The Next Dimension of Video Experience: Sensory Effects

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***Abstract*—This work presents a new dimension for Quality of Experience (QoE), i.e., sensory information. Sensory information enhances the user experience by providing additional so-called sensory effects (e.g., wind, light, vibration) which are rendered together with multimedia content. Furthermore, the work describes two subjective quality assessments conducted in this area including their results.**

Keywords-Sensory Information; MPEG-V; Subjective Quality Assessments; Quality of Experience

I. Introduction

Lately, the research on Quality of Experience (QoE) is increasing rapidly. In contrast to Quality of Service (QoS), QoE emphasizes the (end-)user instead of the (end-)devices. There are many different publications in the field of QoE comprising, e.g., the definition of various dimensions for QoE [1] or the specification of a theoretical framework for QoE [2]. One dimension in this area recently gained momentum is 3D video [3].

We are currently researching a new approach which goes one step beyond 3D by adding another (new) dimension of QoE, i.e., sensory information, to multimedia content. Sensory information provides so-called sensory effects that may stimulate other senses than vision or audition, e.g., olfaction, mechanoreception, equilibrioception, or thermoception. Such sensory effects can accompany multimedia content (e.g., movies, music, text) via various distribution channels (e.g., Blu-ray Disc, Internet).

In one of our previous publications [4] we – and others [5] – proposed to annotate multimedia content with a so-called Sensory Effect Metadata (SEM) description. This description consists of effect definitions (i.e., effect type, effect intensity, effect duration, timestamps, etc.). The multimedia content is rendered on traditional devices (i.e., TV screens) and the sensory effects are played back (synchronized to the multimedia content) on devices such as fans, vibration chairs, lamps, etc. This approach is illustrated in Fig. 1. It has to be pointed out that the mentioned SEM description is currently standardized in Part 3 of MPEG-V Media Context and Control [6]. MPEG-V not only provides detailed information on how to annotate multimedia content with sensory effects it also offers descriptions for controlling devices that are able to render sensory effects (e.g., MPEG-V-capable vibration chairs). A short overview of the different parts of MPEG-V and their usage on the basis of broadcasting is presented in [7]. It is worth mentioning that sensory effects are not limited to installations, e.g., in home environments. Research investigated how sensory effects can be applied to mobile devices. For example, in [8] a mobile phone with light and vibration effects is introduced.

At this point in time our work focuses on the investigation of light, vibration and wind effects. However, there is ongoing research with multimedia content accompanied by scent effects [9]. An overview of different methods for providing scent is given in [10]. Further, [10] describes different scenarios in which scent can be used or was used in the past.

II. Evaluation of Sensory Effects

According to our knowledge, there are only few publications in the area of sensory effects. Thus, studies on the acceptance of multimedia content enriched with sensory effects are sparse. Therefore, we conducted two subjective

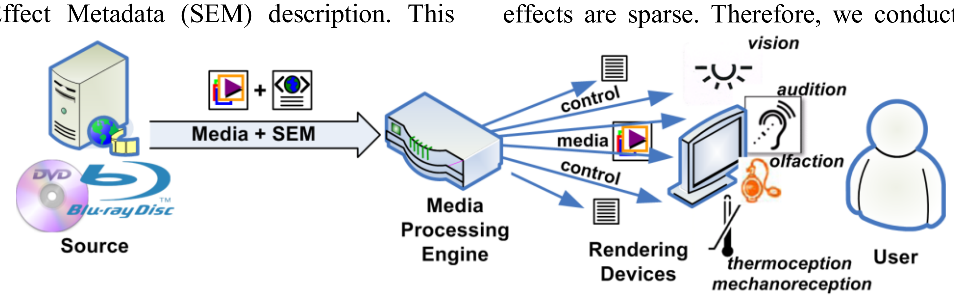

Figure 1. Concept of sensory effects [4].

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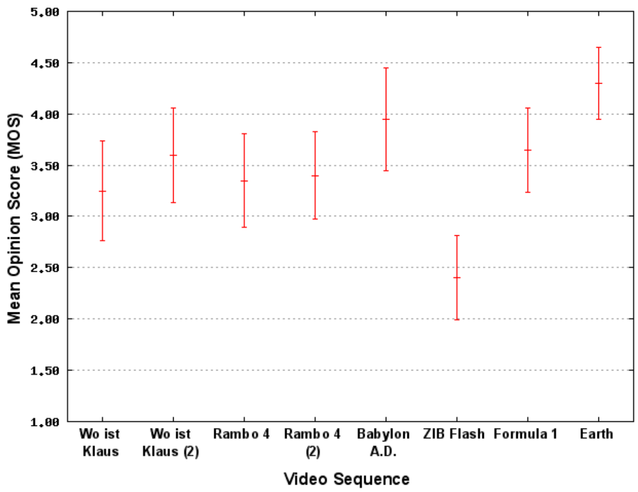

Figure 2. Mean opinion score and confidence interval [11].

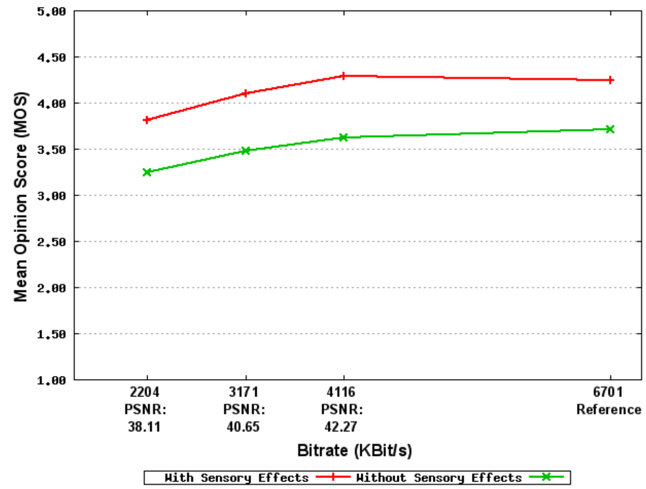

Figure 3. MOS vs. PSNR/bit-rate for the documentary sequence [12].

quality assessments in the field of sensory effects [11][12]. It should be noticed that for each of the assessments the amBX premium kit [13] was used which consists of a wall washer light with controller unit, left & right 2.1 sound speaker lights and a sub woofer, a pair of fans, and a wrist rumbler. We used the freely available Software Development Kit (SDK) from amBX to create a multimedia player which controls these devices. The multimedia player uses the earlier mentioned SEM descriptions for handling sensory effects. Note that the player is able to automatically calculate the light effects. This is done by retrieving the currently displayed frame and splitting it into three parts (left, center and right). From each part the average color is calculated and the player sets each light of the amBX system to the corresponding color (i.e., left part of the frame is used for the left light, the center part for the wall washer and right part for the right light). Wind and vibration effects are provided via the additional SEM description. The multimedia player is described in detail in [11].

The first subjective quality assessment [11] was carried out to determine, if the usage of sensory effects leads to an enhanced, unique, and worthwhile user experience. For this assessment we invited 25 students (13 female and 12 male). For performing the evaluation we used the *Degradation Category Rating (DCR)* method as defined in ITU-T P.911 [14]. It has to be pointed out that we changed the five-level impairment scale defined in ITU-T P.911 to a five-level enhancement scale. We modified the voting scale because we wanted to evaluate the enhancement of the user experience introduced by adding additional sensory effects to a video sequence instead of evaluating the impairment of the video quality. The participants had to watch six different video sequences from different genres (i.e., action, news, commercial, documentary, and sports). Each sequence was shown once without sensory effects and once with sensory effects (i.e., wind, vibration, and light). After each paired presentation the participants had to evaluate the enhancement of the sequence enriched with sensory effects compared to the sequence without sensory effects. Furthermore, some sequences were shown twice to test the reliability of the participants. Fig. 2 illustrates the results of the first subjective quality assessment. The figure presents the mean opinion score (MOS) and the 95% confidence interval for each video sequence. The results indicate that not every genre benefits from using sensory effects. For example, sensory effects enhance the user experience for the action and documentary genre, but for news additional sensory effects are annoying due to the shown situation reports (i.e., still pictures in the background and moderator talks about the event). Moreover, the content of the video is very important for the enhancement of the user experience. For example, the action sequence *Rambo 4* is rated differently than the action sequence *Babylon A.D.* Furthermore, the results of the sequences which were presented twice differ, i.e., a video sequence presented the second time was rated higher than the sequence shown the first time. This leads to the assumption that the more often a video with sensory effects is presented the more the user experience will be enhanced. For more detailed results please see [11].

The second subjective quality assessment [12] evaluated the influence of sensory effects on the perceived video quality. For this assessment we invited 24 students (11 female and 13 male). For performing the evaluation we used the *Absolute Category Rating with Hidden Reference (ACR-HR)* method as defined in ITU-T P.910 [15]. In the ACR-HR method the participants rate each video sequence separately without knowing the reference sequence (i.e., with the highest video quality). As test sequences we used the documentary (i.e., *Earth*) and an action (i.e., *Babylon A.D.*) video from the first experiment. Instead of using the full length videos we shortened the videos to be compliant with the standardized evaluation procedure. From each video sequence we generated four videos with different bit-rates, i.e., 2Mbit/s, 3Mbit/s, 4Mbit/s and 7Mbit/s. Each participant watched 16 video sequences (eight with sensory effects and eight without sensory effects) in total. After each video sequence the participants had to rate the overall video quality ranging from excellent to bad. The results of this subjective quality assessment indicate that sensory effects can enhance the perceived video quality. Fig. 3 depicts the MOS and the four different bit-rates including the peak signal-to-noise ratios (PSNR) for the documentary video. Obviously, the MOS for each video quality presented with sensory effects is higher than for the same without sensory effects. Furthermore, we calculated the average difference between the two curves using the Bjontegaard Delta [16] method. For the documentary sequence enriched with sensory effects we received a rating which is 0.6 MOS points higher than without sensory effects. Moreover, the lowest quality with sensory effects is still higher rated than the reference quality without sensory effects. Note that for providing confident results for a wide range of sequences/genres more experiments are necessary. Though, these first results allow the assumption that storage space can be reduced by using additional sensory effects. For example, the documentary sequence with the highest quality had 17 megabytes and the lowest one had 5.6 megabytes. The SEM description accompanying the video sequence only had a few kilobytes. Thus, for this particular sequence, there is a possible storage reduction of around 67%. For more detailed results please see [12].

III. Conclusion and Future Work

This work presented an approach to enhance the QoE during the consumption of multimedia content by providing additional sensory effects such as wind, light and vibration. Furthermore, it introduced two subjective quality assessments conducted in this area and presented their results. The results of both assessments appeared promising and indicated that sensory effects can increase the user experience and the perceived video quality.

As previous research showed promising results for locally stored multimedia content we plan to investigate the impact of sensory effects on web content (e.g., YouTube videos). Further, we will work on a live test-bed for conducting user studies in the field of sensory effects on a large scale. This test-bed will enable us to perform subjective quality assessments with a larger number of participants worldwide. Furthermore, with the test-bed we expect to be able to conduct further investigations to arrive at more general conclusions about the improvement of the user's experience and the perceived video quality in combination with sensory effects. Another future work item is the evaluation of different color calculation algorithms (e.g., dominant color) for providing a better user experience. Moreover, we plan to investigate the impact of further sensory effects (i.e., olfactory effects) on the user experience.

Acknowledgment

The author thanks Prof. Hermann Hellwagner and Dr. Christian Timmerer for their guidance and support in this research. This work was supported in part by the European Commission in the context of the ALICANTE project (FP7-ICT-248652).

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