Post-processing expressive rendering effects for visual deficiency

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Visual accessibility appears not to be the essential priority of artists when they produce an artwork. However, they do not choose colors randomly but depending on the message they want to deliver, which can be partially or entirely misunderstood by people with vision problems. This paper proposes to study the possibility of using expressive post-processing effects which can be applied on any kind of 2D image sequence and which allow to improve image perception for many kinds of visual impairments.

Keywords: Expressive Rendering; Accessibility; Visual Impairment.

1. Introduction

Images surround us. Their goal is to transmit information which can be emotional or informational. Realistic images often contain too many details disrupting the message to be delivered. Thus, artists often simplify images highlighting information using stylization. In computer graphics it is called expressive rendering or NPR (Non-Photorealistic Rendering).

The relation linking the 3D scene and the dual nature of 2D picture (both flat and representing 3D objects) is intricate due to the complexity of the human visual system.[1] Thus, our idea consists in optimizing the image for the viewer's needs. This is the reason why games, software interfaces and even TV broadcast should allow users to attempt different stylizations and adjust their preferences to satisfy their requirements. Nowadays, most game engines support post-processing effects, turning screen space methods into a cheap and powerful tool for stylization of games, but despite the great diversity of effects developed by researchers, game engines contain almost no screen space NPR effects. NPR is also used in video-games to help the user to perceive interesting objects or danger. Such effects can serve other purposes than entertainment like alleviating visual impairments and our

understanding of human perception may help in achieving this goal.

This work addresses the topic of seamless integration of styles using expressive post-processing methods to help people with visual impairment by gathering a collection of screen space stylization methods and applying it to any kind of video or image stream. Our effects have been applied to existing video-games created with a well-known game engine, Unity.[2] Using post-processing effects implies that their inclusion into an existing game requires negligible effort.

2. Visual impairement

This section presents visual impairments that can be alleviated using NPR.

2.1. *Color vision deficiency*

This problem is an inability or a decreased ability to see certain colors or to perceive color differences, leading to different perceptions.

- Monochromacy: people see in grey level due to a lack of cones.
- Dichromacy: color vision defect where one of the 3 colors (RGB) detected by the 3 types of cones does not function properly or not at all. People without red retinal photoreceptors are called protanopes. Deuteranopes do not have green retinal photoreceptors. Tritanopes are rare, they do not pocess blue retinal receptors.

2.2. *Amblyopia*

The stereoscopic vision is the perception of the same image by two different sensors: our eyes. These images are perceived from a slightly different angle allowing our brain to reconstruct a complex information: depth perception.

People born with Amblyopia use other visual benchmarks to estimate distances, such as object position at different depths. Distances are better apprehended when the object is moving: filling a glass can be tricky.

2.3. *Photophobia*

The human visual perception system functions well in a high dynamic range of light conditions, from moonlight to the brightest sunshine. However, people suffering from photophobia are intolerant to ordinary bright light.

Glare can affect our ability to see clearly. It may occur when a light source is too strong for our eyes like when coming from dark we enter a bright room. Glare resulting from extreme bright light can also reduce

our visual performance. Caused by eye diseases, it may occur at an ordinary light intensity level as well. With age, some eye problems may happen and the eye structure becomes less clear. The most common example is a cataract: the light is scattered making things unclear and blurred. Its thickness impacts on the blur importance. Other kinds of glare causes also exist (macular degeneration (AMD), uveitis, ocular albinism or corneal problems). The most obvious way to cope with glare is to limit the amount of light entering the eye. Tinted and polarized lenses help to minimise it. Light activated sunglasses which get darker in brighter conditions are also a solution. How to minimize visual impairment with NPR? We propose to study briefly how artists use perception.

3. How art uses perception

Artists use stylization to highlight information they want to deliver. They do not choose the style randomly but they use the human perception and a specific stylization to convey the desired message.[3] Nowadays, artistic effects are widely used in movies and video games but are not used to help people with visual impairments. Hereafter, we present the three principal characteristics we perceive and what type of information they convey.

Contours are abrupt changes of light intensity level and are the base of our visual perception.[4–6] When contours are not drawn, our visual system tends to imagine them to dissociate the different objects observed. Contours serve two main goals: they are, by themselves capable of depicting abstracted objects that our brain can recognize and they aid our perception process by enhancing details (e.g. silhouettes or texture lines) on images with great diversity in color and texture. Additionally, artists use the decreasing thickness of contours at the background to emphasize depth.

Light is often used by artists to create the illusion of depth. Following specific stylizations, it may be a great help in understanding scene geometry and produce different depth sensations.[7]

Colors also permit to create depth. Artists use the detail level and the desaturation of colors to depict depth.

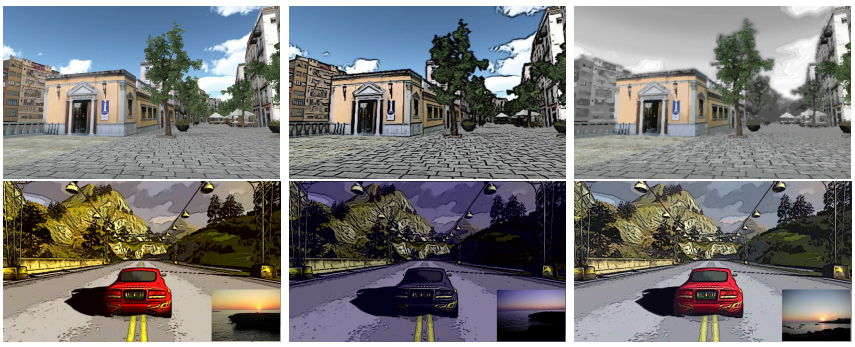
4. Implementation framework

Our effects are created as post-processing running on the graphic hardware and in image space, in order to provide easy portability and fast applicability to different graphic engines and architectures. We have integrated them into the Unity game engine.[8] In previous work, we showed that such effects

are capable of real-time performance and thus we can process the rendered image stream on-the-fly; details are given in.[9] The effects have been packed into a coherent library (a.k.a. *unitypackage*), which can be imported into other Unity projects.

5. NPR effects for visual impairment

We propose a set of screen space methods to modify the style of the rendered image stream which implies real-time rates and temporal coherence.



(A) (B) (C)

Fig. 1. Example effects. Upper row: (A) Original image with photo-realistic rendering, (B) Edge enhancement, (C) Depth illusion using desaturation and image simplification based on depth. Lower row: color stylization by example in the Unity Car Tutorial.

5.1. *Edge enhancement*

In order to better distinguish different objects in images and to locate them in the scene, we propose to use edge enhancement.

There are two main approaches for edge extraction. The first class of methods tries to mimic artists: lines follow object silhouettes. The second follows a perceptual viewpoint: the sensitivity of our eyes to abrupt changes in light intensity, utilizing classic edge detection methods of image processing that search for pixels of high gradient magnitude. The former approach depicts shapes better but forfeits texture information while standard edge detection methods provide a less clean representation of shape contours, but preserve texture details. Their combination preserves only the benefits.[10] It can help Amblyopia and color deficiency that may lead to merge different objects.

Among the edge detection methods, variations of the *Difference of Gaussian* filter, which has a biological relevance by providing a model to the activation mechanism to certain retinal cells,[11] allow to control edge thickness. We adopted the separable, flow-based implementation proposed by Kyprianidis et al.[12] and the extension proposed by Winnemöller.[13]

As artists do, we can decrease thickness following depth, also helping to locate an object in the scene for Amblyopia.

5.2. *Abstraction level following depth*

We reduce the scene complexity using depth by changing the main components of a style: color and texture.

Artists often use less saturated colors to distract viewer's attention from less important parts of images.[14] Saturation can be modified by converting the pixel color into HSL or HSV. Fragments farther or closer from the focus point (alterable in our implementation) are desaturated, based on a linear distance from this point. We use an exponential correction with user specified exponent to control how fast saturation changes with depth.

Background is often smoothed in artistic depictions due to lower importance of background objects. Depth-based parametrization of texture simplification filters[15,16] can produce higher abstraction level for the background objects.

5.3. *Color palette modification by example*

This technique may be used for daltonism using images with adapted colors depending on the color vision deficiency.

Automatic *color style transfer* methods allow to specify example images for color palette adjustment to obtain a similar color histogram. The average and variance of the color input distribution are adapted to the image. Different color spaces[17,18] may be used to compute average and variance to get slightly different results. Pyramid reduction techniques are commonly used for computing the average and variance in parallel.[19]

6. Conclusion

We have proposed NPR effects that can be used to help people with visual impairment. Using vision and perception knowledge permits to understand how we can help people. Visual impairments and NPR techniques have been linked. Results show that NPR has a visual impact on the targeted visual problems. In future work, we plan to adapt more NPR techniques and to present a user study for each technique and impairment.

References

1. F. Durand, An invitation to discuss computer depiction, in *Proceedings of the 2nd international symposium on Non-photorealistic animation and rendering*, NPAR '02 (ACM, New York, NY, USA, 2002).
2. Unity Demo Projects, Unity (2013), http://unity3d.com/learn.
3. S. McCloud, *Understanding Comics the invisible art* (Harper Paperbacks, 1994).
4. D. Marr and E. Hildreth, *Proceedings of the Royal Society of London Series B* **207**, 187 (1980).
5. J. Koenderink, What does the occluding contour tell us about solid shape? *Perception* **13**, 321 (1984).
6. S. E. Palmer, *Vision science: photons to phenomenology* (MIT Press, Cambridge, Mass., 1999).
7. G. Roig, *Peindre la lumière*, oskar éditions edn. (Guides Oskar, 2010).
8. Unity Technologies, Unity (2013), http://unity3d.com.
9. M. Magdics, C. Sauvaget, R. Garcia and M. Sbert, Post-processing NPR effects for video games, in *12th ACM International Conference on Virtual Reality Continuum and Its Applications in Industry: VRCAI 2013*, 2013.
10. N. Redmond and J. Dingliana, A hybrid approach to real-time abstraction, in *Proceedings of Eurographics Ireland, 2009*, 2009.
11. R. A. Young, The Gaussian derivative model for spatial vision: I. Retinal mechanisms *Spatial Vision* , 273 (1987).
12. J. E. Kyprianidis and J. Döllner, Image abstraction by structure adaptive filtering, in *Proc. EG UK Theory and Practice of Computer Graphics*, 2008.
13. H. Winnemöller, Xdog: advanced image stylization with extended difference-of-gaussians., in *NPAR*, eds. J. P. Collomosse, P. Asente and S. N. Spencer (ACM, 2011).
14. N. Redmond and J. Dingliana, Influencing user attention using real-time stylised rendering, in *EG UK Theory and Practice of Computer Graphics, Cardiff University,, United Kingdom, 2009. Proceedings*, eds. W. Tang and J. P. Collomosse (Eurographics Association, 2009).
15. H. Winnemöller, S. C. Olsen and B. Gooch, Real-time video abstraction *ACM Trans. Graph.* **25**, 1221(jul 2006).
16. C. Tomasi and R. Manduchi, Bilateral filtering for gray and color images, in *Proceedings of the Sixth International Conference on Computer Vision*, ICCV '98 (IEEE Computer Society, Washington, DC, USA, 1998).
17. E. Reinhard, M. Ashikhmin, B. Gooch and P. Shirley, Color Transfer between Images *IEEE Comput. Graph. Appl.* **21**, 34(sep 2001).
18. H. Zhao, X. Jin, J. Shen and F. Wei, Real-time photo style transfer, in *CAD/Graphics*, 2009.
19. L. Szirmay-Kalos, L. Szécsi and M. Sbert, *GPU-Based Techniques for Global Illumination Effects* Synthesis Lectures on Computer Graphics and Animation, Synthesis Lectures on Computer Graphics and Animation (Morgan & Claypool Publishers, 2008).