

Sensory Effect Representation for Barrier-free Broadcasting Service

Ji Hoon Choi*, Chung Hyun AHN*, Jeongil Seo*, Ohseok Kwon**

*Realistic Media Research Department, ETRI(Electronics and Telecommunications Research Institute), Korea

**Department of Computer Science & Engineering, Chungnam National University, Korea

cjh@etri.re.kr, hyun@etri.re.kr, seoji@etri.re.kr, oskwon@cnu.ac.kr

Abstract— Realistic media broadcasting service must be for deaf-blind peoples who could not be immersed in emotion by senses of sight or hearing because the existing barrier-free broadcasting service supports just descriptive information about contents. This paper proposes an authoring, transmission, and representation method of the sensory effect metadata for the barrier-free broadcasting service. Finally, this paper explains the test result and the feasibility of sensory effect representation devices.

Keywords— realistic broadcasting, barrier-free broadcasting, sensory effect, scent blending, MPEG-V

I. INTRODUCTION

With the emergence of realistic broadcasting services such as a high-quality audio/video (AV)-oriented UHD and a panoramic broadcasting service, Realistic media broadcasting has recently been considered as a type of next-generation broadcasting. Realistic media broadcasting augments immersion and reality by providing users with a sensory effect representation of information matched and synchronized using AV.

The multimedia-related international standards organization, Moving Picture Experts Group (MPEG), has created a family of standards used for coding audio-visual information in a digital compressed format such as MPEG-1, MPEG-2, MPEG-4, MPEG-7, MPEG-21, and MPEG-V. The MPEG-V standard (ISO/IEC 23005) provides the architecture and metadata for the interaction and interoperability between virtual worlds and the real world through various sensors and actuators [3]-[5].

The aim of this paper is to provide an overview of the barrier-free emotion broadcasting system interworking with sensory effect representation devices, particularly regarding the representation and verification of a blended scent. This paper is organized as follows. In section II, we describe the proposed barrier-free emotion broadcasting system and sensory effect representation devices. In section III, we show the representation and verification result of sensory effect representation devices. Finally, we summarize our paper and provide some concluding remarks in section IV.

II. BARRIER-FREE EMOTION BROADCASTING SYSTEM

The authoring tool creates sensory effect metadata synchronized with the AV. The transmission server multiplexes a broadcasting content and a sensory effect metadata. A broadcasting program is broadcast with synchronized sensory

effect metadata to the barrier-free broadcasting terminal and the sensory effect representation device. When users want to view the barrier-free emotion broadcasting service, they can feel augmented emotion without senses of sight or hearing by using sensory effect representation devices.

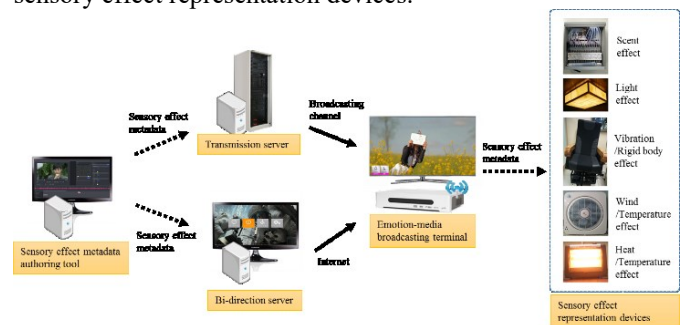


Figure 1. The conceptual diagram of the barrier-free emotion broadcasting service

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A. Sensory Effect Metadata Authoring Tool

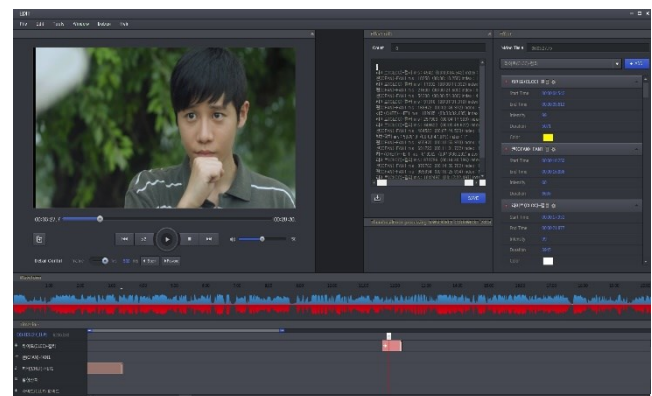


Figure 2. Main view of sensory effect metadata authoring tool

The sensory effect metadata authoring tool has main functions as follows [6]:

- a template-based GUI
- a random access play through shot boundary detection,
- a timeline visualization per sensory effect

- the generation of metadata on 16 sensory effects based on MPEG-V[3]-[5]
- the representation of the verification of sensory effect metadata interworking with the sensory effect representation devices[3]-[5]
- the generation of single file format designed to store and manage the AV and sensory effect metadata based on the MPEG-A (ISO/IEC 23000) part-9 DMB-AF file format[6]

B. Transmission Scheme of Sensory Effect Metadata

When a broadcasting stream is provided to a terminal interworking with sensory effect devices, the barrier-free terminal may determine whether to activate the sensory effect representation devices by the emotion broadcasting descriptor.

Table 1 shows the syntax of an emotion broadcasting(EB) descriptor including general descriptor fields and emotion_service_type. More specifically, the emotion_service_type defines the types of emotion broadcasting service interworking with the sensory effect representation devices. The EB descriptor is located in a program map table (PMT) of the program specific information (PSI) in MPEG-2 TS and a virtual channel table (VCT) or the event information tables (EITs) of the program and system information protocol (PSIP).

TABLE 1. EMOTION BROADCASTING DESCRIPTOR SYNTAX.

Syntax	Semantics
EB_descriptor(){	
descriptor_tag	descriptor identifier
descriptor_length	descriptor length
reserved	
emotion_service_type	service type
}	

Table 2 shows a section of sensory metadata. The sensory effect metadata is transmitted to the barrier-free broadcasting terminal because they are a type of temporal event data synchronized with the AV. If emotion_service_type is '1', the SEM_byte is a URL of the SEM-byte in Table 2.

TABLE 2. SENSORY EFFECT METADATA SECTION.

Syntax	Semantics
EB_section(){	
table_id	
section_syntax_indicator	
private_indicator	
reserved	
EB_section_length	
if(section_syntax_indicator = '0'){	
for(i=0; i<N; i++){	
SEM_byte	Sensory effect metadata
}	
}	
else {	
table_id_extension	
reserved	

version_number	
current_next_indicator	
section_number	
last_section_number	
for(i=0; i<EB_section_length-9; i++){	
SEM_byte	Sensory effect metadata
CRC-32	
}	

C. Barrier-free Broadcasting Terminal

The barrier-free broadcasting terminal has a device control module and sensory effect metadata-parsing module for deaf-blind peoples who could not be immersed in emotion by senses of sight or hearing.

In Fig. 3, the barrier-free broadcasting terminal consists of the control module, the sensing module, the sensory effect metadata module, and the legacy DTV module.

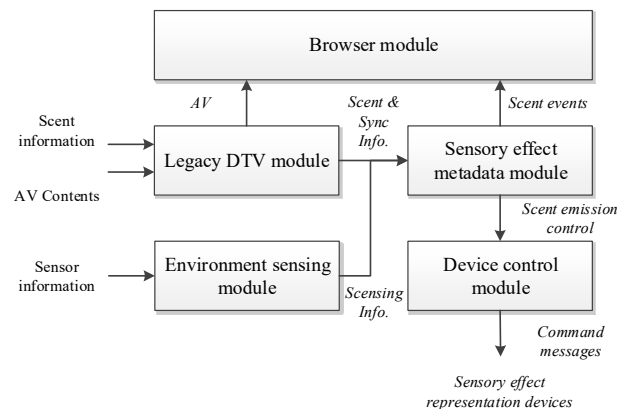


Figure 3. Structure of the barrier-free broadcasting terminal

Especially, the sensory effect metadata module generates a control message for a sensory effect representation synchronized with the AV after receiving the sensory effect metadata and the illuminance/humidity/temperature sensing information [7].

The barrier-free broadcasting terminal receives the EB_descriptor contained in the PMT or PSIP to activate the sensory effect representation devices by the emotion broadcasting descriptor. If the barrier-free broadcasting service for deaf-blind peoples is currently operating, the barrier-free broadcasting terminal connects to the sensory effect representation devices, and receives the status and capability information of the sensory effect representation device.

The barrier-free broadcasting terminal receives the sensory effect metadata of the EB_section data on the received TS and bi-direction server. The sensory effect metadata module parses the sensory effect metadata and transfers them from the sensory effect metadata module to the device control module to be synchronized with the AV in terms of time.

D. Sensory Effect Representation Devices

In this paper, we designed and implemented five sensory effect representation devices to verify the sensory effect metadata defined by MPEG-V, which are a motion chair to verify the rigid body motion and the vibration effect, the lighting device to verify the lighting and flash effects, a heater device to verify the temperature effect, a fan device to verify the wind and temperature effects, and a scent display device to verify the blended scent effect.

The sensory effect representation devices receive a device control message from the sensory effect metadata module of the terminal, and send an ACK message to the terminal after checking for errors in the sensory effect metadata. The sensory effect representation devices then operate according to the sensory effect metadata synchronized with the AV.

Table 3 shows the structure of the common device control message [7].

TABLE 3. FIELD DEFINITION OF COMMON DEVICE CONTROL MESSAGE.

Field of msg.	Definition	Value	Bytes
STX	Start of text	'0x02'	1
Device_name	Device type defined on MPEV-V	ASCII	10
Device_number	Device number of same device type	ASCII	2
Device_command	Command set	ASCII	2+5xN
ETX	End of text	'0x03'	1

The device command of Table 4 is designed to send different sensory effect metadata for each sensory effect representation device. On the other hand, the device command of Table 5 is designed solely for scent blending.

TABLE 4. DEVICE COMMAND STRUCTURE FOR SENSORY EFFECT REPRESENTATION DEVICE.

Syntax	Bytes	Notes
Device_command byte() {		
command_type	4	ASCII
intensity	3	ASCII
duration	5	ASCII
}		

TABLE 5. DEVICE COMMAND STRUCTURE FOR SCENT DISPLAY DEVICE

Syntax	Bytes	Notes
Device_command byte() {		
number_of_commands	1	ASCII
for(i=0;i<number_of_commands;i++){		
command_type	1	ASCII
scent_tag	1	ASCII
intensity	3	ASCII
duration	5	ASCII
}		
blower_speed	1	ASCII
}		

Figure 4 shows an emotion broadcasting service using the color light device, the fan device, the heat device, the emotion chair and the scent display device synchronized with the AV.



Figure 4. Sensory effect representation devices synchronized with AV

1) Augmented touch sense with moving, wind, vibration, and heat effect information: The designed and implemented emotion chair operates by using rigid body effect metadata. The emotion chair provides movement with up to six degrees of freedom using a three-axis motor and a linear controller. In addition, there are four vibration oscillators (2 x 2) to generate 3D vibration to the back of the motion chair. The motion chair can therefore express the pitch and left/right direction of the sound in a 2 x 2 spatial arrangement to augment the insensitive vibration sense in comparison with the auditory sense.

2) Augmented sight sense with light effect information: The light device represents the true color using a three-color LED (RGB) and a white LED after receiving the color, the brightness, and the luminous pattern information from the barrier-free broadcasting terminal. In addition, the light device represents a similar color sense synchronized with the video by using the color temperature and brightness.

3) Augmented smell sense with scent effect information: The scent display device had 20 scent cartridges, as shown in Table 6, and control the scent persistency and intensity with two pumps. More specifically, it is possible to control the scent persistency and intensity according to the regulation of an air flow of each pump. Moreover, the scent persistency is determined according to the operation time of the solenoid valves on the scent cartridges. Because a blended scent is made by mixing different scents, the scent display device can control the intensity and persistence for each scent source by adjusting the duty cycles of the flow rate width modulation [8]-[10].

TABLE 6. TABLE 6. LIST OF SCENT CARTRIDGES OF SCENT DISPLAY.

1	Curry	6	Butter	11	Aqua	16	Lavender
2	Musk	7	Apple	12	Orange	17	Hospital
3	Rose	8	Grape	13	Lemon	18	Jasmine
4	Aqua	9	Garlic	14	Banana	19	Charcoal
5	Olive	10	Lilac	15	Acacia	20	Cypress

It is impossible to provide all scents in the real world in a broadcasting environment because the scent display device is too small to have every kind of scent, and the user's preference may differ for various types of broadcasting content.

Therefore, we believe the most important aspect for the representation of scents is how many kinds of scents that be provided to viewers using the limited number of scents available in the scent display device.

In this paper, we designed and implemented a scent display device for scent blending and an electronic nose for feasibility

verification of the blended scent mixed by the scent display device.

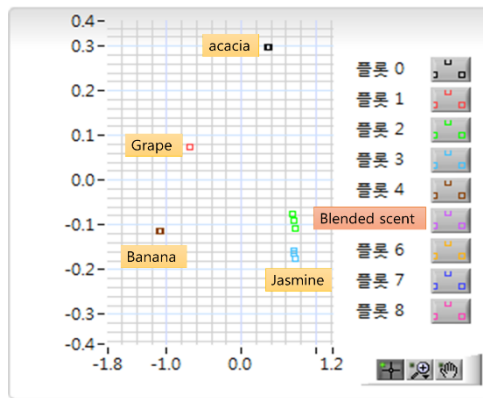


Figure 5. PCA result of scent blending

We blend acacia (5%), grape (5%), lilac (5%), and jasmine (80%) scents using the implemented scent display device. Therefore, the results of a principle component analysis (PCA) show that the blended scent data group is almost located among the four data groups in Fig. 5. This means that the blended scent is similar to jasmine chemically. However, the blended scent is not similar to jasmine when smelled with a human nose.

As a result, we tested the blended scent using the scent display device to mix 20 scents depending on the ratio and combination.

III. CONCLUSIONS

In conclusion, we designed a realistic media broadcasting system and sensory effect representation devices to augment emotion of deaf-blind peoples. In addition, we simulated the sensory effect representation devices with the sensory effect metadata authoring tool and showed results of implementation for the barrier-free emotion broadcasting service.

Realistic broadcasting has gone beyond classic viewing and the constrained UI/UX of current DTV, and aims at realistic broadcasting combining the five human senses. The realistic media broadcasting as a new barrier-free broadcasting service for deaf-blind peoples is used to broadcast enhanced content interworking with sensory effect representation devices, whereas UHD and panoramic TV are sight-hearing-oriented broadcasting services.

In the near future, the realistic DTV broadcasting augmenting the five human senses will be activated by verifying the feasibility and backward compatibility.

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Emotional UI/UX"). His research interests are Smart TV, IPTV, and DMB.

Ji Hoon Choi received the B.S and the M.S degrees in electronic engineering from Kyunghee University, Suwon, Korea, in 1999 and in 2001, respectively. In 2001, he joined the Realistic Broadcasting Media Research Department in ETRI(Electronics and Telecommunications Research Institute, Daejeon, Korea, where he have been working on the project("Development of Broadcasting System based on Personalized



broadcasting services and new broadcasting services for disabled people.

Chung Hyun AHN received his PhD degree in GIS/RS from Chiba University, Japan, in 1995 and worked as a member of the research and teaching staff at Chiba University. He has been working at ETRI since 1996, leading many projects in GIS/RS (1996-2000) and digital broadcasting areas (2001-present). He was the leader of the Next Broadcasting Service Planning Team. Currently, his major research focus is emotion-based



Institute (ETRI), Daejeon, Korea, since 2000. His research activities include image processing, audio processing, multi-modal user interface, and realistic broadcasting systems.

Jeongil Seo received the Ph.D. degree in electronics from Kyungpook National University (KNU), Daegu, Korea, in 2005 for his work on audio signal processing systems. He was worked as a member of engineering staff at the Laboratory of Semiconductor, LG-semicon, Cheongju, Korea, from 1998 until 2000. He has worked as a director at the Immersive Media Research Section,



Ohseok Kwon received his BS degree in Electronics Engineering from Seoul National University, Seoul, Korea in 1977 and the MS in Electrical Engineering from Korea Advanced Institute of Science Technology, Daejeon, Korea in 1980. Since 1980, he has been a professor in the Department of Computer Engineering at Chungnam National University, Daejeon, Korea. His research interests include embedded system, pattern recognition and intelligent information system.