Accurate and Efficient Rendering of Detail using Directional Distance Maps

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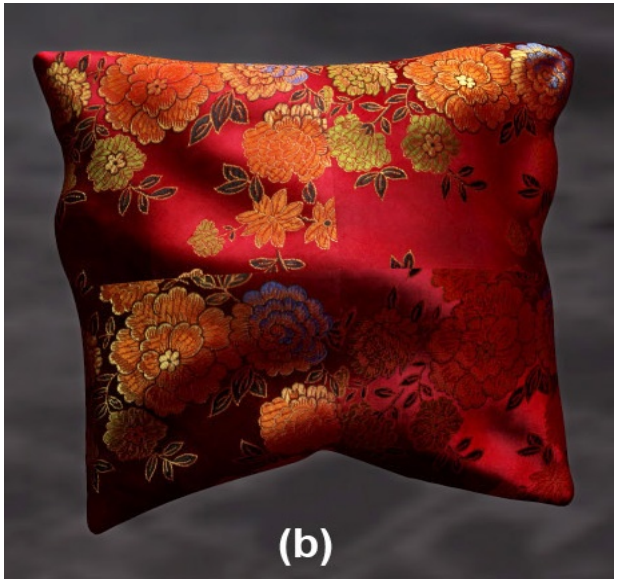
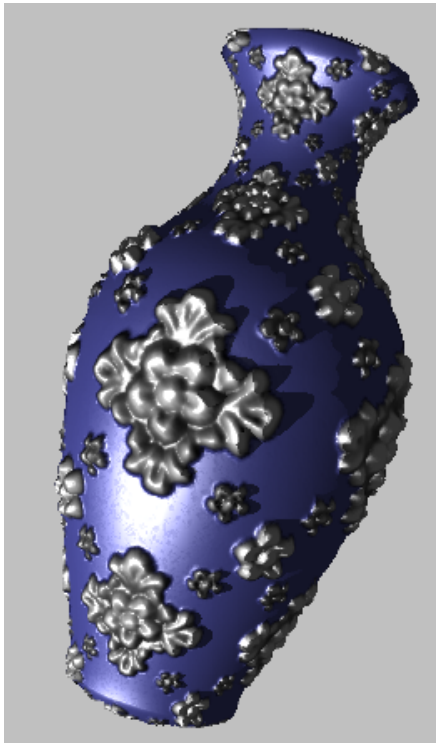
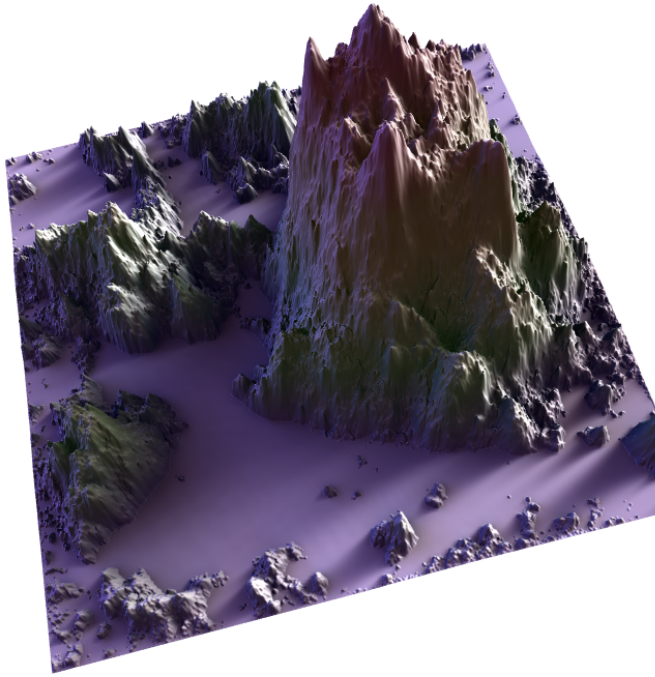
Mesostructures



microstructures



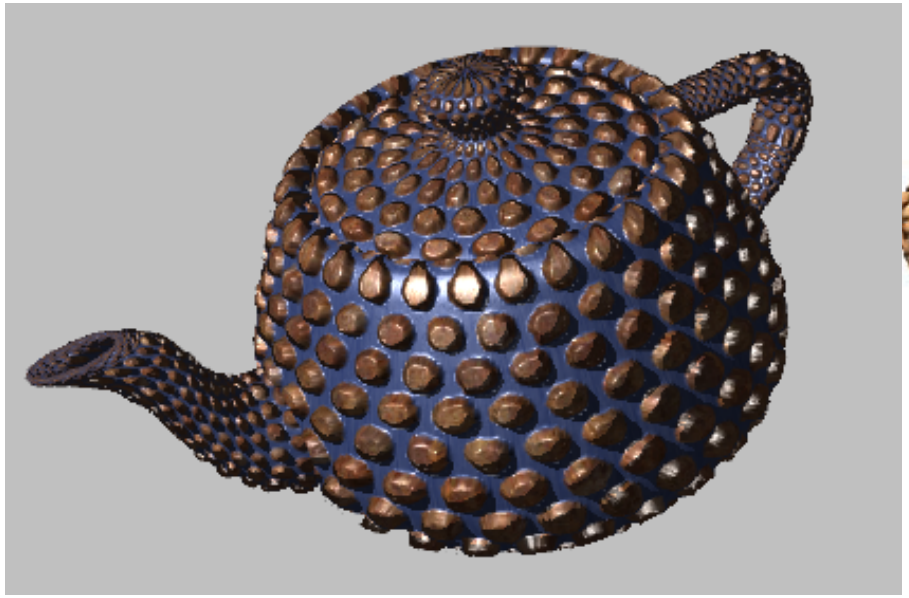
mesostructures



macrostructures

Mesostructures

- height field vs non-height field



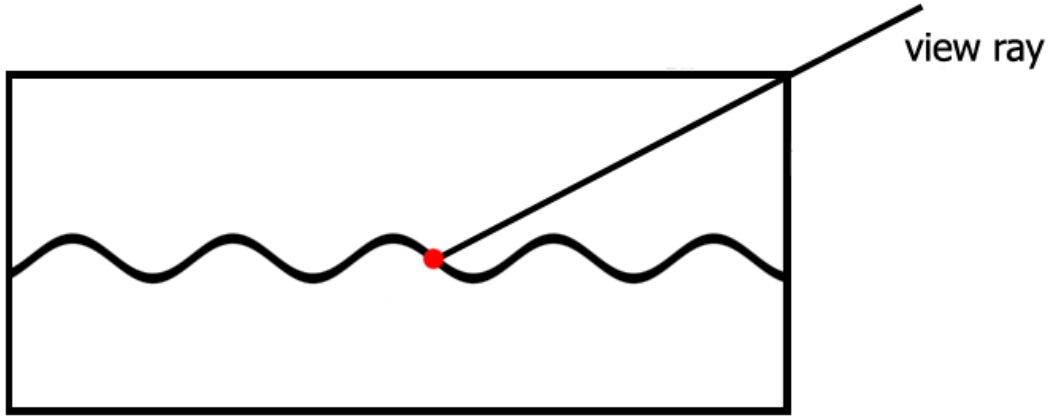
- alters shadows, occlusion, and silhouettes

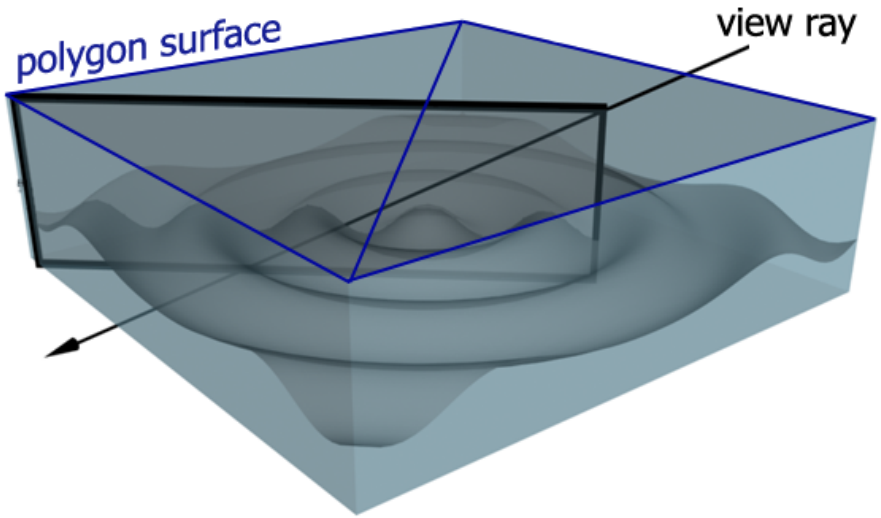
Mesostructure Rendering

- Tessellation
  - generates large number of micro-polygons
- Ray-tracing
  - generates large number of triangles
- Per-pixel displacement mapping
  - works at interactive rates
  - provides performance-quality trade-off

Per-Pixel Displacement Mapping

- render low-resolution mesh
- cover all fragments (pixels)
- recompute color and depth of each fragment





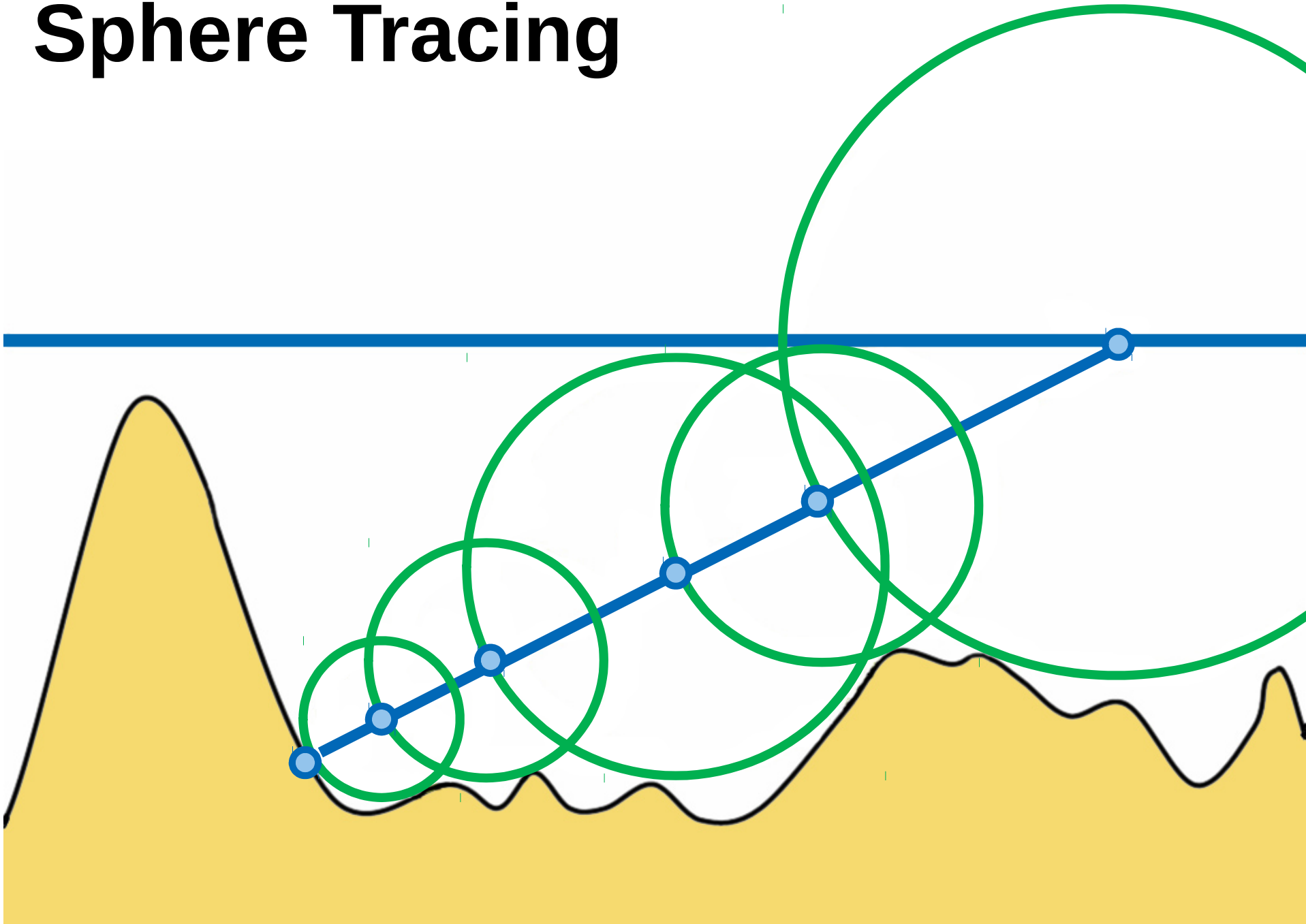
Previous Work

- Height-field mesostructures
  - Relief mapping and variants
  - [Policarpo et al. 05], [Risser et al. 05], [Tatarchuk 05]
  - Cone mapping
  - [Dummer 05], [Policarpo and Oliveira 07]
  - Erosion and dilation map
  - [Kolb and Salama 2005]
  - Others
  - [Oh et al. 06], [Tevs et al. 08], [Baboud et al. 06]

Previous Work

- Non height-field mesostructures
  - Relief mapping
  - [Policarpo and Oliveira 06] : limited non-height field
  - Generalized displacement mapping
  - [Wang et al. 04]: height field and non height-field
  - linear interpolation errors
  - Sphere tracing
  - [Hart 1996], [Donnelly 05]: height field and non height-field
  - linear interpolation errors

Sphere Tracing

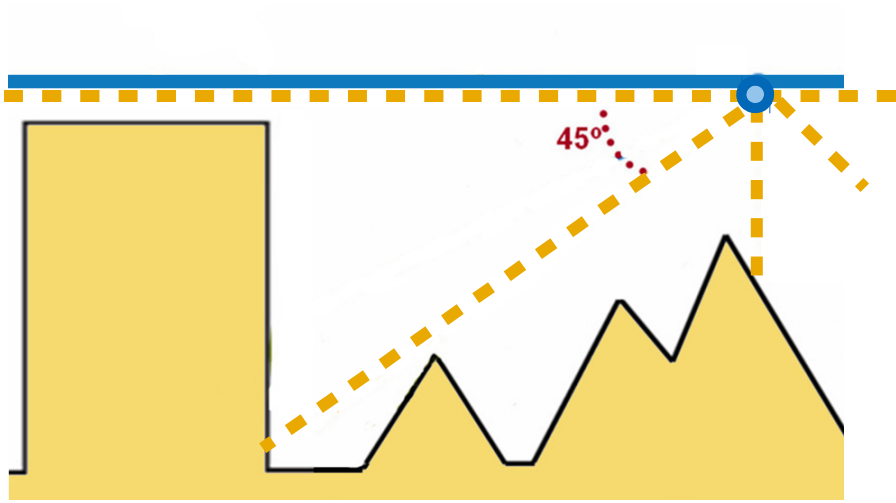


Sphere Tracing

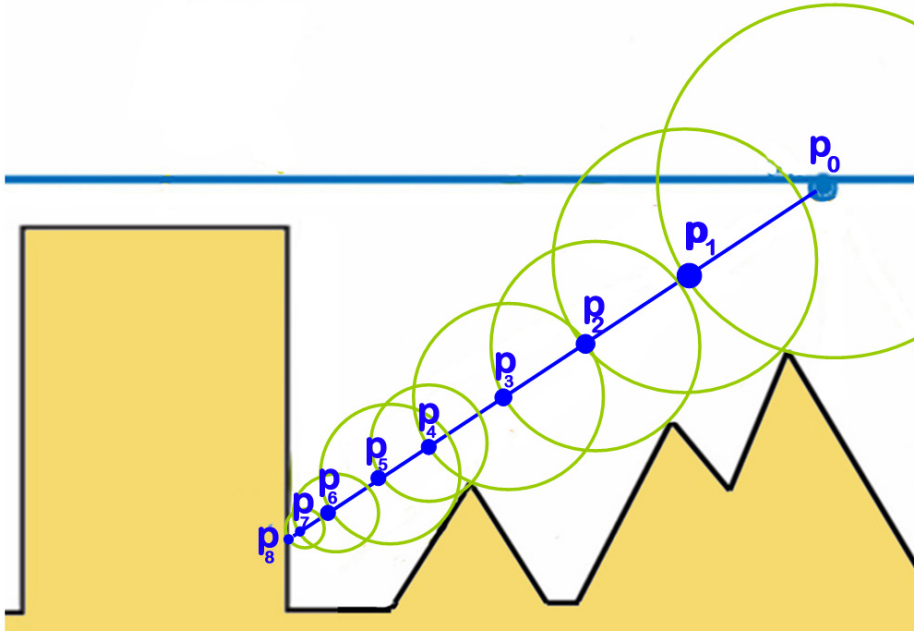
- Drawbacks
  - Slow convergence
  - points close to surface
  - Limited accuracy
  - based on sampling resolution of distance maps
  - High memory requirement
  - distance maps stored as 3D texture

Directional Distance Map

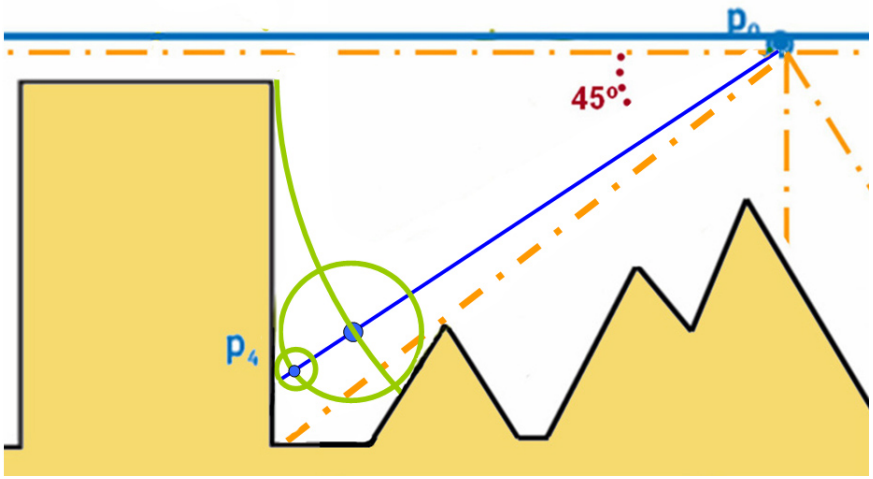
- Directional Distance Map
  - “look forward”
  - distance only in direction of ray important
  - direction cone
  - limits field of view of the ray
  - small #of direction cones
  - “front to back”



Comparison



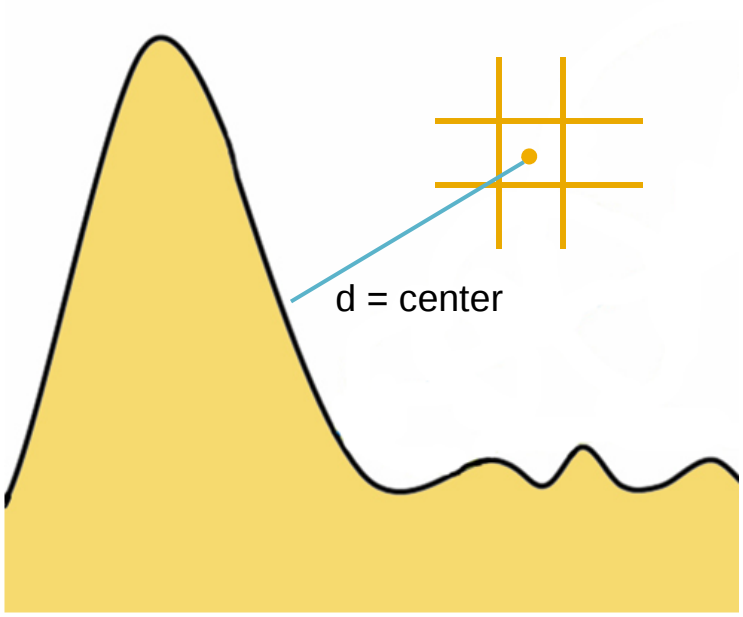
with distance map



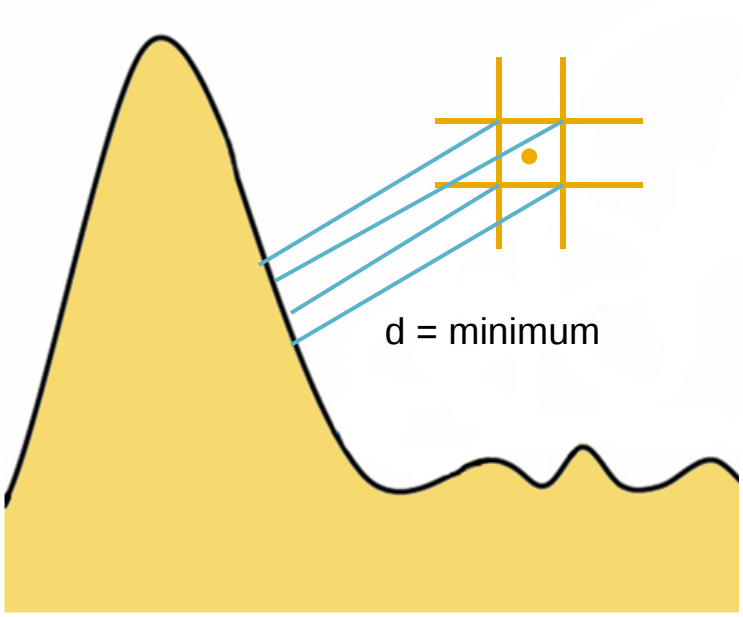
with directional distance map

Accurate intersection

- conservative distance
- nearest distance from *anywhere* within a voxel



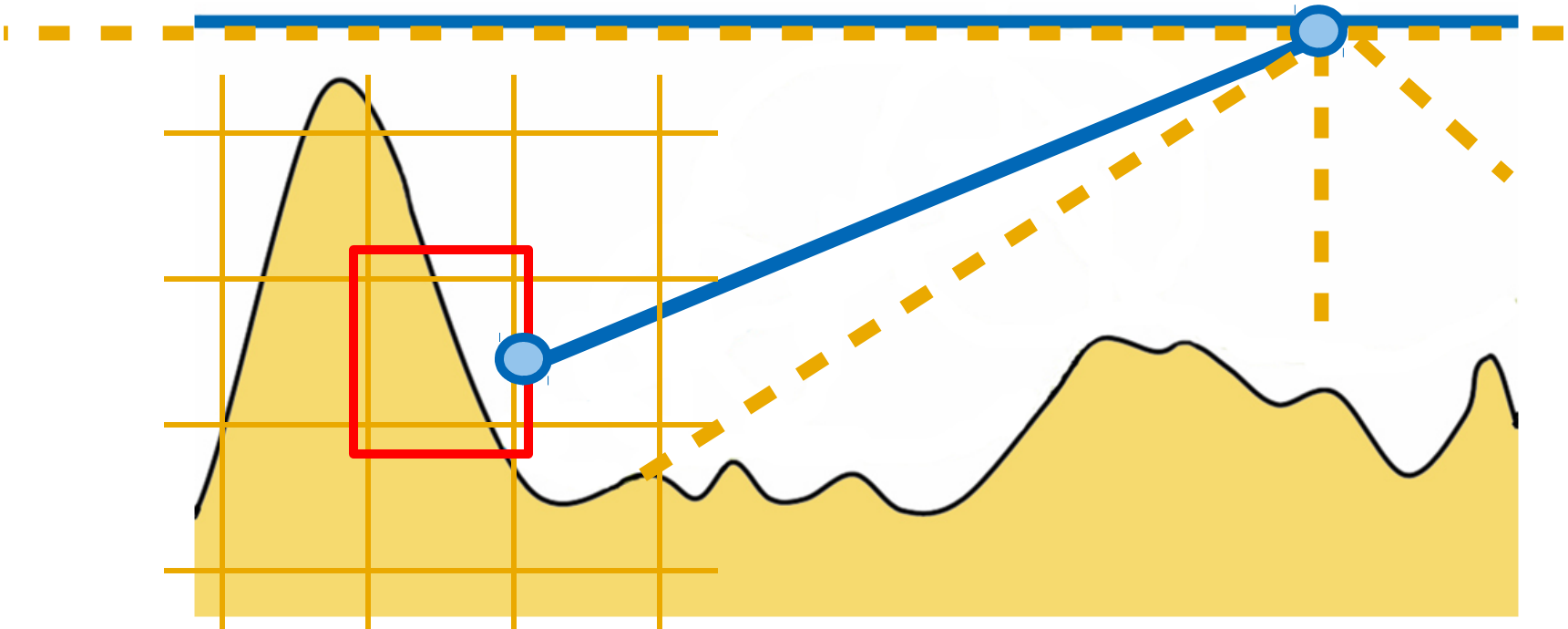
original sphere tracing



our technique

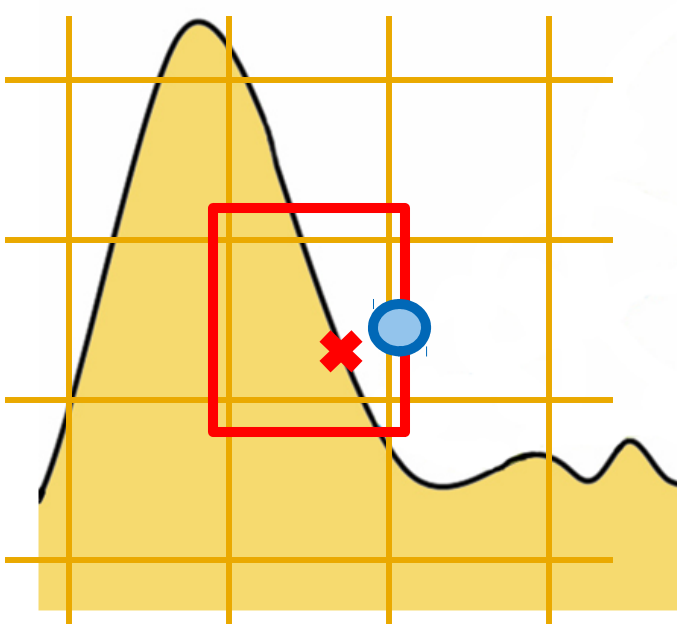
Accurate intersection

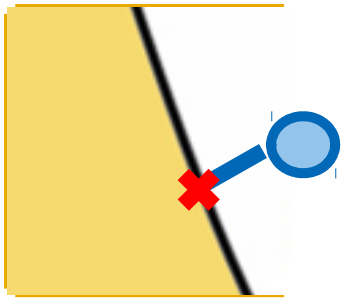
- Quadric surface approximation
- voxel with surface has value 0



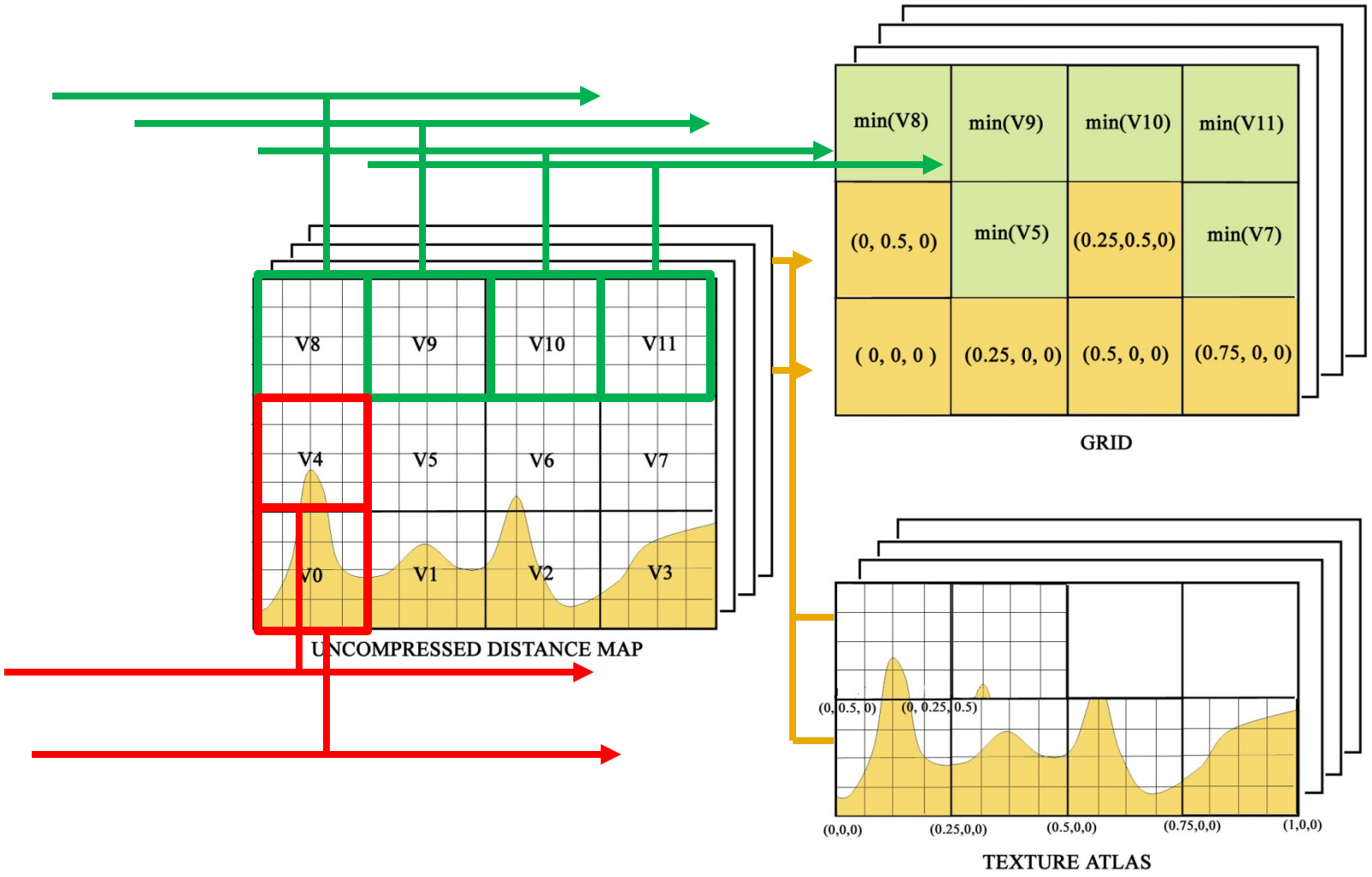
Accurate intersection

- Quadric surface approximation
- voxel with surface has value 0
- perform ray-quadric intersection





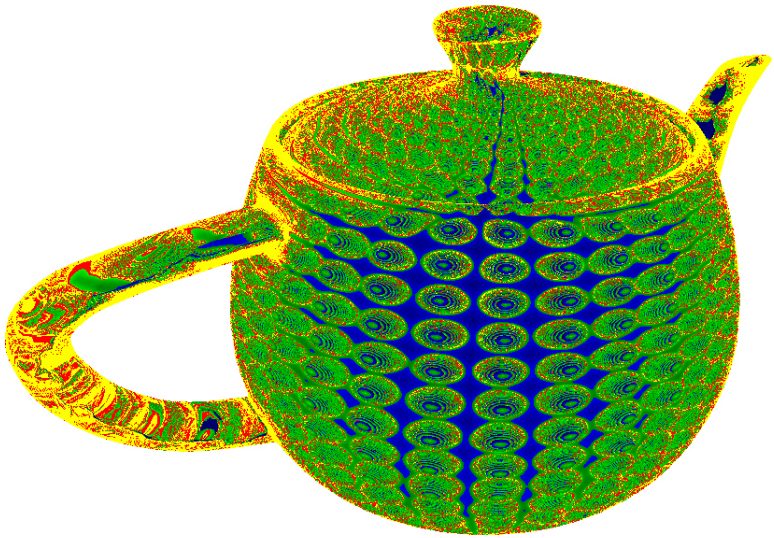
Distance map compression



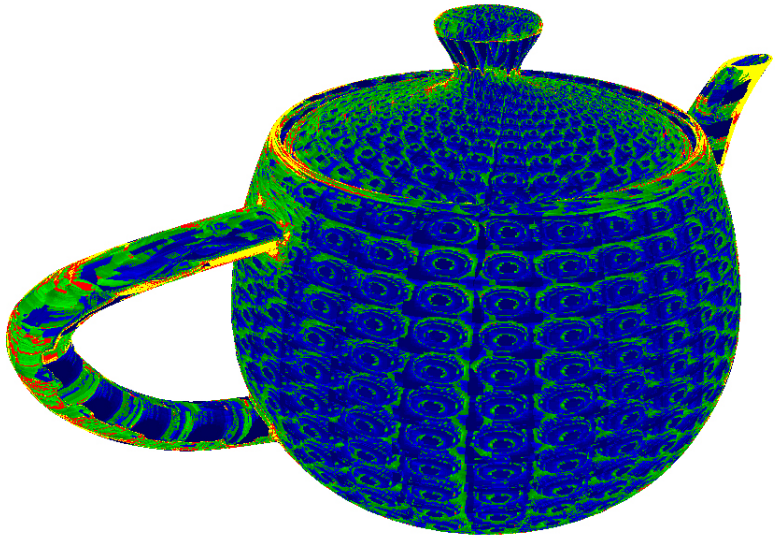
RESULTS

Results

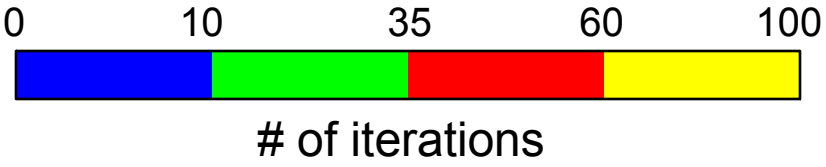
- Faster convergence



with distance map



with directional distance map



Results

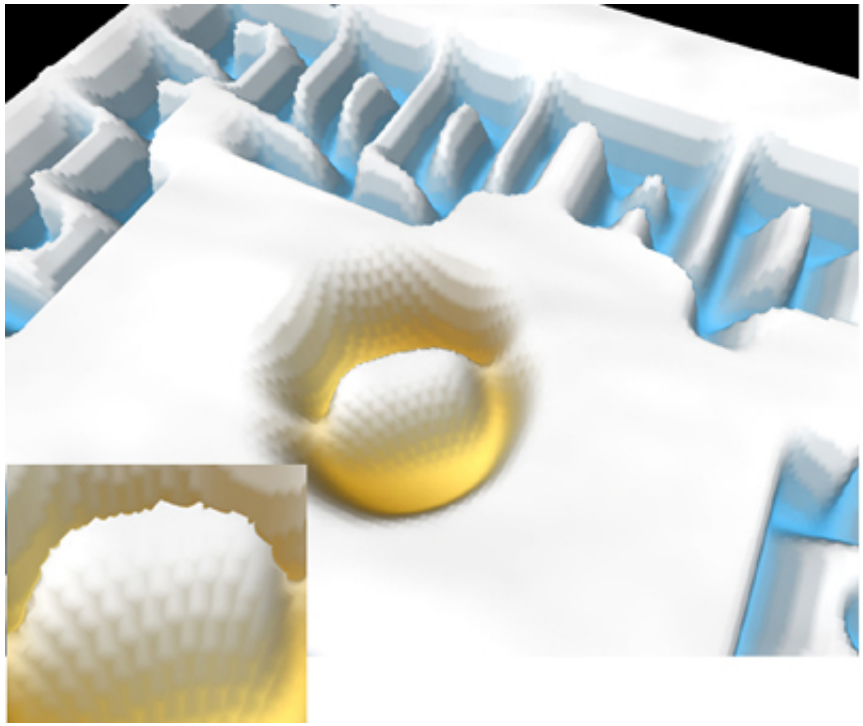
- Only few direction cones suffice

	Distance map	DDM 2×1	DDM 4×1	DDM 8×1
Shape	5.5	4.2	4	3.9
Teapot	4.4	3.1	2.8	2.7
Golden ball	8.3	7.1	6.1	5.8

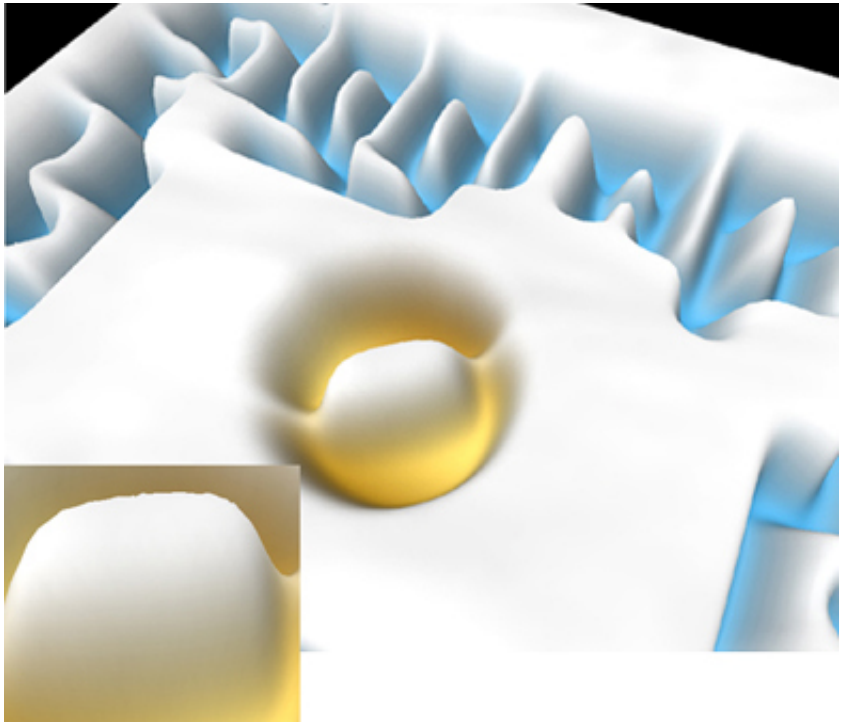
Performance (in ms) of sphere tracing with distance map and directional distance map (DDM) at varying number of directions.

Results

- Quality improvement



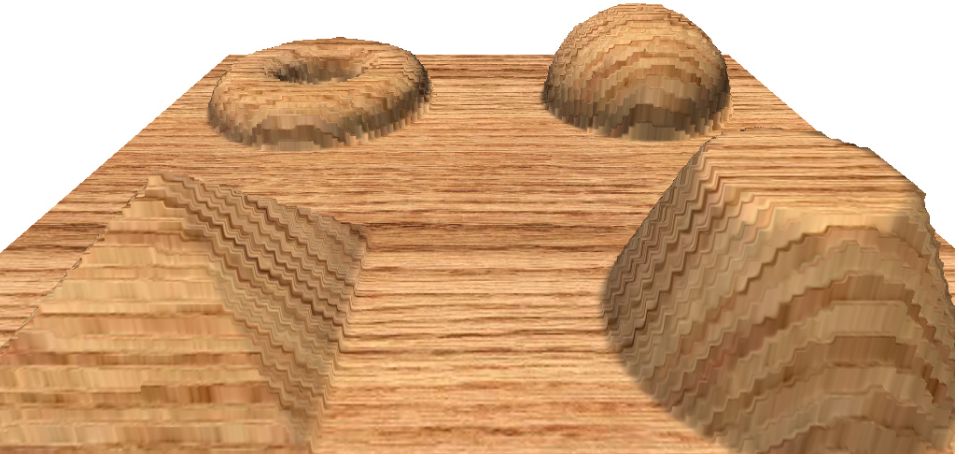
with distance map



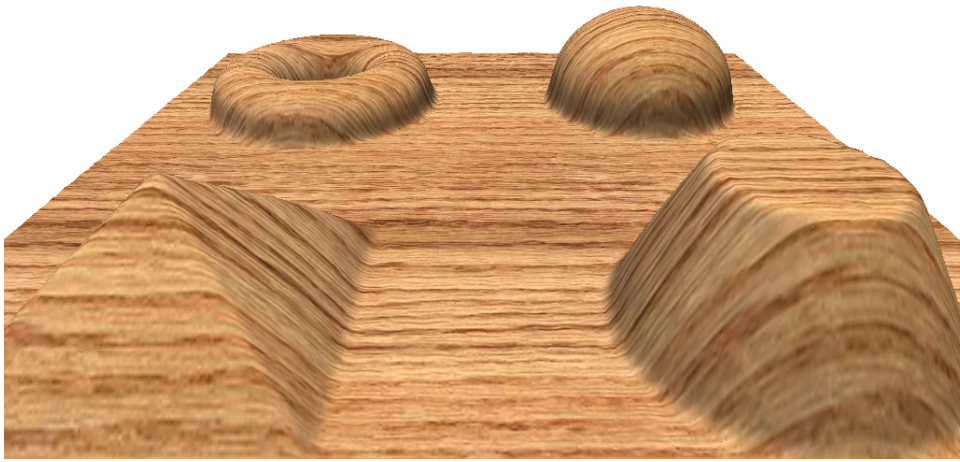
with DDM + ray-quadric intersection

Results

- Quality improvement



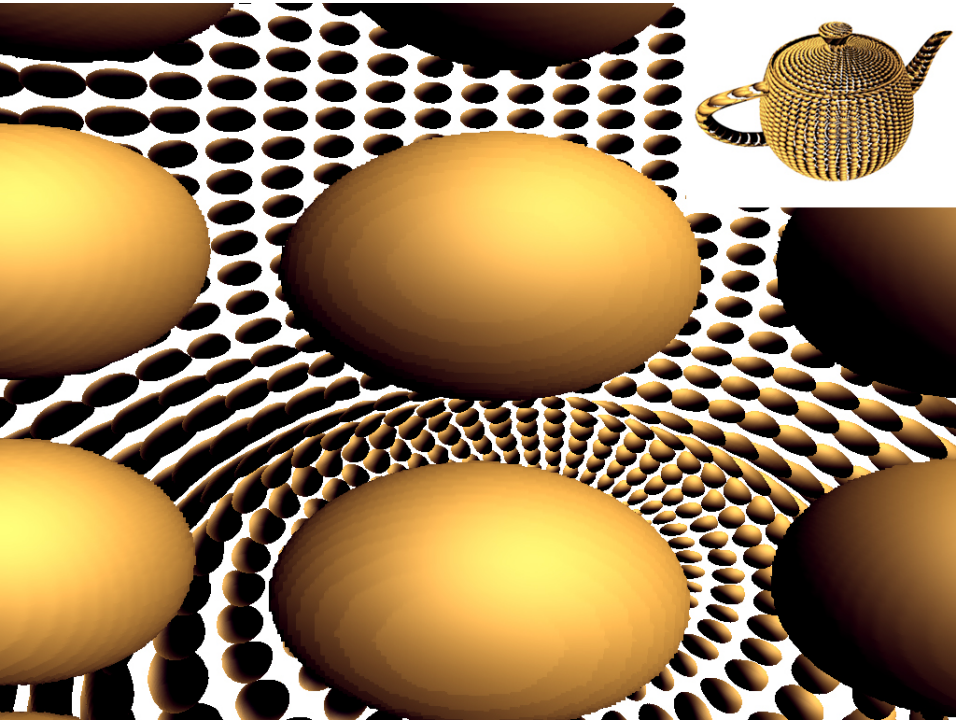
with distance map



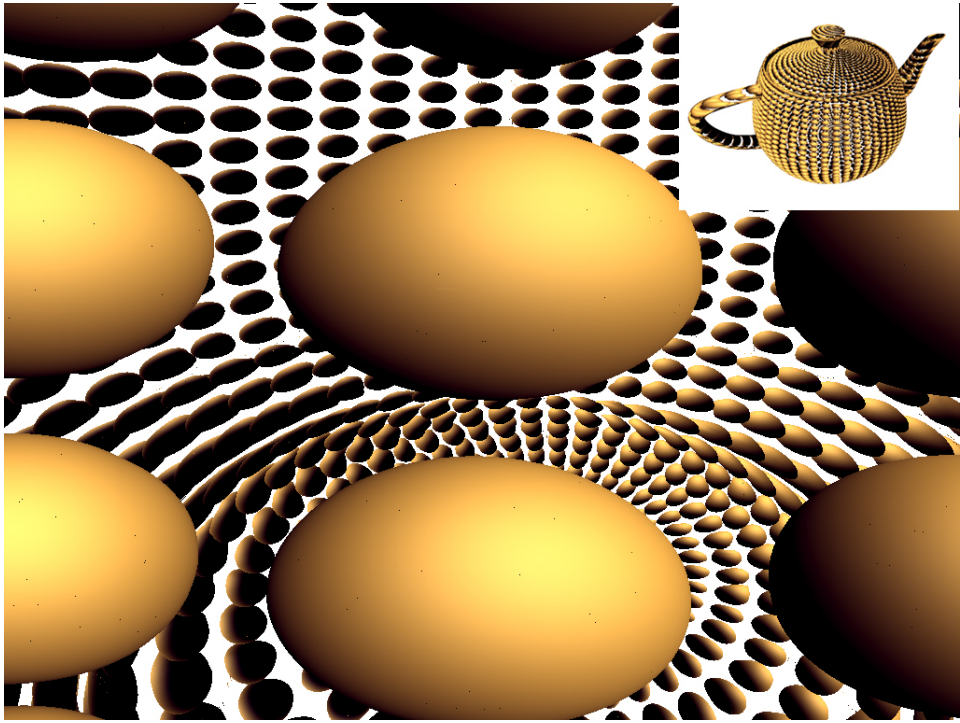
with DDM + ray-quadric intersection

Results

- Quality improvement



with distance map



with DDM + ray-quadric intersection

Results

- Performance

Model (No. of beads)	Relief map	ST Distance map	ST DDM 4×1	ST DDM + Quadric 4×1
Plane(400)	21.7	8.3	3.0	7.4
Cylinder(1600)	38.5	17.5	3.9	16.4
Teapot(4900)	23.8	25.0	10	50
Box(196)	27.7	12.7	6.3	30.3

Performance (in ms) for Relief Mapping, Sphere Tracing (ST) with distance map, ST with DDM and our technique (ST with DDM and quadric)

Results

- Compression efficiency

Model	Uncompressed	Compressed LOOKUP + ATLAS	Compr. Effic.
Beads	$(256^2 \times 64) \times 8$	$128^2 \times 256 + 128^2 \times 256$	4
Kitten	$(256^2 \times 64) \times 8$	$64^2 \times 128 + 64^2 \times 512$	12.8
Golden ball	$(256^2 \times 64) \times 8$	$32^2 \times 64 + 16^2 \times 256$	256

Compression efficiency of directional distance map (DDM) for different models.

THE END