Stereo Coherence in Watercolour Rendering

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Abstract

We investigate stereo coherence – or consistency of stereoscopic views – in non-photorealistic rendering (NPR) by example. We designed and carried out a pilot user study that compared stereoscopic animations created using two different watercolour rendering styles. The rendering styles use image-space and object-space noise respectively. A clear majority of participants preferred the object-based technique and found it more comfortable to watch than the image-space technique which suffers from the 'shower door effect'. Based on these preliminary results, we conclude that stereo coherence is indeed a desirable property for non-photorealistic rendering techniques.

CR Categories: I.3.3 [Picture/Image Generation]: Display algorithms; I.3.7 [Three-Dimensional Graphics and Realism]: Color, shading, shadowing, and texture

1 Introduction

Temporal coherence is an important issue in NPR that has received significant attention in recent years [DeCarlo et al. 2004; Collomosse et al. 2005; Bousseau et al. 2006]. We argue that similar attention should be given to the issue of stereo coherence, which we define as the consistency of both views in stereoscopic imagery. In the real world, the two views created by our eyes are inherently consistent, as they are both projections of the same 3D world. However, this is not necessarily the case for NPR techniques.

Image-space NPR techniques, in particular, are prone to introduce inconsistencies when applied to stereo imagery. This is because each view is processed independently without ensuring stereo coherence. In object-based techniques, on the other hand, styles are applied in the 3D world, and projected twice to produce the stereo views. As projection is stereo coherent, object-based techniques often are as well.

Our aim is to experimentally evaluate the importance of stereo coherence in NPR. As this is very much a subjective, if not subconscious, issue of visual perception, we decided to approach it by studying how people perceive stereoscopic renderings of two watercolour rendering techniques.

2 Experiment

To evaluate the perception of stereo coherence, we created two similar rendering styles based on Bousseau *et al.*'s per-frame watercolour technique [2006]. Their main difference is how the watercolour's turbulence flow texture is generated: the first method uses a dynamic image-space noise texture, and the second method uses an object-space dynamic solid texture [Bénard et al. 2009].

We rendered both techniques stereoscopically with quad-buffered OpenGL and displayed them using a stereoscopic 3D projector by Lightspeed Design Inc. Stereo settings, such as screen size and distance, were calibrated before the study, to ensure optimal stereo viewing conditions. As up to 12% of people have problems with fusing stereo images, we started each session by showing a test image with a recessed square on a textured background, to identify if individual participants were affected by binocular vision problems.

Each participant was then shown rendered versions of the same model of a building block, performing a pre-recorded rotation in the centre of the projection screen (see figure 1 for an example). The sequences were shown alternately and repeated again, for about ten seconds each. The participants were then asked how comfortable they found viewing each sequence, and if they could see any differences between them. Finally, they were asked to express a preference for one of the two sequences.

We had six participants in our pilot study, all passing the initial stereo test. Five out of six participants saw differences between the two rendering techniques, and all of them preferred the object-based technique, as "buildings looked more textured" compared to the image-based technique which had "flatter textures" which were "swimming". Overall, participants also found the object-based method more comfortable to watch. The coherence of the noise layer is also illustrated in figure 1.

3 Conclusions

Previously it has been unclear what benefits object space gave. We show that people have strong preferences when viewing with stereoscopic 3D, likely due to better coherence. It appears that stereo coherence is closely related to temporal coherence, as object-based techniques are also more likely to be temporally coherent than image-based techniques. However, further research is warranted to study this relationship in more detail.

In the future, we would like to perform further comparative user studies based on other rendering styles. It is our hope that this work will also provide additional insights into how to improve stereo coherence of existing rendering styles.

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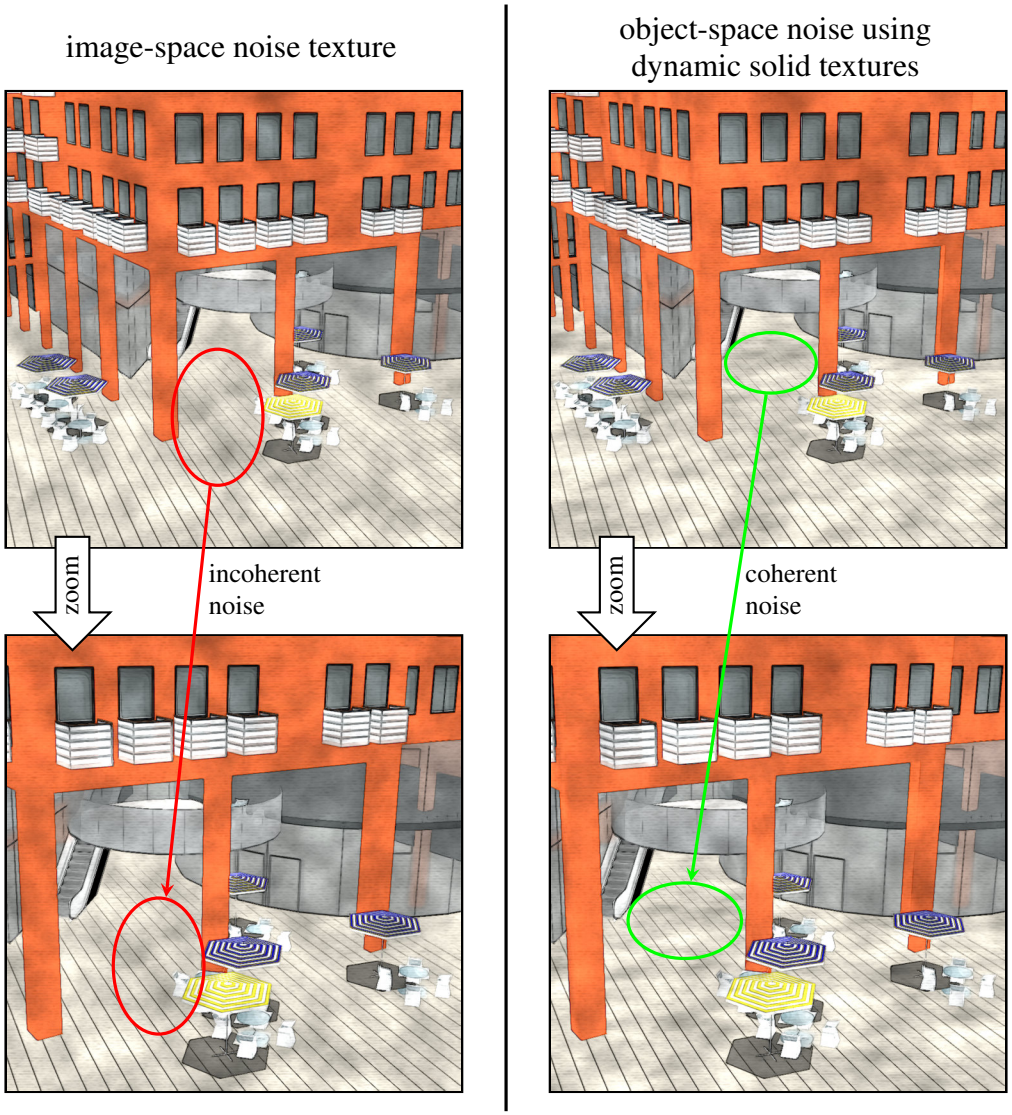

Figure 1: *Visual comparison of noise coherence when zooming into a scene. Left: the motion of the image-space noise is inconsistent with the geometry's motion, resulting in the 'shower door effect'. This is even more apparent when the zoom is animated continuously, or if shown stereoscopically. Right: the object-space noise is fixed to the geometry and moves coherently.*