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Reducing complexity in polygonal meshes with view-based saliency ☆

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ABSTRACT

Salient features in 3D meshes such as small high-curvature details in the middle of largely flat regions are easily ignored by most mesh simplification methods. Nevertheless, these features can be perceived by human observers as perceptually important in CAD models. Recently, mesh saliency has been introduced to identify those visually interesting regions. In this paper, we apply view-based mesh saliency to a purely visual method for surface simplification from two approaches. In the first one, we propose a new simplification error metric that considers polygonal saliency. In the second approach, we use viewpoint saliency as a weighting factor of the quality of a viewpoint in the simplification algorithm. Our results show that saliency can improve the preservation of small but visually significant surfaces even in visual algorithms for surface simplification. However, this comes at a price, because logically some other low-saliency regions in the mesh are simplified further.

1. Introduction

Research into automatic polygonal simplification has been very active over the last years. Literature on computer graphics is replete with good simplification methods (Cignoni et al., 1998; Garland, 1999; Luebke, 2001; Luebke et al., 2003). Recently, van Kaick and Pedrini (2006) carried out a study of the most relevant geometric error metrics. Probably, the most important topic of discussion in the field is to develop techniques that make surface simplification algorithms to be conducted by visual or perceptual criteria. Lindstrom and Turk (2000) were the first to tackle the problem of *visual similarity* by developing a purely image-based metric for their simplification method. The visual appearance is crucial when dealing with visualization and graphical manipulation. Although graphics hardware is constantly evolving, increasing the performance of new graphical devices. Simplification is still essential to reduce the number of elements in a mesh improving its quality and use. It is known that, in general, small high-curvature details in the middle of largely flat regions (see Fig. 1(a)) are ignored by most mesh simplification methods, mainly because simplifying these details introduces very little error. However, these small surfaces are likely to be perceived as being visually important in CAD models. A flat region in the middle of densely repeated

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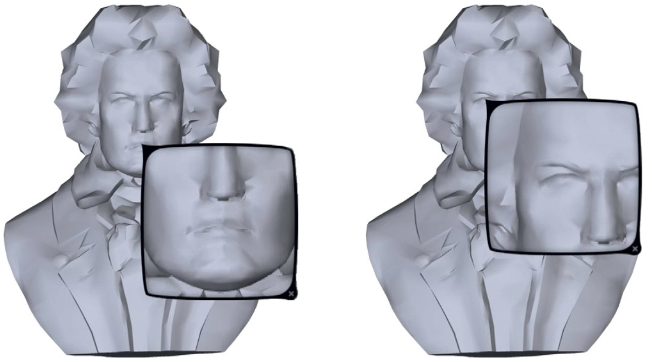

(a) High-curvature details in the middle of largely smooth area (e.g. the mouth)

(b) Flat region surrounded by rough surface (e.g. the eye)

Fig. 1. Salient regions.

high-curvature bumps (see Fig. 1(b)) is also perceptually significant. In recent times, *mesh saliency* has been introduced to identify visually interesting regions that are different from their surrounding context in 3D meshes. The goal here is to maintain the most salient regions during the process of simplification.

Human eyes do not scan a scene in a raster-like fashion, but rather our eyes jump rapidly between features within the scene. Visual attention comprises two processes, a bottom-up process which is purely stimulus driven and makes our eyes attract to salient features in a scene, and the top-down process which focuses attention on one more objects that are relevant to accomplish a specific visual task (Laurent and Koch, 2000). Many researchers have performed several studies using eye-tracking in different areas of computer graphics. Chalmers et al. (2006) carried out some eye-tracking experiments for selective rendering and Myszkowski et al. (2001) for animation quality measures. Howlett et al. (2004) presented a survey which demonstrates that saliency can improve simplification for human viewers.

Watanabe and Belyaev (2001) proposed a method to identify regions in meshes where the main curvatures have locally maximal values along one of the principal directions (typically along ridges and ravines). This method was also applied to mesh simplification. Hisada et al. (2002) proposed a method to detect salient ridges and ravines by computing the skeleton and finding non-manifold points on the skeletal edges and associated surface points. Lee et al. (2005) proposed a multi-scale saliency for meshes based on the Gaussian-weighted center-surround evaluation of surface curvatures. The center-surround mechanism allows the regions in a mesh that are different from their local context to be identified with greater precision. Their approach was also incorporated into mesh simplification using QSlim, a purely geometric simplification algorithm (Garland and Heckbert, 1997, 1998), and into viewpoint selection. Kim and Varshney (2006) presented a visual-saliency-based operator to enhance selected regions of a volume. Gal and Cohen-Or (2006) introduced a method for partial matching of surfaces by using the abstraction of salient geometric features and a method to construct them. More recently, Feixas et al. (2009) have proposed a view-based mesh saliency based on an information channel between a set of viewpoints and the polygons in the mesh.

In this paper, we incorporate view-based mesh saliency (Feixas et al., 2009) into the viewpoint-driven simplification scheme introduced in Castelló et al. (2008a, 2008b). We present two methods. In the first one, we make use of polygonal saliency to propose a new simplification error metric. In the second method, we use viewpoint saliency to weight the viewpoints in the viewpoint-driven simplification algorithm (Castelló et al., 2008a, 2008b). As shown in our experiments, including view-based mesh saliency in the simplification method allows for a better preservation of small, but visually significant, salient regions. However, some other regions with low saliency are simplified more drastically. Consequently, there is no guarantee that the global simplification error can always be reduced, but saliency produces better simplifications according to perception.

The rest of the paper is organized as follows. In Section 2, we briefly review the related work on Information Theory and introduce the Jensen–Shannon divergence which is the basis for the definition of view-based mesh saliency. In Section 3 we apply both polygonal saliency and viewpoint saliency to the viewpoint-driven simplification approach. Section 4 shows the results of our experiments. Finally, in Section 5 we present our conclusions and future work.

2. Background

In this section, we review the Jensen–Shannon divergence, some information-theoretic viewpoint quality measures and polygonal saliency and viewpoint saliency (Feixas et al., 2009).