Perceptual Metrics Quality: Comparative Study for 3D Static Meshes

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ABSTRACT

A 3D mesh can be subjected to different types of operations, such as compression, watermarking etc. Such processes lead to geometric distortions compared to the original version. In this context, quantifying the resultant modifications to the original mesh and evaluating the perceptual quality of degraded meshes become a critical issue. The perceptual 3D meshes quality is central in several applications to preserve the visual appearance of these treatments. The used metrics results have to be well correlated to the visual perception of humans. Although there are objective metrics, they do not allow the prediction of the perceptual quality, and do not include the human visual system properties. In the current work, a comparative study between the perceptual quality assessment metrics for 3D meshes was conducted. The experimental study on subjective database published by LIRIS / EPFL was used to test and to validate the results of six metrics. The results established that the Mesh Structural Distortion Measure metric achieved superior results compared to the other metrics.

KEYWORDS

3D Meshes, 3D Triangle Mesh, Human Visual System, Objective Metrics, Perceptual Quality, Quality Assessment, Static Metrics 3D, Statistical Modeling

1. INTRODUCTION

With technological advances in telecommunication, hardware design and multimedia, the use of 3D data is now well established in several industrial domains, like digital entertainment, scientific visualization, computer-aided design, architecture and many others (Rindos, Vouk, Jararweh, 2014; Gupta & Garg, 2015).

The 3D content is mostly represented by polygonal meshes, or sequences of polygonal meshes (i.e. dynamic meshes), which may be associated with colour information or texture maps. For its transmission, protection, visualization or manipulation (Chowdhuri, Chakraborty, Dey, Azar, Megeed Salem, Chaudhury & Banerjee 2014; Chowdhuri, Roy, Goswami, Azar, Dey, 2014), this 3D content is subject to a wide variety of processing operations such as compression, filtering, simplification, watermarking and so forth. These operations introduce distortions which may alter the visual quality of the 3D content; this is a critical issue, as these processing operations are often targeted at human-centered applications with viewing as the intended use.

The three-dimensional (3D) computer graphics technologies are widely used in numerous applications on the market including the medical domain, 3D gaming network, 3D virtual world in
immersive and 3D visualization applications (Cooperstock, 2011). Furthermore, emerging products, such as the 3D televisions and 3D gaming devices open new avenues possibility for an improved user experience during the interaction with 3D environments (Abderrahim & Jeder & Bouhlel, 2013). Thus, the 3D models are becoming a popular new form of media (Daly & Brutzman, 2007).

In several application domains, 3D mesh data are conventional for digital entertainment, scientific visualization, and cultural heritage. The ability for 3D mesh visualization has been developed from desktops to mobile (Chowdhuri & Chakraborty & Dey & Azar & Abdel-Megeed & Salem & Chaudhury & Banerjee, 2014) devices as well as the web content. The 3D mesh models are usually composed of a large number of connected vertices and faces to be rendered and/or to be real-time streamed (Salehpour & Behrad, 2012). The massive number of vertices/faces provides more detailed representation of a model, which increases the visual quality. However, this causes a loss in performance due to the increased calculations. Therefore, a compromise between the visual quality graphic models and the processing time is compulsory.

In addition, an extensive range of 3D mesh processes are obliged, such as simplification, transmission, filtering, compression (Abderrahim & Techini & Bouhlel, 2013) and watermarking (Masmoudi & Bouhlel & Puech, 2012). Such processes inevitably lead distortions that alter the visual rendered data quality. This requires the measurement of the 3D graphics content quality. Assessment metrics for the 3D Mesh Visual Quality (MVQ) were comprehensively deliberated for accurately evaluates the perceptual impacts of the distortions to predict the distorted 3D data visual quality compared to the original data (El-Bendary & El-Tokhy & Shawki & Abd-El-Samie, 2012).

Consequently, several metrics for predicting the adverse effects of the visual artifacts were developed. Such metrics are based on Laplacian coordinates, types of curvature computation, geometric attributes, and conventional geometric distance. For example, the 3D models transmission of network-based applications Figure 1 (Gupta & Thakur & Garg & Garg, 2016; Cardoso & Pedrinaci & Leidig & Rupino & Leenheer, 2013) requires accurate compression that compromise between visual quality and transmission speed (Cheng & Basu, 2007).

Many applications require specified level of detail, 3D meshes and 3D optimized models such as in the medical (Ryan & Tormey & Share, 2014) applications that dedicated to surgery (El-Bendary & El-Tokhy & Kazemian, 2012; Aribi & Khalfallah & Bouhlel & Elkadri, 2012).

Figure 1. 3D model transmission through the network
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