The Role of Contrast in the Perceived Depth of Monocular Imagery

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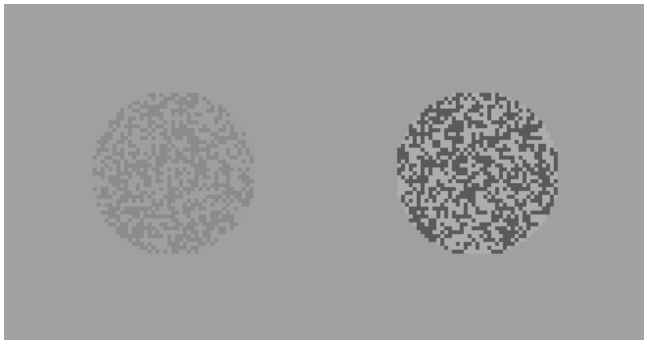

Figure 1: *The perceived depth of an object is related to the contrast both between the object and the background, and within the object itself.*

1 Introduction

There are many visual cues that provide sensations of depth or distance in our observations of real-world 3D scenes as well as 2D images. In the latter case, these cues are *monocular* in that the images appear the same to both retinae and do not have binocular disparity that can be used to form depth judgments. Examples include perspective, relative sizes of objects, familiarity with sizes of objects, occlusion, contrast, brightness, color saturation, and haze. Contrast and brightness are of particular interest to us since they can be manipulated through a much greater range on high dynamic range displays than is possible on conventional displays.

2 Experiments

We conducted three experiments to analyze the relationship between contrast and perceived depth of objects in an image, and found statistical significance in all three experiments.

Our first experiment was designed to reproduce the results obtained by [Ichihara et al. 2007] on random dot patterns (Figure 1), and extend them to natural textures. The results are substantially similar to those of Ichihara et al. Increases in texture contrast corresponded with increases in the perceived closeness of a disk, and the effect of texture contrast was significantly more pronounced at low levels of area contrast than at high levels. We then extended the analysis of Ichihara et al. and observed that perceived closeness generally increases as the area contrast of a disk increases, with texture contrast being held constant, when the area contrast is positive (bright area on a dark background). When the area contrast is negative (dark area on a brighter background), perceived closeness increases as the area contrast increases at low levels of texture contrast, but decreases as area contrast increases at high levels of texture contrast. In the second part of the first experiment, we observed that the same relationships held for natural texture images as for random dot images.

Our second experiment was designed to analyze the impact of a higher dynamic range on depth perception. The results of this experiment generally showed the same relationships between area

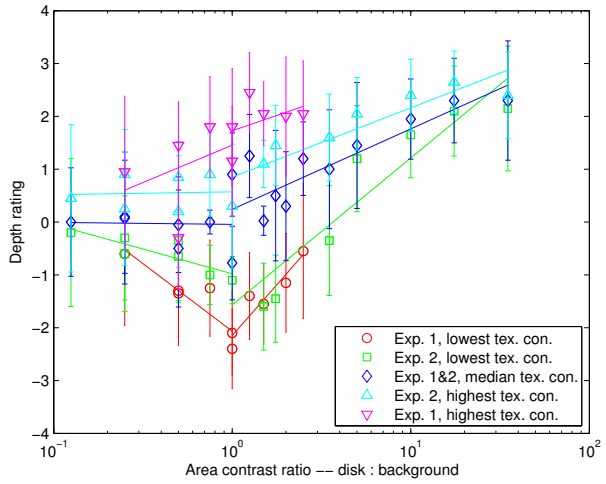

Figure 2: *The effect of varying area contrast ratios on the perceived depth of disks, at low, medium, and high levels of texture contrast. The error bars show the standard deviations around the means, while the solid lines are best-fit lines for their corresponding data points.*

contrast, texture contrast, and perceived depth as were observed in the first experiment. Increases in texture contrast generally corresponded with increases in the perceived closeness of a disk, more so at low area contrast levels than at high (positive or negative) area contrast levels. Additionally, the increase in positive area contrast yielded an increase in the perceived closeness of a disk, particularly at lower texture contrast levels. Figure 2 shows the effect of area contrast on perceived depth, and the increased effect of the high levels of area contrast achievable on HDR displays over the lower levels of area contrast achievable on LDR displays.

Finally, our third experiment looked at depth within a scene rather than the closeness of disks, and was designed to analyze how the contrast of the highlights of a texture patch in a scene can affect the perception of depth within that scene. We found that subjects indicated a greater sense of depth as the contrast of the highlights was increased.

Additional details and results[1] are described in [Rempel et al. 2011].

References

ICHIHARA, S., KITAGAWA, N., AND AKUTSU, H. 2007. Contrast and depth perception: Effects of texture contrast and area contrast. *Perception 36*, 686–695.

REMPEL, A. G., HEIDRICH, W., AND MANTIUK, R. 2011. The role of contrast in the perceived depth of monocular imagery. Tech. Rep. TR-2011-07, The University of British Columbia.

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[1] http://www.cs.ubc.ca/labs/imager/tr/2011/Rempel_Depth_Perception