Towards a Quality Framework for Immersive Media Experiences: A Holistic Approach

Asim Hameed, Shafaq Irshad, and Andrew Perkis[3]

Department of Electronic Systems
Faculty of Information Technology and Electrical Engineering, Norwegian University of Science and Technology, Norway
asim.hameed@ntnu.no, shafaq.irshad@ntnu.no,

Abstract. Immersive Media Technologies have emerged as popular media form. Their captivating nature makes them a powerful tool for participation and storytelling in a variety of domains attracting multidisciplinary interest. Existing frameworks for user-perceived quality in immersive media experiences are limited due to their exclusion of narrative dimensions. This research expands upon the current technology-centered Quality of Experience (QoE) framework by including Content Influence Factors based on learnings from IDN. Further, it proposes a conceptual framework for measuring immersive media experiences, which comprise of four constructs: Form, Content, User, and Context. These components are interrelated through their overlapping dimensions, which is discussed through the course of this paper.

Keywords: Interactive Digital Narrative · Immersive Media Experiences · Quality of Experience · Virtual Reality

1 Introduction

Over the years immersive technologies have become inherently interactive and their dependence on narrative has gradually increased [8]. When the end user experiences these technologies it results in Immersive Media Experiences (IME). Underlying concepts and dimensions of IME have been developed from a technological perspective [13, 24, 11] however quality measures are still rudimentary. Current Quality of Experience (QoE) frameworks limit their definition of content to its type (depth, texture, etc.) and reliability. Thereby, excluding the information and experiences it delivers. In turn, also excluding any narrative-based and/or task-based influences of the content on user-perceived quality. For this reason, we believe that assessing quality in Immersive Media Experiences can benefit from the rich scholarship of Interactive Digital Narratives (IDN).

In terms of user-perceived quality, it is not completely clear which factors of an IME are specifically responsible for a users emotion, involvement, and degree of interest. However, immersive media are widely understood from an experiential perspective as a users sense of presence. This framework encapsulates physical, symbolic and psychological dimensions that must be considerd

for user perceived quality inside IMEs. We look at immersion, immediacy, and presence alongside quality of experience (QoE) factors to fully encompass an immersive media experience. Given the richness and complexity of these emerging media environments, it is important to understand the dynamism of these contemporary media forms before developing quality frameworks.

QoE measures are commonly used for multimedia and telecommunication services [14]. They are subject to a range of complex and strongly interrelated factors that fall into three categories of *Human*, *System* and *Context Influence Factors (IFs)* [21]. Despite their interest around user experience, existing frameworks remain predominantly system-centric. With our work we want to focus on a human-centric paradigm by taking into account all those factors that reflect on the user's experience. For this, we accept the important of the above mentioned influence factors for our framework but also include *Content Influence Factors* for their role in overall user satisfaction, and QoE.

2 Framework for Measuring QoE for Immersive Environments

This research understands IME as a union of immersive, interactive and narrative. This section discusses our quality framework in terms of its four constructs: *Form*, *Content*, *User*, and *Context*, where we look at its different dimensions and variables as shown in figure 1.

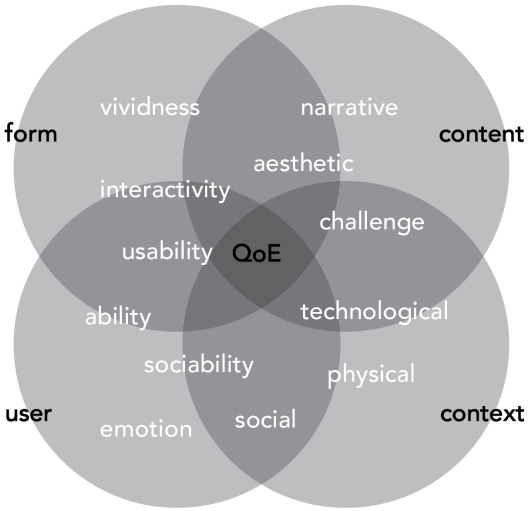

Fig. 1: Quality framework for Immersive Media Experiences (IME)

2.1 Form

We consider form to be the foundation upon which the entirety of IME is built. It comprises of a system-generated world that affords interaction to its users. Appropriating from Steuer, we denote form by its *vividness* and *interactivity*. One is the system's ability *"to produce a sensorially rich mediated environment"*, and the latter is degree to which users can *"influence the form or content of the mediated environment"* [29]. In essence, it is a correspondence between various media technologies to generate immersive-interactive environments.

System

1. **Spatial Presence as Experience Dimension:** A sense of physical presence, specifically *Spatial Presence*, is the "human experience of an immersive virtual environment" [29]. It is what the system grants. Slater [27] associates this with *Place Illusion* (user's response to system immersion) - how a user observes and responds to a simulated environment. Ryan [23] refers to it as a new dimension of *Spatial Immersion* - one that comes from technology not narrative. Elsewhere it is called *perceptual* or *sensory immersion* [32, 16, 2]. The coming together of various system factors to create an illusion of *being* in a virtual world even though one is physically not there.
   In terms of quality, the effectiveness of IME is foremost its ability to deliver a synthetic environment where a user can respond in likeness. System immersion is thus conceptualized as the level of immersion (high or low) directly granted by the system to the user [28, 19]. User-perceived quality is then a sense of presence of a user when he/she are surrounded exclusively by a media technology and provided a rich, continuous stimuli to support their various sensorimotor contingencies.
2. **Vividness as Quality Dimension:** The sensorial encapsulation of the user is ensured by a distinct quality of technology, *vividness* [28, 29]. It is the *"representational richness of a mediated environment ... that is, the way in which an environment presents information to the senses"* [29]. Further expanded into two parts: *sensory breadth* or *realism factor*, which is the number and consistency of inputs; and *sensory depth* or *realness*, which is the quality of richness or resolution of each input. In this research, we consider vividness (extent and fidelity of sensory information) as a user-perceived quality of IVEs that depends on quantifiable system factors of tracking, latency, display persistence, resolution, optics (fov), and spatial audio.

Interaction Interactivity inside IVE derives from its exploratory nature - freedom to explore and actively search. A user is not just a curious onlooker but a perceiver-actor responding to the *affordances* (action possibilities presented by digital elements, artifacts, and objects) of the simulated environment [6]. Considering which, interactivity should be understood as a stimulus-driven variable that depends upon the technological formation of the medium.

Interactivity inside a VE can be quantified under three factors: *speed of interaction* (system response time to user action), *range of interactivity* (number, and extent, of action possibilities with), and *mapping* (system ability to map user input to changes in IVE). The degree to which the interactivity of an IVE, its controller, and feedback mechanisms match the real world has an affect on user's ability in applying natural navigation and manipulation techniques in IVEs.

2.2 Content

We introduce content as a new influence factor in our quality framework for IME. A user removed from his/her immediate context is subsequently immersed into *a reality represented by the medium*, i.e. the broad category objects, actors and events. We argue that an IVE with its inherent interactive qualities is a *live box of action possibilities* produced by the system.

Content, on the other hand, is its *"meaning"*. It is what *"the virtual world purports to be about"* [7]. It is the flow of events, inclusion of social elements, nature of task/activities performed. The overall meaningfulness of the content determines various kinds of presence [15, 25, 10]. Meaning, for the user, is derived from a combination of the content and the context within which the content exists [7]. Users inside IVEs draw signification (meaning) from the aesthetics of the world, the narrative events that unfold, and the activities they perform in it. They take all that as their experience. We divide content into diegetic, non-diegetic, and aesthetic classes of information or experience. For our holistic framework, we will discuss the dimensions of two content factors in specific, i.e. narrative-based and task-based .

Narrative-based: To discuss the influence of narrative factors on quality in IMEs, we can consider the age-old tradition of storytelling [3]. What storytellers achieved through expression, improvisation, theatrics, and exaggeration are now readily available to users as immersive environments produced by computers. Ryan [23] calls it Spatial Immersion (in her triad of spatial, temporal and emotional immersion). IMEs are evolved narrative forms that summon perceptual and sensory faculties. IVE is only a *presentation context* whereas its *narrative context* is the diegetic space of the story that takes place within it [3].

These dimensions are symmetrical to the four narrative-centric factors hypothesized by Rowe et al [22]. These are *narrative consistency* (believability), *plot coherence* (logical order), *drama* (setup-conflict-resolution), and *predictability* (real-world authenticity). The result of which is a *Plausibility Illusion* - an acknowledgement of the truth of the environment [27].

Task-based: The relation between a user's ability and a presented challenge imbues a form of presence called an *experience of flow* [5]. Flow arises when perceived challenges correspond to perceived skills. It is characterized by full involvement, energized focus, and enjoyment. On the contrary, a mismatch between ability and challenge can lead to feelings of frustration and displeasure.

A task inside a VE is determined by its nature and level of challenge (cognitive/motor). Additionally, tasks are also affected by context (e.g. temporal) and depend on the kind of interaction they require, i.e. navigation, selection or manipulation. Task performance improves when a user's ability/skill is matched by the usability of a system. Another important factor (but not a subject of this paper) is the introduction of aesthetic features (e.g. interface graphics, gamification elements, etc.) to enhance user performance. It can be hypothesized that tasks performed inside IVEs influence the emotional state of the users but are also directly influenced by the user's proficiency/ability [31, 26, 1]. .

2.3 User

User, or human, influence factors are deemed influential for the formation of quality [4]. User characteristics, their learning ability and assumed agency play a significant role in shaping their overall perceived quality of an IME. **Characteristics** are demographic attributes as well as perceptual, cognitive and motor abilities of users [12]. Prior experiences of IVEs affect a willful suspension of disbelief as well as allocation of attentional resources [12] in turn, affecting presence. **Other works [33, 17, 9] have identified the effects of age, gender, cultural background, and emotional state on user-perceived quality.**

Due to their characteristic similarity to the real-world, users have a higher chance of learning IVEs [20, 30]. Nash et al. [18] consider navigational knowledge acquisition (spatial ability) as central to learning environments. This may vary across users considering their cognitive performance and perceptual limitations. However, potential for learning can be enhanced when usability aspects of a system are aligned with the goals and mental models of the users to fulfill requirements and tasks.

2.4 Context

Context factors are relevant situational properties that can be broken down into physical, temporal, social, economic, task and technical characteristics [21]. Context factors have considerable effect on the quality levels of any media experience. But since fully immersive media (such as VR) occlude the real-world, we arrive at an inside and an outside. For example, it is worth considering if the user-perceived quality of IME changes with physical locations, e.g. lab versus mall. Similarly, Simulated contextual changes inside virtual environments can also in turn affect user characteristics.

3 Discussion

Immersive Media Experiences (IMEs) are powerful because of the agency they give the end user. They are not mere simulations but entirely new spaces of signification as well. User do not just experience high-fidelity geometries with real-time responsiveness but the meanings those interactions deliver. This is why they require new inclusive measures for quality assessment.

4 Conclusion

This research paper presents a modified quality framework of IMEs. In addition to immersivity and interactivity, the framework draws from theories and approaches in IDN to include narrativity as an important facet. The paper presents a four constructs i.e. Form, Content, Context and User, that determine quality in IMEs. For its practical use, the framework emphasizes on the importance of signification (the meaning delivered) aspects of these experiences for the user. We believe that any user-perceived experience evaluation is incomplete without considering narrative-related and task-related dimensions inside content.

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