Capturing 3-D Texture with a Digital Camera

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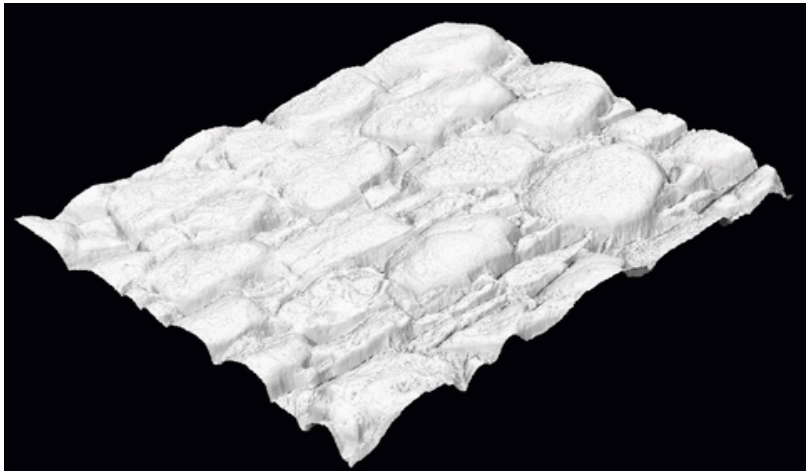
Depth Hallucination – The Short Story

- 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

BAY
ALARM

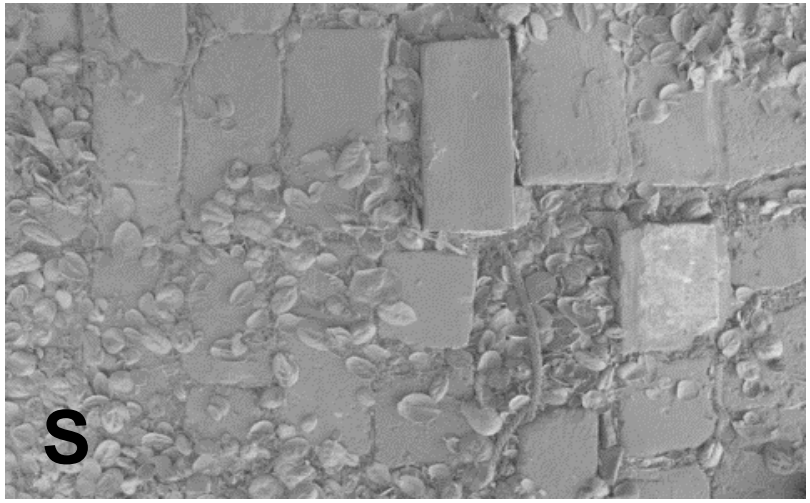
Albedo Estimation

- 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

$$\frac{I_f(j) - I_d(j)}{I_c(j)}$$

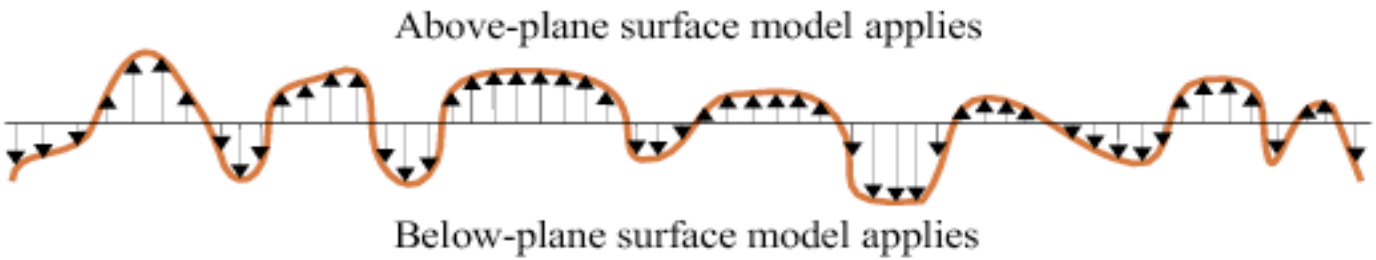
Compute Shading Image

=



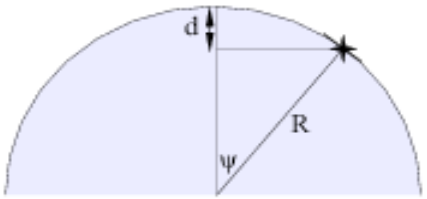
Depth Estimation from Shading Image

- We formulate a hypothesis about local surface structure

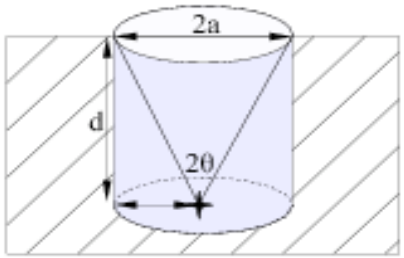


Above/Below Plane Models

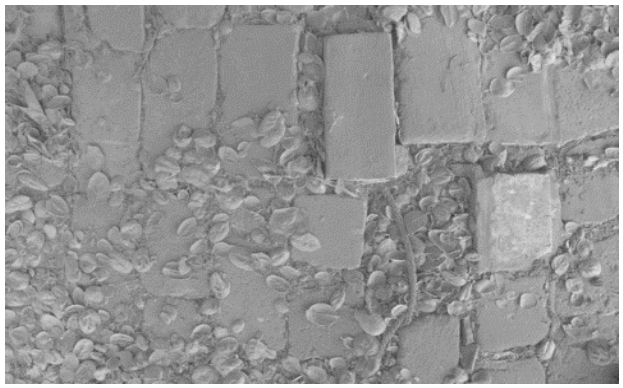
- Above plane model



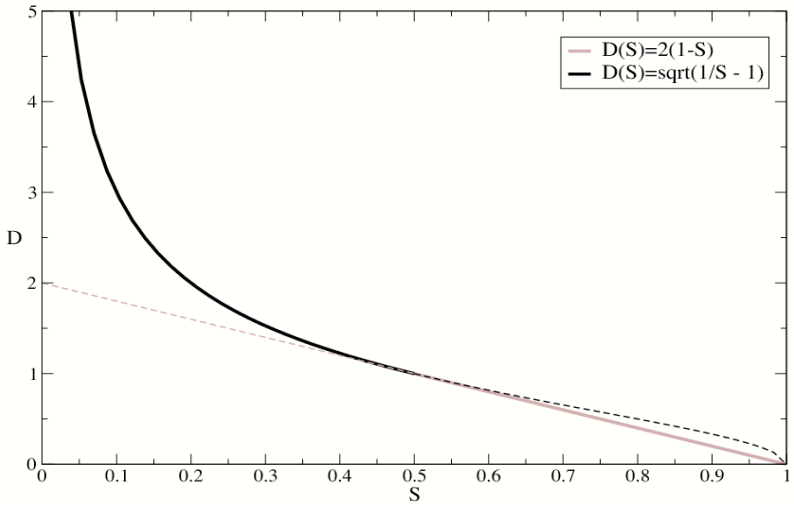
- Below plane model



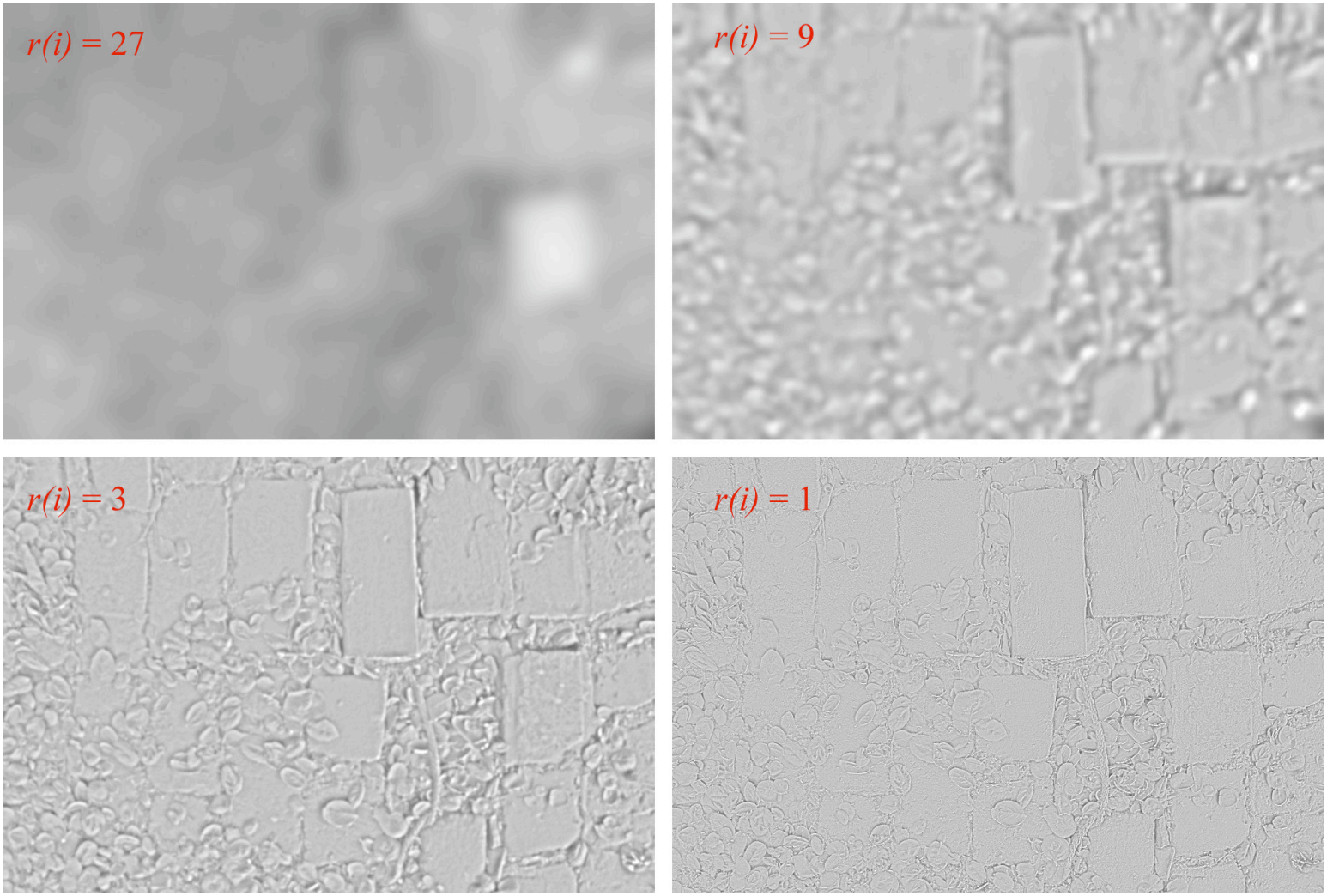
Combined Surface Model



$$D(S) = d/a = \begin{cases} \text{Sqrt}(1/S-1) \\ 2(1-S) \end{cases}$$

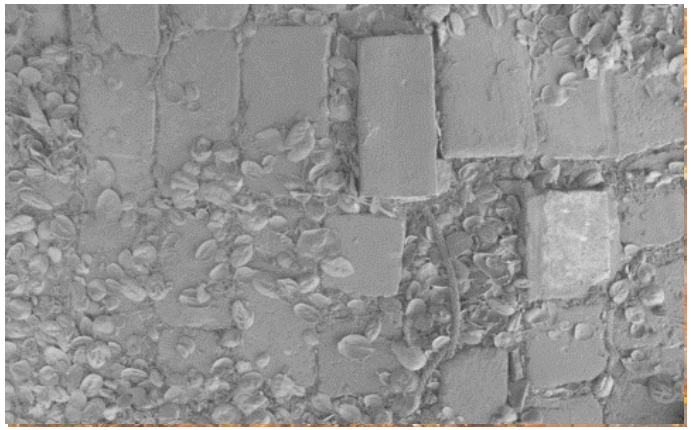


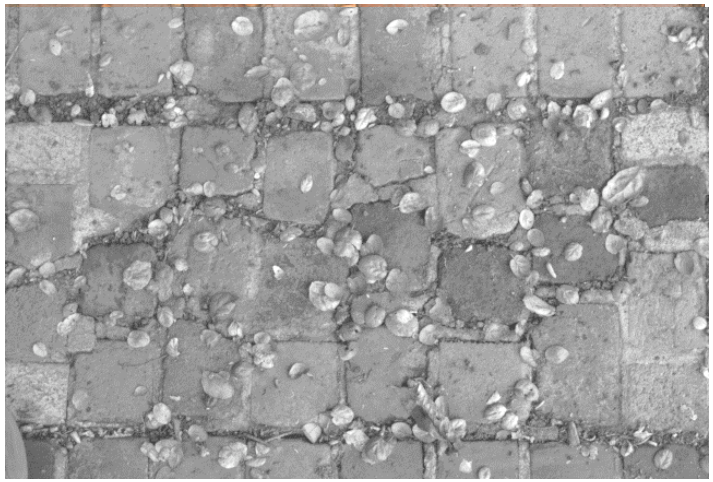
Apply at Multiple Scales



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