Parallel Architecture and Algorithms for Real-Time Synthesis of High-Quality Images Using Voxel-Based Surfaces

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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

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

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

0 otherwise.

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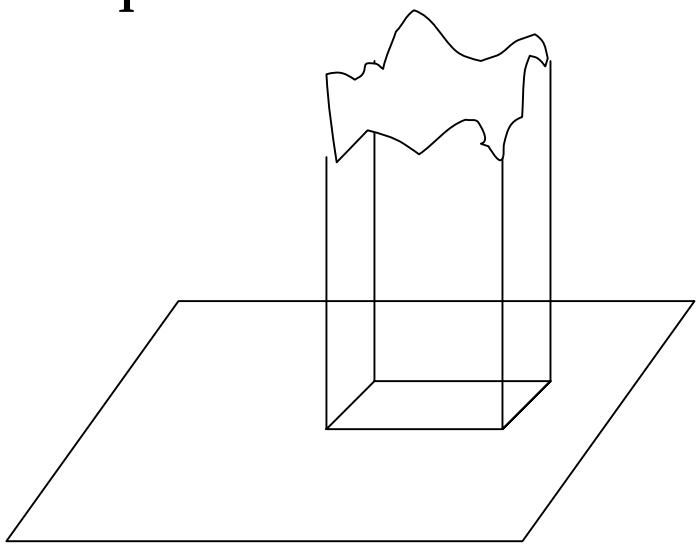
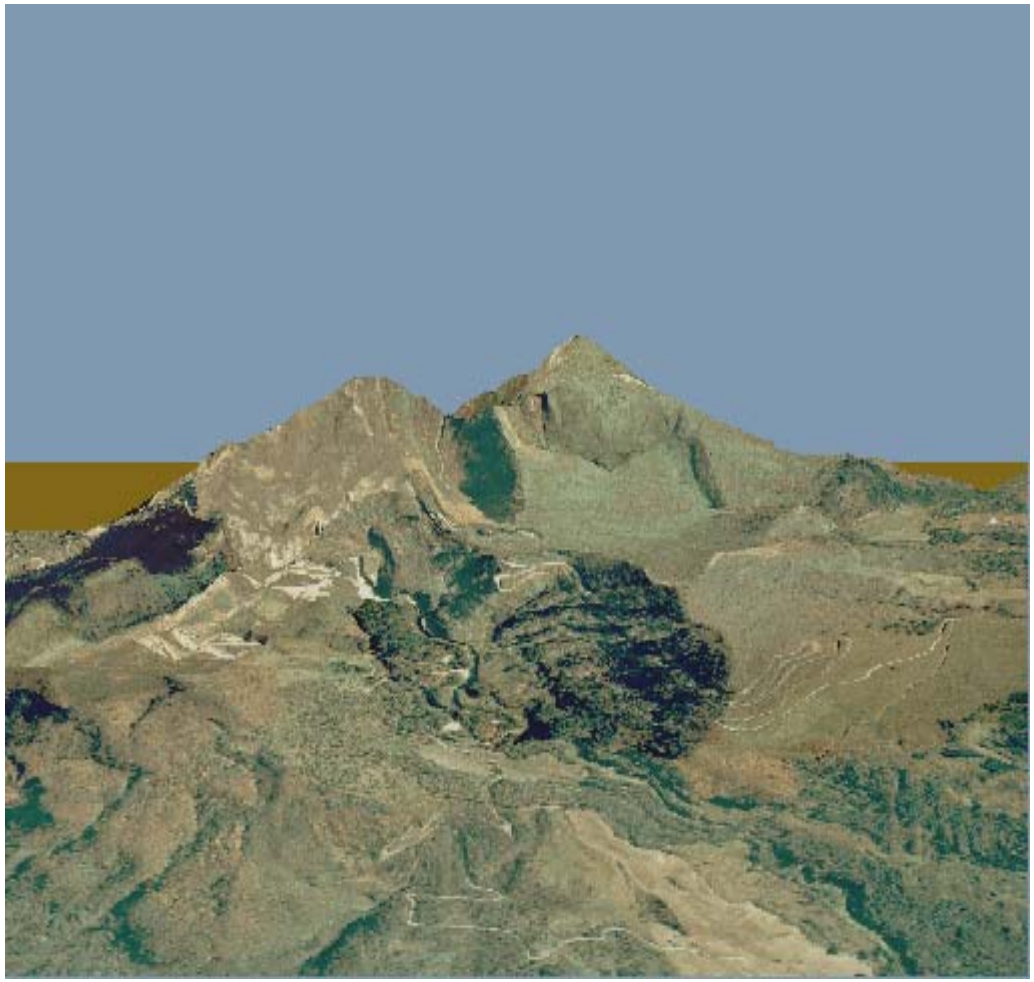
The scene, that are discribed by free forms with analytical perturbation functions require 500 times less information than by polygonal representation (4K-2M)

Perturbation Scalar Functions

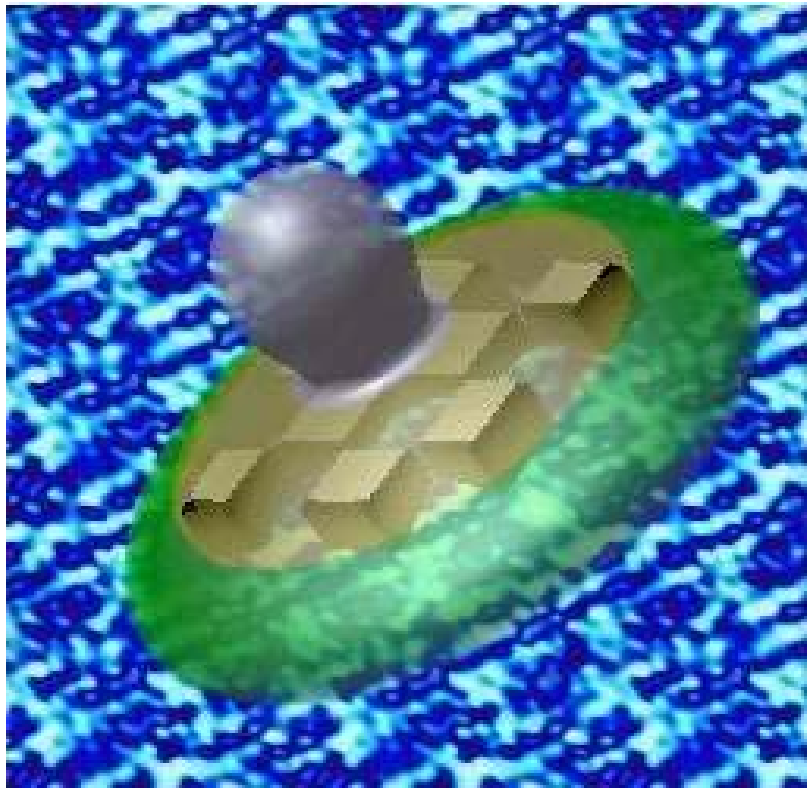
- Is defined as 2-dimensional array of deviations from quadric.





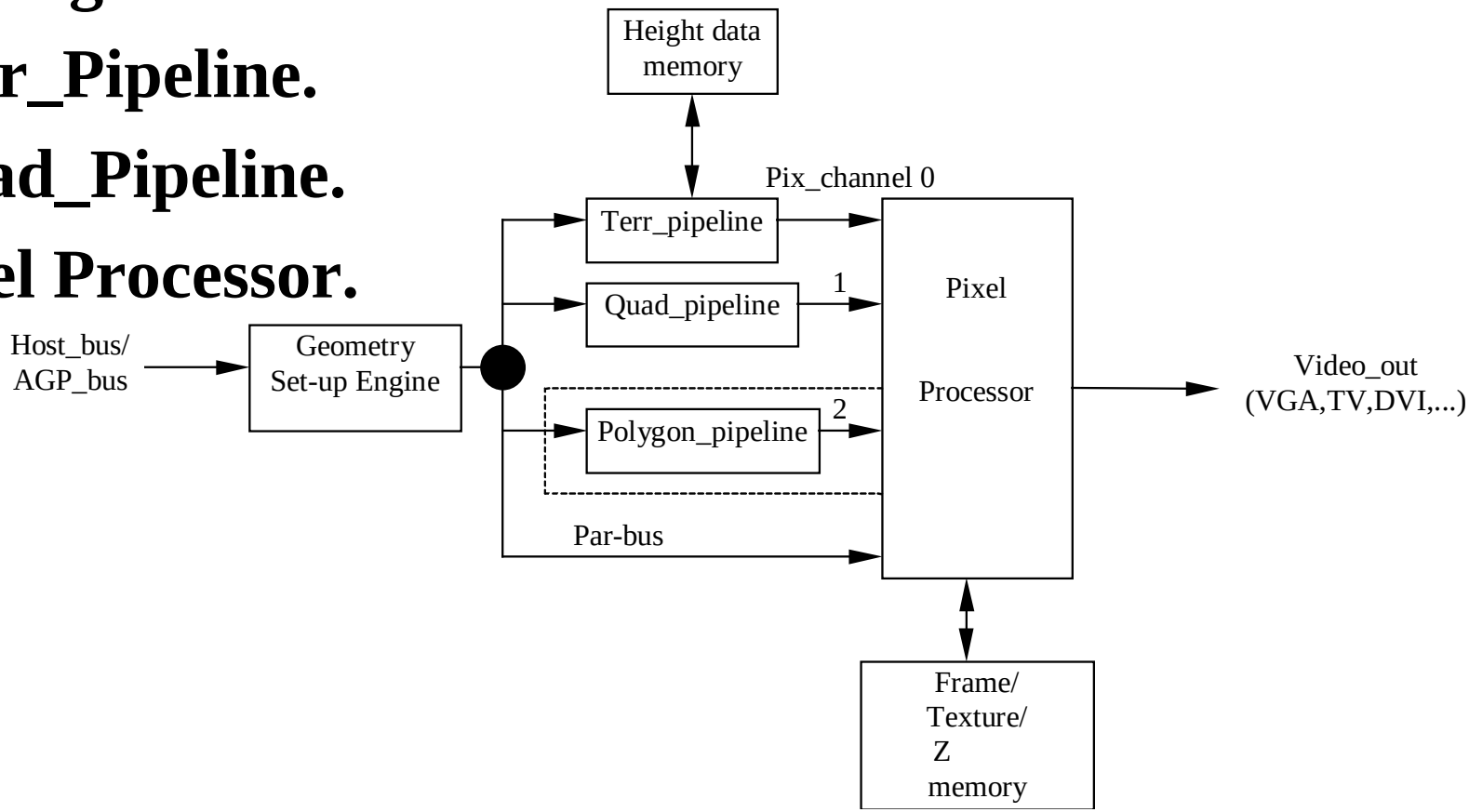
3D Texture

In addition, while solving the descriptive function in the form of inequality $F(X) \geq 0$, we can visualize not only the surface but also the internal structure of the object



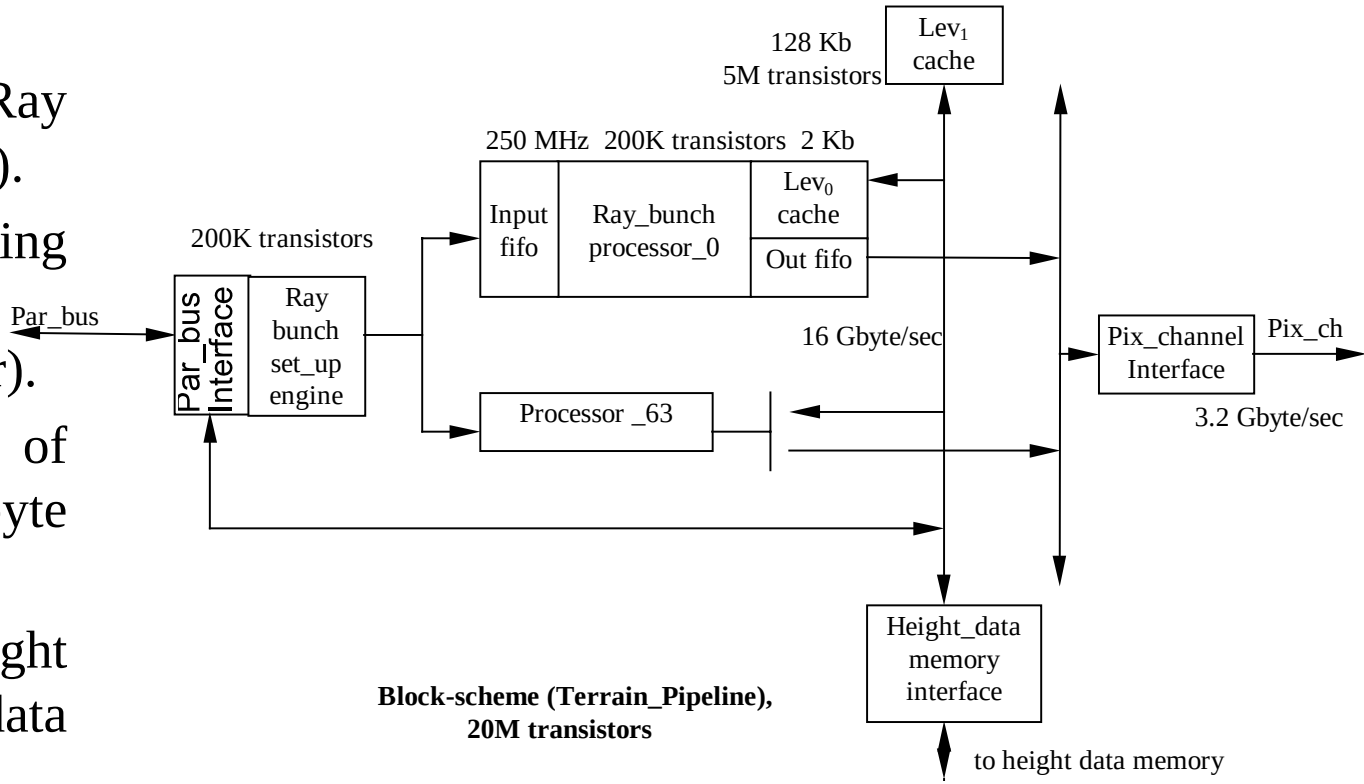
Chip-Set Voxel-Volumes

- **Geometry Set-up Engine.**
- **Terr_Pipeline.**
- **Quad_Pipeline.**
- **Pixel Processor.**



Channel of processing of terrain (Terr_Pipeline)

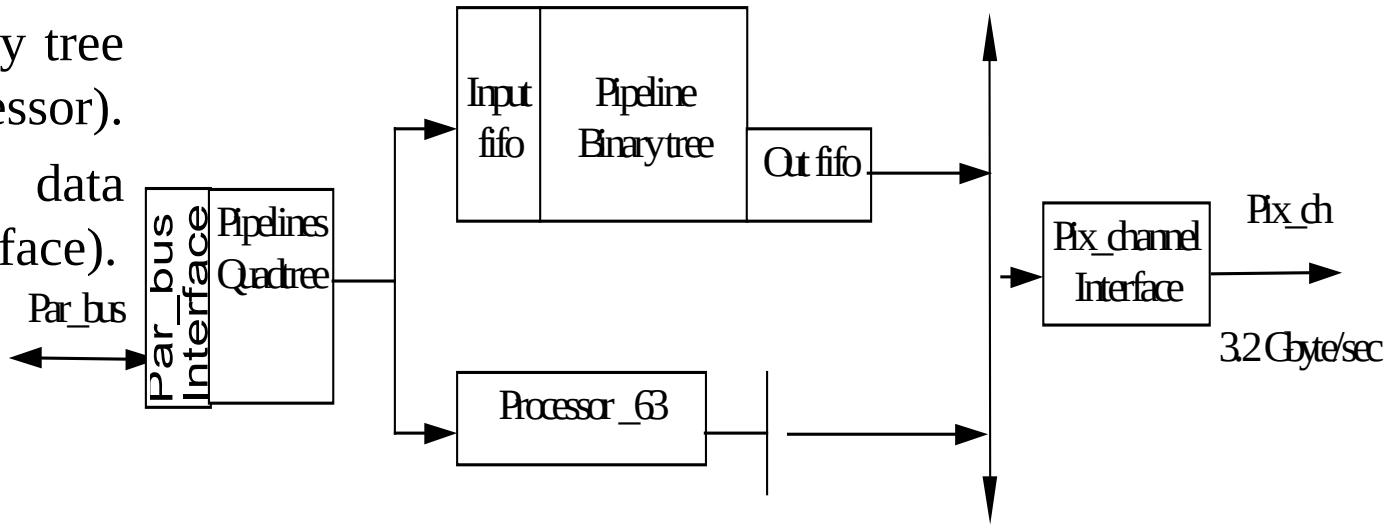
- Interface input data (Par_bus Interface).
- Preprocessor (Ray bunch Set-up Engine).
- Processor of processing the rays of binary (Ray_bunch Procesor).
- Cache data maps of heights 128 Kbyte (Cache Lev1).
- Interface data height maps (Hight_data Memory Interface).
- Interface output data (Pix_channel Interface).



Block-scheme (Terrain_Pipeline), 20M transistors

Channel of processing of quadrics (Quad_Pipeline)

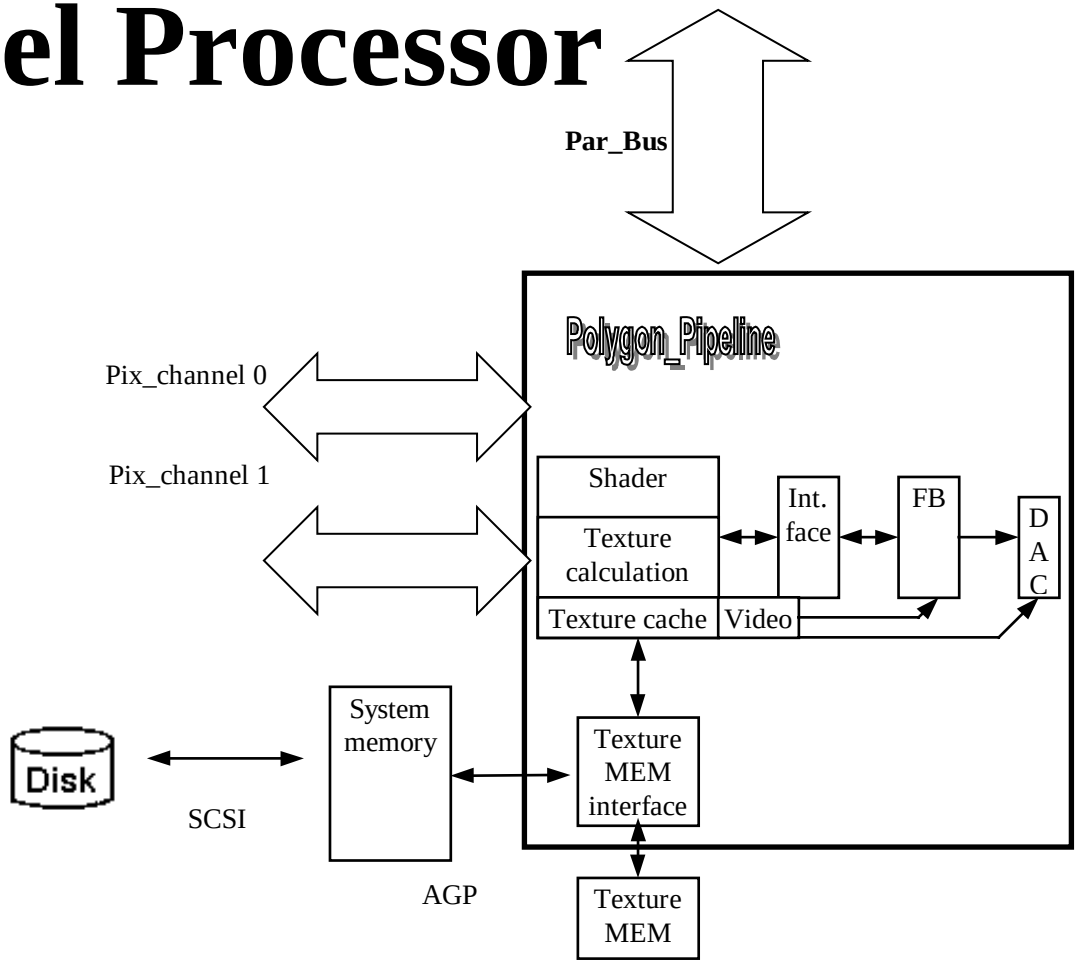
- Interface input data (Par_bus Interface).
- Processor of quaternary tree (Quad_tree Processor).
- Processor of binary tree (Binary_tree Processor).
- Interface output data (Pix_channel Interface).



Block-scheme (Quad_Pipeline), 12M transistors

Pixel Processor

- Channel of processing the triangles (Polygon_Pipeline).
- Interface a texture memory (Texture Memory Interface).
- Block of calculation of colour (Shader).
- Block of calculation of texture (Texture calculation).
- Block of removing the invisible surfaces on the algorithm Z-buffer.
- Frame Buffer.
- DAC.



Block-scheme (PIXEL PROCESSOR), 15M transistors