36.2: Quantifying “Sparkle” of Anti-Glare Surfaces

Darren K. P. Huckaby
EuropTec USA Inc., Clarksburg, WV, USA

Darran R. Cairns
Dept. of Mechanical & Aerospace Engineering, West Virginia University, Morgantown, WV, USA

Abstract
Textured surfaces are widely used for anti-glare surfaces. Modern high resolution displays are placing higher demands on these layers. Developing techniques to quantify the subjective appearance of speckle caused by overlays is crucial to developing the next generation of overlays. We report on the use of a simple optical bench to measure speckle contrast and the comparison of these measurements to subjective scores for sparkle. We show that for a set of specially prepared acid etched samples there is a direct correlation between speckle contrast and subjective sparkle.

1. Introduction
Textured diffusing surfaces are widely used in the display industry for the reduction of glare [1]. Examples include CRT faceplates, touch panels and polymer films. Topographical texture reduces reflections through the random scattering of reflected light and thus can greatly enhance the ability to read displays in certain lighting conditions. This glare reduction can be particularly useful in applications where distinct bright light sources may be present.

Textured surfaces can be produced by a wide variety of methods. One method is the removal of material from a smooth surface by acid etching or sand-blasting. Alternatively, rough coatings can be applied to a smooth surface by spraying, polymer web-coating or dip-coating. Some examples of such textured surfaces are shown in Figure 1. In general there is a tradeoff between glare reduction and the degradation of transmitted properties. Perhaps most noticeable is an increase in transmitted haze. Much work goes into the development of textured anti-glare surfaces that optimize glare reduction with only small increases in haze. Haze is the result of diffraction effects and can be correlated to the feature size of the diffusing surface. However, with recent increases in the brightness of displays speckle has also become very important. Laser Speckle is a random collection of alternately dark and bright spots observed when a laser is scattered from a wall or by a transparent diffuser [2]. While speckle is most often connected with lasers and has received some consideration in laser projection displays [3-5] it is not limited to laser systems. Any coherent light source can cause speckle as long as light from the source is still coherent and that there is sufficient distance between the diffusing surface and the observer that multiple spots on the surface can interfere with each other. The manifestation of this phenomenon is sometimes termed sparkle and can appear as random fluctuation in intensity on a display as the viewers head moves from side-to-side. Speckle is most often quantified by the speckle contrast [6].

The greater the speckle contrast the more objectionable the sparkle. Speckle is strongly dependent on the roughness of the illuminated substrate. However, the speckle contrast is also feature size and angle dependent. This dependence on feature geometry suggests that surface topography can be tuned to produce anti-glare surfaces that have both good anti-glare properties and relatively low speckle contrast values, i.e. they reduce reflected glare without exhibiting excessive sparkle. In this contribution we describe our work in quantifying speckle for anti-glare surfaces produced by acid etching with various degrees of roughness and comparing this to subjective measurements from subjects.
2. Experimental
We have produced anti-glare surfaces with a variety of roughness values by acid etching. Samples were dipped in an acidic solution to produce 60° Gloss values ranging from 35 to 120. An optical bench was constructed comprising of a 5mW He-Ne laser incident onto a glass sample with the image projected onto a velum screen. The image was then captured using a CCD camera (Nikon D50) and the intensity distribution measured using image analysis software (MATLAB Image Analysis ToolPack). A neutral density filter and a central beam stop were used to attenuate the light intensity so that the detector was not saturated. Image processing was performed as a circular scan and the speckle contrast determined as a function of distance from the center using the standard deviation and mean intensity (see Figure 2).

Figure 2. Optical setup for capture of laser speckle pattern from textured surface
Subjective measurements were obtained using a ten point scoring system. Subjects were given 5 samples with different gloss levels and asked to place them in front of a CRT and score them with 1 indicating no sparkle and 10 intense sparkle. Thirty subjects took part in the study and each subject had all five samples to compare while scoring.

3. Results
An example image captured from an acid etched sample with a 60° gloss of 120 is shown in Figure 3. The average intensity clearly decreases radially from the center to the outside. An example of the variation of intensity as a function of distance from the center is shown in Figure 4. The average intensity is normally distributed and fluctuations in intensity are clearly visible. Figure 5 shows the speckle contrast (standard deviation/mean intensity) as a function of distance from the central maximum. Figure 6 graphs the speckle contrast versus gloss level for five samples and also shows the results of the subjective study. The subjective sparkle ratings and speckle contrast measurements both increase linearly with increasing gloss. The gloss was controlled during etching by dip-time with high gloss samples being etched less than low gloss samples. An increase in etch time leads to an increase in roughness and an associated lower gloss value. The lower the gloss the lower the speckle and sparkle because the rough surface reduces coherent scattering.

The speckle contrast method of quantifying sparkle looks very promising and we are continuing to refine the measurement technique on other anti-glare surfaces. It is easy to automate and is very repeatable. The ability to compare different textured surfaces in a quantifiable way would be a powerful design tool. The ability to detect small changes in speckle will also enable the development of a better understanding of the development of new overlays that maximize glare reduction while minimizing sparkle. As next generation displays become higher resolution and backlights become brighter sparkle is becoming a greater issue.
4. Conclusions

Textured surfaces are widely used in the display industry and as displays improve it is important to understand the surface in more detail. The optical properties of such rough surfaces can be very difficult to compare. Widely used metrics such as transmission, haze and gloss measurements are widely used in industry but these metrics alone are not always satisfactory in evaluating the appearance. Our results highlight the possibility to understand how to tailor surfaces to produce the next generation of diffusing surfaces. We have shown that there is a strong correlation between speckle contrast and subjective sparkle. This method may be useful for enabling standardized measurements of sparkle.

5. Acknowledgements

D.K.P. Huckaby gratefully acknowledges the financial support of a NASA space grant. D.K.P. Huckaby, and D.R. Cairns gratefully acknowledge the financial support of Europtec USA Inc.

6. References