TEXTURE SYNTHESIS

Given a texture, create more

All examples from Wei & Levoy
Texture Synthesis

Don’t expect too much

All examples from Wei & Levoy

Texture Synthesis

And amazing successes

All examples from Ashikhmin

All examples from Wei & Levoy

CSE 872 Fall 2011
**HOW DOES IT WORK?**

**Big idea**
- assumptions:
  - Markov random field model
  - stationarity
- find pixels with similar neighbors
  - scanline order (causal neighborhood)
- implementation: exhaustive search

**DETAILS**

**Choices**
- neighborhood size & shape
  - Causal vs. Non-causal
- hierarchy (speed & quality)
- toroidal neighborhoods for tilability
- distance measure
- acceleration structures (TSVQ)
- cut search space (O(log N))
HIERARCHY

Applications

What are instances of synthesis?
- repair (inpainting)
- image editing
- extrapolation
- user control (introducing bias)
**Resources**

**Papers**
- Wei & Levoy
  - Fast Texture Synthesis using TSVQ
- Ashikhmin
  - Synthesizing Natural Textures
    - Use verbatim copies – faster & less blur
- check their web pages

**Surfaces**

How to carry to surface?

- surface given as mesh
  - synthesis into textures
  - synthesis onto vertices (fine enough)
**DIRECT SYNTHESIS**

Color vertices
- issues:
  - local orientation
  - synthesis order...
  - flattening/resampling
  - hierarchy?
  - notion of scale (Jacobian...)

**ORIENTATION FIELD**

Images from Wei & Levoy
**Orientation Field**

Construction choices
- interpolation
  - push/pull with interpolation (Turk)
    - project to tangent plane
  - use symmetry (Wei&Levoy)
  - incorporate geometry?
- user painted

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**Synthesis Order**

No obvious ordering on surface
- punt: random (Wei&Levoy)
- geodesics from seed point (Turk)
  - integral lines of orientation field
  - fast marching methods
  - priority queue on vertices
  - arrival time
**LOCAL NEIGHBORHOOD**

Not a pixel grid when on surface...
- use local tangent frame
  - walking on surface
    - rectangular (Turk)
    - radial (Ying et al.)
  - local flattening

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**HIERARCHY**

How to build pyramid?
- retiling (Turk)
  - upsampling with fixed vertices
- mesh simplification
  - edge collapse
- modern approaches
  - resampling
**Scale, Features & Blending**

Explicit control desirable

- Progressively Variant Textures (Zhang et al.)
- Textons, expl. scale

**Texture Map Directly**

Avoid needing zillions of vertices...

- Ying et al.: keep texture maps
- mapping
Comparison

Hierarchical or coherent?

Algorithmic Generation

Reaction diffusion textures

- biological pattern formation

\[ \dot{C} = a^2 \nabla^2 C - bC + R \]
On the Surface

Examples

Details

Implementation

- discretize equations
- regular grid: finite differences
  \[ \nabla^2 C_{i,j} \approx \frac{C_{i+1,j} + C_{i-1,j} + C_{i,j+1} + C_{i,j-1} - 4C_{i,j}}{h^2} \]
- time discretization
  - forward Euler \[ C^{t+\Delta t} = C^t + \Delta t f(C^t) \]
  - backward Euler \[ C^{t+\Delta t} = C^t + \Delta t f(C^{t+\Delta t}) \]
**Anisotropy (Diffusion)**

Account for distortion

\[
\dot{C} = A = Tr(D^T Q^T HQD)
\]

- new variables
- Jacobian has to enter (surface)

\[
V^T J^T J V = I \quad \rightarrow \quad \hat{A} = V^T A V
\]

**Numerical Solution**

Iterative methods very slow

- explicit Euler requires tiny time step
- implicit Euler requires solution of linear system
  - ill-conditioned...
  - multigrid (use libraries for this...)
**RD Systems**

Need multiple species
- two concentration arrays $C^+$ $C^-$
- two diffusion arrays $a^+$ $a^-$
- reaction function $R^+ = R^- = \begin{cases} k & C^+ > C^- \\ 0 & \end{cases}$
- initialize with random values
- lots of ideas in Witkin & Kass

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**Examples**

Witkin & Kass
**Graphcut Textures**

- No predetermined patch size

![Graphcut Textures Diagram]

**Texture Optimization**

- Markov Random Field-based similarity metric
- Expectation Maximization

![Texture Optimization Diagram]
Multiscale Texture

[Han et al ‘08]

Learning More

Papers
- Texture Synthesis over Arbitrary Manifold Surfaces, Wei&Levoy
- Texture Synthesis on Surfaces, Turk
- Synthesis of Progressively Variant Textures on Arbitrary Surfaces, Zhang et al.
- Texture and Shape Synthesis on Surfaces, Ying et al.
- Reaction-Diffusion Textures, Witkin&Kass
- Generating Textures on Arbitrary Surfaces Using Reaction-Diffusion, Turk

Tons more...
- try google for these terms...