Introduction to the Special Issue on Measuring Quality of Experience for Advanced Media Technologies and Services

QUALITY of Experience (QoE) has been defined as "the degree of delight or annoyance of a person experiencing an application, service, or system. It results from the fulfillment of his or her expectations with respect to the utility and/or enjoyment of the application, service or system in the light of the person's personality and current state." (Qualinet White Paper on Definitions of Quality of Experience; P. Le Callet, S. Möller, and A. Perkis, eds.; version 1.2, March 2013). This implies that QoE assessment methods must take into account not only system performance parameters and content quality metrics, but also notions such as user perception, satisfaction, expectations, and context. Recent objective metrics for multimedia quality make use of natural image statistics, machine learning, distortion modeling, to name a few approaches. There is also a strong link to quality issues in communications and networking, as exemplified by recent work on QoE modeling and monitoring solutions for adaptive streaming.

Progress in technology has led to a stunning increase in the quality of multimedia content over the past few decades. Ultra-HD or 3D displays have become affordable nowadays, and high-definition streaming is quickly replacing conventional media libraries at home as well as on mobile devices. At the same time, quality considerations have become a lot more intricate, because of the added complexities in content generation, processing, distribution, and display. New developments in areas such as computational imaging or spatial sound reproduction keep adding to the list of challenges in quality measurement. Quality assessment now goes beyond a "technical" notion of quality to more holistically addressing QoE in terms of context- and user-awareness. In lab, crowdsourcing, or field tests, researchers collect ground-truth data that not only reflect QoE in terms of rating opinion, but also include the users' emotional response, physical state, and behavior.

The 16 papers in this special issue cover a wide range of topics, including subjective QoE assessment, quality of stereoscopic video and other immersive experiences, video streaming, and machine learning for QoE.

I. QoE Assessment Methods

The issue starts with exploring user study designs and quality assessment protocols, including psychophysical and physiological techniques. The first paper by Engelke et al. on "Psychophysiology-based QoE Assessment: A Survey" provides an overview of the topic, including a classification of methods relevant to QoE, and describes related psychological processes, experimental design considerations, and signal analysis techniques. It is followed by "Multimodal Physiological Quality-of-Experience Assessment of Text-to-Speech Systems" by Gupta et al., which explores the use of two neuroimaging techniques to better understand changes in neuronal activity and cerebral blood flow resulting from synthesized speech of varying quality. Radun et al. present "Did You Notice It? – How Can We Predict the Subjective Detection of Video Quality Changes from Eye Movements?" They show that detection of the degradations changes the viewing strategy from a search with short fixation to an evaluation with long fixations.

"Performance of Four Subjective Video Quality Assessment Protocols and Impact of Different Rating Pre-processing and Analysis Methods" is studied by Kumcu et al. They evaluate four different viewing and scoring protocols, namely forced choice, two ratio-scaled paired comparison methods (preference and dissimilarity), and single stimulus. In a similar vein, Krasula et al. explore the "Preference of Experience in Image Tone-Mapping: Dataset and Framework for Objective Measures Comparison". The paper studies observers' preference in two different viewing scenarios, showing that the presence of the high-dynamic-range reference can significantly influence the subjects' preferences. The authors are also making the dataset and framework publicly available.

II. Immersive Experiences

Several papers of this special issue are devoted to quality of immersive experiences. In the audio domain, spatial signal reproduction has evolved stereophonic to 3-dimensional sound. Schoeffler et al. review popular methods for subjective assessment of spatial audio in their paper on "Evaluation of Spatial/3D Audio: Basic Audio Quality vs. Quality of Experience."

Quality assessment of stereoscopic images and video is still receiving a lot of attention. The paper "Quality Index for Stereoscopic Images by Jointly Evaluating Cyclopean Amplitude and Cyclopean Phase" by Lin et al. proposes a full reference stereo image quality assessment framework based on phase congruency features, visual saliency, and binocular rivalry. Binocular vision properties are also the focus of "Stereoscopic Video Quality Assessment Using Binocular Energy" by Galkandage et al. Their paper introduces full-reference stereoscopic image and video quality metrics based on a model that considers binocular suppression and recurrent excitation. Carballeira et al. address a promising technology for better glasses-free 3D viewing with "Multiview Perceptual Disparity Model for Super Multiview Video." The model focuses on the perceived quality of comfort and smoothness in the viewpoint transitions.

"A Study of User Perception of the Quality of Video Content Rendered Inside a 3D Virtual Environment" by

Pourashraf et al. assesses the impact of resolution and frame rate of video on QoE when video is rendered inside a 3D virtual space and viewed from arbitrary perspectives. Using a mathematical model for video rate as a function of spatial and temporal resolutions, the network load can be significantly reduced with little or no perceptual impact.

III. Video Streaming

In today's complex video compression and distribution system, the quality of streaming video content is an issue of major academic and commercial concern. Using data from a large-scale field trial for a large Japanese video streaming service, Kimura et al. propose "QUVE: QoE Maximizing Framework for Video-Streaming", which uses information about rebuffering, encoding conditions, and network quality. Duanmu et al. introduce "A Quality-of-Experience Index for Streaming Video" that accounts for the effects of playback stalling events. Zupancic et al. present "Two-Pass Rate Control for Improved Quality of Experience in UHDTV Delivery," which is tested on UHDTV content and improves over traditional rate-control algorithms.

In the paper "Closing the Gap: Human Factors in Cross-device Media Synchronization", Mu et al. explore the quality of multi-stream experiences delivered across many devices and the synchronization challenges that come with the heterogeneity of devices, networks, and associated user expectations in such a scenario.

IV. Machine Learning

Powerful deep learning techniques and big data analytics, which have seen great success in various domains, are also being applied to QoE measurement. Barri and Dooms review the current state-of-the-art and challenges of such methods in their paper on "Data-Driven Modules for Objective Visual Quality Assessment Focusing on Benchmarking and SLAs." They highlight the importance of taking into account the disagreement between subjects, and finding suitable machine learning methods to address such issues. To conclude the special issue, Kim and Lee propose a "Fully Deep Blind Image Quality Predictor" based on a convolutional neural network that generates a local quality map, similar to full-reference metrics.

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We hope that you will find the articles in this special issue interesting, stimulating, and useful for your own research.

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