3D QUALITY IS MORE THAN JUST THE SUM OF 2D AND DEPTH

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ABSTRACT

The success of 3DTV, as one of the emerging multimedia formats, will largely depend on the quality of experience it provides to viewer when compared to conventional 2D media. Therefore reliable methods for quality assessment are crucial in order to optimize 3D systems and services. The goal of this paper is to review recent developments in 3D video quality assessment, and to discuss its future directions.

Keywords *— 3DTV, subjective quality evaluation, objective quality metrics*

1 INTRODUCTION

Recently, the interest in 3DTV, as one of the emerging multimedia formats, has remarkably increased due the rapid technological development. Furthermore, efforts have been devoted to creation of suitable 3D content, to feed this growing market. However, one of the most important factors for a sustainable success of 3DTV is that it provides an increased quality of experience (QoE) when compared to traditional 2D media formats.

One of the challenges for 3D video is that simply adding depth to a 2D video usually is not enough to create a high quality 3D video improving viewers experience, through a feeling of immersion or presence. Quite the contrary, unrealistic depth cues can almost certainly lead to eyestrain and fatigue.

The goal of this paper is to provide a high-level overview of current approaches for 3D quality assessment and to discuss some of its challenges.

2 SUBJECTIVE 3D QUALITY ASSESSMENT

Since human viewers are the final and most important judges of any 3DTV system or service, subjective tests are widely used for quality assessment or optimization. Furthermore, subjective quality scores usually serve as reference for the development and validation of objective quality metrics.

Existing methods can be grouped into psycho-perceptual and user-centered approaches [1]. Conventional *psycho-perceptual* evaluation methods examine the relation between physical stimuli and sensorial experience in a highly controlled laboratory environment. The overall quality or certain quality attributes are judged with full attention on the evaluation task. *User-centered* evaluation methods relate the quality evaluation to the use of a system or service. This is achieved by taking into account typical users, required system characteristics, potential usage scenarios context, and goal-related evaluation tasks.

2.1 Psycho-perceptual approaches

Subjective video quality evaluation according to standardized methods has a long history. Especially the methods described in ITU-R BT.500 [2] are commonly used for assessing 2D video quality. Another method, which has become quite popular, is the subjective assessment methodology for video quality (SAMVIQ) [3]. This approach is an adaptation of the DSCQS method with the direct comparison of multiple stimuli in order to provide a more reliable discrimination for low and high quality levels. However, all double and multi stimuli methods have to be considered as artificial, as in realistic scenarios, users usually do not compare different instances of a same content.

Although it has been recognized quite early [4] that suitable evaluation criteria have to be defined for 3D video, standard subjective evaluation methodologies are currently lacking. The only attempt so far has been described in ITU-T BT.1438 [5] and states that the methods from ITU-T BT.500 [2] are also applicable in 3DTV scenarios. Therefore, most of the subjective quality tests for 3D video are primarily based on the methodologies developed for 2D video.

2.2 User-centered approaches

Evaluating the quality from a user perspective rather than from a system perspective has become increasingly important in multimedia quality assessment. Several standardization bodies have started to explore possible

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methodologies for user-centered quality assessment. Although most of such efforts are directed at multimedia data in general, they may also be applied to 3DTV.

One of the promising ideas is to split *quality of experience (QoE)* into quality of service (QoS), which describes the technical quality of a system, and quality of perception (QoP) which describes the information transfer and the user satisfaction. Instead of collecting only the overall quality scores, recent studies [6] also try to identify the underlying *quality factors* based on questionnaires or interviews. In order to evaluate the quality of a multimedia system or service in a more *realistic context*, subjective quality tests are not only conducted in controlled laboratories, but also less controlled field settings [7]. For the user-centered evaluation of 3D quality, some additional aspects need to be considered. The concept of *presence* can be assessed through questionnaires or qualitative methods [8]. Viewers of 3D content may also experience symptoms like eyestrain, disorientation and fatigue, which are typical in virtual environments. This can be measured subjectively using a simulator sickness questionnaire (SSQ) [9].

3 OBJECTIVE 3D QUALITY ASSESSMENT

Since subjective quality tests are quite time consuming and cannot be used for online quality assessment, objective quality metrics are developed to predict the perceived quality of multimedia data.

Existing visual quality metrics can be split into two big families: model-based, and feature-based. Model-based metrics take the "top-down" approach by modeling the human visual perception and estimating the visibility of artifacts. Feature-based metrics estimate the quality in a "bottom-up" fashion by measuring the strength of visual artifacts through signal processing methods. Depending on the needed reference information, objective quality metrics can be further divided into three categories: full reference (FR) metrics which require an entire reference video, reduced reference (RR) which rely on some features extracted from the reference video, and no reference (NR) metrics that analyze the test video only.

A straightforward way to apply 2D quality metrics to 3D is to estimate the quality for the stereo views separately and to combine them into an overall score. While such an approach may work for impairments, which may affect both channels equally, it will fail for other cases. Besides, spatial and temporal masking effects involved in 2D and 3D vision, are also affected by binocular suppression and inter-channel relations. The *binocular suppression theory* [10] describes the masking effects between the images perceived by the different eyes and is commonly applied for asymmetric video coding. Furthermore, the overall 3D quality may not only be affected by the quality of the individual channels, but also by the image content or depth structure of the scene. 3D quality metrics are a fairly new research area and only a handful number of methods have been proposed so far. Most are based on well-established 2D metrics and try to incorporate depth information in different ways, and often they do not take into account directly, the special characteristics of 3D perception.

For the development of reliable objective quality metrics it is crucial to understand and to quantify the influence of various 3D artifacts on the perceived quality. Based on that, more accurate models of the human visual system that consider both 2D and 3D perception need to be developed. Furthermore, in order to get reliable quality estimates for a typical context the assessment should be done in realistic scenarios.

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