Advanced Modeling

Inhalt

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- Soft objects [HeBa96] 10-5
- Superquadrics [HeBa96] 10-4
- Structure-deforming Transformations
- Particle Systems [HeBa96] 10-20
- Terrain simulation
- Vegetation simulation

Sweeps

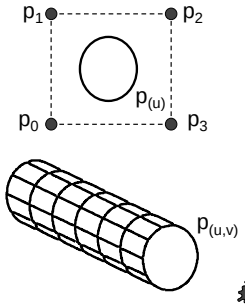
modelling of objects with symmetries:

- translational
- rotational

represented by 2D shape and a sweep-path, which moves the shape through a 3D space region

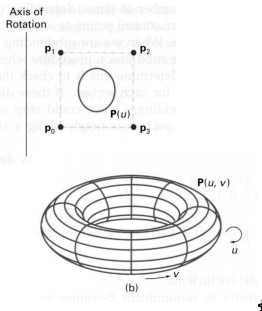
Translational Sweeps

translating the control points of spline curve P(u) (top) generates the solid (bottom), whose surface is described by point function P(u,v)



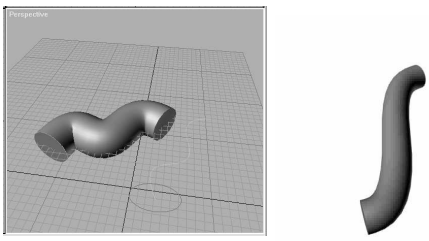
Rotational Sweeps

- The control points of spline curve P(u) are rotated about the given rotation axis.
- Connecting the control points sampled at given angles yields the surface P(u,v)



Sweeps: Spline

splines may also be used as a sweep path



rendered with Kinetix 3D Studio MAX

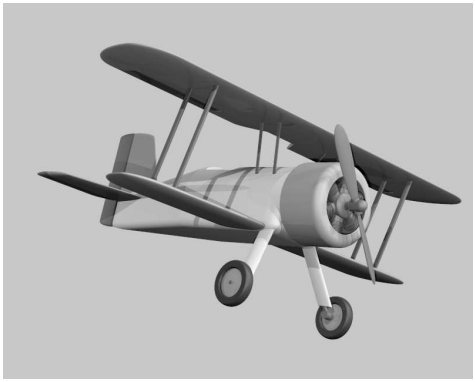
Sweeps - pros and cons

Advantages:

- Generates shapes that are hard to do otherwise

Disadvantages:

- Hard to render
- Difficult modeling

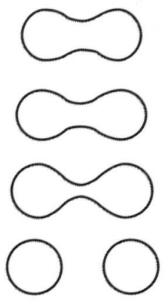


Blobby Objects

- modelling of molecular structures, water droplets, melting objects, and muscle shapes.
- no fixed shape (it changes when in motion or close to other objects)

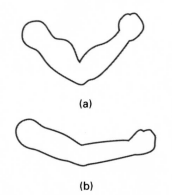
Soft Objects: Blobs

Molecular bonding: As two molecules move away from each other, the surface shapes stretch, snap, and finally contract into spheres



Soft Objects: Blobs

- volume of object is to be preserved during movement
- the total volume has to stay constant



Definition of Blobby Objects

combination of Gaussian density functions:

$$f(x,y,z)=\sum_k b_k e^{-a_k r_k^2} - T = 0$$

where $r_k^2 = x_k^2 + y_k^2 + z_k^2$

T is a specified threshold, *a* and *b* adjust the blobbiness

Definition of Blobby Objects

- metaball model uses density functions, which drop off to 0 at a finite interval
- "soft object" model uses same approach with a different density-distribution characteristic.

Superquadrics

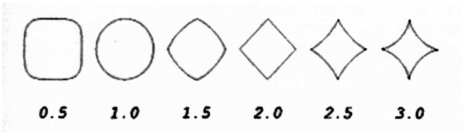
- generalization of quadric representation
- additional parameters are incorporated
- increased flexibility for adjusting object shapes
- one additional parameter for curves and two parameters for surfaces

Superellipse

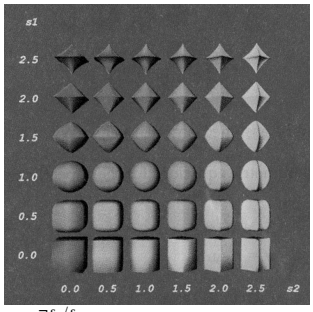
exponent of x and y terms of a standard ellipse is allowed to be variable:

$$\left(\frac{x}{r_x}\right)^{2/s} + \left(\frac{y}{r_y}\right)^{2/s} = 1$$

influence of *s*:



Superellipsoid

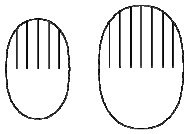


influence of the two exponent parameters s_1 and s_2:

$$\left[\left(\frac{x}{r_x}\right)^{2/s_2} + \left(\frac{y}{r_y}\right)^{2/s_2}\right]^{s_2/s_1} + \left(\frac{z}{r_z}\right)^{2/s_1} = 1$$

$$\left|\sqrt{\frac{x^2+y^2}{a^2}}\right|^n + \left|\frac{z}{b}\right|^n = 1$$

Supereggs



Sub-species of Superellipsoids

Will balance on either end for any a,b and n.

Structure-deforming Transformations

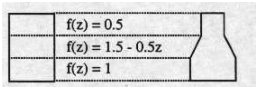
Or non-linear transformations

- Tapering: non-linear scaling
- Twist: non-linear rotation
- Bend: also non-linear rotation

Tapering

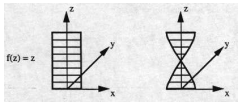
Scale factor is a function:

$$X = \begin{pmatrix} f_1(s) & 0 & 0 \\ 0 & f_2(s) & 0 \\ 0 & 0 & f_3(s) \end{pmatrix} \cdot x$$



Twist

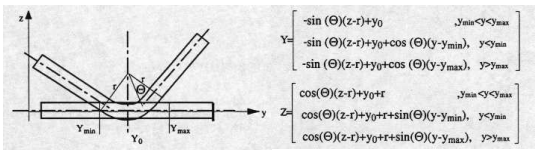
Angle of rotation is a function, e.g., for rotation about z-axes:



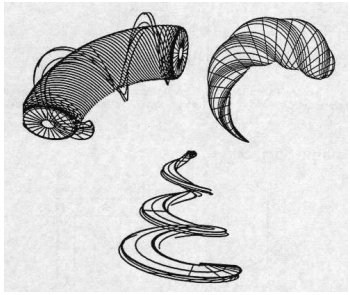
$$X = \begin{pmatrix} \cos f(s) & -\sin f(s) & 0 \\ \sin f(s) & \cos f(s) & 0 \\ 0 & 0 & 1 \end{pmatrix} \cdot x$$

Bend

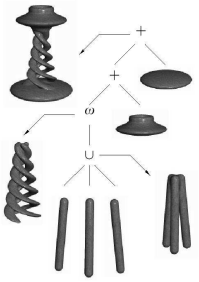
Also a non-linear rotation, e.g.,



Examples 1



Examples 2



Particle Systems: Introduction

modelling of objects changing over time by flowing, billowing, spattering, or expanding

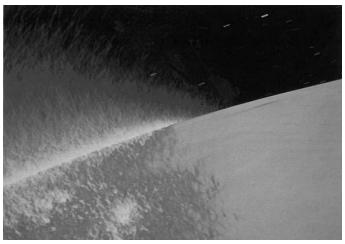
modelling of natural phenomenia:

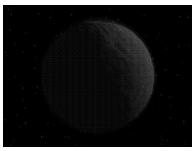
- rain, snow, clouds
- explosions, fireworks, smoke, fire
- sprays, waterfalls, clumps of grass

Particle Systems

1982 Star Trek II: The Wrath of Khan

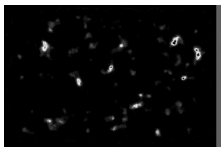
frame of animation (© Pixar 1982)





look-a-like scene

Particle Systems: Examples



Building

Planet

Hive

Boom

clash

Particle Systems

- a certain number of particles is rendered
- particle parameters change over time:
  - location
  - speed
  - lifetime
- particles die after some time and are deleted

Particle Systems (2)

- particle shapes may be spheres, boxes, or arbitrary models
- size and shape may vary over time
- motion may be controlled by external forces, e.g. gravity

Particle Systems (3)

particles can interfere with other particles, which causes a more entropic movement, e.g. sprays of liquids

Particle Systems: Bomb

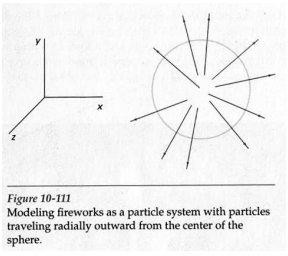


Figure 10-111
Modeling fireworks as a particle system with particles traveling radially outward from the center of the sphere.

Particle Systems: Grass Clumps

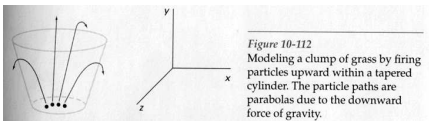


Figure 10-112
Modeling a clump of grass by firing particles upward within a tapered cylinder. The particle paths are parabolas due to the downward force of gravity.

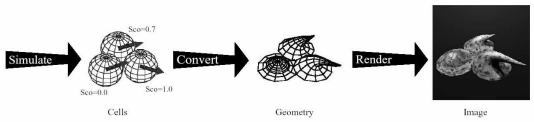
lifetime can be encoded by color: from green to yellow

Cellular Texture Generation

A cellular particle system, that changes geometry of surface

- cell state
- cell programs
- extracellular environments

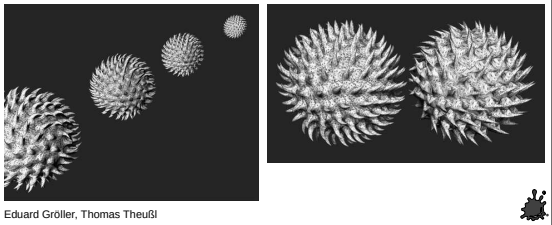
Cellular Texture Generation



- Cell state: position, orientation, shape, chemical concentrations (reaction-diffusion)
- Cell programs:
  - Go to surface, die if too far from surface, align, adhere to other cells, divide until surface is covered, ...
  - Differential equations
- Extra cellular environment: neighbor orientation, concentration, ...

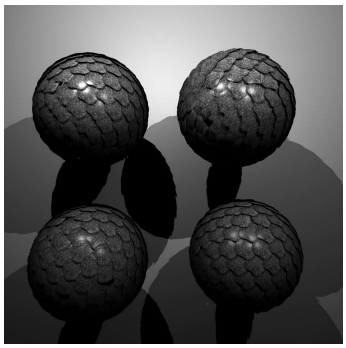
Cellular Texture Generation 2

Levels of Detail (LOD): Use fewer polygons for further distances



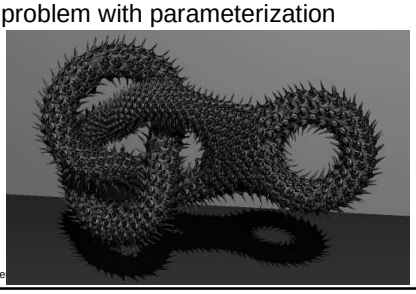
Cellular Texture Generation 3

Cell: group of polygons with texture and transparency maps



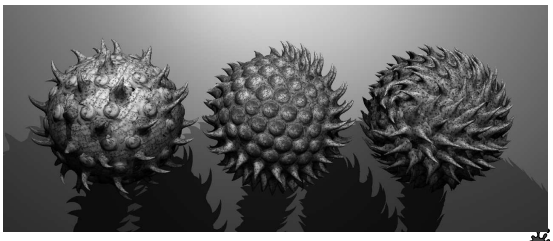
Cellular Texture Generation - Examples

- handling of unusual topologies
- no problem with parameterization



Cellular Texture Generation - Examples

- reaction-diffusion determine pattern of bumps and thorns



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Cellular Texture Generation - Examples

- cells (fur) oriented like their neighbors

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Cellular Texture Generation - Examples

- cells (fur) similarly oriented

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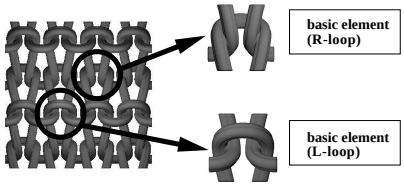
Modeling and Visualization of Knitwear

- Knitwear: simulation of thin 3D structure with instanced volume elements



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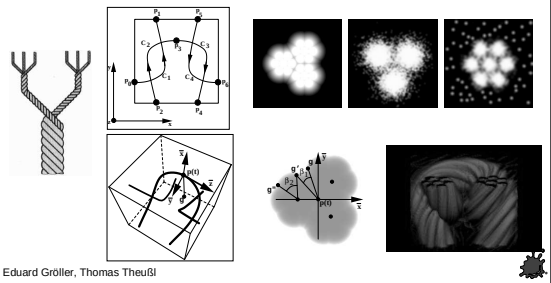
Visualization of Knitwear

- Volume element: 2D cross-section swept + rotated along parametric curve



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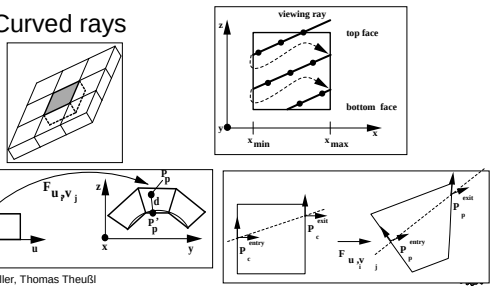
Visualization of Knitwear

- Rendering with raycasting
  - Surface tiled with volumetric elements
  - Curved rays



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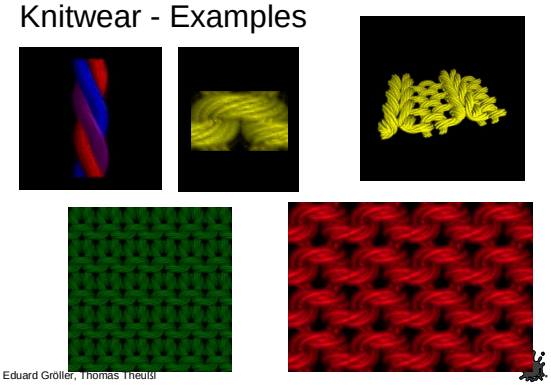
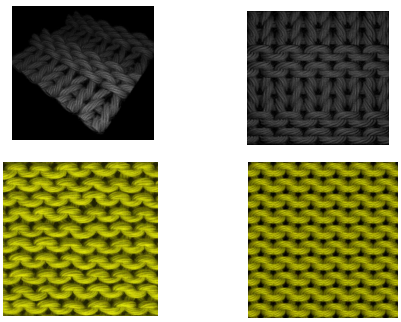
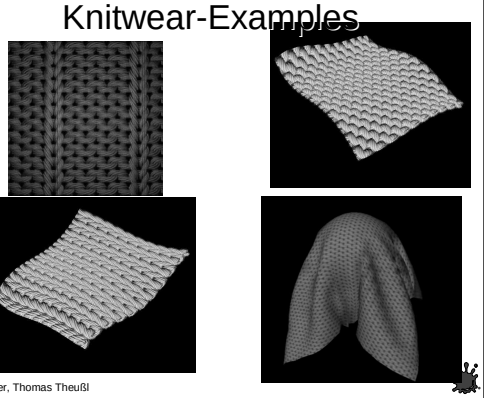
Knitwear - Examples



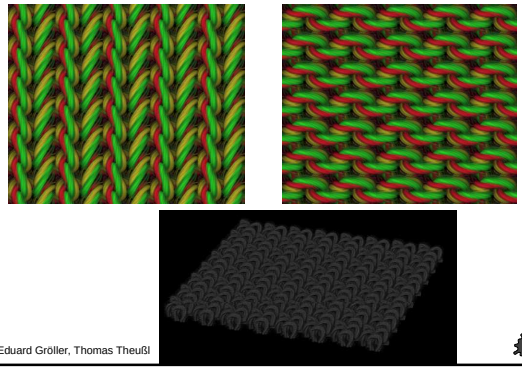
Knitwear-Examples



Knitwear-Examples



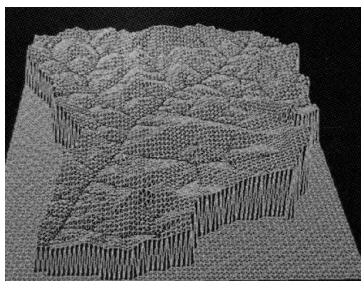
Knitwear-Examples



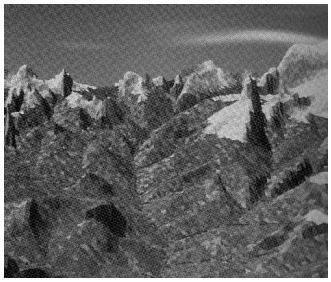
Terrain Simulation

- Fractals
- Geographical Data
- Simulations
- Hybrids

Terrain Simulation



Terrain Simulation



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Terrain Simulation

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Terrain Simulation

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Terrain Simulation

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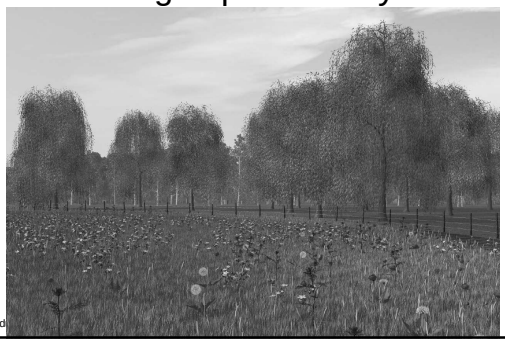
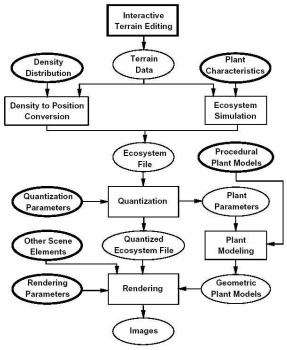
Realistic modeling and rendering of plant ecosystems



Ed

Scene Synthesis System



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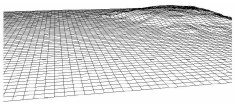
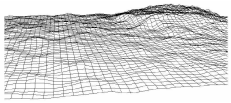
Terrain Specification

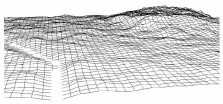
Height map

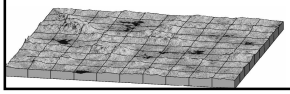


Hills through noise synthesis



Stream through masking



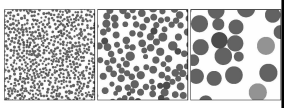


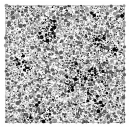
Water concentration (blue=high, yellow=low)

Specification of Plant Populations

- Space-occupancy
  - Explicit specification (counting plants, painting)
  - Procedural generation (cellular automata, reaction-diffusion)
- Individual based
  - Explicit specification (survey, interactive specification)
  - Procedural generation (point pattern generation model)

Self-thinning:
Green: not dominated
Red: dominated
Yellow: old





Distribution of eight species

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Realistic modeling and rendering of plant ecosystems (2)

for realistic appearance: complex models necessary

- plant distribution by ecosystem simulation and/or manual setting
- reduce geometric complexity by approximate instancing (similar plants, groups of plants or plant organs)
- parametrized models of individual plants

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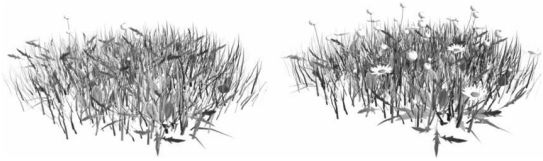
Plant ecosystems - Examples



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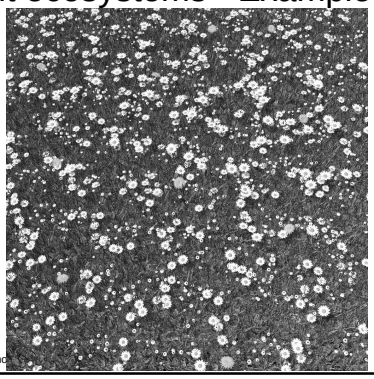
Plant ecosystems - Examples



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Plant ecosystems - Examples

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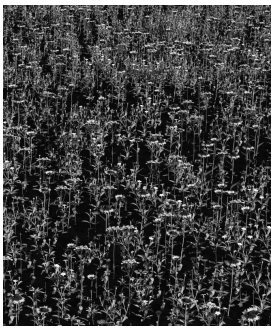
Plant ecosystems - Examples

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Plant ecosystems - Examples


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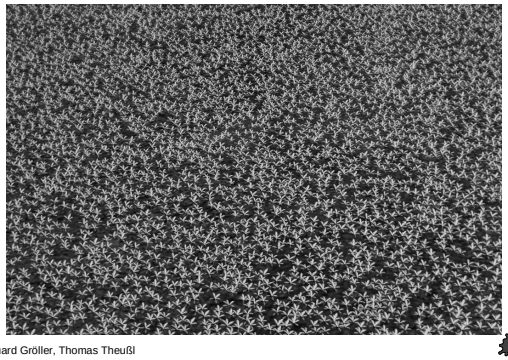
Plant ecosystems – Self Thinning



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Plant ecosystems – Self Thinning

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Plant ecosystems - Examples

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