Capturing 3-D Texture with a Digital Camera

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Depth Hallucination – The Short Story

• Acquire Textured surface model
  – From a single view
  – Using only a digital camera and a flash.
Why Do We Want Depth?

• Classical Texture Mapping
  – Images mapped to 2D geometry
  – No self-shadowing/silhouette detail

• Real-world textured surfaces
  – Visually rich, changes with view and lighting
  – Common in nature and the built environment
  – Aesthetics / ornamentation
Real-World Examples
Depth Hallucination Method

• Steps:
  – Capture flash / No-flash image pair
  – Estimate Albedo
  – Estimate a shading image
  – Calculate depth

• Assumptions:
  – Diffuse/sky illumination
  – Global curvature ignored
  – Specular reflectance removed
Albedo Estimation

• Starting with flash / no-flash input pair
  – Correct for Ambient lighting using no-flash image
  – Correct for vignetting using flash calibration image

• Result – Albedo map

\[
\frac{I_f(j) - I_d(j)}{I_c(j)}
\]
Compute Shading Image

\[ S = I_a - I_d \]
Depth Estimation from Shading Image

• We formulate a hypothesis about local surface structure
Above/Below Plane Models

• Above plane model

• Below plane model
Combined Surface Model

\[ D(S) = \frac{d}{a} = \begin{cases} 
\sqrt{1/S - 1} \\
2(1-S) 
\end{cases} \]
Apply at Multiple Scales

$r(i) = 27$

$r(i) = 9$

$r(i) = 3$

$r(i) = 1$
Simplified Capture w/o Flash

• Histogram Matching
  – Needs exemplar model
  – Single diffuse-lit photo
  – Match histograms
  – Create rendering
Validation

• First user study
  – Rank sequentially presented images
  • Photos – 3.97
  • Relit images – 3.22
  • Histogram matched – 2.98
Validation

• Second user study
  – Select most plausible surface
    • No significant difference in people’s subjective choices
Limitations

• Our method will fail if:
  – Surface geometry cannot be represented as a height field
  – Daylight is heavily biased towards one dominant direction
  – Surface contains highly reflective or translucent materials
Conclusion

• Simple method
• Results – like photographs
  – 75% of participants rated our images more likely to be photos
  – Participants unable to decide if renderings of hallucinated depth or laser-scans more plausible