled). These images were reproduced by a PC from a DVD by the MEG2 Standard. The projector was an EPSON's LCD projector (Model No.:EMP-835) with a luminance level of 3000 lm, contrast ratio of 600:1 and a pixel count of liquid crystal panel (3LCD) of 1024 x 768. The visual distance was 2 m. The subjects were seven university students with normal audio and visual senses (ages ranging from 21-23). They were asked to respond to a questionnaire with an interval scale of five stages concerning the readability of the subtitles and the quality of the image.

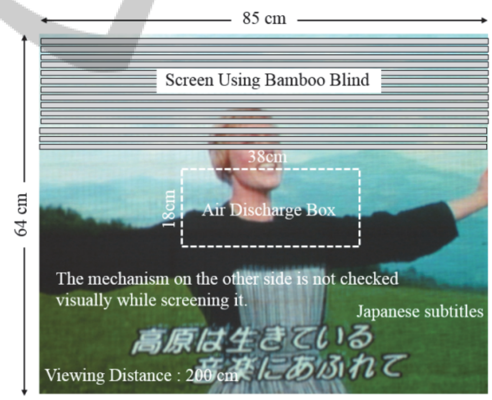


Figure 7: Image projected to bamboo blind type screen. Movie: The Sound of Music.

Fig. 7 shows a scene from The Sound of Music projected to the BS. Because the surface of the screen became brighter by the projected image, the blowing system behind the screen was not perceived. Fig. 8 shows the average scores of the questionnaire. The scales of readability were: 1. Cannot read, 2. Difficult to read, 3. No opinion, 4. Can read without problem, and 5. Can clearly read. The average score from the BS was 3.9, which means that the subtitles are largely read without problem. The scales of satisfaction in the quality of image were: 1. Not satisfied at all, 2. Barely satisfied, 3. No opinion, 4. Rather satisfied and 5. Greatly satisfied. The average score of the BS was 3.3, which means they were rather on the side of satisfaction. There were many opinions in the free description column of the questionnaire such as that human's movement and countenances could be accepted without an uncomfortable feeling and that although not satisfactory, it could be appreciated. However, the score of the BS was low by 0.8 compared to that of the PS at 4.1, and as a result of test, the difference between both screens was clear at a significant level of 5%.

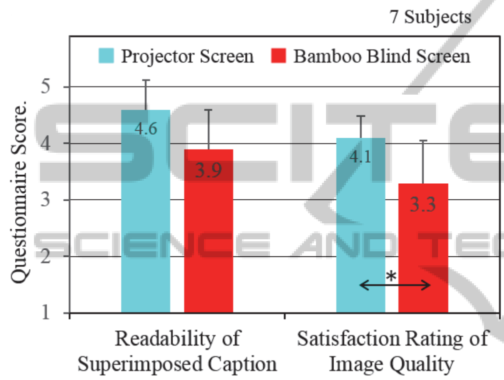


Figure 8: Subjective evaluation to video images.

3.6 Discussion

It was discovered that because there are gaps in the horizontal direction on the bamboo blind-type screen, it is easy to control bending the airflow in the horizontal direction using blades. The accidental error in the actual airflow angle to the blade angle was less than 1/3 of the case where holes were made on the LED panel. An accidental error of 11% occurred at $\theta = \pm 30$ degrees. With this extent of error, it is possible to selectively present scent and airflow in the direction of the users with the error taken into consideration. If it is possible to send scent only in a particular direction, not diffusing it, it requires less scent and is advantageous to switch the scent in accordance with the scene of image. As the reasons of error previously described, it can be considered that because the gaps are narrow, when the air is passing though them, it causes friction and the bamboo blinds are raised up from the rotation axes by wind pressure and the airflow turbulence occurs there. For the latter case, it is possible to make improvement by devising a way to install the bamboo blind.

Regarding the quality of image, although there is a bit of a problem, potential future improvement will be discussed. The size of the bamboo blind-type screen was 85 cm in width and 64 cm in length. The diameter of the rod of the blind was 1.26 mmφ and the gap was 0.87 mm so that the picture element pitch in the vertical direction was 2.13 mm. Because there was no gap in the horizontal direction, if a high-resolution projector is used, the number of pixels can be ensured with the specification of this device. However, the number of pixels in the vertical direction is limited to approximately 300 because of constraint of the picture element pixel, as described above. This rough pixel density is considered to affect the quality of image. If the gap is approximately 1 mm, the airflow can be sent to a location a few meters away. Therefore, if the gaps are approximately 1 mm, the size of the screen is made larger, and the image is observed from more distant location, the quality of image can be improved.

According to the NTSC standard, the displayable number of scanning lines is 436 in the vertical direction, and for the visual vertical resolution, the number of scanning lines is multiplied by the Kell factor and is said to be about $436 \times 0.7 \fallingdotseq 305$. It can be inferred from this idea that if the size of the screen is made to be 1.5 times larger, the same quality of image can possibly be obtained. Meanwhile, according to the HDTV standard, the total number of scanning lines is 1,125 and the number of effective scanning lines is 1,080. Therefore, if the size of the screen is made to be 3-4 times larger, the same quality of image can possibly be obtained. It is a large size screen about 3 meters in width, and even though it is not uncommon as a digital signage (Musgrave G., 2001), its application to this field can be expected.

Because the experiment of paragraph 3.5 considers the distinctiveness of a bamboo blind screen, it is different from a usual image quality evaluation. Therefore, the evaluations of a resolution and visual tiredness, etc. will be necessary in the future.

4 CONCLUSIONS

Authors proposed a KMMD that can integrally present visual, smell and breeze-feeling information. This system was installed with a screen with small holes and gaps, and airflow and scent generating devices behind the screen. The author et al. produced a trial device, discussed a method presenting scent using its functions, and clarified the following:

(1) When a blade mechanism was installed behind a bamboo blind-type screen, the deviation of the direction of airflow became small and it became possible to control sending airflow in a given direction by the rotation of the blades.
(2) It was possible to send scent in the airflow in only a predetermined direction.
(3) In the evaluation experiment for the image quality on the bamboo blind-type screen, although the quality of image was lower than the conventional screen, it could be appreciated. If the size of gap in the bamboo blind is the same, it is possible to improve the quality of the image by making the size of the screen larger and projecting high-resolution images. Therefore, the system that integrally presents scent and breeze in accordance with the contents of images while maintaining the desired quality of image can be realized.

As the tasks regarding KMMD in the future, the following are pointed out: further precision of the mechanism to control sending airflow in a given direction, higher definition along with larger screen structure and development of the mechanism of blending scent in airflow. It is also necessary to develop the contents with a high realistic sensation utilizing the environment that can integrally present image, scent and breeze. It is also desirable to discuss its application to digital signages, large screen virtual game, simulator with high reality, scent education system, etc. in the future.

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