Visualization for Mobile Applications

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Introduction

- Use of mobile devices have grown over the years
  - Small form factor
  - Low power consumption
  - Processing and graphics performances
  - Easy to operate
  - Variety
  - Ubiquity
- Cellular service
  - Appropriate call rates
  - Coverage
  - SMS facility
  - Internet access
- Wide scope for building mobile applications

Mobile Application in Healthcare: Simple Applications

- Health Information System
  - User can query and check details of nearby health facility centres
  - GPS enabled system: Application to query the requirements with the user position from the publicly available free database services
  - Non-GPS enabled system: SMS query to some publicly available server available through specified number. Example: Dr. SMS service by Kerala State IT Mission
- Notification/Reminder Services
  - Doctor or medical test appointment reminder
  - Availability notification for patient admission after registration
  - Medication reminders

Mobile Application in Healthcare: Advanced Applications

- Monitoring services
  1. Remote embedded sensors for monitoring certain parameter of the patients
  2. Application in the mobile device can accept data through wireless communication
  3. Data can be collected periodically and sent to certain distant location
  4. Send or activate an alarm signal if a certain threshold have been reached

- Mobile Imaging
  1. Access and visualize patient's visual test data anywhere
  2. 2D or 3D data: CT scans, MRI scans etc.
  3. Remote and non remote processing and rendering of data
  4. Application should be interactive

Mobile Application in Pollution Awareness

- Pollution monitor system
  - Measuring sound pollution using sound recorder
  - Visibility test for air pollution or smog using camera
  - Using accelerometer to measure vibrations or shockwave
- Feeding databases with location and pollutant measurement
- Mobile application with GPS system can provide pollution level by accessing these databases
- Interpolate based on road traffic, industrial concentration and pollution level in nearest regions

Other Useful Mobile Application

- Farming information system
  - Rainfall and other statistic
  - Identifying appropriate crop(s) for cultivation
  - Farming methodology and other information
- Fishing Information System
  - Present satellite images provides 2D information on concentration of school of fishes
  - In future it may provide 3D information (i.e. including depth)
- Education
  - Access to educational services through mobile devices
  - Education information system

Scalar Fields

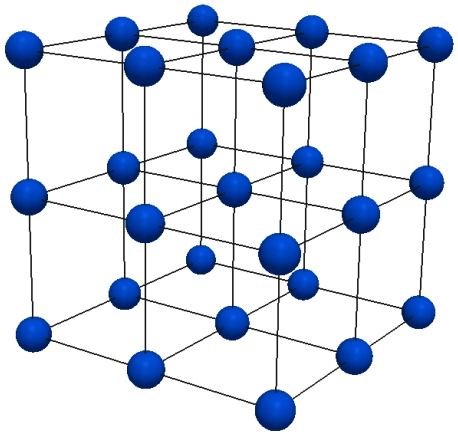


Figure: A $3 \times 3 \times 3$ 3D scalar field

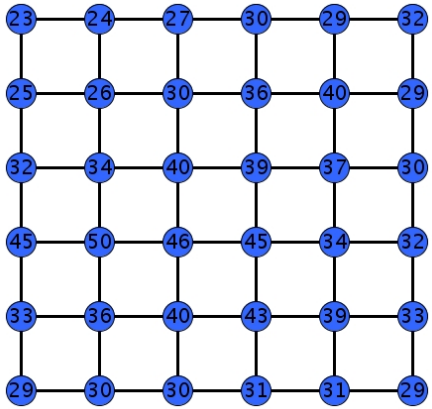


Figure: A 6×6 2D scalar field

Definition: A set of n points $(p_1, p_2, ..., p_n)$ in a d-dimensional space $\mathbb{R}^d$, with accompanying scalar measurements $(h_1, h_2, ..., h_n)$

Sources:

- Computational Fluid Dynamics
- Laser scans
- Radar Imaging
- Medical Imaging

Volume Rendering

It is the technique where beneficial portions of the 3D scalar field are identified (using *transfer function*) and rendered as a 2D image onto the screen.

- Provides optical properties for each point.
  1. Scalar value
  2. Gradient
- Generates new points through interpolation.
- Generates the colour of each pixel of the screen by composition from back to front.
- FOSS volume renderer
  - Voreen (http://www.voreen.org)
  - Simian (http://www.cs.utah.edu/ jmk/simian)
  - ImageVis3D (http://www.sci.utah.edu/cibc/software/41-imagevis3d.html)

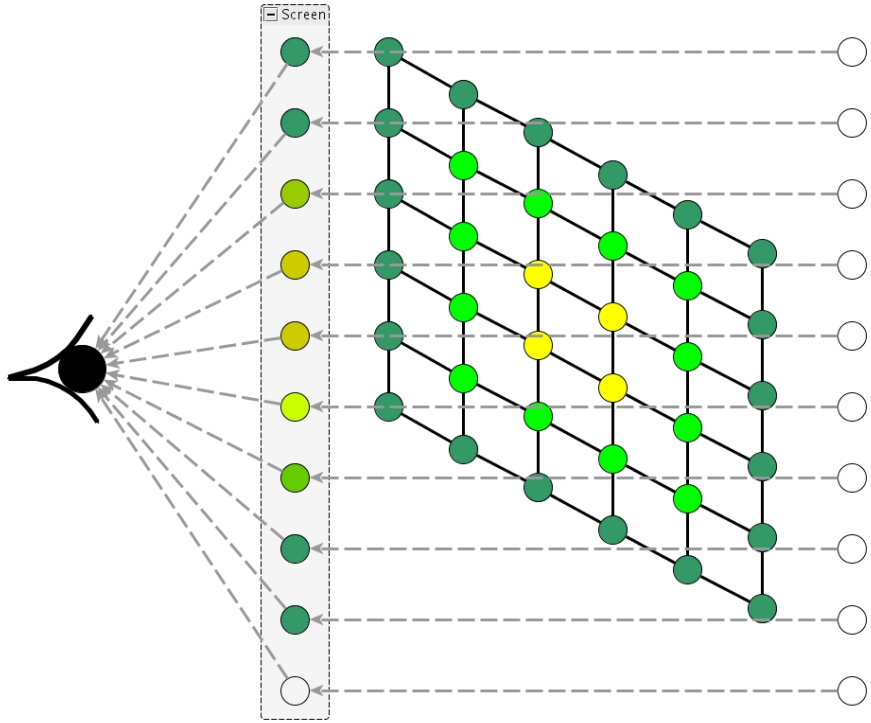
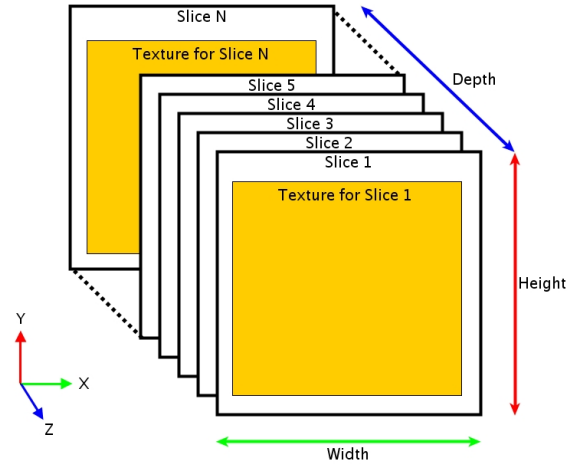
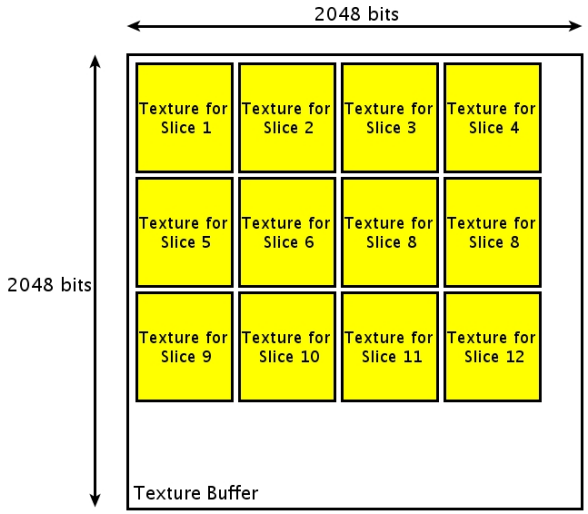


Figure: Compositing along a viewing ray

Volume Rendering on Mobile Devices



View Axis Aligned Slices



A Texture Atlas

Our implementation of volume renderer is based on the paper "***Interactive Volume Rendering on Mobile Devices***" by **Manuel Moser** and **Daniel Weiskopf** with some improvements.

- GPU-based.
- Use of OpenGL ES 2.0.
  - Access to programmable shader of GPU.
  - Allows Postclassification
- Uses axis aligned slices (rectangles).
- Conversion of 3D Scalar data to Alpha Textures.
  - Use of texture atlas to reduce number of rendering calls.
- Use of Pixel Buffer to implement Zoom In/Out.

Volume Renderer Implementation and Results

Implementation:

- Hardware: Nokia N900
- Software:
  - PowerVR SDK
  - Qemu and ScratchBox
  - QTCreator

Results:

Data name	Dimensions	Memory	FPS
Silicium	$98 \times 34 \times 34$	110 KB	34.75
Fuel	$64 \times 64 \times 64$	256 KB	35.56
CTA Ear	$128 \times 128 \times 30$	480 KB	20.19
Hydrogen atom	$128 \times 128 \times 128$	2 MB	13.58
Engine	$256 \times 256 \times 128$	8 MB	4.78
Skull	$256 \times 256 \times 256$	16 MB	2.34
Vertebra	$512 \times 512 \times 512$	128 MB	1.24

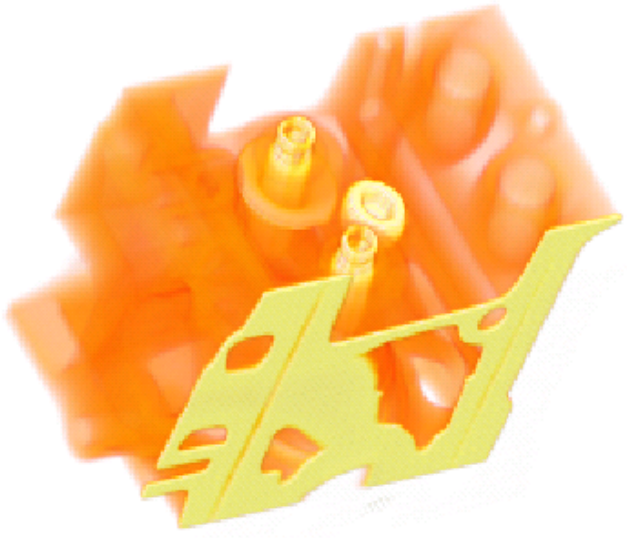
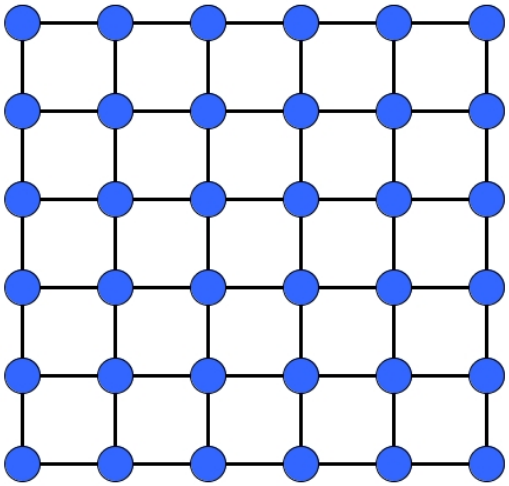


Figure: A volume rendered image of Engine data on Nokia N900.

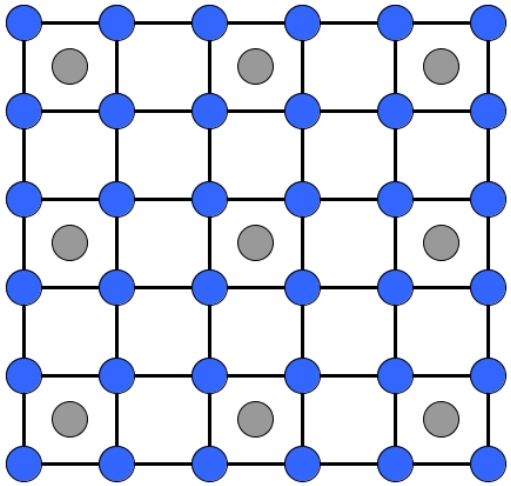
Downsampling

Downsampling of a 2D Scalar data



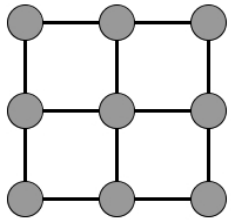
6 x 6

Identification of cell

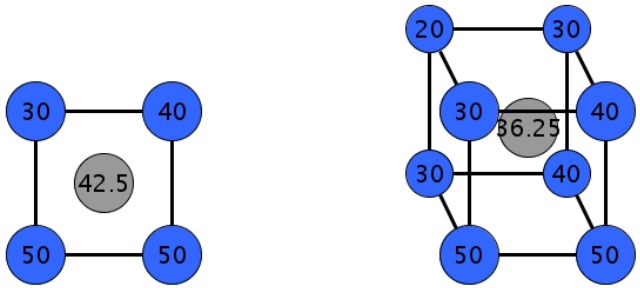


6 x 6

Downsampled data



3 x 3



Average value based Downsampling

Topological Properties of a Scalar Field

- Topological Properties → Topological Structures → Level Sets
- Critical Points: Minima, Saddles and Maxima

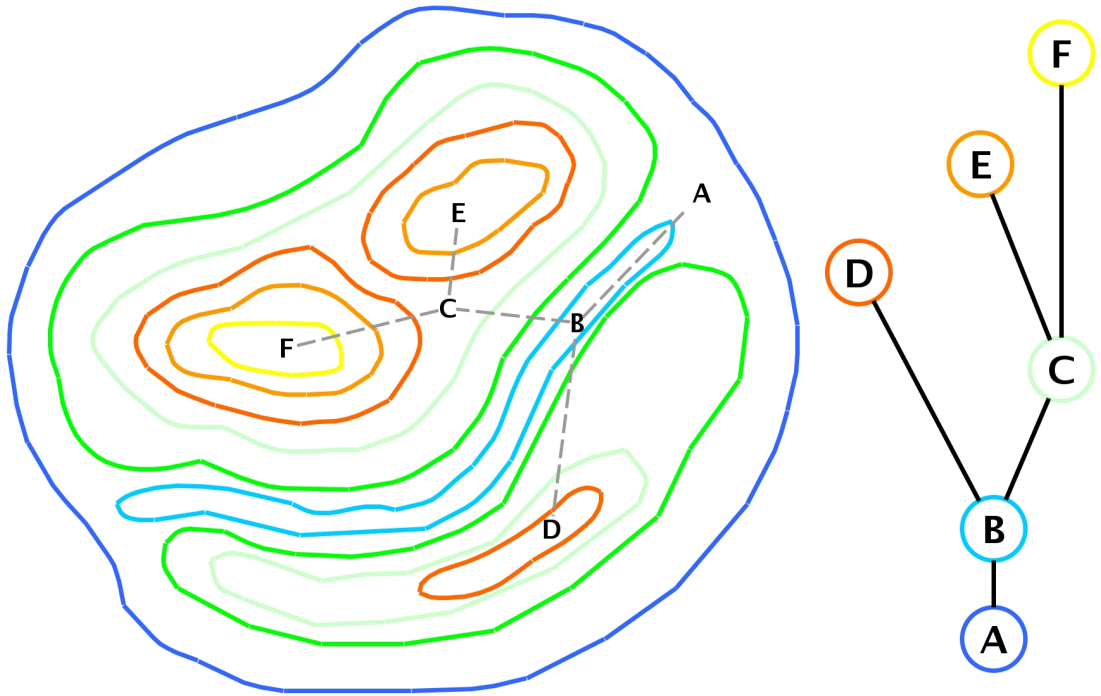


Figure: A terrain with contours (right picture) representing a 2D scalar field; The critical points are: A is a minima, B and C are saddles, D, E and F are maxima; The graph on the right shows how the contours begins from A, splits at B and C, and finally ends at D, E and F.

Neighborhood

26-points based Neighborhood:

1. Trilinearly interpolated points have degree 6 each.
2. Bilinearly interpolated points have degree 4 each.
3. Points which are not found through interpolation.

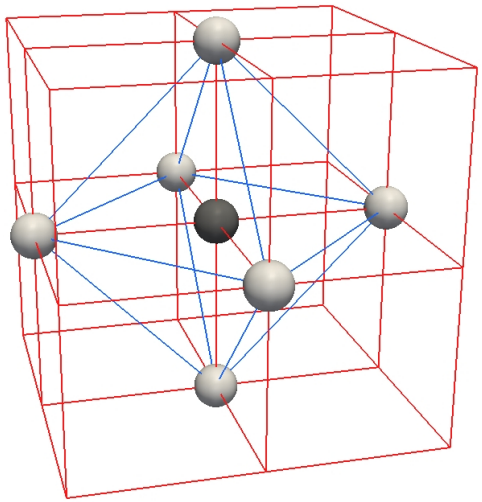


Figure: 6-points based

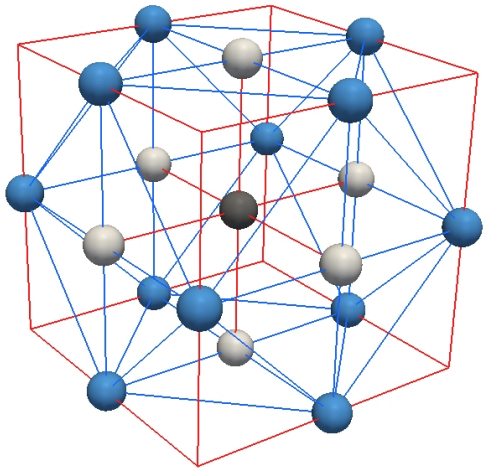


Figure: 18-points based

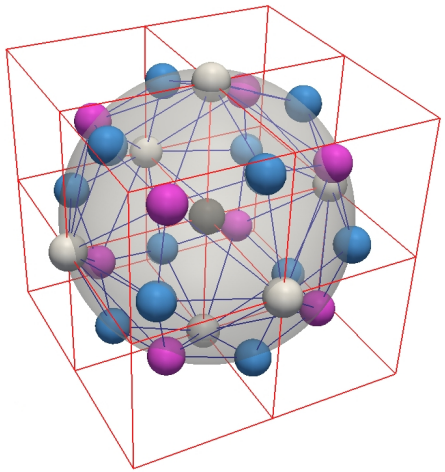
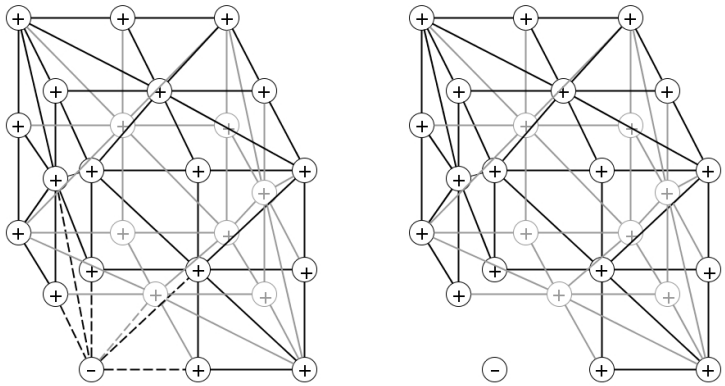


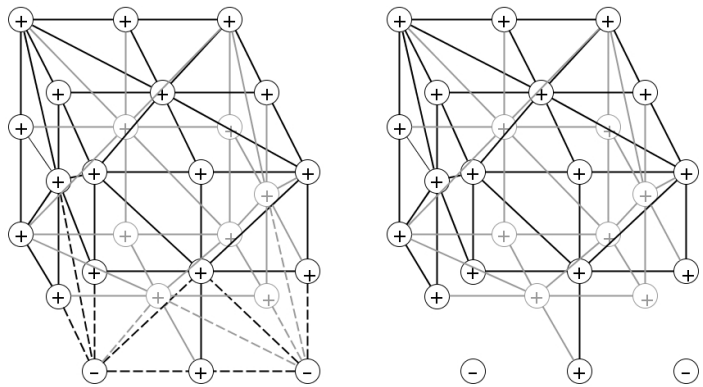
Figure: 26-points based

Classification of Points

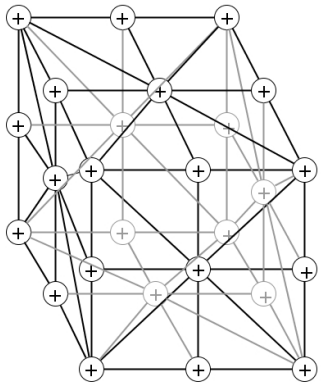
Regular Point (2 components)



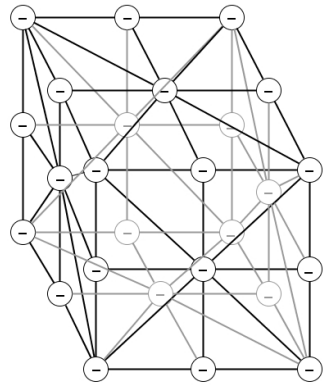
Saddle Point (3 or more components)



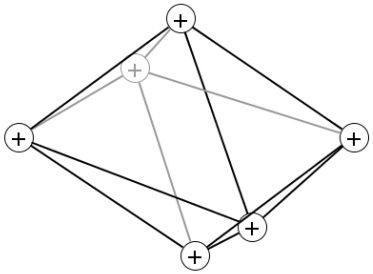
Minimum Point (1 component)



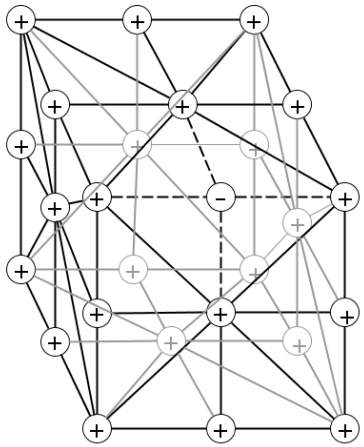
Maximum Point (1 component)



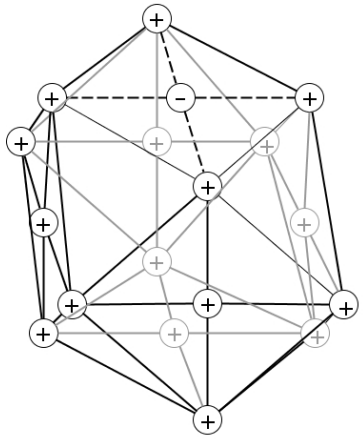
Differences among Neighborhoods



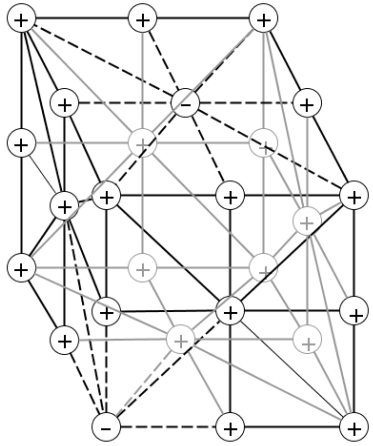
Extremum



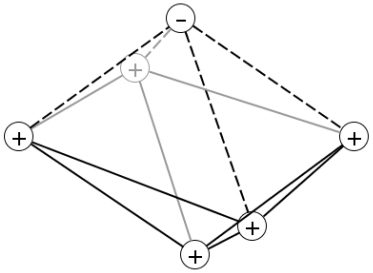
Regular



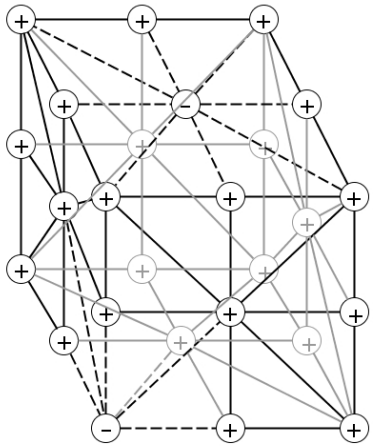
Regular



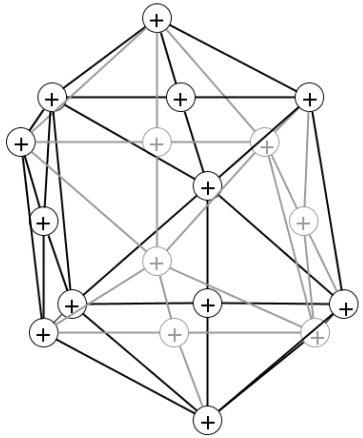
Saddle



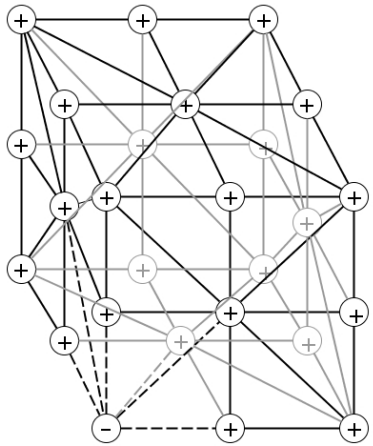
Regular



Saddle



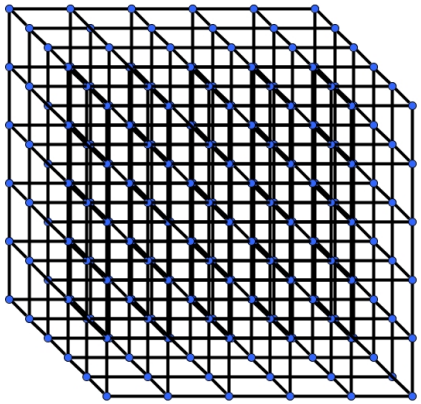
Extremum



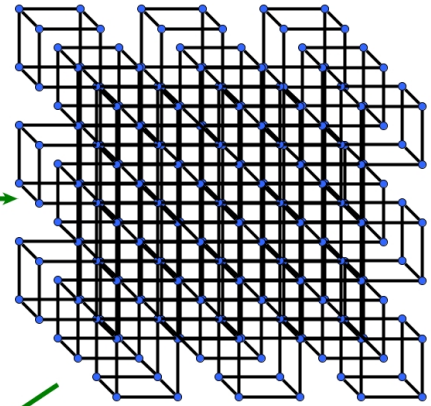
Regular

Downsampling Algorithm

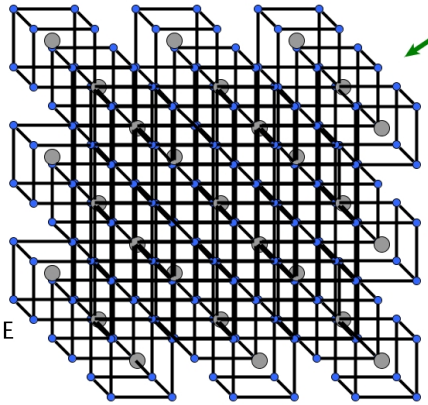
Original Data 6X6X6



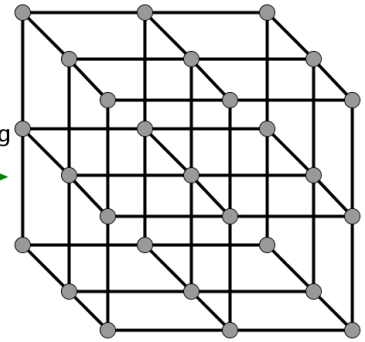
Step 1: Partition into cubes



Step 2



Step 3: Form the downsampled Data (3X3X3) using the new points



Step 2:
For each Cubic cell, classify each points.
The value of the new point will be:

i. IF all the points are REGULAR
   The VALUE of the point NEAREST to the AVERAGE VALUE
ii. ELSE IF all the points are either SADDLE or EXTREMUM
   The VALUE of the point FARTHEST from the AVERAGE VALUE
iii. ELSE IF all the points are REGULAR except one SADDLE or EXTREMUM
   The VALUE of the SADDLE or EXTREMUM
iv. ELSE IF two or more ponts are either all SADDLE or all EXTREMUM and rest are REGULAR
   The VALUE of the CRITICAL point FARTHEST from the AVERAGE VALUE

Results: Fuel Data

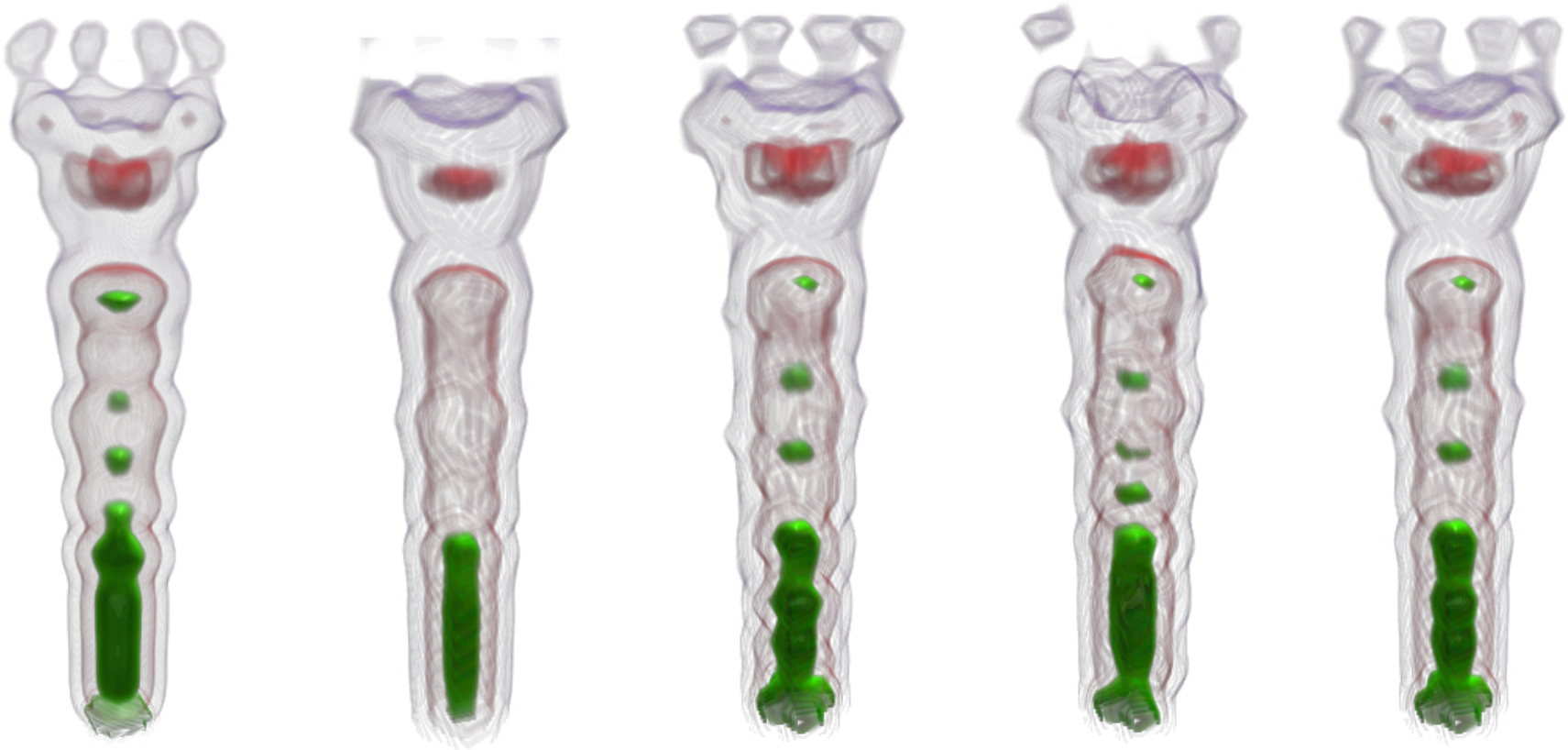


Figure: Fuel($64 \times 64 \times 64$ to $32 \times 32 \times 32$): From left original data, average based downsampled data, 6-points based, 18-points based and 26-points based

Results: Silicium Data

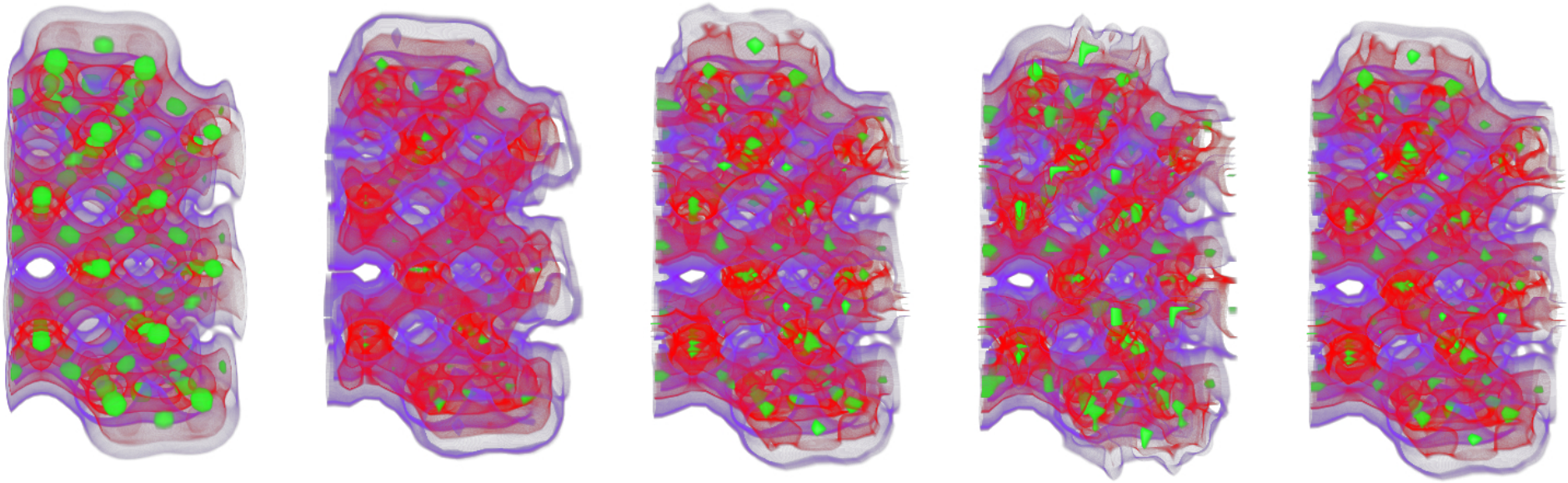


Figure: Silicium($98 \times 34 \times 34$ to $49 \times 17 \times 17$): From left original data, average based downsampled data, 6-points based, 18-points based and 26-points based

Conclusion

- Volume rendering tool for Mobile Devices for visualizing Scalar Fields.
- Mobile hardware limitations leads to low interactive rates for Large Scalar Fields.
- Addressing this problem using Downsampling of the Scalar Fields.
- Downsampling introduces errors.
  1. Geometric
  2. Topological
- Minimized topological errors

References


Manuel Moser and Daniel Weiskopf, "*Interactive Volume Rendering on Mobile Devices*", In Proceedings of "Vision, Modeling, and Visualization VMV '08 Conference", pages 217-226, 2008.


Martin Kraus and Thomas Ertl, "*Topology-Guided Downsampling*", In Proceedings of International Workshop on Volume Graphics '01, pages 129–147, 2000.


Gunther H. Weber, Gerik Scheuermann, Hans Hagen and Bernd Hamann, "*Exploring Scalar Fields Using Critical Isovalues*", in Proceedings of IEEE Visualization Conference '02, pages 171-178, 2002.


Charles D. Hansen and Chris R. Johnson, "*The Visualization Handbook*", Part II Scalar Field Visualization: Volume Rendering, pages 127-258.


http://www.imgtec.com/Newsletters/with_imagination/issue7_10.pdf, "*With Imagination*", issue 7, page 3, 2010.


Klaus Engel, Markus Hadwiger, Joe M. Kniss, Christof RezK-Salama and Daniel Weiskopf, "*Real-Time Volume Graphics*", A. K. Peters Ltd., pages 441-459, 2006.


Mobile Technology's Promise for Healthcare, http://www.csmg-global.com/Perspectives/AllCSMGArticles/tabid/335/articleType/ArticleView/articleId/593/Mobile-Technologys-Promise-for-Healthcare-2010.aspx, 2010.


What's That Sound? Two Tools Track Noise Pollution, http://mobileactive.org/whats-sound-two-tools-track-noise-pollution, 2009.


Cellphone camera air pollution, http://www.wired.com/gadgetlab/2010/09/cellphone-camera-air-pollution/

Questions???

Thank You !!!