Texture Synthesis: Surfaces and RD Textures

Surfaces

How to carry to surface?

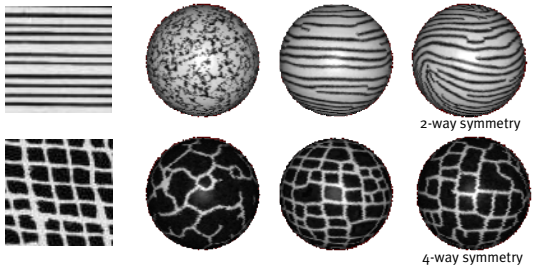
- surface given as mesh
  - synthesis into textures
  - synthesis onto vertices (fine enough)

Direct Synthesis

Color vertices

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

Orientation Field



Orientation Field

Construction choices

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

Synthesis Order

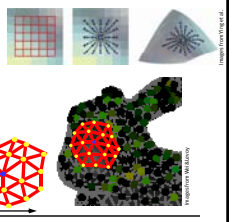
No obvious ordering on surface

- 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...

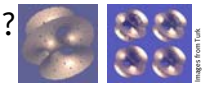
- use local tangent frame
  - walking on surface
    - rectangular (Turk)
    - radial (Ying et al.)
  - local flattening (Wei&Levoy)



Hierarchy

How to build pyramid?

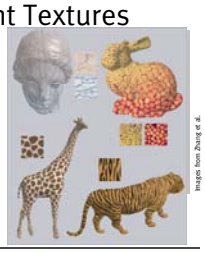
- retiling (Turk)
  - upsampling with fixed vertices
- mesh simplification
  - edge collapse
- modern approaches
  - resampling



Scale

Explicit control desirable

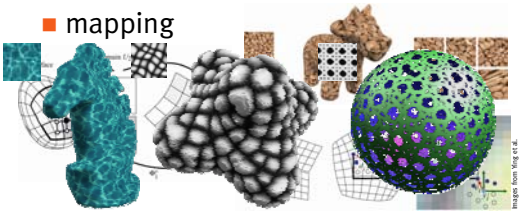
- Progressively Variant Textures (Zhang et al.)
  - Textons, expl. scale



Texture Map Directly

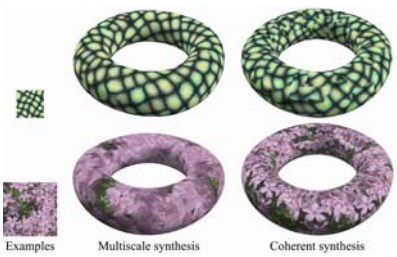
Avoid needing zillions of vertices...

- Ying et al.: keep texture maps
- mapping



Comparison

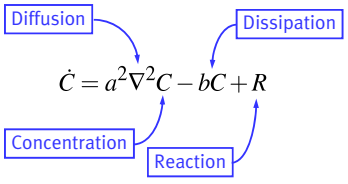
Hierarchical or coherent?

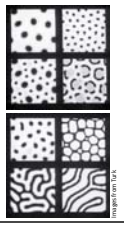


Algorithmic Generation

Reaction diffusion textures

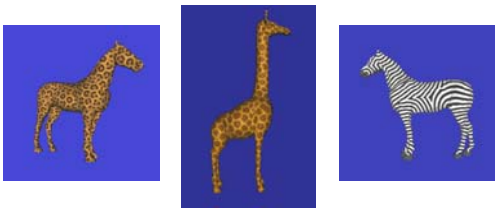
- biological pattern formation





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

rates along coordinate directions

Hessian

$$\begin{pmatrix} a_1 & 0 \\ 0 & a_2 \end{pmatrix}$$

$$\dot{C} = A = Tr(D^T Q^T H Q D)$$

Rotation

Image from Witkin&Kass

- new variables
- Jacobian has to enter

$$V^T J^T J V = I \longrightarrow \hat{A} = V^T A V$$

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

Examples

Witkin&Kass

Learning More

Papers

- Appearance-Space Texture Synthesis, Lefebvre&Hoppe
- Texture Synthesis over Abitrary 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…