LCIS: A Boundary Hierarchy For Detail-Preserving Contrast Reduction

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Abstract

High contrast scenes are difficult to depict on low contrast displays without loss of important fine details and textures. Skilled artists preserve these details by drawing scene contents in coarse-to-fine order using a hierarchy of scene boundaries and shadings. We build a similar hierarchy using multiple instances of a new *low curvature image simplifier* (LCIS), a partial differential equation inspired by anisotropic diffusion. Each LCIS reduces the scene to many smooth regions that are bounded by sharp gradient discontinuities, and a single parameter K chosen for each LCIS controls region size and boundary complexity. With a few chosen K values $(K_1 > K_2 > K_3 ...)$ LCIS makes a set of progressively simpler images, and image differences form a hierarchy of increasingly important details, boundaries and large features.

We construct a high detail, low contrast display image from this hierarchy by compressing only the large features, then adding back all small details. Unlike linear filter hierarchies such as wavelets, filter banks, or image pyramids, LCIS hierarchies do not smooth across scene boundaries, avoiding "halo" artifacts common to previous contrast reducing methods and some tone reproduction operators. We demonstrate LCIS effectiveness on several example images.

CR Descriptors: I.3.3 [**Computer Graphics**]: Picture/image generation - *Display algorithms*; I.4.1 [**Image Processing and Computer Vision**]: Enhancement -*Digitization and Image Capture*

Keywords: Signal Processing, Displays, Non-Realistic Rendering, Level Of Detail Algorithms, Radiosity, Weird Math.

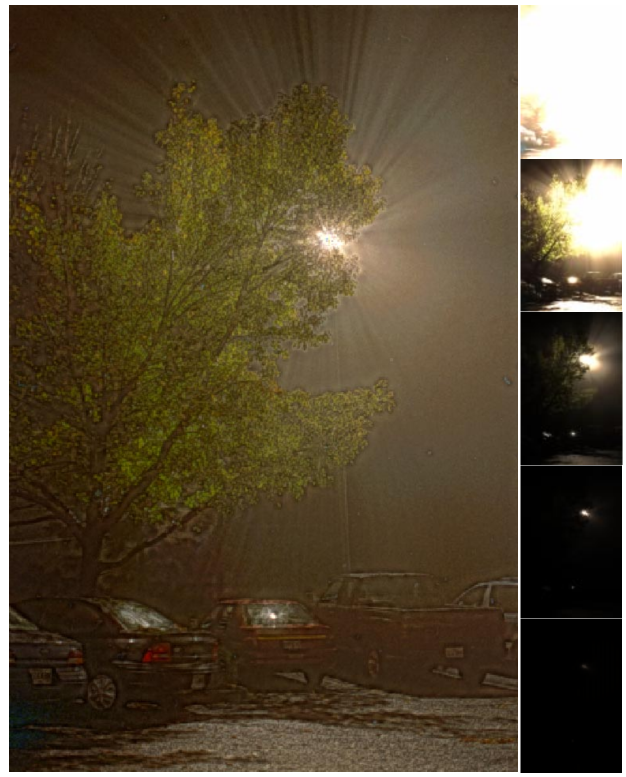

Figure 1: This low contrast image of a streetlight on a foggy night was made by LCIS methods from an extremely high contrast radiance map [2]; Small images show the original scene radiances scaled by progressive factors of 10. Despite scene contrasts greater than 100,000:1, LCIS methods preserve details impossible to capture in a single photograph, including long, dramatic fog streaks, asphalt texture, and tree details in highlight and shadow.

1 Introduction

Local adaptation, the ensemble of local sensitivity-adjusting processes in the visual system, reveals visible details almost everywhere in a viewed scene. Even while driving at night, we see few shadows that are truly featureless black. We can read the tiny lettering on the dazzling surface of a frosted incandescent bulb in a desk lamp, yet we also see the dark room around us. Mechanisms of visual appearance often cause us to underestimate large scene contrasts. For example, we measured a piece of paper on a desk to find it was 1,200 times brighter than the dark carpet in the foot-well beneath it, yet we could easily see the fibrous textures of both simultaneously. Making an image such as Figure 1 that captures both the high contrast appearance of a scene and its small low-contrast details is contradictory and difficult, and currently the best, most satisfying depictions of these scenes may be the creations of skilled artists.

For three important reasons listed here, cameras and computer graphics renderings have severe difficulties capturing, preserving, and displaying the subtle textures and details in high contrast scenes. First, available display contrasts are small and are easily overwhelmed by the scene contrasts, where contrast is the ratio between two measured light intensities. Newspaper photographs achieve a maximum contrast of about 30:1, typically CRT displays offer contrasts of no more than 100:1, and only the best photographic prints can provide contrasts as high as 1000:1. However, scenes that include visible light sources, deep shadows, and specu-

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