Human vision operates over about nine orders of magnitude, from starlight at 10^{-4} candelas/meter^2 to daylight at 10^5 cd/m^2. In any given scene, the eye can adapt comfortably over a smaller range of about four orders of magnitude. This still exceeds the dynamic range of conventional display devices and media, which at best cover a range of about 100:1 – only two orders of magnitude. The rest of the information, which would be perceived in the real world as detail in bright and dark regions, is lost above the maximum display value or below the black level. This limitation has serious ramifications for simulated imagery, especially when it is needed to evaluate visual performance or in virtual reality (VR) environments. Previous tone mapping work by Tumblin and Rushmeier[1], Ward[2], and Ferwerda et al[3] did not consider the question of local adaptation. Chiu et al[4] looked into this problem, but their solution resulted in reverse gradients and did not account for human visual response.

In this sketch, we present a new method for mapping scenes and images containing high dynamic range information to conventional (and VR) displays. The technique matches object visibility as its primary goal, meaning that objects visible in the real world will be visible on the display, and conversely, objects not visible in the real world will not be visible on the display. As a secondary goal, the method attempts to reproduce a viewer's subjective response, meaning that the impression of the displayed image should correlate well with memories of the actual scene.

The starting point of our method is a histogram of scene brightnesses, which we define as the log of luminances averaged over 1° areas. These areas correspond to foveal adaptation levels for possible fixation points in a scene or image. We then apply a histogram adjustment procedure to remove portions of the brightness population that are under-represented in the scene, since they convey relatively little visible information. We compress this unused dynamic range so that important objects in bright and dark regions can be included within the usable dynamic range of the display. The eye tends not to notice the compressed information as missing, since human vision is designed to perceive object detail, not relative brightnesses.

Once we have solved the problem of making visible world objects also visible on the display, we need to consider human visual limitations, so that objects *not* visible in the real world are *not* visible on the display. First, we adjust our brightness histogram to match local human contrast sensitivity. Next, we add veiling luminance around bright areas (e.g., light sources) to simulate scattering in the eye. In dark scenes, we also model the loss of color sensitivity in accord with measurements of mesopic and scotopic response. Finally, in very dark regions, we may adjust image resolution locally to match limits in human visual acuity.

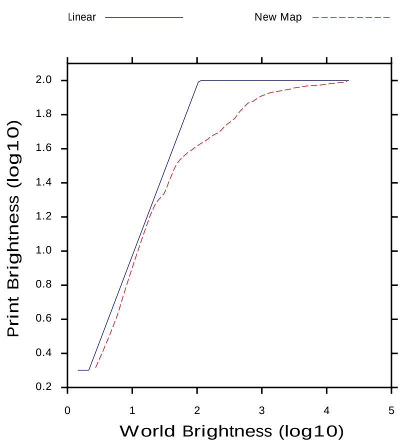

FIGURE 1 Plot of linear tone mapping used in Figure 2 versus new tone mapping used in Figure 3.

FIGURE 2 An unadjusted simulation of a bathroom scene mapped with a standard linear tone reproduction operator.

FIGURE3 The same simulation reproduced using the new tone mapping operator, which models human contrast sensitivity and disability glare.

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