

# 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

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

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

Quadratics 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.

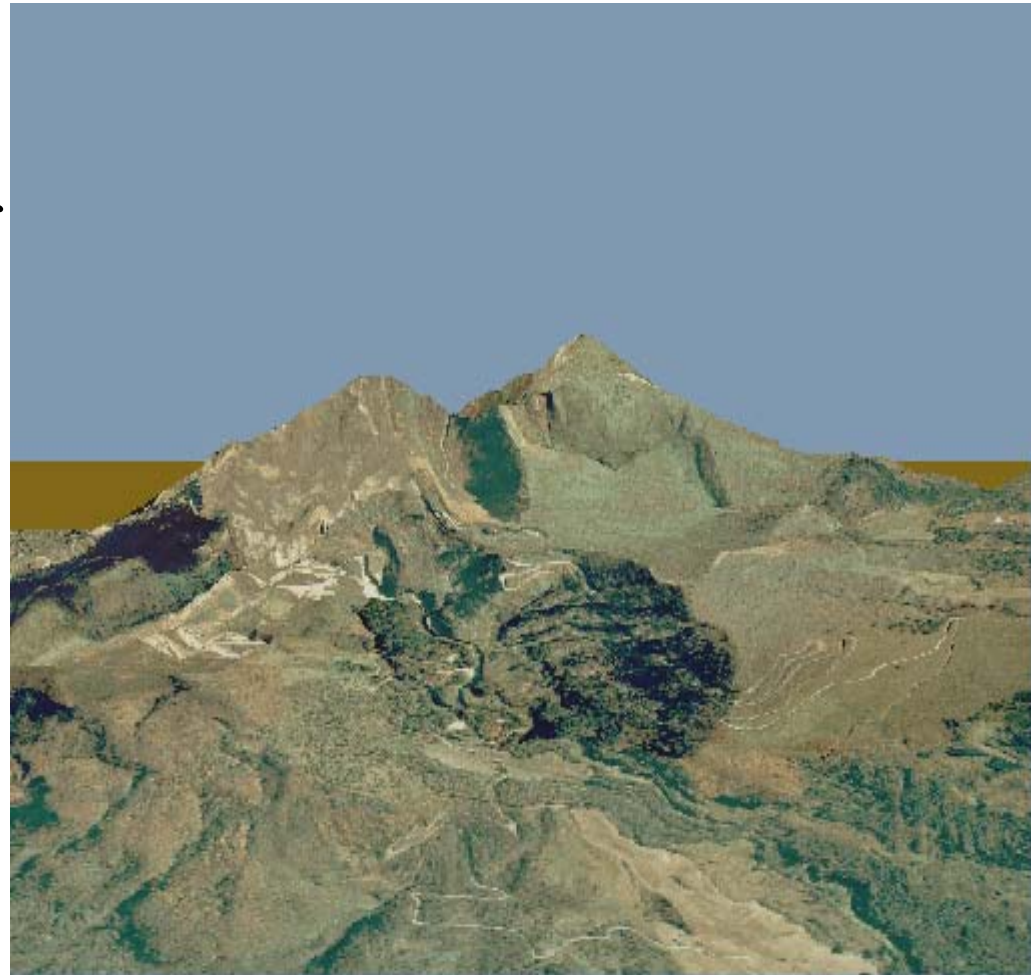
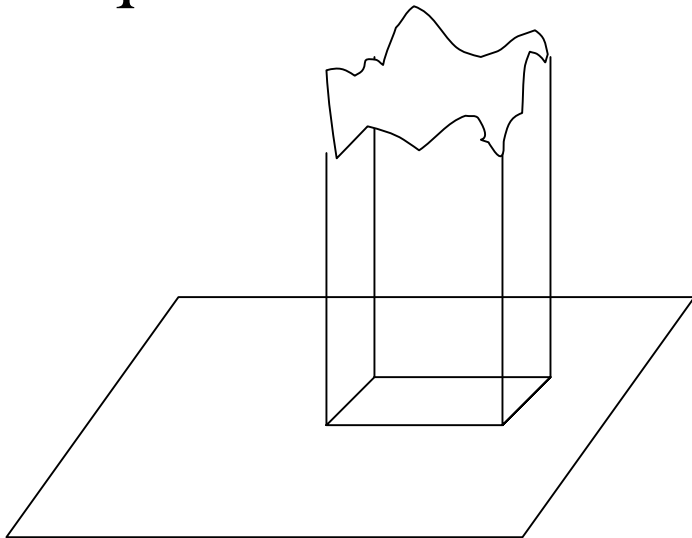
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The scene, that are described by free forms with analytical perturbation functions require 500 times less information than by polygonal representation (4K-2M)



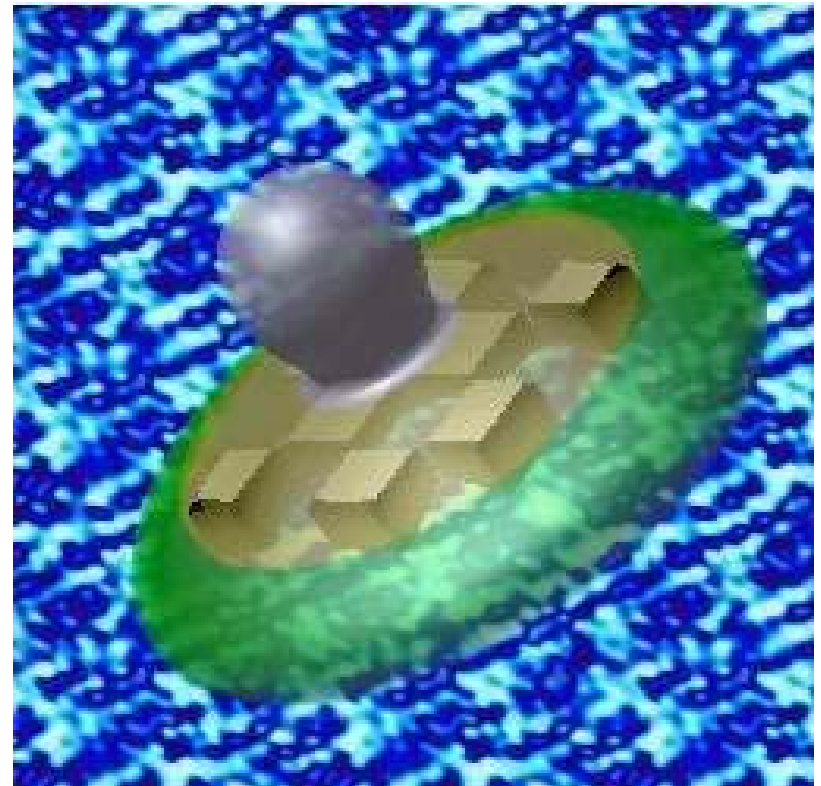
# Perturbation Scalar Functions

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



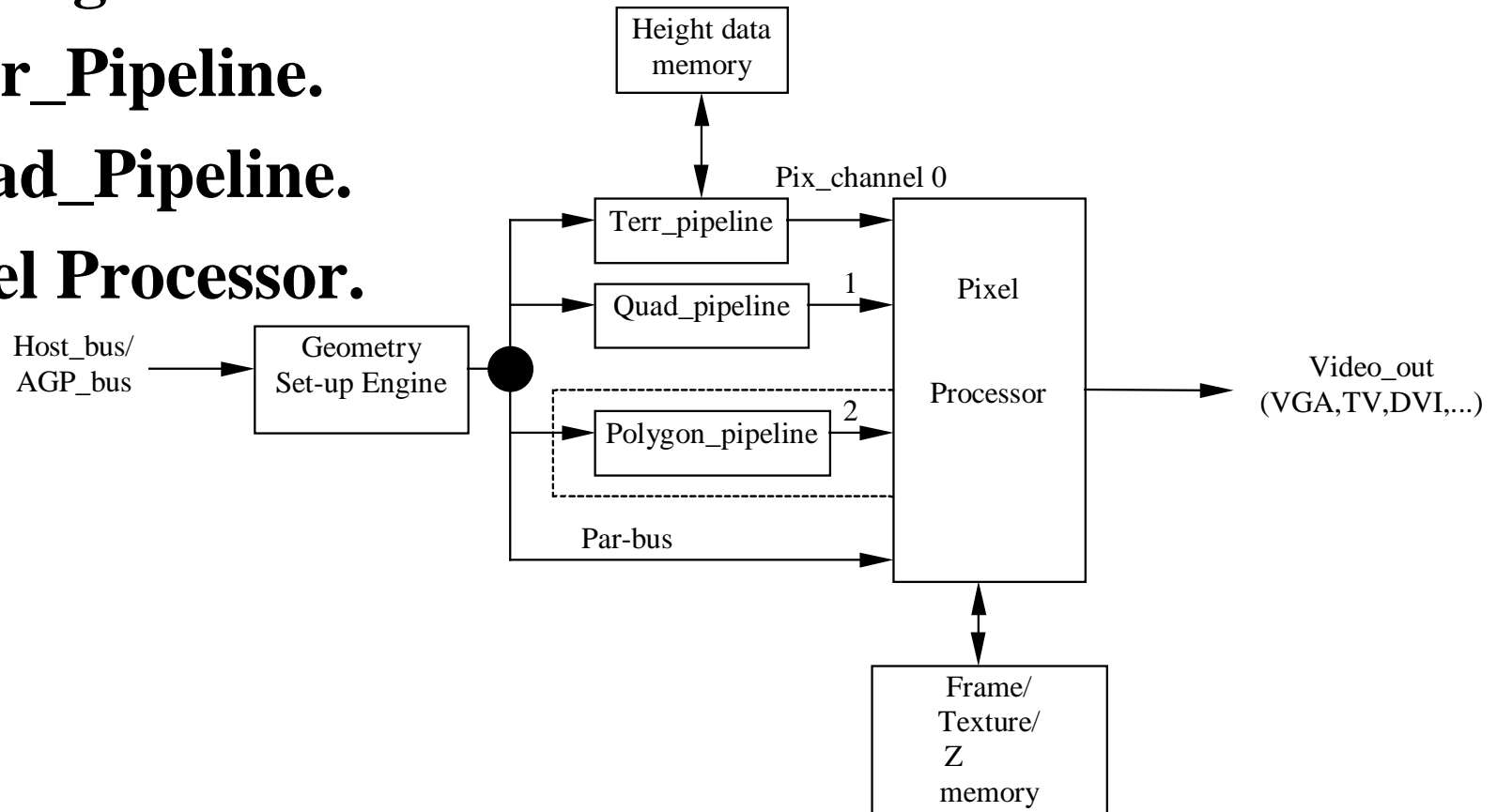
# 3D Texture

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



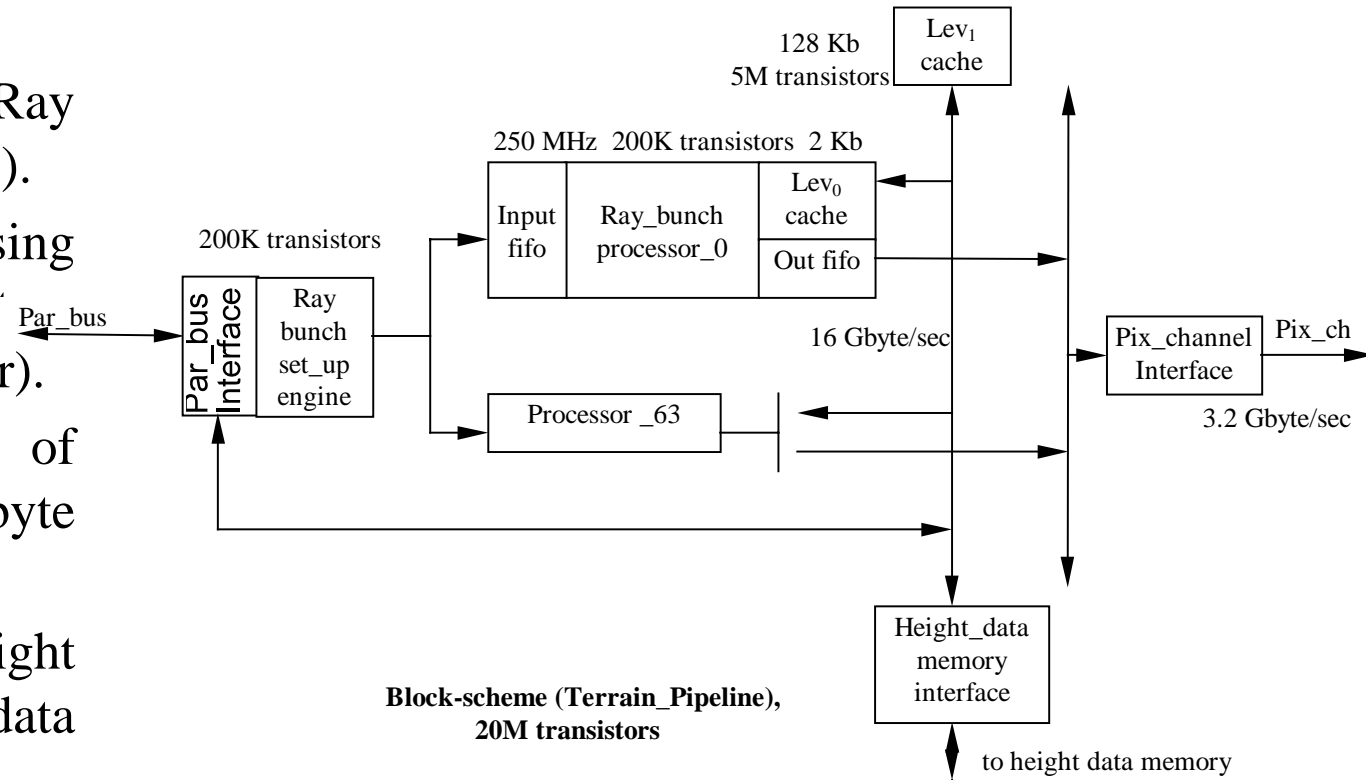
# Chip-Set Voxel-Volumes

- **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 Processor).
- Cache data maps of heights 128 Kbyte (Cache Lev1).
- Interface data height maps (Height\_data Memory Interface).
- Interface output data (Pix\_channel Interface).

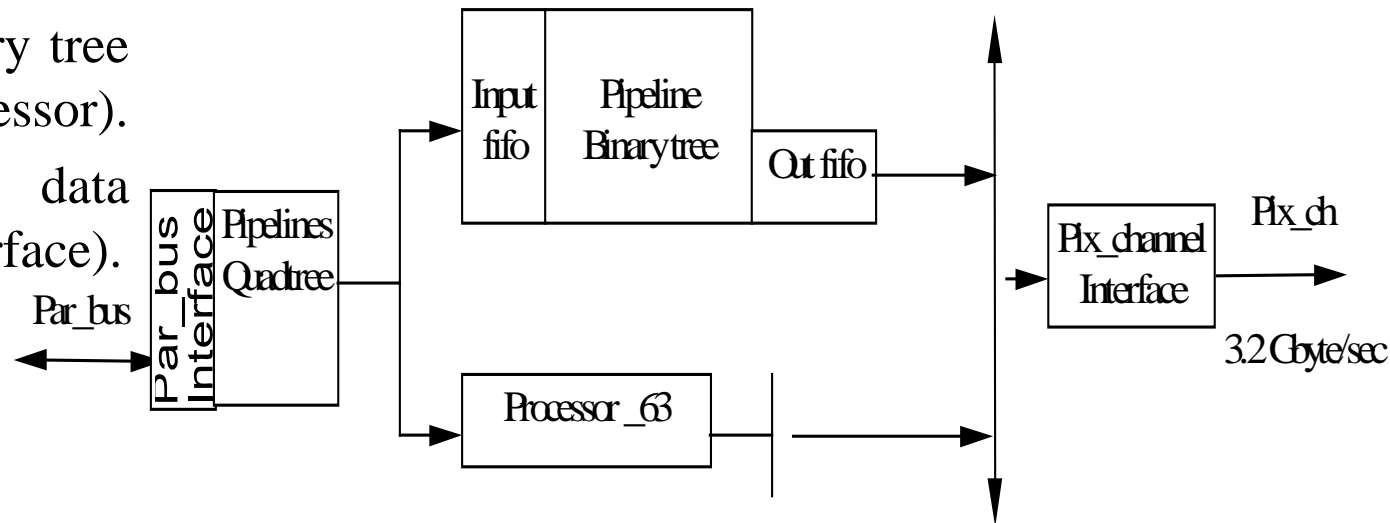




# Channel of processing of quadrics

## (Quad\_Pipeline)

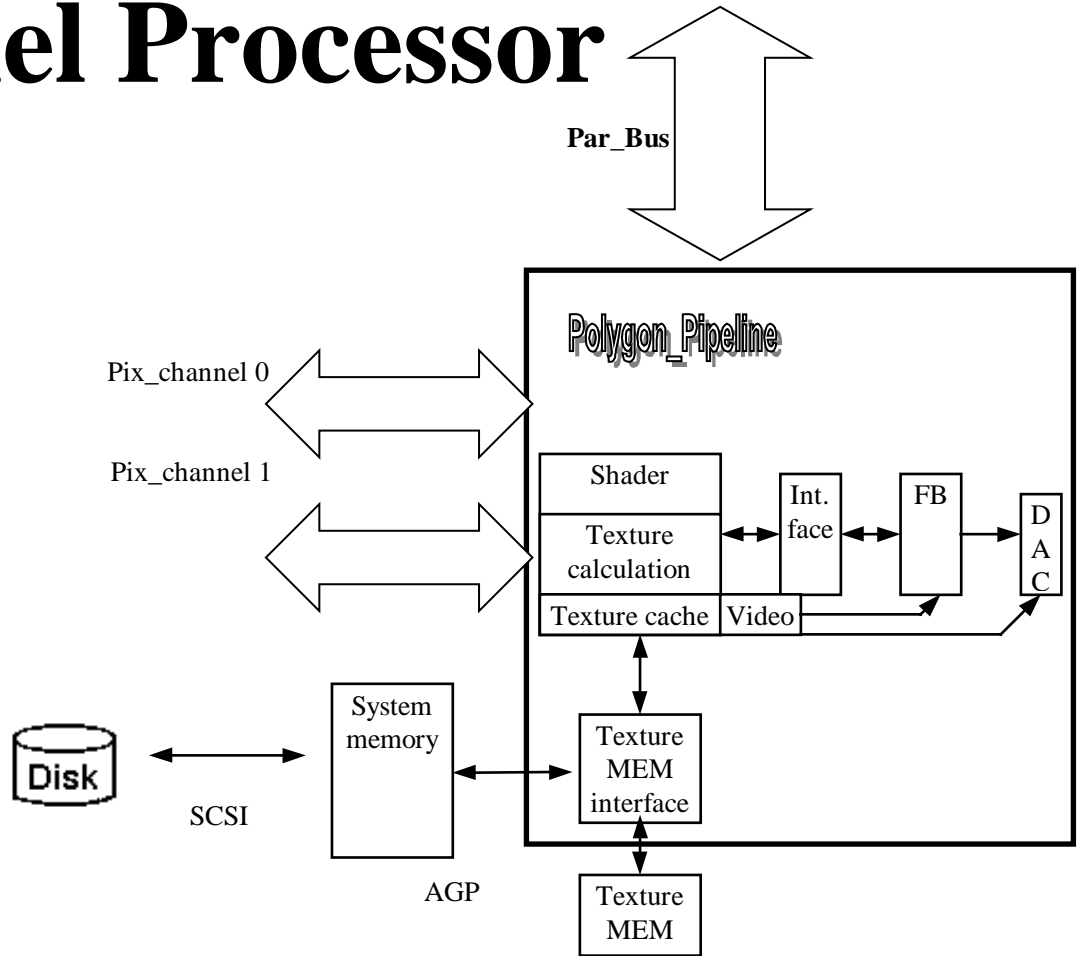
- Interface input data (Par\_bus Interface).
- Processor of quaternary tree (Quad\_tree Processor).
- Processor of binary tree (Binary\_tree Processor).
- Interface output data (Pix\_channel Interface).



**Block-scheme (Quad\_Pipeline),  
12Mtransistors**

# 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