LR B-splines: New spline technology for compact representation of measured shape

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*SINTEF is a Norwegian research foundation dominantly working within technology (2000 employees)

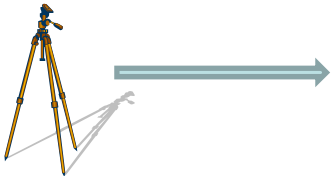
R R R
L L L
...

Stereo images

"Local" textured point clouds for each image pair

...

Alternative: Laser scanners or other traditional equipment combined with images



"Global" textured point cloud with high coverage

3D/stereo video stream

Compact textured Spline representation

Triangulations

- Why do triangulations dominate shape representation?
  - The traditional Open GL graphics pipeline (the technology of the 1990s) was based on efficient rendering of triangle structures.
  - Representing the shape by tailored triangulations thus made sense to get optimal graphics performance.
  - Representing a measured point cloud by a triangulation is fairly well understood.
  - Thinning the triangulations when it becomes too voluminous
    - However, thinning introduces artefacts
  - Texture mapping, bump mapping to give realism.
- Challenge: Non-planar shapes is represented by a structure of planar triangles introducing artificial breaks
  - Zooming reveals the breaks and approximation.

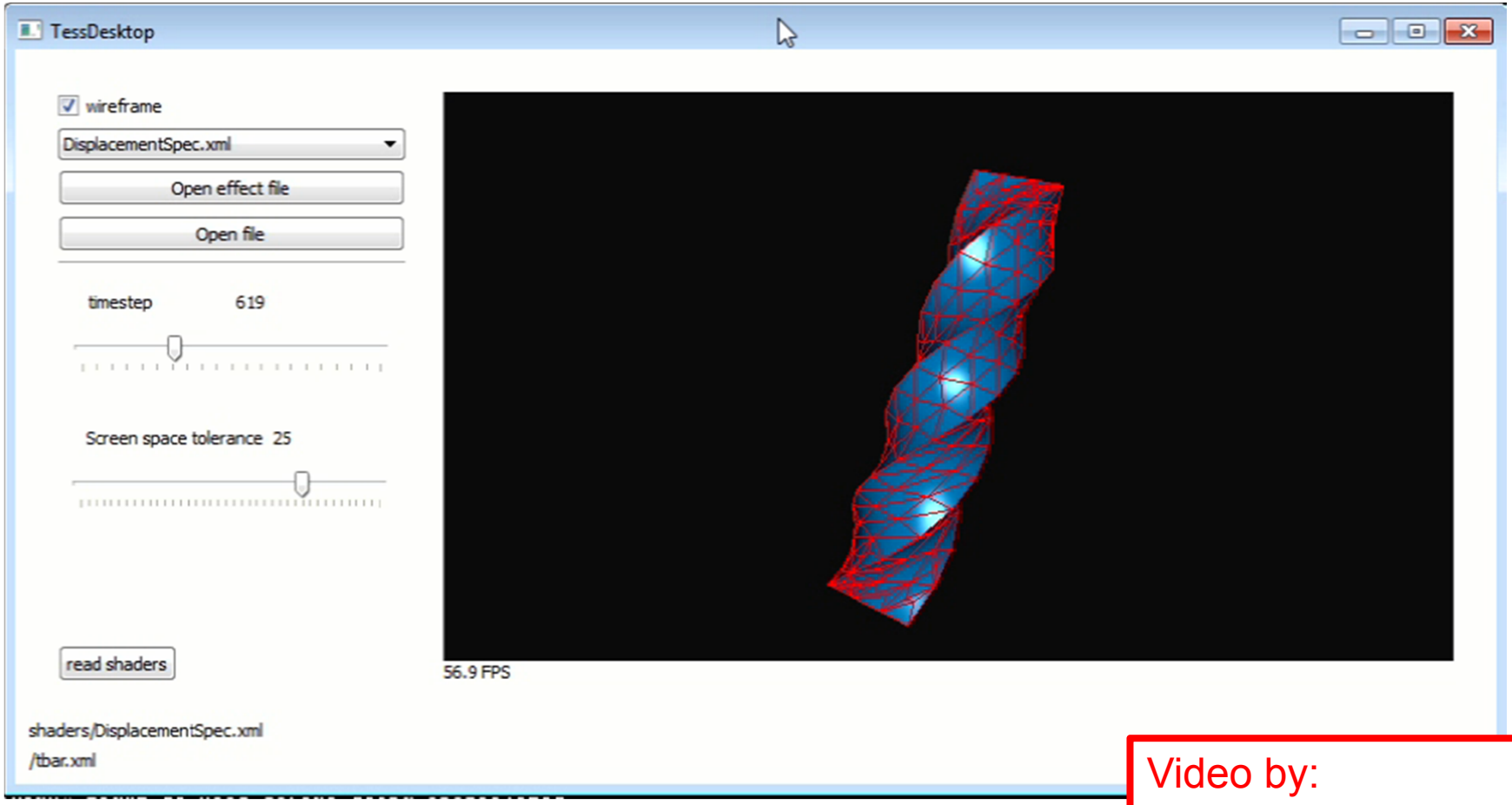
Cultural shapes

- Old objects were to a great extent hand crafted, thus many have a more sculptured shape than factory produced objects.
- Old objects have been exposed to wear and tear over the years, this has modified the shape, smoothing corners and edges scratching surface and making indentations.
- Old objects are frequently smooth, but with arbitrary local shape variation
  - Factory produced object are designed with Computer Aided Design systems that combine elementary surfaces, smooth spline surfaces with a high grade surface quality.

Why spline representation for cultural shapes

- Shape approximation by splines offers representation with tangent, curvature or higher order continuity.
- A spline representation of a sculptured shape is considerably more compact than the triangle representation
- Spline representations are very well suited for current programmable graphics processors (GPUs) on PCs and mobile devices
  - The spline representation can be rendered on the GPU freeing the application from handling large triangle structures.
  - Triangles can be produced from the splines as needed for visual quality

Isogeometric view dependent tessellation on the GPU of a spline model



Video by:
Jon Hjelmervik,
SINTEF ICT

Click her for video:
http://www.youtube.com/watch?v=KOsDBx8yEt0&list=UU_GWvrs307jzpjIWvQxWwHA&index=1&feature=plcp

Challenges with traditional spline represented surface

- Traditional B-spline represented surfaces do not allow local refinement of the surface model
- Consequently they are not well suited for the abitrary local shape variation in cultural objects

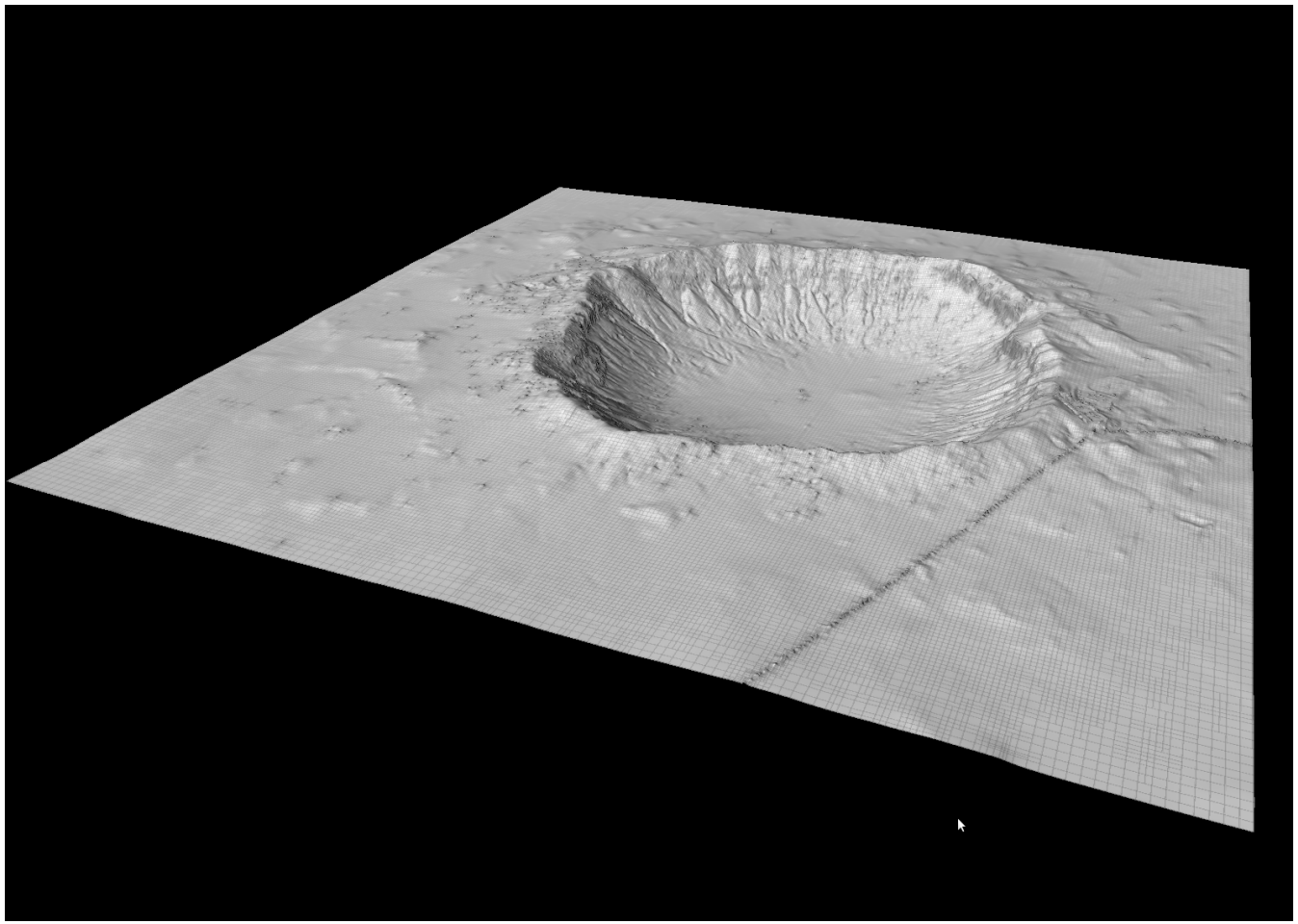
New approach; Locally refined B-splines

- Inspired by the T-splines introduced in 2003 by Tom Sederberg we addressed in 2009 the challenge of shapes represented by locally refined B-splines
  - The theory is available in a preprint, and expected soon to appear in Computer Aided Geometric Design. http://www.sintef.no/upload/IKT/9011/geometri/LR-splines%20SINTEF%20Preprint%20-%20signatures.pdf
  - The approach allows the introduction of additional modelling freedom in areas with large local variations.

First test of the new spline technology on terrain data

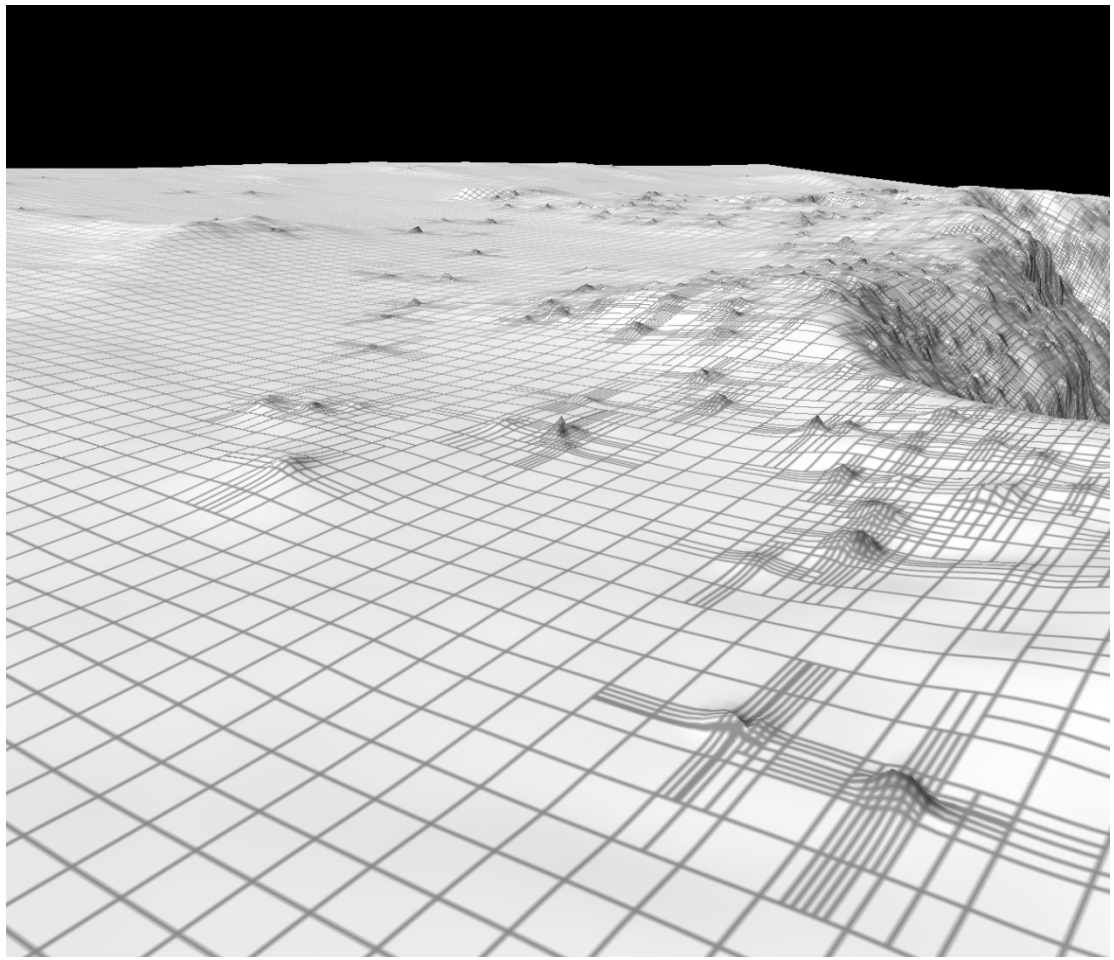
- After developing the theory for the Locally Refined B-splines (LR B-splines) we have recently started to test the technology of terrain data sets
  - We will further augment the technology in the FP7 IP IQmulus that starts on November 1, 2012 (4 years duration)
  - We want to establish cooperation with others that allows us to test the technology on a broader range of datasets.
- Some examples on Terrain Data.

Approximation of large data set Barringer crater Arizona



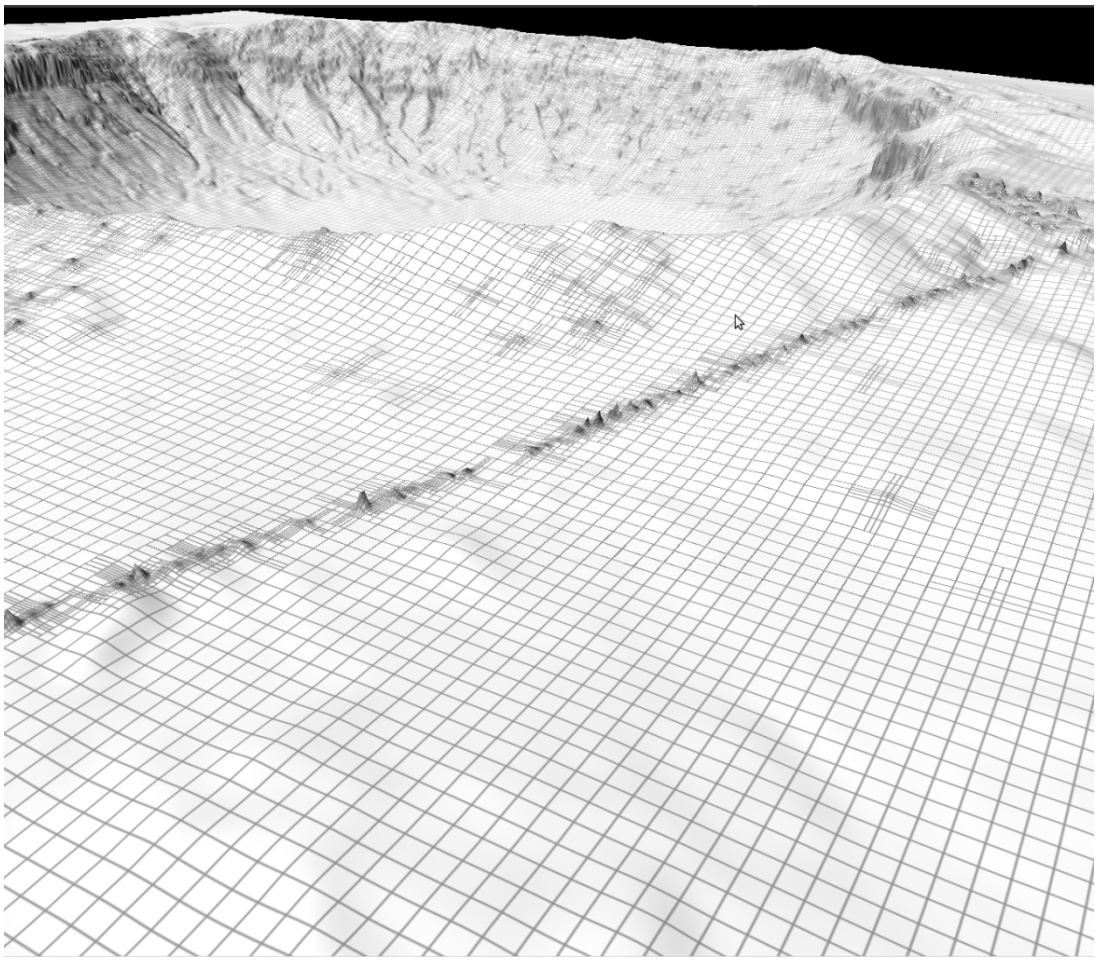
Data courtesy of http://www.opentopography.org/

Local refinement to adapt to fine details



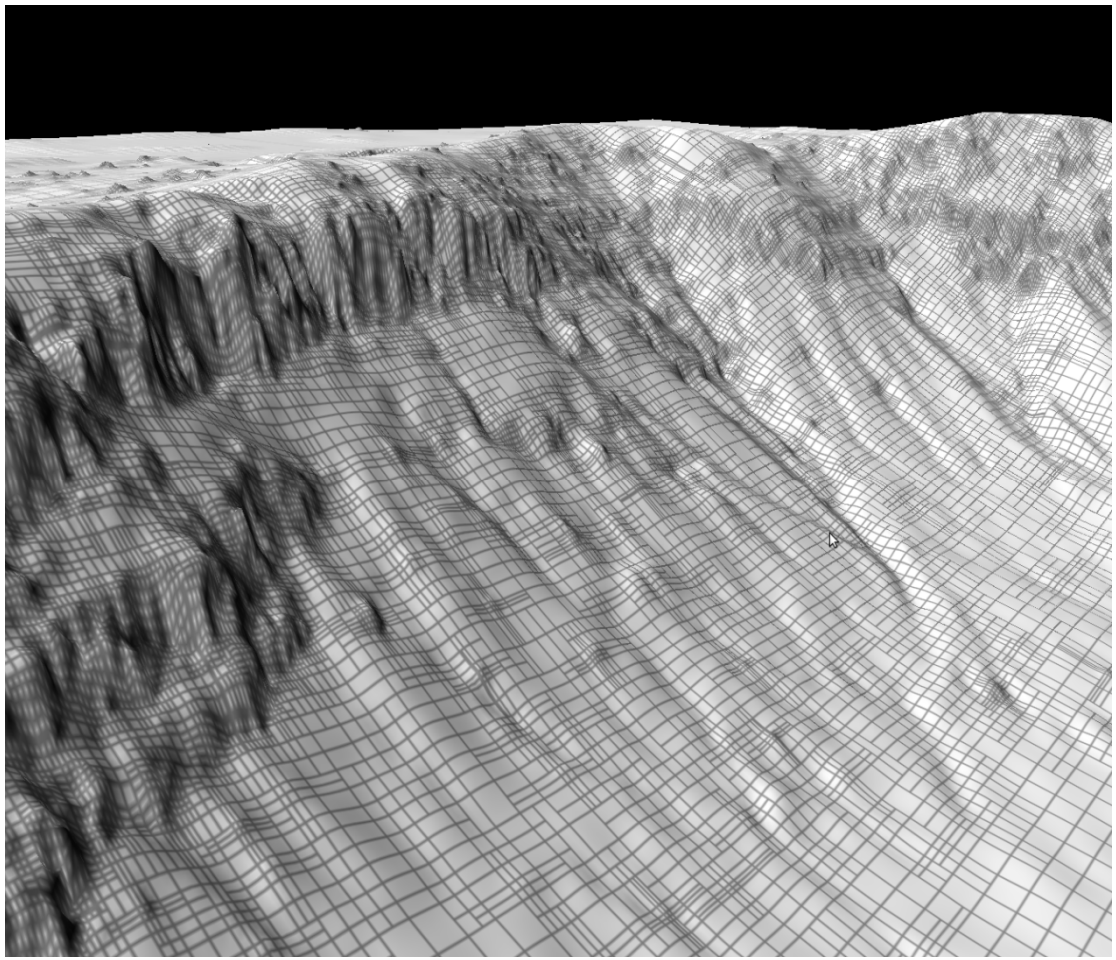
Data courtesy of http://www.opentopography.org/

Data along powerline? reproduced

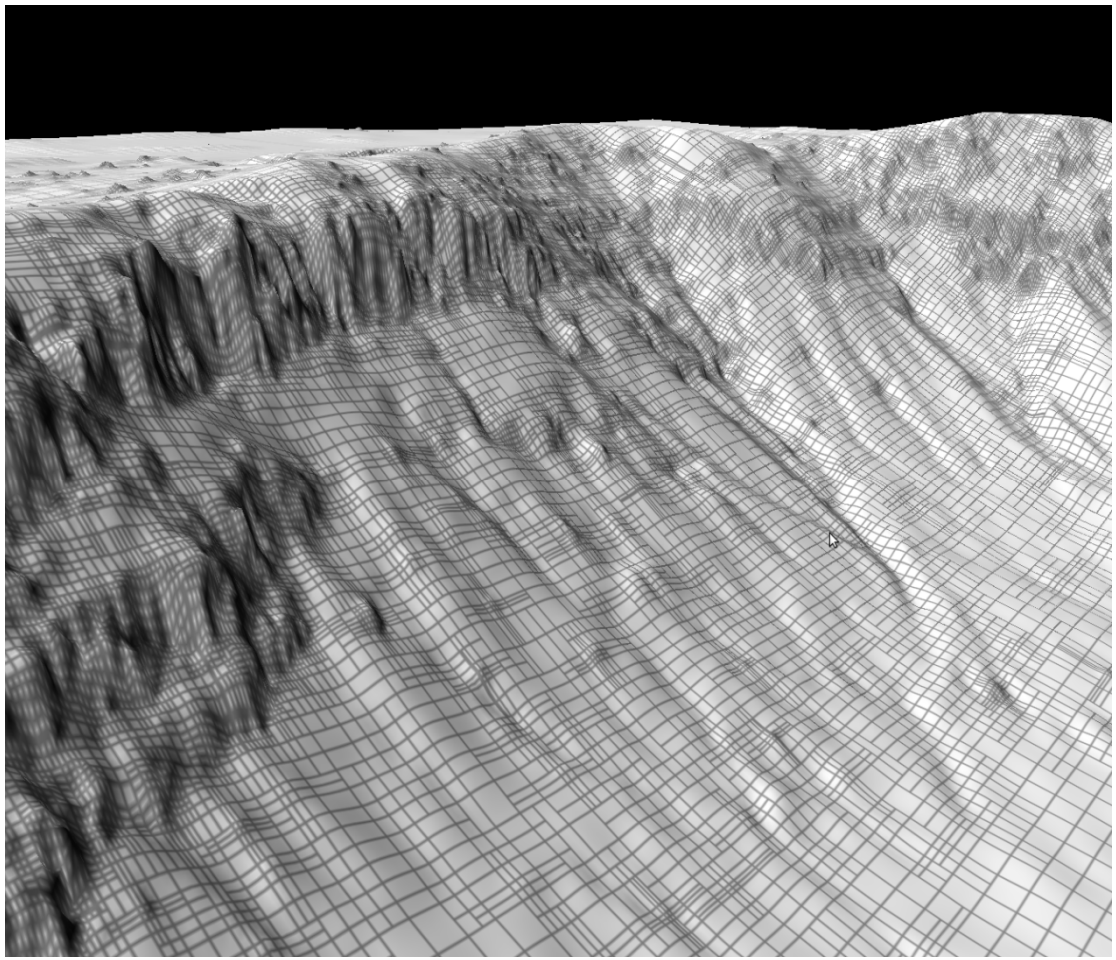


Data courtesy of http://www.opentopography.org/

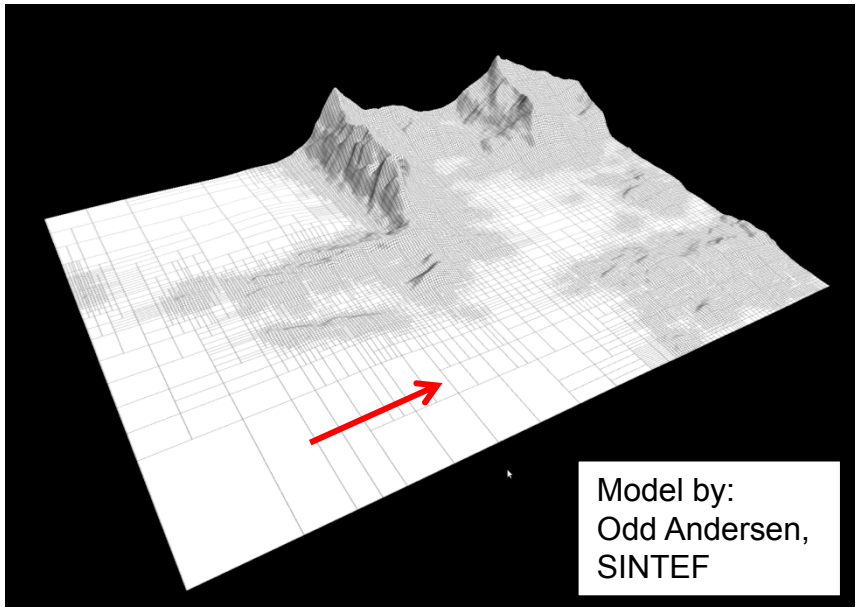
Details along inside slope

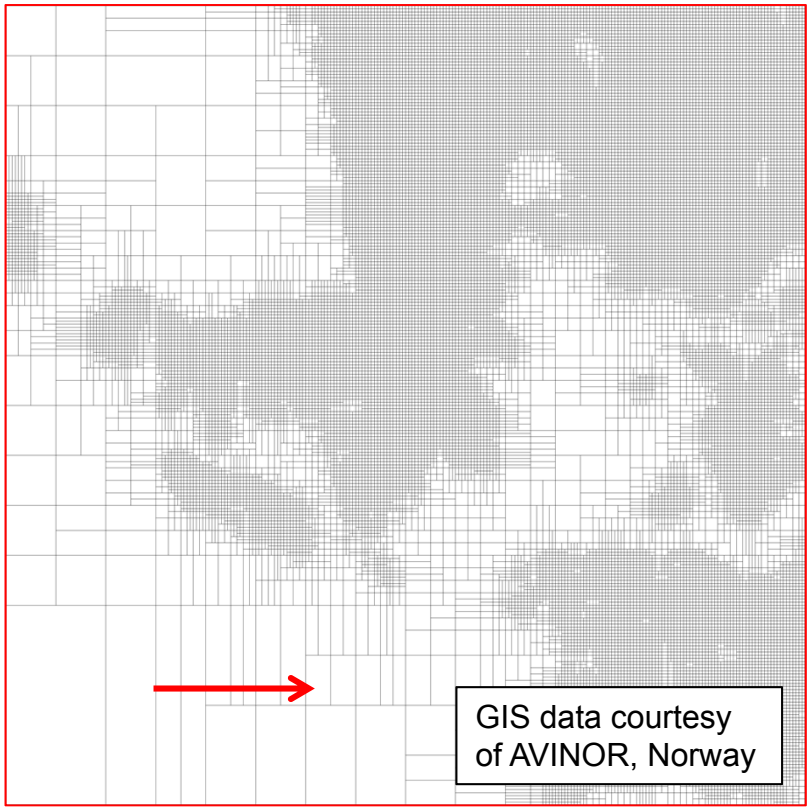


Details along inside slope



Local refinement for LR B-splines

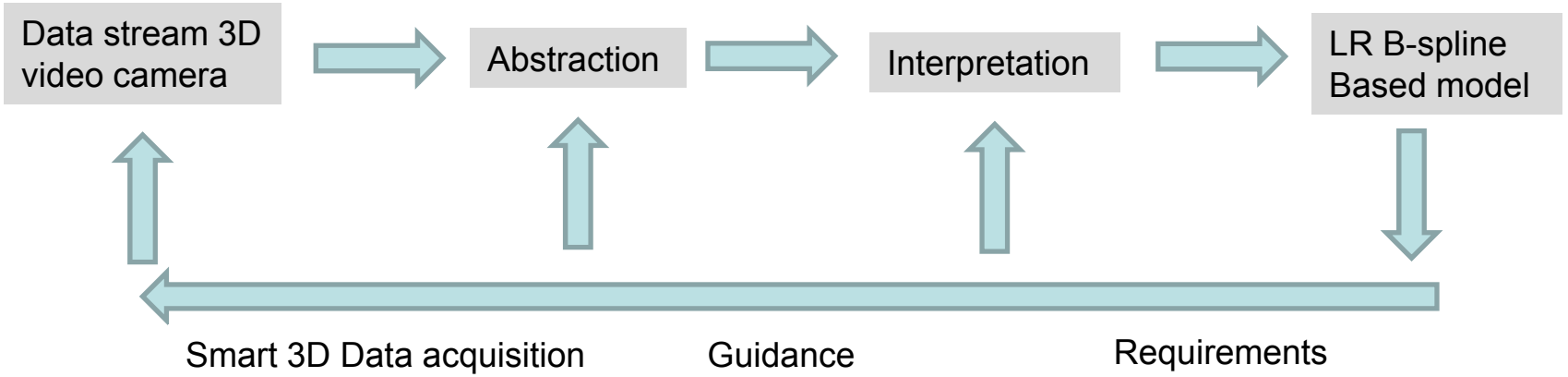




- Refine in mesh projected on 3D surface
- Refine in 2D mesh in parameter domain
- Vector specifiying refinement knotline

- Automatic checking:
  - Spline space filled?
  - LR B-spline basis exists?
  - Automatic corrections possible

New paradigm for acquisition and analysis



- Replace point based models by semantic annotated LR B-spline based models representing structure and surface shape.
- Instant creation of textured LR B-spline based models
- “As-is” models of natural and human made structures and shapes
  - Fast, adaptive acquisition
  - Resolution and representation on demand
  - Increased data quality, decreased cost
  - Create, validate and correct 3D models to reflect reality

Summing up

- I have presented some technology components
  - 3D video camera
  - LR B-splines
  - A real time pipeline for 3D data processing
- Combining these can significantly increase the speed and quality for the modelling of 3D cultural shapes from 3D data acquisition.