Texture Synthesis: Surfaces and RD Textures

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

2-way symmetry

Orientation Field

Construction choices

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

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 (Wei&Levoy)

**Hierarchy**

How to build pyramid?
- retiling (Turk)
  - upsampling with fixed vertices
- mesh simplification
  - edge collapse
  - modern approaches
  - resampling

**Scale**

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

Account for distortion
- Hessian
  \[ \tilde{C} = A = \text{Tr}(D^T O^T \text{HOD}) \]
- new variables
  - Jacobian has to enter
  \[ V^T J^T J V = I \rightarrow \tilde{A} = V^T A V \]

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 \( C^+ \quad C^- \)
- two diffusion arrays \( a^+ \quad a^- \)
- reaction function
  \[ R^+ = R^- = \begin{cases} k & C^+ > C^- \\ 0 & \end{cases} \]
- initialize with random values
- lots of ideas in Witkin & Kass

Examples

Witkin & Kass
Learning More

Papers

- Appearance-Space Texture Synthesis, Lefebvre&Hoppe
- 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...