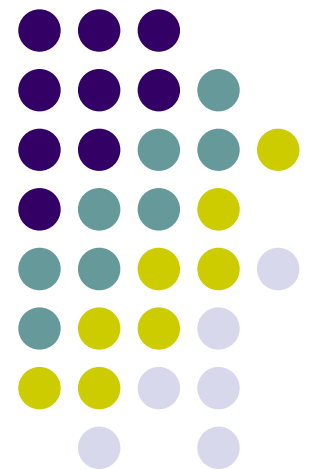
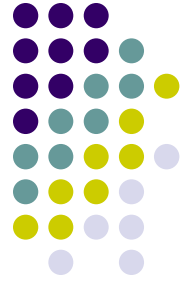


Volume Rendering with Stippling

May 17, 2005

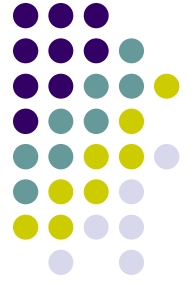
Raymond Li





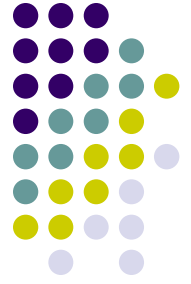
Introduction

- Simulate hand-drawn techniques
- Specifically target stippling
- Stippling uses dots to give the impression of shading, light, silhouettes, boundaries, and structure
- A region with more stipples usually means a higher density or a boundary



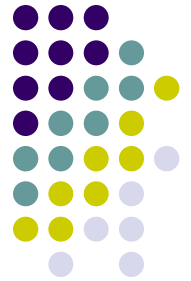
Objective

- Implement stipple rendering engine
- Originally wanted to get basic engine working and finish by adding feature enhancements
- Although silhouette and boundary feature enhancements are implemented, silhouette curves are much more interesting
- Silhouette curves are implemented



Stippling

- Point rendering system (object-order viewing)
- Use orthogonal projection
- 5x5x5 cube represents voxel
- Voxel attributes (intensity, boundary, silhouette) are “mapped” to stipples in cube
- Poisson disc distribution for stipples



Feature Enhancements

- Stipple count (N_i)

$$N_i = N_{\max} * T$$

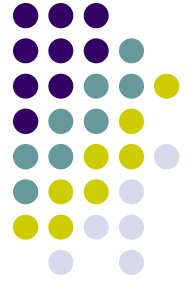
- T represents feature enhancements

$$T = T_b * T_s$$

- T_b and T_s are the boundary and silhouette feature enhancements, respectively

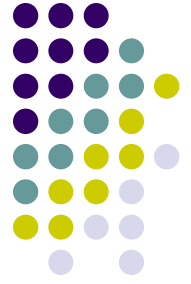
- $T_b = v_i * (k_{gc} + k_{gs} * (\text{gradient_magnitude})^{k_{ge}})$

- $T_s = v_i * (k_{sc} + k_{ss} * (1 - (\text{abs}(\text{gradient_vector} \cdot \text{eye_vector}))^{k_{se}}))$



Silhouette Curves

- Outline volume, important features
- Use edge-enhancement (LoG)
- If all criteria satisfied, draw center line in direction of (gradient_vector x eye_vector):
 1. $v_i * \text{LoG}(v_i) < Th_{\text{log}}$
 2. $\text{eye_vector} \cdot \text{gradient_vector} < Th_{\text{eye}}$
 3. $\text{gradient_magnitude} > Th_{\text{grad}}$
- 11x11x11 LoG kernel, sigma=1.4



Results

- A stipple volume rendering engine is successfully implemented with boundary and silhouette enhancements
- Silhouette curves are also implemented
- Rendering engine is fast even without hardware acceleration
- Each rendering of the sample volume datasets took no longer than about 10 seconds
- Visit website...



References

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<http://en.wikipedia.org/wiki/Stippling>
- PURPL - Non-photorealistic rendering using stippling techniques.
<http://www.ecn.purdue.edu/purpl/projects/vstipple>