The Visualization of Free Forms and Voxel Volumes in Real Time

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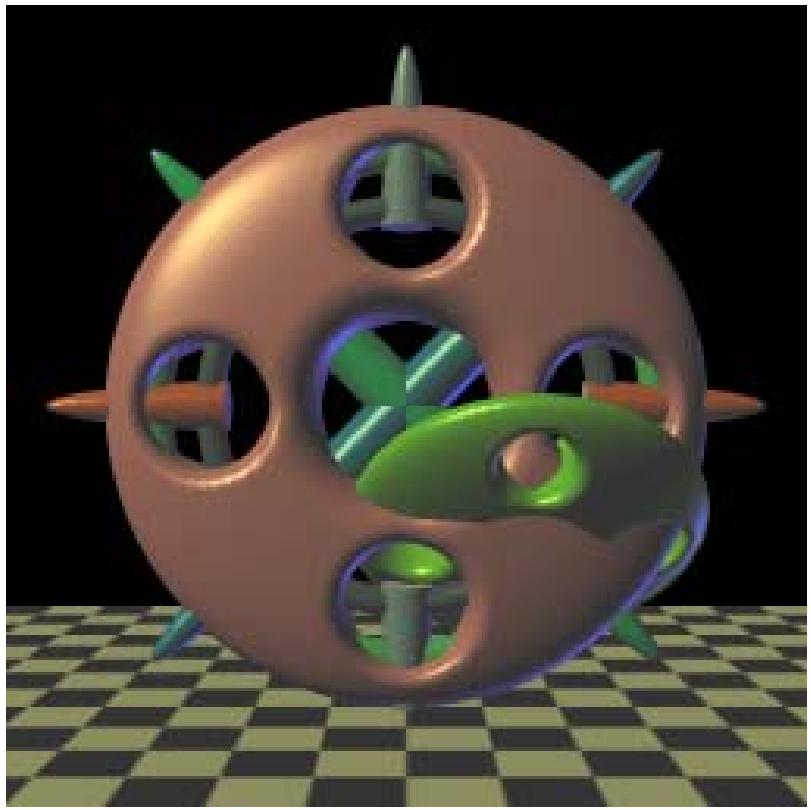

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Polygonal Object Representation

Disadvantages:

- large number of polygons
- objects borders have form of broken line
- there is no information about inner object structure
- it's difficult to realize special effects (distortion)
- What to do: It's better to form objects from free form primitives.

Free Form Surfaces

The base - 2-nd order surfaces - quadrics

$$F(x,y,z)=Ax^2+ By^2 +Cz^2+Dxy+Exz+Fyz+Gx+Hy+Iz+K>=0$$

There are 3 kinds of free form surfaces:

- Quadrics
- Quadrics together with disturbance (perturbation) functions
- Representation as a set of 3D volumes - voxels

Perturbation Implicit Functions

Quadrics with implicit functions

$F'(x,y,z) = F(x,y,z) + R(x,y,z)$, где

$R(x,y,z,)=Q^2(x,y,z)$ if $Q(x,y,z)>0$

0 otherwise.

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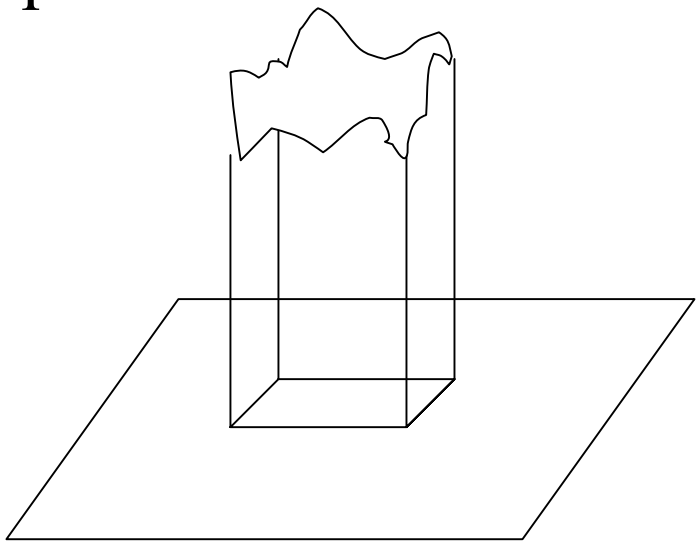
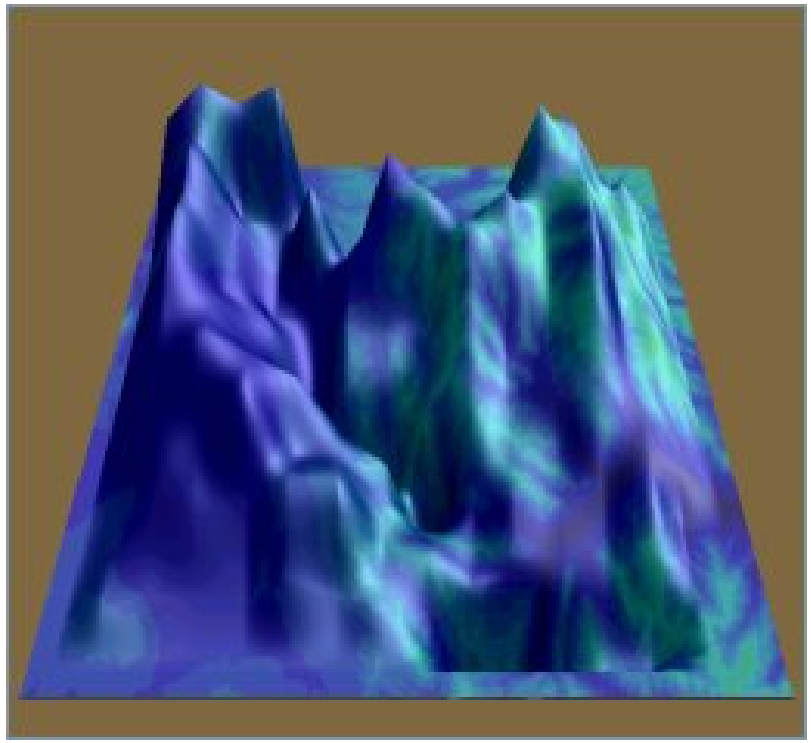
The scene, that are discribed by free forms with analytical perturbation functions require 500 times less information than by polygonal representation (4K-2M)

Perturbation Scalar Functions

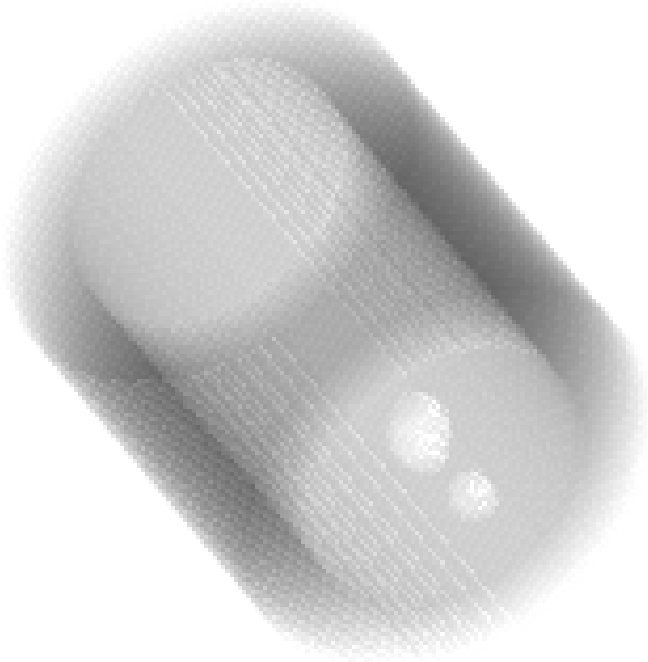
- Is defined as 2-dimensional array of deviations from quadric.





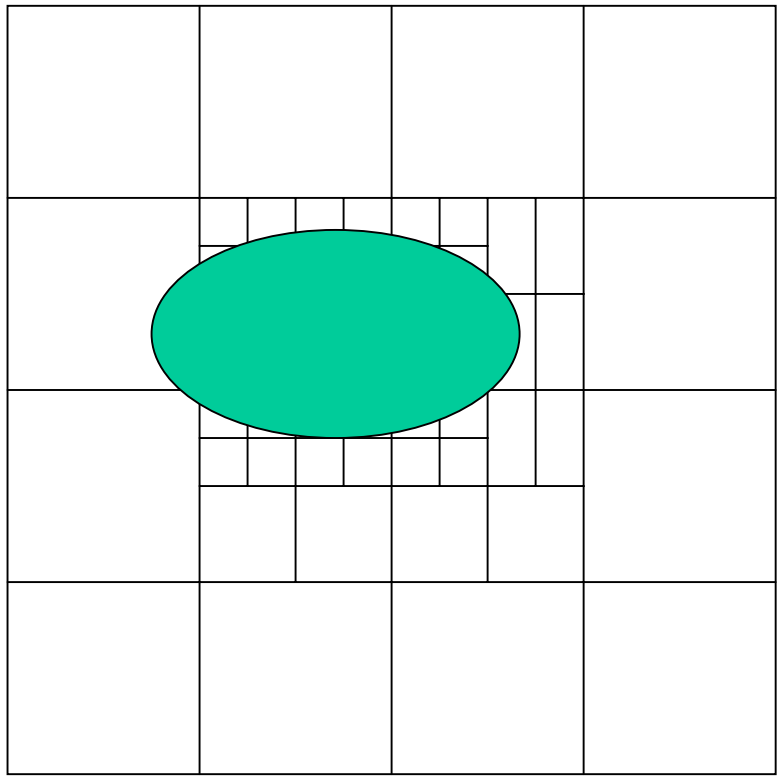
3D Texture

- Texture value- density
- Half-transparent cylinder, that was obtained from volume data (densities).



Rasterization Method-Multylevel Ray Casting

- For cube - recursive space subdivision
- For pyramid - by using perspective transformation
- For representation inner structure - subdividing along Z coordinate.
- Passing along empty (uniform) domains.



Color calculation

- Color calculation:

$C=(k_aC_a+ k_dC_d+ k_sC_s) / (k_a+ k_d+ k_s)$

Diffuse reflection

$C_d = (n,l)\ C_{light}C_{surf}$

Specular reflection

$C_s= (r,v)^pC_{light}$

(r - reflect. direction;

v - viewer direction.)

Equipment & Sphere of Use

It’s possible to create hardware for free form implementations.

The sphere of using:

- simulators
- computer tomography
- science visualization