Perceived Directionality of $1/f^\beta$ Noise Surfaces

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1 Introduction

We are investigating the perceived characteristics of 3D surface texture by using rendered images of synthetic surfaces with precisely defined characteristics. We compute texture features directly from the height data and present observers with animated images that mimic the way in which people rotate surface textures when assessing their characteristics. This both eliminates illumination induced bias and provides observers with rich, realistic stimuli.

Previously we used a similar approach to establish a perceptual scale of visual roughness of random-phase $1/f^\beta$ noise surfaces [Padilla et al. 2008]. Here we focus on directionality and present the results of a novel psychophysical investigation of the directionality of such surfaces. In our previous work, these have been isotropic, but are now modified by adding a directionality term which controls the texture's $directional\ variance$. They are rendered and animated using a simple Lambertian model (Figure 1). The goal of performing this work is to establish the relationship between the directional variance introduced into these surfaces and their perceived directionality. The Direct Ratio Estimation Method [Torgerson 1958] is used to derive the psychophysical scale in which a subject assigns a ratio of the sensory magnitudes of two presented stimuli (sense-ratio), and the geometric means of these ratios are computed to create the scale values which provide the least-square estimates of the scale values.

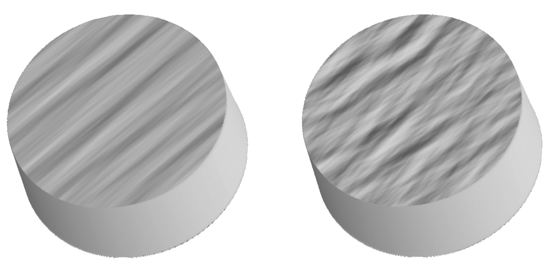

Figure 1: *Example surfaces.*

2 Experimental Design, Setup and Results

The stimuli were created by rendering modified $1/f^\beta$ noise surfaces. Their magnitude spectra have the following form:

$$P(f,\theta) = (1/f^\beta)e^{(\theta-\theta_0)/(2\sigma^2)} \ , \qquad (1)$$

where f, θ are the polar frequency domain coordinates, β is the surface roll-off factor, θ_0 is the dominant direction, and σ^2 is defined as the 'directional variance'.

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A total of 15 synthetic surface textures were generated using this model at different directional variances. The surfaces were chosen to have equal distances on the scale of $\log^2(\sigma^2)$. This scale was chosen to provide visually distinct surfaces.

To obtain the psychophysical scale of the perceived surface directionality, eight subjects were presented with pairs of surfaces and asked to identify the more directional surface and to give the sense-ratio.

We found that a simple exponential function $s = ae^{-bv}$ (Figure 2) is sufficient to model the relationship between the perceived directionality and a surface's directional variance, where s is the perceived directionality and $v = \log^2(\sigma^2)$. A linear least square regression was used to fit the exponential in log-space, which gave the following parameter values:

$$a = 8.7172 \qquad b = 0.3503$$

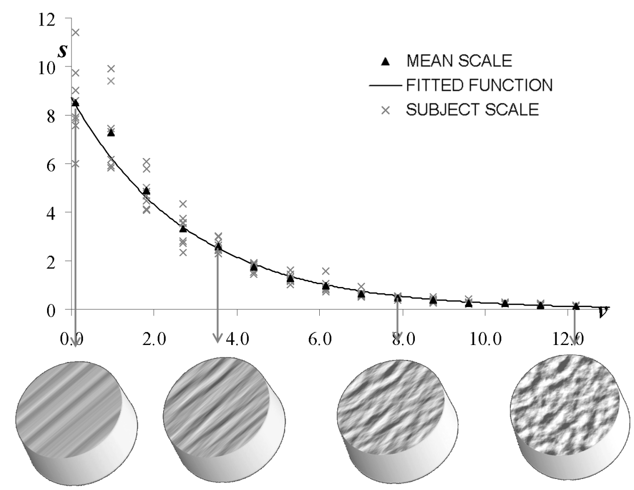

Figure 2: *Perceived directionality (s) vs log-squared-variance (v).*

3 Conclusions

We have presented a novel psychophysical investigation into the perceived directionality of $1/f^\beta$ noise surfaces. Instead of still imagery, we have used animations of wobbling surfaces to provide rich stimuli. Furthermore, we have used a parameter computed directly from the surface height function in order to avoid illumination induced bias. The results indicate that, for these surfaces, an exponential relationship exists between the perceived directionality and the log-squared directional variance. We believe that this result may be exploited in perception-based texture retrieval tasks.

References

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TORGERSON, W. S. 1958. *Theory and methods of scaling*. New York: Wiley.