SENSORY EFFECT DATASET AND TEST SETUPS

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ABSTRACT

Additional constituents for the representation of multimedia content gained more and more attention. For example, the amount of cinemas equipped with additional devices (e.g., ambient light, vibrating seats, wind generators, water sprayers, heater/coolers) that stimulate senses going beyond audition and vision increases. On the content side the MPEG-V standard specifies – among others – Sensory Effect Metadata (SEM) which provides means to describe sensory effects such as wind, vibration, light, etc. to be attached to audio-visual content and, thus, offering an enhanced and immersive experience for the user. However, there is a lack of a common set of test content allowing for various subjective user studies and verification across different test sites. In this paper we provide our dataset comprising a number of videos from different genres enriched with MPEG-V compliant Sensory Effect Metadata descriptions. Furthermore, we describe possible test setups using off-the-shelf hardware for conducting subjective quality assessments.

***Index Terms*—**Sensory Experience, Sensory Effects, MPEG-V, Dataset, Test Environment

1. INTRODUCTION

Every day new multimedia content is generated, uploaded to the Internet, or provided via other means of distribution (e.g., DVD, Blu-Rays). All these distribution channels and content generation methods have in common that they only stimulate the human visual and/or hearing senses. Recently, new research areas for stimulating additional senses like olfaction, mechanoreception, or thermoreception have emerged [1][2].

Due to this recent development, the Motion Picture Experts Group (MPEG) introduced the MPEG-V standard [3]. This standard provides means for connecting the real world with the virtual world by describing, e.g., avatars, virtual objects, and sensory effects. This work focuses on part 3 of MPEG-V referred to as Sensory Information which provides the possibility to describe sensory effects such as wind, vibration, light, temperature, etc. MPEG-V Sensory Information allows controlling devices which are capable of rendering sensory effects (e.g., fans, vibrations chairs, lamps, air conditioners) through a media processing engine (e.g., set-top-box) which supports MPEG-V. The overall goal is increasing the Quality of Experience (QoE) by providing users an immersive viewing experience.

As MPEG-V is a fairly new standard there is the lack of datasets providing multimedia data enriched with SEM descriptions. In particular, most datasets lack the necessary length for testing sensory effects or do not contain suitable content. For example, many sequences are showing only in-door scenes where vibration, wind, etc. are not appropriate.

Therefore, in this paper we provide a dataset comprising audio-visual sequences of different length, resolution, and bit-rate annotated with SEM descriptions including wind and vibration effects. Please note that they have been used in previous subjective quality assessments, i.e., for testing the benefits of sensory effect [4] or the influence of sensory effects on the perceived video quality [5].

The remainder of the paper is organized as follows. Section 2 describes related work. Section 3 provides details about the actual dataset and its usage. A proposal for test environments using different configurations of devices is given in Section 4. Section 5 concludes the paper including future work items.

2. RELATED WORK

Sensory effects and MPEG-V are research areas which are taken up by many researchers. For example, there is ongoing research on the impact of olfaction on multimedia [2][6]. In [2] an overview of various olfactory devices and future research areas are given. From the same authors a user study with olfaction has been conducted and is presented in [7]. The study evaluates when a scent has to be rendered to be well perceived with videos. A new olfactory display is presented in [6] which is based on ink-jet technology.

Besides olfaction, there is ongoing research on the impact of light on the video experience [1][8] and on using MPEG-V for broadcasting [9]. Furthermore, the concept of Single Media Multiple Devices (SMMD) has been introduced in [10]. Finally, MPEG-V can also be used in haptic research, e.g., for controlling appropriate devices such as the haptic vest presented in [11].

As one can see MPEG-V provides many application areas for which subjective quality assessments have been conducted or need to be conducted. There are already numerous datasets available such as Xiph.org [12] or TrecVid [13]. The problem with these datasets is that their focus is mainly on visual quality, coding performance, or retrieval and search. Additionally, many datasets only provide low resolution content (e.g., below 720p). Recently, Xiph.org offers high quality creative-commons movies, e.g., Sintel, Big Buck Bunny, or Elephants Dream, which resolve this issue of missing high resolution content.

3. SENSORY EFFECT DATASET

3.1 Sensory Effect Dataset

During the research on enhancing the QoE with sensory effects we discovered that most of the existing datasets do not provide suitable video content for performing evaluations of multimedia content enriched with sensory effects. For example, the default test sequences used for video quality evaluation (e.g., foreman, mobile) cannot be enriched with additional effects as they are too short and/or difficult to annotate due to the lack of appropriate effects such as vibration or wind.

Therefore, we collected in total 76 video sequences from different genres, i.e., 38 action (cf. Table 1), 12 documentary (cf. Table 2), 8 sports (cf. Table 3), 5 news (cf. Table 4), and 13 commercial (cf. Table 5) sequences, and enriched them with sensory effects (i.e., wind, vibration and light). For selecting the video sequences, we mainly evaluated them based on their content, e.g., fast or slow motion, availability of scenes that can be annotated with sensory effects (i.e., wind, vibration), and possible impact on the viewer's emotional states (i.e., fiction vs. reality). Furthermore, we selected video sequences from different genres for evaluating the impact of sensory effects on the five major genres (i.e., action, sports, commercial, news, and documentary) available on television or in cinemas.

The tables show the name of the sequence, their resolution (incl. frames per second), bit-rate, and length. Furthermore, the tables present the number of annotated vibration and wind effects which are available via SEM descriptions. Please note that light effects are not provided within the SEM descriptions as they can be easily calculated automatically [14][15]. Only the trigger for the media processing engine for automatic color calculation is given via the SEM descriptions. It has to be mentioned that the different bit-rates and lengths result either from recommended lengths by the ITU [16][17] and from different evaluation scenarios (i.e., watching content on a television or computer, or consuming content through Web sites).

The SEM descriptions are authored with our open-source *Sensory Effect Video Annotation (SEVino)* tool which can be downloaded from the *Sensory Experience Lab (SELab)* Web site [18]. Figure 1 shows a screenshot of *SEVino* with a loaded video file (upper part of the figure) and annotated effects (lower part of the figure). For a more detailed description of *SEVino* the interested reader is referred to [14]. The SEM descriptions generated by *SEVino* are compliant to part 3 of the MPEG-V standard. Note that the annotation of wind and vibration effects was performed internally on a subjective basis. Thus, we discussed which effect with which parameter is suitable for what sequence/scene.

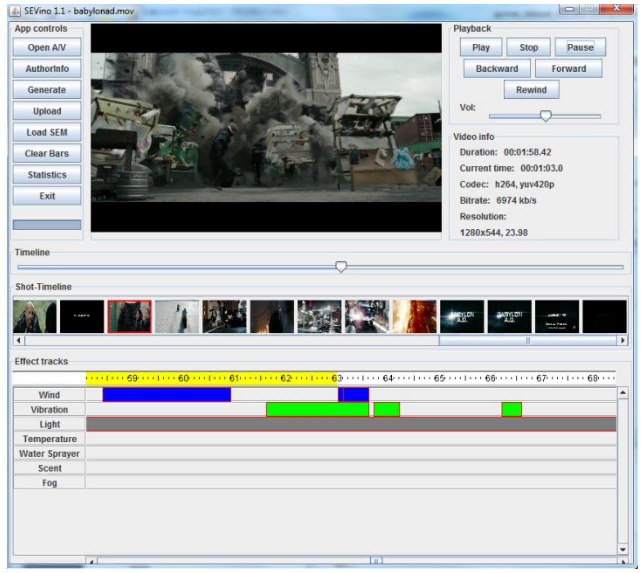

Figure 1. Sensory Effect Video Annotation (SEVino).

After the selection and annotation of the video sequences we performed an internal review of the sequences and refined the effects if necessary. Afterwards, the annotated sequences were presented to people not involved in this research area to retrieve their feedback. After refining the sequences using their feedback we finally added the sequences with their SEM descriptions to the dataset.

Some sequences appear more than once in the dataset due to their usage within different user studies. For example, *Babylon A.D.* is available in different resolutions used in Web-based tests [15] and it has different bit-rates for evaluating the impact of sensory effects on the perceived video quality [5].

Our dataset has the advantage that it already provides SEM descriptions for a number of sequences from different genres. Thus, the time consuming procedure of generating the SEM descriptions can be omitted. Furthermore, there are already studies using most of the sequences from the dataset [4][5][15] and, thus, they can be used for comparing results.

The entire dataset is available per request on the *SELab* Web site [18].

3.2 Sensory Effect Dataset Usage

The sensory effect dataset can be used both for conducting traditional video quality assessments based on different

Table 1. Sequences of the Action Genre.

Name	Resolution (WxH@FPS)	Bit-rate (kbit/s)	Length (sec)	Wind/ Vibration	Name	Resolution (WxH@FPS)	Bit-rate (kbit/s)	Length (sec)	Wind/ Vibration
2012	1280x720@25	2186	29.10	6/8	CSI	1024x576@25	8000	135	14/6
A Chinese Ghost Story	624x336@25	1084	63.00	13/11	Fast & Furious	1280x544@60	7935	8.25	1/4
After Life	960x528@25	2042	117.16	18/4		1280x544@60	7445	11.77	4/1
Alien	640x464@25	720	62	8/5		1280x544@24	6055	129.17	19/13
Alien Resurrection	640x360@24	1807	85	10/4		1280x544@60	5779	6.83	5/1
Babylon A.D.	1920x816@24	8585	125	20/13	Fringe	1280x720@25	2369	49.58	10/2
	1280x544@24	7884	6.34	2/3	Indiana Jones 4	1280x544@60	8235	6.55	1/1
	1280x544@24	6975	118.42	20/13		1280x544@60	7810	10.5	5/2
	1280x544@24	6717	7.84	3/2		1280x544@24	5688	112	16/7
	1280x544@24	6316	34.5	8/9		1280x544@60	5478	8.08	1/1
	1280x544@24	6259	7.97	2/2	Iron Man 2	1280x720@30	2190	30.09	15/8
	1280x544@24	4045	34.5	8/9	Ken Ishii	1280x720@25	2506	228.96	16/6
	1280x544@24	3112	34.5	8/9	Kick Ass Trailer	1280x720@30	2114	20.09	5/1
	1280x544@25	2800	24.92	5/3	Password Swordfish	640x272@24	1373	37.04	4/3
	1280x544@24	2154	34.5	8/9	Pirates of the Caribbean	640x272@25	960	47.04	10/1
	1280x544@24	2148	28.18	4/3	Prince of Persia	1280x534@24	2031	24.89	7/6
	960x528@25	2725	23.95	5/3	Rambo 4	1280x544@24	6486	58.1	3/7
Big Buck Bunny	960x528@25	2110	25.31	5/2	Transporter 3	1280x544@24	7082	125.14	33/21
Centurio	640x272@25	866	129.57	37/4	Tron Legacy	1280x720@25	2379	25.08	7/4

Table 2. Sequences of the Documentary Genre.

Name	Resolution (WxH@FPS)	Bit-rate (kbit/s)	Length (sec)	Wind/ Vibration
African Cats	1280x720@24	2562	19.1	6/1
Earth	1280x720@25	7070	66	24/1
	1280x720@25	6701	21.38	8/1
	1280x720@25	4116	21.38	8/1
	1280x720@25	3171	21.38	8/1
	1280x720@25	2205	21.38	8/1
	960x528@25	2321	21.24	9/1
Expeditionen ins Tierreich Serengeti	1280x720@25	2856	31.04	1/28
The Last Lions	1280x720@30	1850	37.04	25/6
The Last Mountain	1280x720@24	3167	30.04	14/4
The Volcano That Stopped Britain	1280x720@25	2133	33.1	10/4
Tornado Alley	1280x720@24	968	35.04	9/2

Table 4. Sequences of the News Genre.

Name	Resolution (WxH@FPS)	Bit-rate (kbit/s)	Length (sec)	Wind/ Vibration
Etna erupts	1280x720@25	3165	40.07	19/13
Japan Earthquake	1280x720@30	3090	33.1	5/14
STS131 Launch	1280x720@30	2812	30.09	7/5
Tornado	1280x720@30	1299	31.03	4/12
ZIB Flash	1024x576@30	8021	83.05	5/1

qualities and for evaluating the impact of sensory effects on different conditions (e.g., emotions, perceived video quality, QoE). For evaluating sensory effects additional devices (e.g., lamps, vibration chairs, or fans) are mandatory to render the corresponding sensory effect (i.e., light, wind, or vibration).

As the dataset is based on the MPEG-V standard it can be used with any device or software supporting MPEG-V. Thus, the video sequence is loaded in a video player together with the corresponding SEM description to receive an enhanced viewing experience. Available players and tools are, for example, the *Sensory Effect Media Player (SEMP) [4]* and *AmbientLib [15]* which can process SEM descriptions and render them on devices such as the *amBX system [19]*. These tools are freely available through the SELab Web site.

Table 3. Sequences of the Sports Genre.

Name	Resolution (WxH@FPS)	Bit-rate (kbit/s)	Length (sec)	Wind/ Vibration
Formula 1	1280x720@25	5527	116.2	41/4
Formula 1 Malaysia 1	1280x720@30	2745	35.03	9/4
Formula 1 Malaysia 2	1280x720@30	2650	30.04	8/3
Freefly Jump	1280x720@30	1954	32.08	6/11
GoPro HD Berrecloth	1280x720@24	3552	32.08	11/23
GoPro HD Ronnie Renner	1280x720@30	2445	23.16	7/7
Red Bull Air Race	1280x720@30	2319	36.05	10/1
Travis Pastranas	1280x720@30	2619	32.08	8/8

Table 5. Sequences of the Commercial Genre.

Name	Resolution (WxH@FPS)	Bit-rate (kbit/s)	Length (sec)	Wind/ Vibration
Active O2	1280x720@25	3002	35.4	23/3
Audi	1280x720@30	2245	30.19	9/5
Audi 2	1280x720@25	1579	33.28	6/5
Bridgestone Carma	1280x720@30	2421	31.25	14/4
BYU	1280x720@25	2522	30.07	6/2
BYU Commercial	960x528@25	2475	23.41	5/2
Dirt 2	1280x720@25	2388	52.06	22/15
GoPro HD Thunderhill Racing	1280x720@30	2429	30.09	8/3
Jeep Grand Cherokee	1280x720@24	1294	31.99	2/7
Old Spice	1280x720@30	2201	32.07	6/1
Starcraft 2	1280x720@25	1854	43.73	12/2
Verizon	1280x720@24	1819	30.15	4/4
Wo ist Klaus?	1024x576@30	4534	59.16	12/4

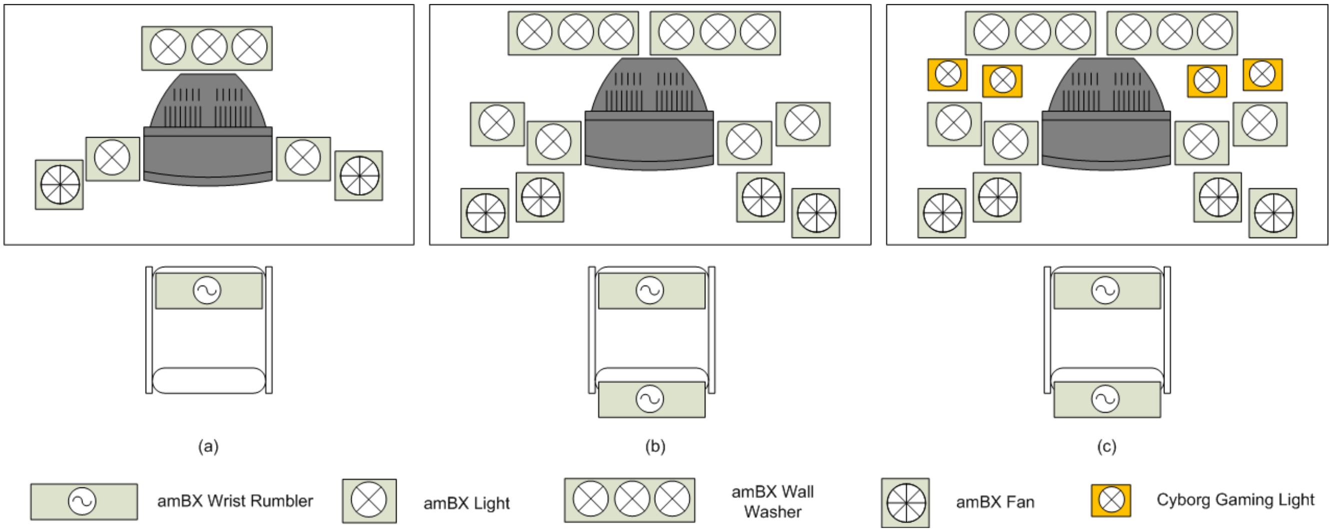

Figure 2. Different Test Setups: (a) One amBX Set; (b) Two amBX Sets; (c) Two amBX Sets and Two Cyborg Gaming Lights.

4. TEST ENVIRONMENTS

For evaluating the introduced dataset (cf. Section 3) we conducted some subjective tests (i.e., [4][5][15]). As we saw that there are some important parameters (e.g., setup of sensory devices) which should prevail during such tests, we present in this section different test setups we used for our subjective quality assessments and/or we find most suitable for conducting subjective quality assessments of sensory effects. The setup of the test environment (i.e., location) is mainly based on standardized procedures such as the ITU-T Recommendation P.910 [16] or ITU-R Recommendation BT.500-11 [17]. Furthermore, we also based the setup on the paper from Storms et al. [20] which describes in detail a test setup for a subjective quality assessment. Note that most of the video sequences from the presented dataset (cf. Section 3) have been tested with the suggested setups.

4.1 Location

All sessions of the experiment should be conducted in an isolated room under the same ambient conditions (e.g., lighting). Before each session the following conditions should prevail:

- All nonessential electronic equipment is turned off (e.g., monitors and PCs not needed for the test, mobile phones etc.).
- Windows are closed and covered with translucent blankets or other material reducing the lighting (e.g., blinds). Furthermore, all overhead lights are turned off, if necessary or desired, a ceil flooder can be used to generate a pleasant atmosphere.
- The entry door to the room is closed and a “Do not disturb” sign is placed on the outside of the door.

4.2 Test Setup

Figure 2 depicts three different test setups with a different number of available devices. Currently, these setups only focus on the amBX system [19] and on the Cyborg Gaming Lights [21] but can be extended by further devices, e.g., perfumers such as [22] and [23]. The setup for one amBX system consists of 2 fans, 2 light-speakers, a wall washer (i.e., controller unit with three integrated lights that project light on the wall behind the screen), a wrist rumbler, and a subwoofer. Note that the amBX system is designed for gaming purposes. Thus, the wrist rumbler is normally placed in front of the keyboard and the user puts his/her wrists on it during gaming. The setup using one amBX system is illustrated in Figure 2 (a). For a better experience of the vibrations from the wrist rumbler it is advisable to instruct the participant to put it on his/her thighs. Another possibility would be to mount the wrist rumbler on the seat which requires additional manual skills.

Figure 2 (b) presents a test setup with two amBX systems. In this case the additional devices are positioned in pairs (e.g., putting both left fans together). Furthermore, the additional wrist rumbler can be left out or mounted additionally to the chair. For the latter it is suggested to mount the first wrist rumbler under the seat and the second wrist rumbler on the backrest of the seat.

The third test setup, shown in Figure 2 (c), consists of two amBX systems and additionally two sets of Cyborg Gaming Lights. As the Cyborg Gaming Lights are very light intense it is suggested to position them either behind or beside all other devices or at least behind the amBX light-speakers (cf. Figure 3) and direct the light onto the wall. Depending on the size of the room the lights can be positioned to flood only the wall directly behind the monitor or to flood also other parts of the wall (e.g., ceiling, side walls). This setup has the major advantage of having a broad light field on the sides and background of the display instead

Figure 3. Test Setup with Two amBX Sets and Two Cyborg Gaming Lights.

Figure 4. Test Setup with a Control Station (Foreground) and the Actual Test Computer (Background).

of only having two small lights on the left and right of the display. Furthermore, the colors of the Cyborg Gaming Lights are more light-resistant than the provided lights of the amBX system.

For all three test setups one subwoofer is placed below the table. Additional subwoofers may be used but it has to be mentioned that a subwoofer may amplify the vibration effect depending on the volume. Furthermore, the wall washer(s) should be placed behind the monitor in such a way that the participant is able to see the emitted light behind the monitor. Thus, it is advisable to elevate the wall washer(s), which is/are placed behind the monitor, as it is depicted in Figure 4.

Depending on the method of the subjective quality assessment the assessment initiator is advised to use a control station and an actual test computer. The control station is used to start the tests and handle errors that may occur during the assessment or for providing a visual feedback (e.g., the video currently played) for the initiator. The test computer is used for conducting the test and for retrieving results. Figure 4 depicts an example of such a setup where the control station can be found in the foreground for starting and error handling. The test computer for showing the videos with the connected amBX system can be seen in the background.

4.3 Evaluation

The evaluation of the different test setups as presented earlier has been done both internally and through subjective quality assessments.

During our previous subjective quality assessments [4][5][15] we only used a single amBX system (cf. Figure 2 (a)). The assessments were planned for only a single amBX device and, thus, we omitted the usage of additional devices. Furthermore, the evaluations were the first one of this kind. Figure 4 depicts one of our test setups used during our subjective quality assessments.

The other two test setups (i.e., Figure 2 (b) and (c)) using multiple amBX systems and additional sets of Cyborg Gaming Lights were based on the previous configuration. We started by duplicating the amBX system and, thus, one can see that the positions of the two amBX systems are nearly identical. For the third setup (cf. Figure 2 (c)) we extended the second one with two sets of Cyborg Gaming Lights and evaluated the increased lighting for multimedia content.

For using these setups in subjective quality assessments one has to take the newly added sensory effects into account. Standard evaluation methods specified by the ITU are based on audio/video quality evaluations only. Thus, in the following we describe the procedure of preparing and evaluating a subjective quality assessment for sensory effects.

First, one has to decide what he/she wants to evaluate and, thus, selecting a suitable standard evaluation method (e.g., *Degradation Category Rating (DCR)* [16]) is necessary. We are not suggesting a specific method for performing the evaluation as this is still under investigation but existing evaluation methods can be used with minor modifications. Standard evaluation methods usually come with a five-level impairment scale which – depending on the evaluation scenario (e.g., comparing a video without sensory effects to the same video with sensory effects for evaluating the impact on the viewing experience) – needs to be transformed into a five-level enhancement scale, i.e., very annoying, annoying, imperceptible, little enhancement, and big enhancement. For example, if one wants to evaluate the enhancement of the QoE one can ask the participants to rate the enhancement of the video sequence with sensory effects compared to the sequence without sensory effects using the five-level enhancement scale.

The assessment itself can be conducted the same way as defined for the standard assessment methods. Also, the evaluation of the results can be performed as usual. The only difference is that now the evaluations are performed on the enhancement of sensory effects rather than on the impairment of the video quality, e.g., through video compression algorithms. It is also possible to conduct significance analyses such as the Student's *t*-test but with respect to the interpretation of the results. Instead of having significant differences between the video quality of the original video and the processed video, we have now significant differences in the enhancement of the viewing experience between videos without and with sensory effects.

5. CONCLUSIONS AND FUTURE WORK

In this paper we provided, to the best of our knowledge, the first MPEG-V dataset comprising different genres, lengths, bit-rates, resolutions, and – most importantly – annotated with sensory effects. Currently, the sensory effects of the dataset comprise vibration and wind while light can be generated automatically based on the actual content. Most of the sequences from the dataset have been used in previous user studies and proven to be suitable for these kinds of subjective tests.

The provided SEM descriptions have been generated with an open-source tool which is based on the most current version of the MPEG-V standard and, thus, the dataset can be used with any MPEG-V-compliant software or device.

Finally, we introduced different test environments for conducting subjective quality assessments using enriched multimedia content. With this proposal for a test environment we want to make a first step towards a common test environment for achieving comparable results throughout different subjective quality assessments possibly conducted by different laboratories.

Based on this dataset and on the suggested test environments we want to conduct further studies using multiple devices. This will comprise the setups described in this paper and additionally, test setups where the participants are surrounded by the devices (e.g., fans from behind). Furthermore, we will update the dataset in the future, like adding additional genres, movies or even sensory effects (e.g., scent) pending on the availability of such devices.

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