Context-aware Material Selective Rendering for Mobile Graphics

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1 Rendering for Mobile Graphics

Modern video games and interactive applications get simultaneously deployed for computers, consoles and mobile devices. These platforms are extremely diverse in terms of computing power. Modern materials and effects such as complex refraction with chromatic aberration and subsurface scattering that are considered standard in high-end desktop computers, do not scale well in portable devices. Hardware restrictions prohibit the use of -necessary for the game aesthetics - effects that demand multiple texture fetches and many arithmetic/logic operations. We present for the first time, a perceptually optimized renderer for mobile platforms incorporating a context-based visual attention model which we call Cognitive Level-Of-Detail (C-LOD). Taking into account the dependence of attention deployment on scene context and object topology the innovative renderer presented saves computational time by automatically and seamlessly removing perceptually non-important details. We will show that integration of a high level saliency model in a level of detail manager enables the usage of complex effects in low-power devices by applying them sparingly only in regions that are expected to be attended.

Attention models have already been of great benefit for applications such as selective rendering. However, existing models estimate attention based mostly on low-level image features and often fail to predict fixations. In our work, we successfully employed semantic information such as scene context and topology integrated in a model of visual attention. We present an innovative high level saliency estimator that incorporates the schema [Henderson et al. 1999], singleton [Theeuwes and Godijn 2002] and canonical form [Becker et al. 2007] hypotheses into the Differential-Weighting Model (DWM) [Eckstein et al. 2006]. The *scene schema* effect states that a scene is comprised of objects expected to be found in a specific context as well objects out of context which are salient. The *singleton effect* refers to the finding that viewer's attention is captured by physically or contextually isolated objects. An object rotated in a way that violates its stored in memory expected posture known as *canonical form*, pops out. The DWM models attentional processing using Gaussian combination rules. We extended DWM to account for high-level object saliency as indicated by the schema, singleton and form hypotheses. A feature uniqueness term is estimated that accounts for the number of salient features in an image. Our extension also encodes temporal effects by generating recurring fixations for objects in a violated form or inconsistent with the context [Becker et al. 2007].

2 Material Level-Of-Detail

We investigated the impact of high level saliency on visual attention by conducting a formal experiment. We systematically controlled the topology of objects in a virtual environment depending on the experimental condition. We recorded the time it took to search for these objects. A total of 40 participants participated. The completion times were subjected to a Multiple Linear Regression (MLR) analysis that indicated that all the factors play a statistically significant role in attention deployment and provided us with the weighting factors that signify the interaction between the scene schema, singleton and form hypotheses to instantiate our model.

Figure 1: *The wax-buddha is tilted in an unexpected way on the left image. C-LOD predicts that a non-canonical appearance of the object will capture the attention of an observer and assigns the highest quality level of a subsurface scattering algorithm versus the lower quality selected for the buddha on the right.*

We developed a plug-in for Unity 3D^{TM} game engine (C-LOD) that constantly examines the available hardware resources. When GPU performance falls below a user-selected threshold C-LOD automatically selects a lower level of detail assigned to three complex effects (subsurface scattering, bump mapping and refraction) for objects predicted not to be attended (Figure 1). The target of C-LOD is to maintain a constant frame rate by dynamically re-adjusting material quality. We performed a validation study both via eye-tracking and by acquiring GPU performance data. We established that by employing C-LOD, complex effects such as subsurface scattering usually omitted in mobile devices can now be rendered without outweighing GPU capability.

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