Summary of the 2011 Paper "An Efficient Direct Volume Rendering Approach for Dichromats" by Chen et al.

Course Visualization 2

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Abstract

Ths is a summary of the paper "An Efficient Direct Volume Rendering Approach for Dichromats" by Weifeng Chen, Student Member, IEEE, Wei Chen, Member, IEEE, and Hujun Bao, that addresses the problem of incorrect perception of volume visualisation results by people with color vision deficiency (CVD). It introduces a new approach for dichromat-friendly and consistent direct volume rendering (DVR), which is built on conventional image recoloring techniques and introduces a novel color composition mode.

1 Motivation

Volume Visualisation is a widely used tool for communication and analysis. A high percentage of the population worldwide is affected by CVD and for those people conventional volume visualisation is not usable.

People with normal vision, or trichromats, have three types of cones in their eyes, that respond to long (L), medium (M) or short(S) wavelengths. The responsivity spectra of the cones define the LMS color space. Dichromats have only two types of cones, which means that their LMS color space is much smaller than that of a person with normal vision. That is the reason why people with CVD are sometimes not able to distinguish between two different colors(see Fig. 1(a)) and may miss important visual classification in the results, provided by the common DVR. The paper of Chen et al. proposes a solution to improve DVR-images for dichromats.

2 Background

The dichromatic perception is simulated by a transformation from the LMS color space to the reduced LMS color space for dichromats, where the transformation matrix is based on different simulation models. The Brettel model, which the presented paper is based on, is the most popular one. The reduced LMS color space for dichromats can be geometrically represented as two half-planes in the LMS color space, and the simulation of the dichromatic perception of a color is done by a projection of the color onto one half-plane(see Fig. 1(b)).

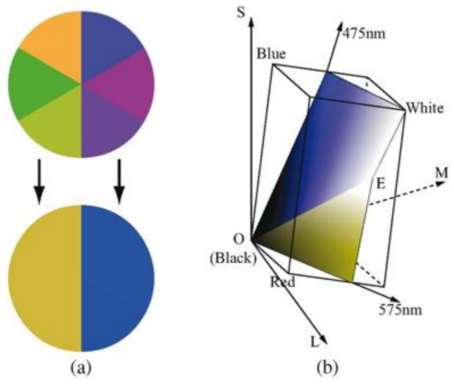

Fig 1 (a)Different colors may result in an identical color for dichromats; (b) Geometric representation of the reduced LMS color space for dichromats [1].

Image recoloring techniques, used in DVR to improve the visual perception for dichromats, may lead to deficient and color-inconsistent results, because the image recoloring is performed on the composed colors for each frame, without taking into account the current viewing configuration. The conventional color composition mode operates in the trichromatic color space, and may return colors that are not distinguishable for dichromats. The approach introduced by the paper resolves those problems by optimizing the image recoloring scheme and employing a novel CVD-friendly color composition mode. It modifies the components of the DVR in order to allow users with normal vision to generate results perceivable for dichromats.

3 Optimizing the Color Transfer Function

The method presented in this paper aims to optimize the transfer function, so the produced images are better perceivable by dichromats than the results of conventional image recoloring methods. Also the authors designed their algorithm in a way so the optimized transfer function is as close as possible to the original transfer function and assigned colors can be preserved. First, a conventional image recoloring process is performed. The results of this operation are then used to guide the optimization of the transfer function. This optimization step needs to be executed only once for a given transfer function.

Because DVR is view-dependent this optimization is not a global complete solution due to 3D occlusions that might appear. To overcome this problem the method was extended to a multi-view optimization. Therefore the best views for calculating the modified transfer function have to be selected by either specifying them manually, or automatically, using uniformly sampled viewing angles. Then multiple DVR results can be incorporated into the optimization process. By putting all the constraints of these results together, a solution that considers influences from multiple views is achieved.

4 CVD friendly color composition

4.1 Color Blending

Conventional models for color composition blend colors in the RGB color space. For image recoloring, the colors are then mapped into the reduced color space for dichromats. The composed colors may be mapped into similar or identical colors during the color blending mode, which leads to an information loss. Therefore the authors of this paper perform the color composition in the reduced LMS color space. The benefit of this procedure is that the result of the composition will always lie in the same color space and produce a distinguishable color for dichromats. In detail the method works as follows. First the RGB colors are transformed to the LMS color space and projected onto the two half-planes that represent the reduced color space for dichromats. Then the geodesic path between the two positions representing the colors to be composed is calculated. Afterwards an intersection point of this path and the intersection line of the two half-planes is calculated. Using this intersection point the euclidian distance of the two colors in the reduced LMS space can be determined and used to weigh the alpha value of the composed color. Finally the calculated color is transformed back into the RGB color space.

4.2 Luminance Consistency

The reduced color space for dichromats is not uniformly distributed due to the fact that it is obtained by projecting the LMS color space onto two half-planes, using a warping transformation that leads to a distortion. So the luminance channel has to be modified after the color composition. This is done analog to the back to front blending of colors in DVR.

5 Implementation Details

We will be implementing the method presented in this paper in XNA 4.0 using c# as programming language and HLSL as shader language.

Our implementation will be based on the volume renderer we created for the visualization 1 lab, but updated to the newest version of XNA. Although we aim to preserve most of the features of our volume renderer, we will focus on implementing image recoloring, optimizing the transfer function and the CVD-friendly composition mode presented in the paper of Chen et al.

The CVD mode will be added as different view, respectively as feature for user with normal vision to generate CVD-friendly volume visualization.

6 References

[1] W. Chen, W. Chen, and H. Bao. An Efficient Direct Volume Rendering Approach for Dichromats. IEEE Transactions on Visualization and Computer Graphics, 17(12), 2011.