High Level Saliency Prediction for Smart Game Balancing

George Alex Koulieris
Technical University of Crete

George Drettakis
REVES/INRIA Sophia-Antipolis

Douglas Cunningham
Brandenburg Technical University Cottbus

Katerina Mania
Technical University of Crete

1 High Level Saliency

Predicting visual attention can significantly improve scene design, interactivity and rendering. For example, image synthesis can be accelerated by reducing computation on non-attended scene regions; attention can also be used to improve LOD. Most previous attention models are based on low-level image features, as it is computationally and conceptually challenging to take into account high-level factors such as scene context, topology or task. As a result, they often fail to predict saccadic targets because scene semantics strongly affect the planning and execution of fixations. In this talk, we present the first automated high level saliency predictor that incorporates the schema [Bartlett 1932] and singleton [Theeuwes and Godijn 2002] hypotheses into the Differential-Weighting Model (DWM) [Eckstein 1998]. 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 (Figure 1a). The *singleton effect* refers to the finding that viewer's attention is captured by isolated objects (Figure 1b). We propose a new model to account for high-level object saliency as predicted by the schema and singleton hypotheses by extending the DWM. The DWM models attentional processing using physiological noise in brain neurons and Gaussian combination rules. A GPU implementation of our model estimates the probabilities of individual objects to be foveated and is used in an innovative game level editor that automatically suggests game objects' positioning. The difficulty of a game can then be implicitly adjusted since topology affects object search completion time.

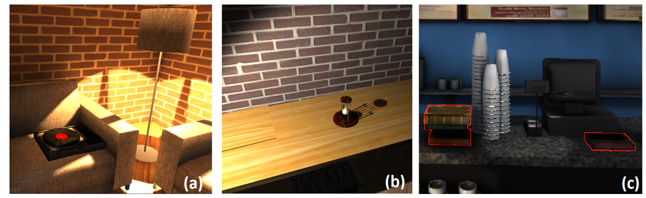

Figure 1: *The record player is out of context (a) and the clepsydra is isolated (b). The books are easy to find as predicted by our tool (c).*

2 Smart Game Balancing

Gameplay greatly depends on attention deployment. Looking for an object is a common task in (Action-)Adventure games, often guiding level advances. Player enjoyment is crucial for the success of a computer game. Enjoyable experiences in games arise primarily from challenge [Sweetser and Wyeth 2005]. Challenge refers to the ability of a game to be sufficiently intriguing and match the player's skill level. To date, designers mostly rely on their experience and instinct while manually placing objects in their levels. However, play-testers able to validate choices in design are not abundant to every game designer and players' abilities vary. Integrating a high level saliency model in a level editor can significantly support the artists by automatically highlighting salient objects and, therefore, facilitate game balancing potentially reducing production time and cost.

Inspired by Adventure games we designed an environment in order to investigate the impact of high level saliency on visual attention & gameplay. We conducted three formal experiments in which we systematically controlled the topology of plot critical objects. Depending on the experimental condition, each object could be in a schema-consistent or a schema-inconsistent location, and could be either positioned by itself or in cluttered surroundings. We then recorded the time it took to search for them. A total of 80 participants participated. We subjected the completion times to a Multiple Linear Regression (MLR) analysis that indicated that both schema consistency and physical isolation play a statistically significant role in attention deployment. The experiments also provided us with weighting parameters indicating the contribution of each hypothesis to attention prediction.

We then developed a plug-in for Unity 3D™ game engine which we call High Level Saliency Modeler (HLSM). HLSM is a GPU-based implementation of our model that guides object placement in a game level editor in order to adjust game difficulty. HLSM highlights objects expected to attract attention (Figure 1c) by estimating in real time an object attendance posterior probability term of our extended DWM. The probabilities are calculated in real time in a shader by both quering the scene graph and utilizing an edge detection kernel run over the depth buffer. The level designer then adjusts game level difficulty based on object saliency; a novel, exciting way to facilitate game design. We finally validated HLSM's efficacy in adjusting game difficulty by implementing a tool which handles the communication of an eye-tracker with the 3D environment viewed and identifies fixations. The tool was used for a rigorous eye-tracking experiment run on a Head Mounted Display which confirmed that game level completion time depends on object topology and focus of attention is successfully predicted by our system.

References

BARTLETT, F. C. 1932. Remembering: An experimental and social study. *Cambridge: Cambridge University*.

ECKSTEIN, M. P. 1998. The lower visual search efficiency for conjunctions is due to noise and not serial attentional processing. *Psychological Science 9*, 2, 111–118.

SWEETSER, P., AND WYETH, P. 2005. Gameflow: a model for evaluating player enjoyment in games. *Computers in Entertainment (CIE) 3*, 3, 3–3.

THEEUWES, J., AND GODIJN, R. 2002. Irrelevant singletons capture attention: Evidence from inhibition of return. *Perception & Psychophysics 64*, 5, 764–770.