

# A Proposal of the Olfactory Information Presentation Method and Its Application for Scent Generator Using Web Service

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## Abstract

Among the human senses, olfactory information still does not have a proper data presentation method unlike that regarding vision and auditory information. It makes presenting the sense of smell into multimedia information impossible, which may be an exploratory field in human computer interaction. In this paper, we propose an olfactory information presentation method, which is a way to use smell as multimedia information, and show an application for scent generation and odor display using a web service. The olfactory information can present smell characteristics such as intensity, persistence, hedonic tone, and odor description. The structure of data format based on olfactory information can also be organized according to data types such as integer, float, char, string, and bitmap. Furthermore, it can be used for data transmitting via a web service and for odor display using a scent generator. The scent generator, which can display information of smell, is developed to generate 6 odors using 6 aroma solutions and a diluted solution with 14 micro-valves and a micro-pump. Throughout the experiment, we confirm that the remote user can grasp information of smell transmitted by messenger service and request odor display to the computer controlled scent generator. It contributes to enlarge existing virtual reality and to be proposed as a standard reference method regarding olfactory information presentation for future multimedia technology.

**Keywords :** Olfactory Information Presentation Method, Scent Generator, Odor Display, Web Service, Multimedia Technology

## 1. INTRODUCTION

Smell output can be said to be the most explorative research area in Human Computer Interaction(HCI). The olfactory may provide robust memories and associate mechanism to build human senses[1, 2]. Although having many advantages, the lack of an effective scent generator, which generates various odors, restricts further research. Recently, there has been great interest in a scent generator device that presents smell output and a commercial device has also appeared [3].

A researchers from Japan attempted to control smell with valves based on Ink-Jet technology, and had developed a technology to blend the diverse scents by combining dozens of scent ingredients[4]. Also, they developed a new odor recorder using an electronic nose based on a QCM sensor array to measure an odor and convert it into digital data in order for it to be represented[5]. It was applied to virtual reality for showing a cooking process, and may be extended to animation and video clip applications.

However, the system can only be used for the exact same sensors and scent generator.

The computer controllable olfactory display systems were commercialized by companies such as Digiscents[6] and Trisenx[7].

Despite these efforts, the information related with olfactory is not sufficiently provided as multimedia information compared with seeing and hearing information. Suitable research needs to be carried out in order to provide information regarding smell related with olfactory working as multimedia information. Olfactory information has to include existing multimedia information instead of being used as independent information.

In order to use olfactory information in multimedia, we have to develop techniques for olfactory information as follows :

- How to derive information from smell
- How to transmit smell information
- How to use a scent generator

In this paper, we propose an olfactory information presentation method, which is a way for using smell as multimedia information. The information of smell can be derived from smell characteristics such as intensity, persistence, hedonic tone, and odor description. It has to change into a digital structure data format such as integer,

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float, char, string, and bitmap, which is an easy way to transmit information of smell for the web service and scent generator. The scent generator is developed to generate odors using aroma solutions with micro-valves and a pump, and display smell according to request information data based on olfactory information transmitted via a web service.

Throughout experimental work, we confirm that the proposed olfactory information presentation method can derive and transmit smell information, and the remote user who receives information requests odor display using a computer controlled scent generator.

## 2. OLFACTORY INFORMATION PRESENTATION METHOD

### 2.1 Presentation method for odor characteristic parameters

Unlike the senses for sight and hearing, the olfactory is controlled by complex chemical compounds, and only human accept it with emotion and feeling. Thus, this sense is difficult to convert into digital information, which limits the olfactory being used as a part of media information.

A guideline on how to convert olfactory sensations onto the data and reference method need to be created for olfactory in order to devise media information that can be used to convey scents as well as other media representing other senses.

Table 1. Odor characteristic parameters

No.	Characteristic	Description
1	Odor Threshold	Above a certain threshold that allows humans to experience the odor
2	Intensity	Describes the strength of the odor relative to different concentrations of n-butanol
3	Persistence	Persistence is a calculated value based on the full-strength intensity and the detection threshold concentration.
4	Hedonic Tone	The degree to which the odor is agreeable or disagreeable
5	Odor Description (Character Description)	The particular characteristic of an odor that distinguishes it from other odors

As a result from various researches for odors and sense of smell, we have learned that odors can categorized under five headings, which are described in Table 1.

Among the five headings for smell parameters, odor threshold is not important, because it is normally generated above the threshold for multimedia application. However, four other elements such as intensity, persistence, hedonic tone, and character description must be included in the presentation of olfactory information.

Intensity describes the strength of an odor sample and is measured at concentrations above the detection threshold. It can be measured at full-strength(i.e., no dilution with non-odorous air) or diluted with non-odorous air. In either case, it can also be measured with a five-step scale using n-butanol, a standard reference chemical(ASTM 1988)[8, 9]. To learn about this scale, trained panelists sniff containers of n-butanol at different concentrations in water(Table 2). Then, they are presented in diluted or full-strength(diluted is always presented first) odorous air samples that are rated against the n-butanol scale.

Table 2. Odor intensity reference scale based on n-butanol

number	Intensity category	Equivalent head space concentration of n-butanol in air (ppm)	Mixture of n-butanol in water (ppm)
0	No odor	0	0
1	Very light	25	250
2	Light	75	750
3	Moderate	225	2250
4	Strong	675	6750
5	Very strong	2025	20250

Persistence is a calculated value based on full-strength intensity and the detection threshold concentration. The slope of the line connecting these two points(on a log-log graph) represents the level of persistence(Fig. 1). Persistence values are normally negative. Persistence indicates how easily the full-strength odorous air is diluted below the detection threshold. Odorous air that has a low persistence(more negativity) will have a steep slope, which indicates that it does not take much fresh air to dilute the odorous air below the detection threshold. Odorous air with a higher persistence(less negativity) will have a shallow slope, indicating that the air requires more dilution to drive it below the detection threshold. Inexpensive perfumes and colognes usually have less persistence than more expensive perfumes and colognes.

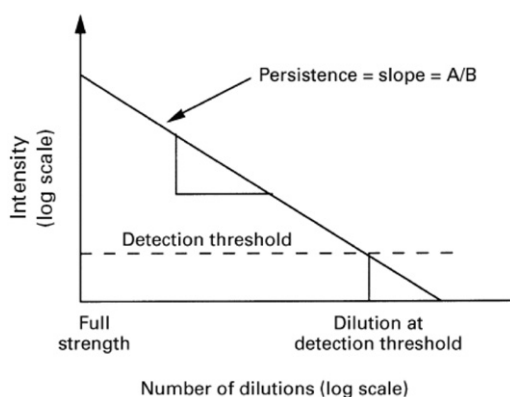


Fig. 1. Persistence calculated from the log-log plot of intensity and dilutions[8].

Hedonic tone describes the unpleasantness or pleasantness of an odor (ASCE 1995)[10]. It is typically rated using a scale that ranges from  $-10$ , which is unpleasant, to  $+10$ , which is pleasant. Neutral odors are recorded as zero. Unpleasantness usually increases with odor intensity. Pleasant odors may increase in pleasantness with odor intensity at low intensities but become less pleasant and even unpleasant at relatively high intensities.

Character descriptors are used to describe the character of the odor. The character of an odor is reported using odor class, which provides a referencing vocabulary for odor quality. Numerous “standard” odor descriptor lists are available. For example, an odor might smell like mint, citrus, earth, or any other select term used by trained panelists.

References for general odor classifications were given by Amoore[11, 12] and Flavornet[13]. Flavornet makes a compilation of aroma compounds found in human odor space. In addition, Flavornet classifies odors according to 25 classes. Class names are used to describe the character of the odor. Each class contains several odors and odorants. Flavornet lists only those odorants that have been found in a human odor space at supra-threshold levels i.e. at levels likely to stimulate ORNs (Olfactory receptor neurons).

When numerous research results are combined, there are 5 ways to present odors, which are shown in table 3.

The first perception presentation may be defined as a labeling process in order to provide a name to the odor in text. The fifth presenting method with odor terminology may be omitted when it can be presented with the other 4 methods. Table 4 shows the relationship between odor characteristics and the presentation method.

Table 3. Representation method of odor quality

No.	Representation Method	Description
1	Perception	Type : flower, fruit, animal, fish Individual : rose, jasmine, peach, cat etc
2	Sensation	sweet-smelling, burnt etc
3	Emotion	like, dislike etc
4	Impression	rustic, sensual, noble, elegant
5	Odor Terminology	simple, oriental etc

From table 4, we can know that odor quality can be represented mostly by using the odor parameters of table 1.

Table 4. Relations of odor characteristic and presentation

Odor Parameter	Representation method for odor quality			
	Perception	Sensation	Emotion	Impression
Intensity	x	x	○	△
Persistence	△	x	△	○
Hedonic tone	x	x	○	△
Odor description	○	○	△	△

○ is a very strong relation, △ is a regular relation, x is a weak relation.

## 2.2 Olfactory representation method using odor characteristic parameters

It is difficult to articulate the perception of odor, which is only described with the odor characteristic parameters shown in table 1. The perception of an odor is often similar to articulating a concrete name in words. The odor characteristics defined in table 1 are impossible to reify the perception presentation of odors. More parameter types such as name and label are used as an odor’s main ingredients with the previous defined parameters in table 1. The labeling parameter is a form of bestowing a concrete name in words or graphical icons (bitmap) on the individual perception of an odor. For example, an odor description can use the term “floral” and the labeling parameter can use the term “lavender.” In real applications, the odor description and labeling parameter can use the preset odor classification tables. The main ingredients present the principle compositions of odors (odorants) in string format. Table 5 demonstrates the presentation method for odors to be used as multimedia information.

Table 5. Olfactory presentation method suggested so that odors can be used as multimedia information

Characteristic	Data		Description
	Category	Data	
Intensity	No odor	0	divided into at least 6 units (can be divided into more units depending upon on purpose)
	Very light	1	
	Light	2	
	Moderate	3	
	strong	4	
	Very strong	5	
Persistence	floating point number		Normally negative
Hedonic Tone	Unpleasant	-1~-4	9 units are common but odors can be divided into more depending on purpose. However, because of the lack of standard measurement protocols and differences among individuals, hedonic tone can be omitted.
	neutral	0	
	Pleasant	+1 ~ +4	
Odor Description	Floral	string	Creating a standard is difficult; therefore present odors in string by using commonly researched odor description texts.
	fruity		
	citrus		
	aromatic		
	:		
Labeling (Perception)	string		Specific names are presented by string or graphic icons, a bitmap is used.
	bitmap		
Main ingredients	string		Present the principle compositions of odor in string.

### 3. ODOR DISPLAY USING SCENT GENERATOR VIA WEB SERVICE

#### 3.1 Scent generator

Odors are transmitted through an application service like MSN Messenger by the scent generator. For this service, we developed a simple scent generator, and transmit odors using the olfactory information presentation method, which is defined in the previous section.

The scent generator used for this experiment can generate 6 odors by using 6 aroma solutions and a diluted

solution. Also, 14 micro-valves are used to prevent any odor escape. Fig. 2 is a system block diagram of the Scent Generator.

The developed scent generator is connected to a PC (Personal Computer) using UART(Universal Asynchronous Receiver Transmitter), and the micro-pump is programmed by PWM(Pulse Width Modulation) to control the amount of air adjusting odor intensity. To regulate odor persistency regarding the generated odors to some extent, micro-valve opening time of a diluted solution was controlled in this experiment. Fig. 3 shows a scent generator developed for a web service.

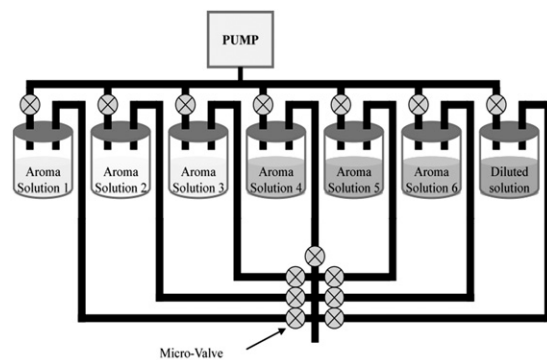


Fig. 2. System block diagram of scent generator.

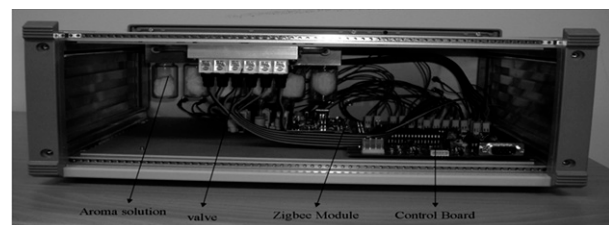


Fig. 3. Scent generator.

#### 3.2 Communication between user and scent generator

The communication between a user and the scent generator requests two data formats of information as shown by Fig 4. One is information for which the scent generator offers information with the scent generator to the user, and the other is information for which the user makes a request for the emission of odor to the scent generator. The user can make requests for the emission of odor to be suited to the scent generator's function by using information on the scent generator. Two data formats were developed based on the olfactory information presentation method.

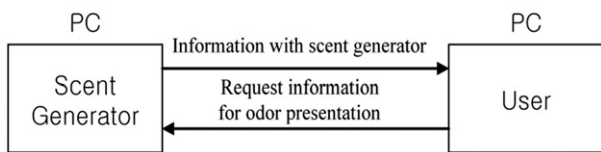


Fig. 4. Information communication for olfactory user interface.

Table 6. The structure of data format for scent generator

Templates	Description	Data type	Bytes	
HEADER	The description of the scent generator	char	1	
number	The number of smells			
Segment	Intensity	The intensity of aroma solutions in a scent generator based on table 6	int	2 × n
	Dilution	The possibility of dilution 0 : impossible 1 : possible	int	2 × n
	Odor description	The name of blended smells can typically be given by using the existing smell classification scheme. String is used for the representation of names	string	2 × n
	Labeling (Perception)	The specific name of a blended smell or labeling in the existing smell classification scheme. Both string and bitmap are used for the labeling of smells.	string	2 × n
			bitmap	(20 × 20 pixels) × n
Main ingredients	Description of the main ingredients of smells in an aroma solution as strings	string	20 × n	
Segment END	Segment END	char	1	

Table 7 shows the data format of the scent generator for providing smell information from the scent generator to the user, which was developed based on the method described in table 6, and the graphic icon by bitmap to show perception presentation for emotional communication. In this paper, odor description and the labeling template can use the preset smell classification tables, because of the difficulty associated with odor classification and description. In table 6, n means the number of preset smells

or blending capable smells in the scent generator.

Intensity template means the maximum intensity of each smell or aroma solution. Dilution template decides the possibility of dilution with each smell or aroma solution. For example, if the intensity template has 2 3 3 and the dilution template have 0 1 1, then the first smell has a “light” intensity and can’t be diluted and the second and third have “moderate” and can be diluted. With the second and third, the scent generator is requested to emit smell as intensity for “very light”, “light” or “moderate” by the user.

Table 7 shows the data format of a user request for smell presentation. In table 7, ScentTime is indicated by the number of seconds that a user wants to continue emitting the scent.

The information of table 6 is registered to the user’s computer. The user can ask for the emission of smell that meets the conditions specified in scent generators. Table 7 shows the data format for demanding the emission of a desired smell to scent generators.

Table 7. The structure of data format for user request

Templates	Description	Data type	Bytes	
HEADER	The description of the scent generator	char	1	
ScentTime	The desired time (sec)of a scent to be emitted	int	1	
Segment	Intensity	The desired intensity of a scent to be emitted	int	2
	Hedonic tone	The desired hedonic tone of a scent to be emitted	int	2
	Odor description	Odor description in text	string	20
	Labeling (Perception)	Labeling in text	string	20
		Labeling in graphic (Bitmap)	bitmap	(20 × 20 pixels) × n
Segment END	Segment END	char	1	

### 3.3 Odor-messenger service

We experimented with transmitting odor by a messenger

service. When a PC is connected to a network and the user is having a conversation, the scent generator transmits the information of the scent generator to the user in the form listed on table 6 and the scent generator is made to register its odor as the form of the emoticon to the other user's chatting window.

We used the graphical emoticon with text for odor description and the labeling of smells. Table 8 shows the used graphical emoticon

Table 8. Odor description ICON used in odor-messenger

Emoticon	Odor description	Labeling
☺	Aroma like flower	Rose
		lavender
😊	Sensual Odor	mint
😋	Appetizing Odor	strawberry
		orange
		coffee
😬	Malicious Odor	putrid

The user has only to type any word and click the emoticon on the left to choose the odor. Fig. 5(a) shows how to choose the odor, and (b) shows the written words and the emoticon. If we click “send”, the user’s computer transmits the user request information to the scent generator’s computer in the form listed on table 8 and the scent generator’s computer shows the text and generates the odor.

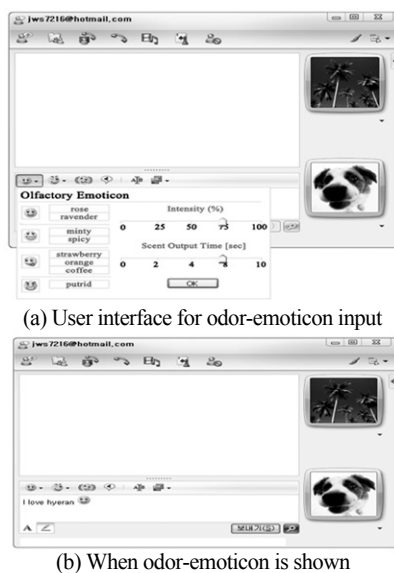


Fig. 5. Odor-messenger program and system structure.

#### 4. CONCLUSIONS & DISCUSSIONS

Recently, people started to become concerned about olfactory display. Odor augments the effect of pre-existing senses and can provide a stronger recalling effect than the current existing media. It can also provide tacit warning messages.

Research in odor transmission as multimedia information needs a standard interface for both odor transmission and scent generating devices. But until now, such a user interface for olfactory like that of vision or auditory is not presented. Olfactory is controlled by a complex chemical composition unlike vision and auditory, and human precepts with emotion and feelings, therefore it is difficult to convert such information into data. In this paper, we proposed an olfactory information presentation method, which is a way to use smell as multimedia information, and show an application for scent generation and odor display using a web service

Necessary reference guidelines that need to be referred in odor usage were presented. We presented the required presentation method when composing an olfactory user interface with these reference guidelines so it could be used in future olfactory user interface technology.

In the near future, olfactory display technology will accelerate the new computing environment and related industries. Especially, olfactory technology in MPEG(Moving Picture Export Group) will lead its application in areas like broadcasting/education, military/sports training and e-learning. Also, the development of olfactory presentation technology will enlarge current virtual reality and augmented reality techniques.

Due to this ripple effect, an olfactory display for the user interface method and a convenient editing model should be presented. We anticipate that the reference guideline for olfactory user interface, as well as required elements and methods for olfactory data presentation be used as a standard reference method with regards to a standardized olfactory user interface.

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