Gloss and Normal Map Acquisition Using Gray Codes (sap_0128)

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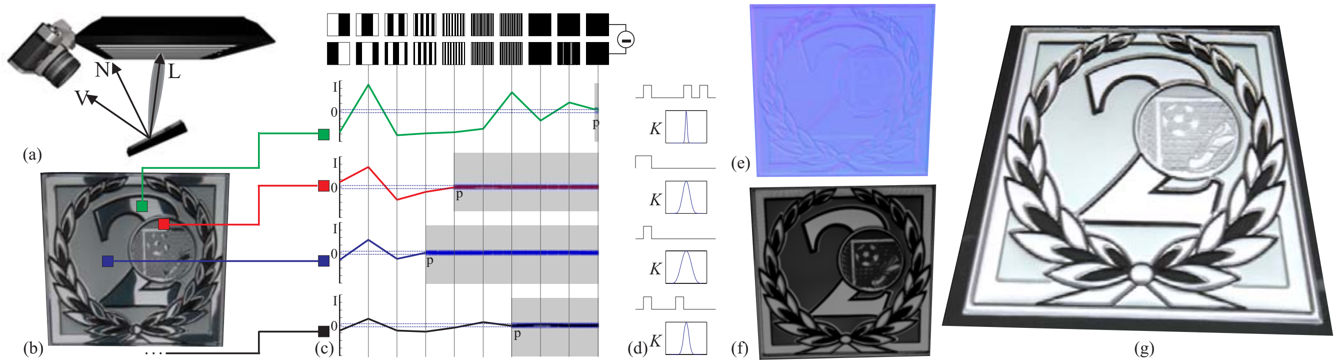

Acquisition pipeline. (a) setup, (b) mesostructure, (c) intensity differences in function of pattern refinement level, (d) detected normal codes and Phong kernels, (e) normal map obtained from detected codes, (f) gloss map consisting of Phong exponents, (g) rendering.

1 Introduction

We propose a technique for gloss and normal map acquisition of fine-scale specular surface details, or mesostructure. Our main goal is to provide an efficient, easily applicable, but sufficiently accurate method to acquire mesostructures. We therefore introduce a setup consisting of cheap and accessible components, including a regular monitor and a digital still camera.

We build on our previously proposed method [Francken et al. 2008], which acquires normal maps by analyzing the reflection of binary patterns (Gray codes). These patterns are successively refined in this process. The key idea in this paper, is that this refinement also allows us to measure the shininess for each spatial location, resulting in a gloss map. Acquiring spatially varying reflectance usually requires a complicated hardware setup, which measures the BRDF at each spatial location. Our method is much simpler and cheaper. Even though we assume a very simplified BRDF model, our technique is able to reproduce the mesostructure's appearance faithfully.

2 Approach

Acquiring local surface orientation and glossiness is achieved by placing the target object in front of an LCD monitor which acts as a light source, and recording the corresponding images using a camera (Fig b). As in our previous technique [Francken et al. 2008], we display stepwise refining vertical and horizontal Gray code patterns. We also display each pattern's complement in order to robustly separate diffuse from specular reflection. The specular reflections then efficiently encode discrete spatial screen coordinates in a bit-wise fashion. In a geometrically calibrated setup, this allows for estimating the ideal reflection direction for each pixel, and which in turn enables us to estimate surface normal by taking the halfway vector between the light and viewing vector L and V (Fig a).

In this work we extend the original system [Francken et al. 2008] by performing a glossiness analysis. As indicated by the gray area in Fig c, after a certain number of pattern refinements, no extra information will be gained as the intensity differences between reflected patterns and their complements will converge to zero. We analyze this convergence process to obtain glossiness information. Without requiring additional input images, we are now able to obtain a per pixel shininess coefficient as well as a surface normal.

The more pattern refinements that can be discerned, the more specular the material will be, and vice versa. This is the case because the reflected pattern is convolved with a kernel around the ideal reflection direction. The number of refinements thus is proportional to the shininess of the material. The size (or narrowness) and shape of the kernel is defined by the specular lobe of the BRDF. For the sake of simplicity as well as compatibility with known tools, we assume a Phong reflection model. This isotropic lobe is then described by a single exponent value n which is stored in the gloss map.

As the desired kernel size is closely related to the last meaningful level of pattern subdivision p, we first try to find that level. This is achieved by taking the subsequent recordings, subtract their corresponding images under complementary illumination, and applying a simple thresholding step on the absolute values of the results. We then find the pattern p from where *all* intensities drop below the threshold (Fig c). The intensities before this point are meant to encode a meaningful position on the screen.

When p is found, it is converted into a corresponding Phong kernel $K(\omega) = \cos^n(\omega)$ (Fig d). Therefore we propose a heuristic which takes into account the following constraints: (1) surface area $\int_0^{\pi/2} K(\omega)d\omega$ under kernel K has to halve if the assigned p increases one level, and (2) K is normalized w.r.t. incoming light angle, distance to screen and screen dimensions. Notice that this kernel fitting is approximate because of the limited number of input images we require and the reflection model we employ. However, as we focus mainly on the efficiency and easy applicability more then on pure accuracy, it yields sufficiently precise results, as can be seen in the next section.

3 Results and Discussion

We have created a proof of concept implementation of the described procedure. The setup we employed consists of a 19 inch LCD monitor and a Canon EOS 400D camera. Experiments were done on different specular materials including plastics, leather, metals, glass and polished marble. For all our results 40 input images were recorded, 20 for each direction. Results are illustrated in the teaser as well as in the supplementary material.

However, improvements are possible regarding convolution kernel approximations. Currently we are looking into recovering more general BRDFs by adding extra and more optimal patterns to allow for a more precise kernel fitting.

References

FRANCKEN, Y., CUYPERS, T., MERTENS, T., GIELIS, J., AND BEKAERT, P. 2008. High quality mesostructure acquisition using specularities. In *Proceedings of CVPR*, IEEE.