



Visualization and Networking Toolkits with Wavelets

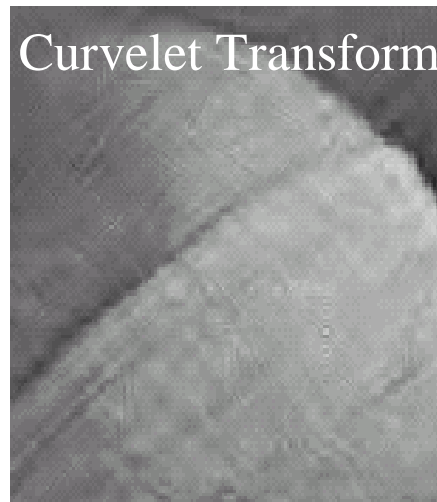
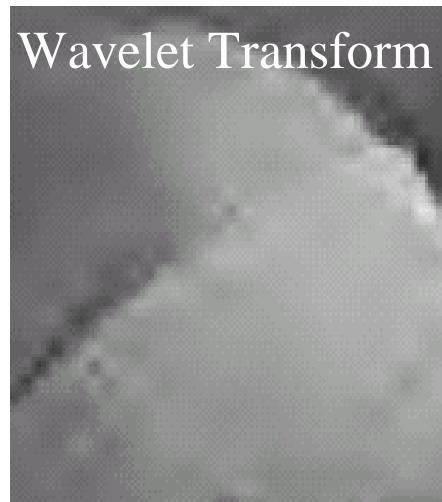
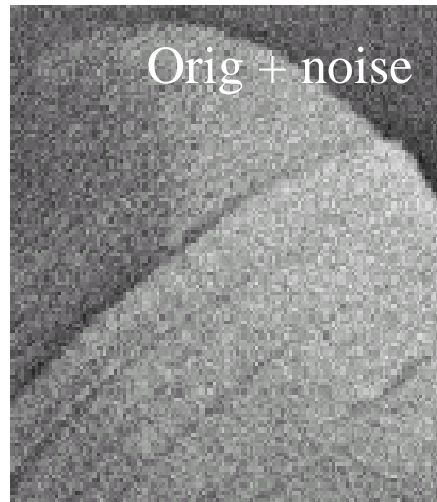
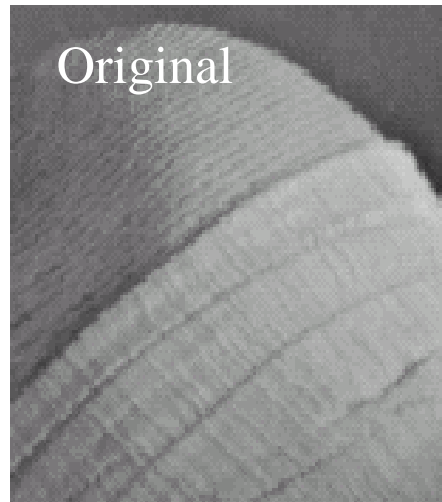
Gordon Erlebacher
Florida State University

David A. Yuen
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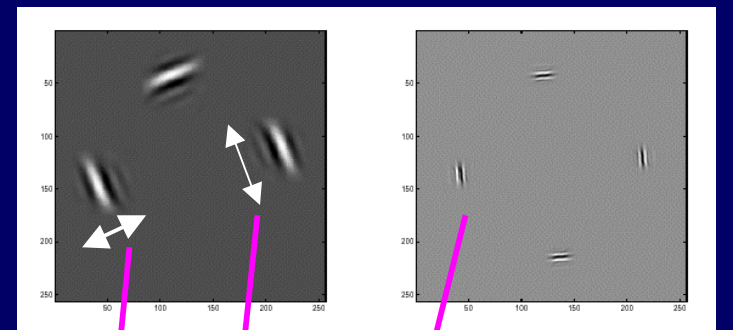
Beyond Wavelets

- ▶ E. Candes (Caltech)
D. Donoho (Stanford University)
- ▶ Wavelets (point singularities)
- ▶ Curvelets (curve singularities)
- ▶ Surflets (surface singularities)
- ▶ Beamlets (edge detection in images)
- ▶ Early development:
 - Inefficient compared to wavelet transforms
 - Compare to wavelets 10 years ago

Curvelet Transform



Based on ridgelets



wavelet

constant

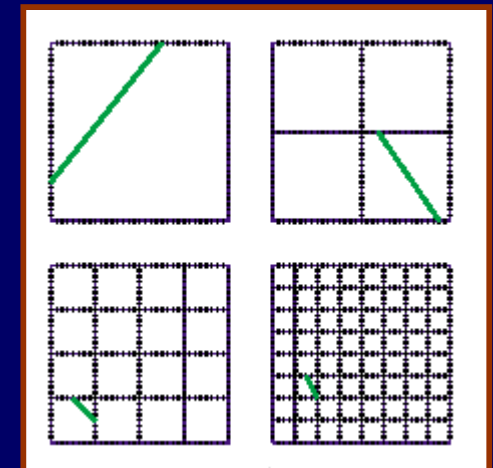
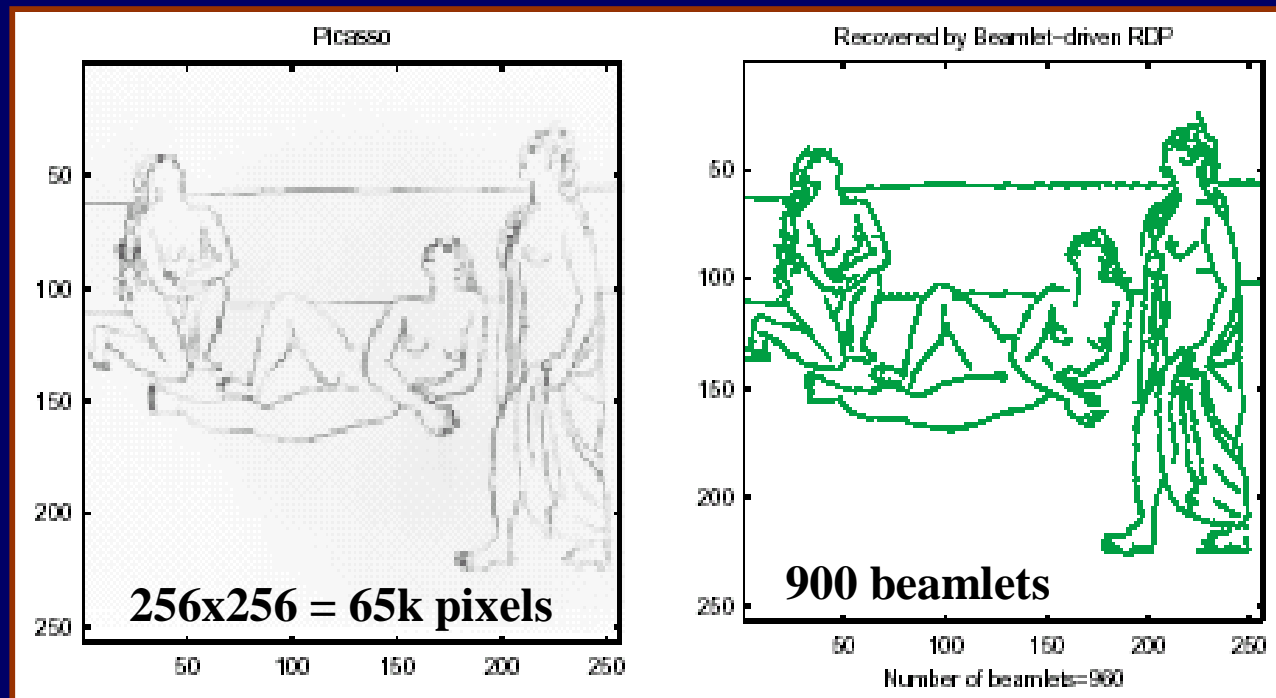
Donoho & Huo

Multiscale

Do & Vetterli 2001

Beamlets

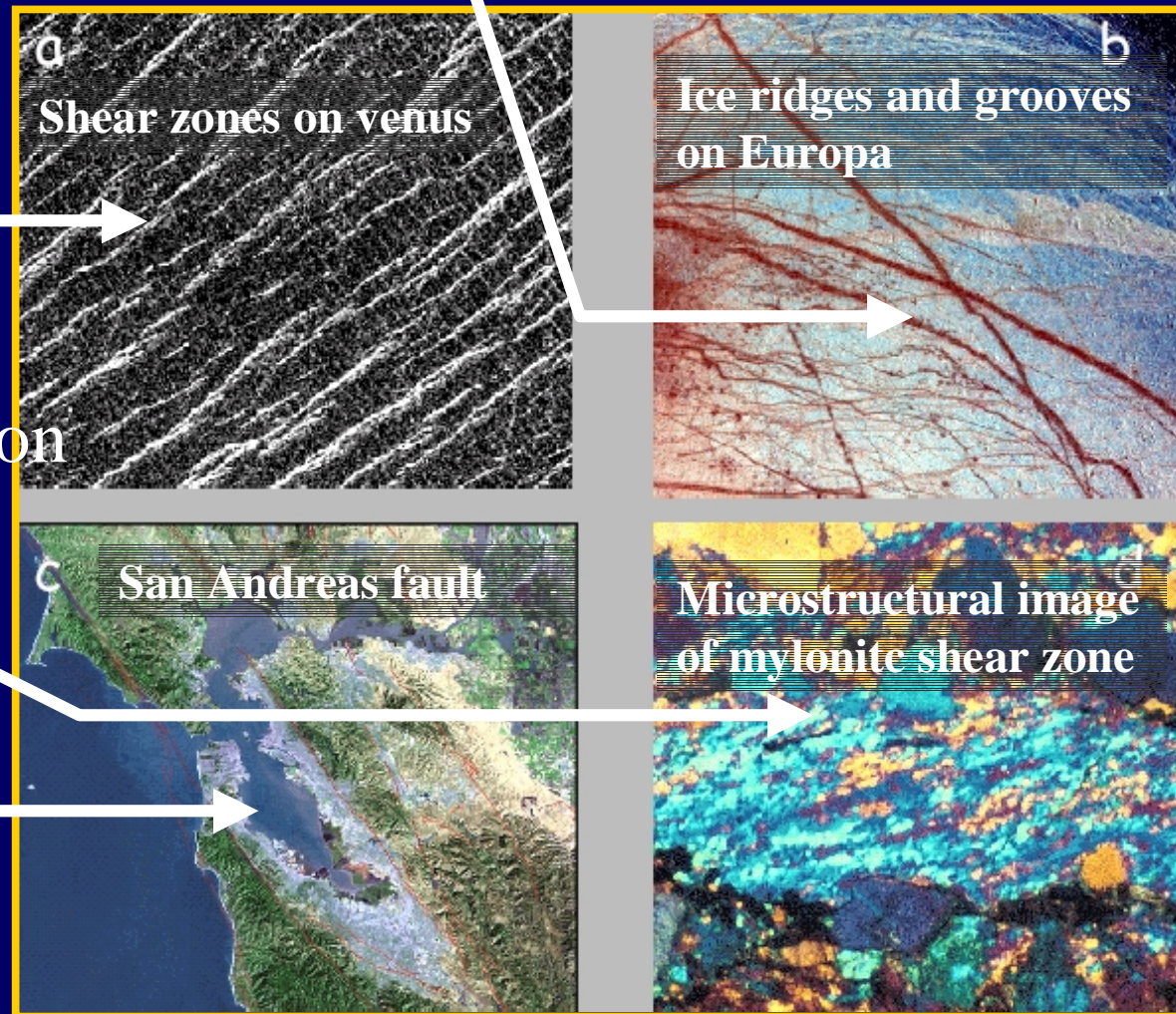
e.g., Edge Extraction



Hierarchical beam basis

Fault extraction via beamlets

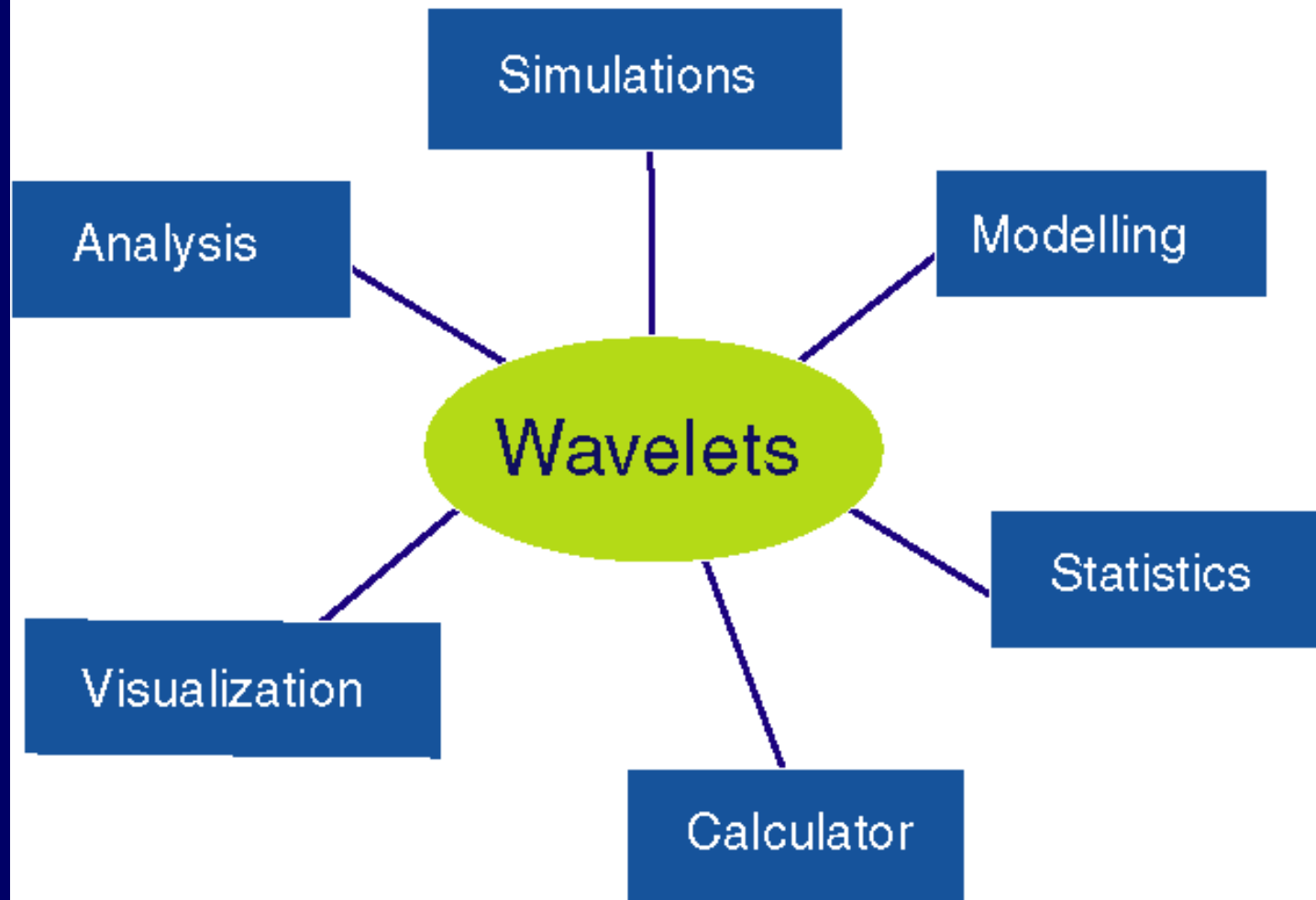
Image from Regenauer & Yuen 2002



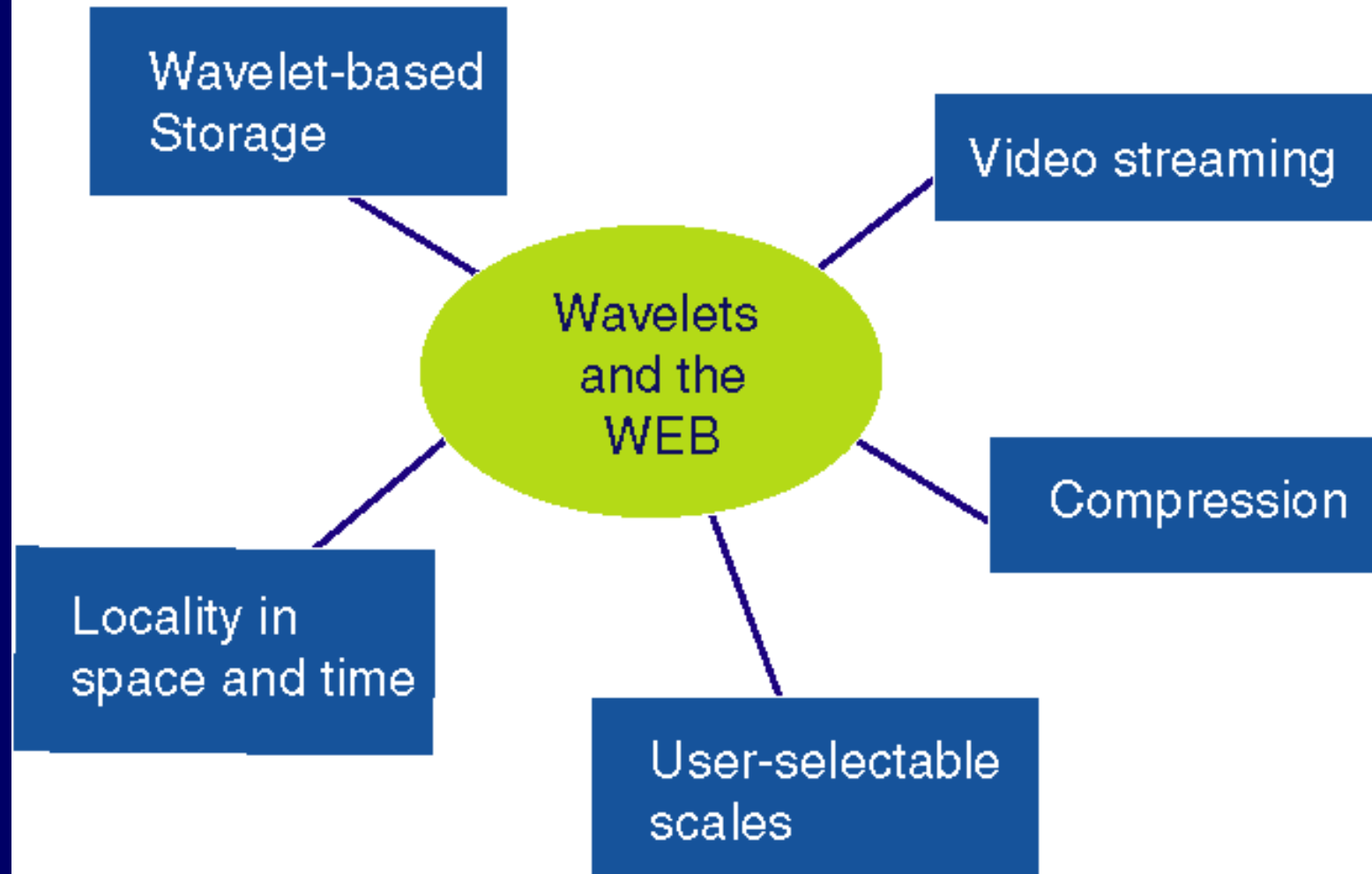
Feature extraction
via wavelets

Returning to wavelets ...

Multiscale Physics



Multiscale Physics



Urgent Needs

- 3D data compression
 - Better data representation
 - Methods for feature quantification
 - Efficient automatic feature extraction
-
- Next two slides illustrate this using
 - 2D thermal convection at increasing Ra
 - 3D thermal convection at high Ra

Temperature field, 2D grid: 3400x500



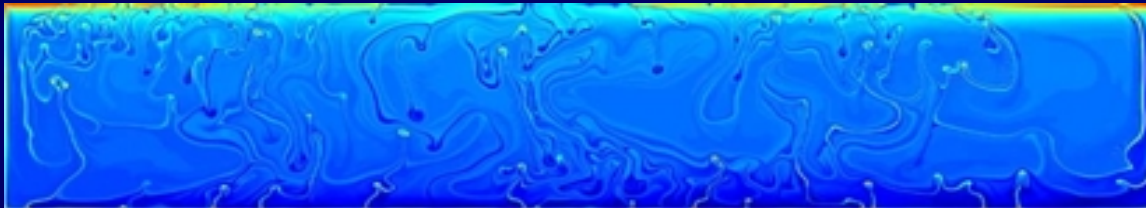
$$Ra = 3 \times 10^7$$



$$Ra = 3 \times 10^8$$



$$Ra = 10^9$$



$$Ra = 10^{10}$$

$$Ra = 10^9$$



Wavelet-Based Toolkit

- Visualization requires the ability to compute auxiliary variables
 - Given velocity, density, pressure, compute temperature transport $\mathbf{u} \cdot \nabla (p / \rho)$
 - Compute the time-derivative of some variable
- Variables must be computed on a time-dependent adaptive grid
- Need to compute variables over
 - User-specified spatial region
 - User-specified scales
 - With a range of thresholds
- Need to compute statistical quantities

Advanced Visualization

Amira: www.amiravis.com

- General-purpose visualization and 3D reconstruction software
- Ideally suited for 3D datasets: scalar and vector fields
- Advanced volume visualization
- Object-Oriented
- Advanced manipulators
 - users can interact directly with the data
- Extensible by the user with developer version
- Flowchart-based
- Harnesses hardware of commodity graphics cards

Wavelet Thresholding

Module development in Amira

The screenshot displays the Amira software interface. On the left, a 3D visualization of a dataset is shown, with a red and orange wavelet thresholding overlay. Text labels within the interface include "Wavelets: 1.2% of coefficients", "Wavelets, 1.2 percent coefficients", "Full dataset", and "Full resolution". On the right, a flowchart is visible, showing a network of interconnected nodes representing the module's logic. Below the flowchart, a GUI panel for a "BoundingBox" object is shown, with fields for "Connected to: HslUniformScalerField3", "Lower left: 0 0 0", "Upper right: 1 1 0.25", and a "Text: show" checkbox. A pink arrow points from the text "Flowchart" to the flowchart area, and another pink arrow points from the text "GUI" to the BoundingBox panel.

Wavelets: 1.2% of coefficients

Wavelets, 1.2 percent coefficients

Full dataset

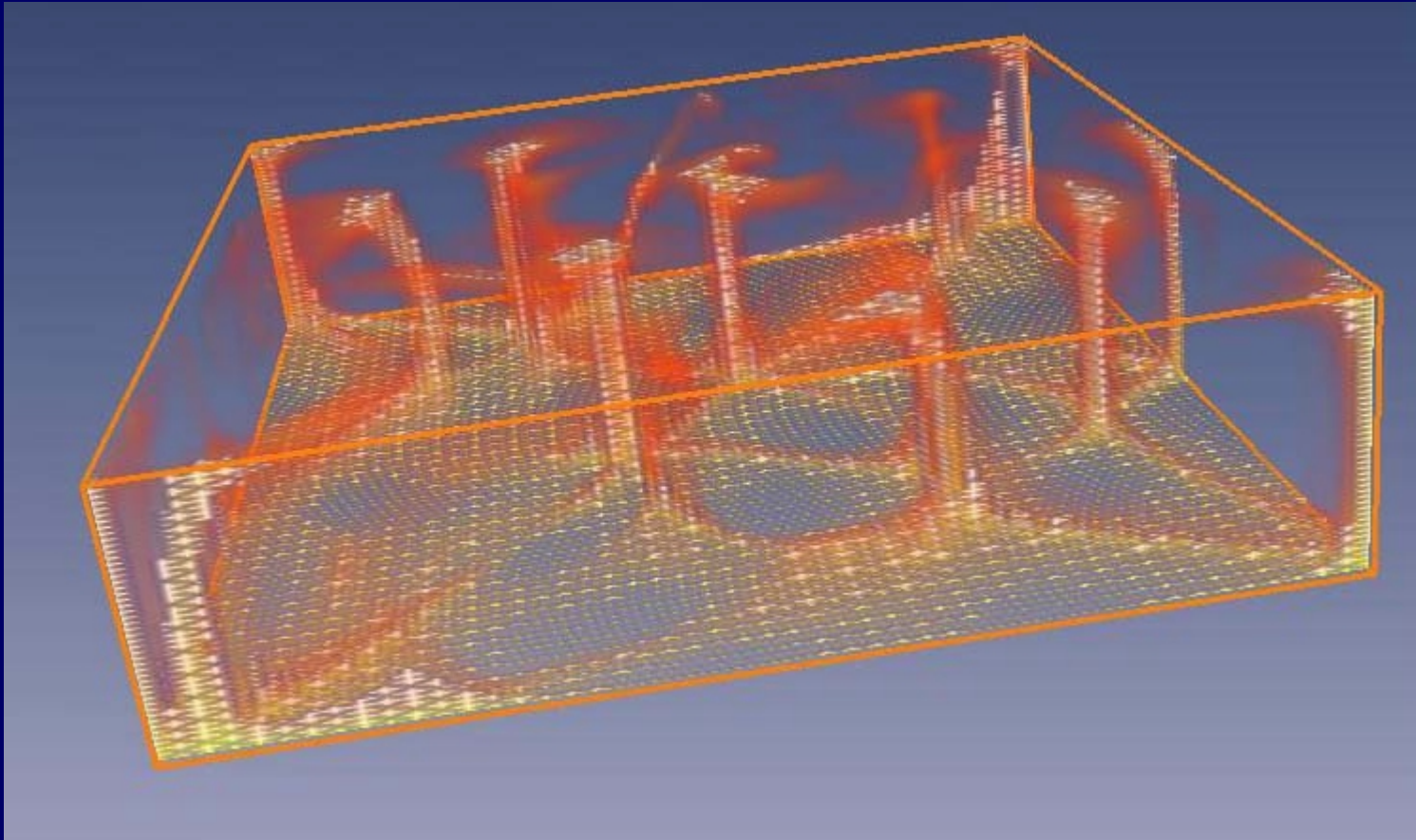
Full resolution

Flowchart

GUI

Wavelet Thresholding

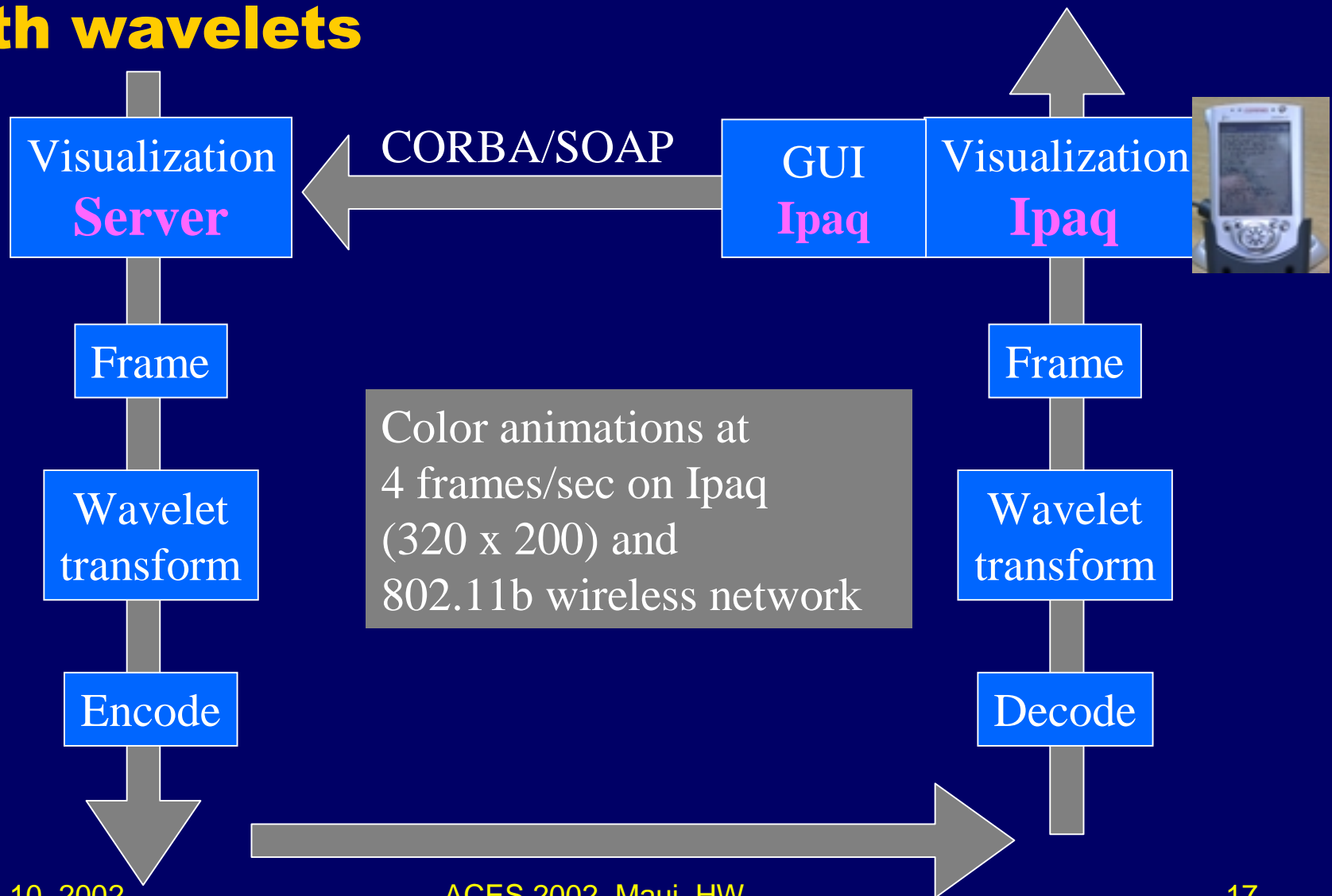
Feature identification



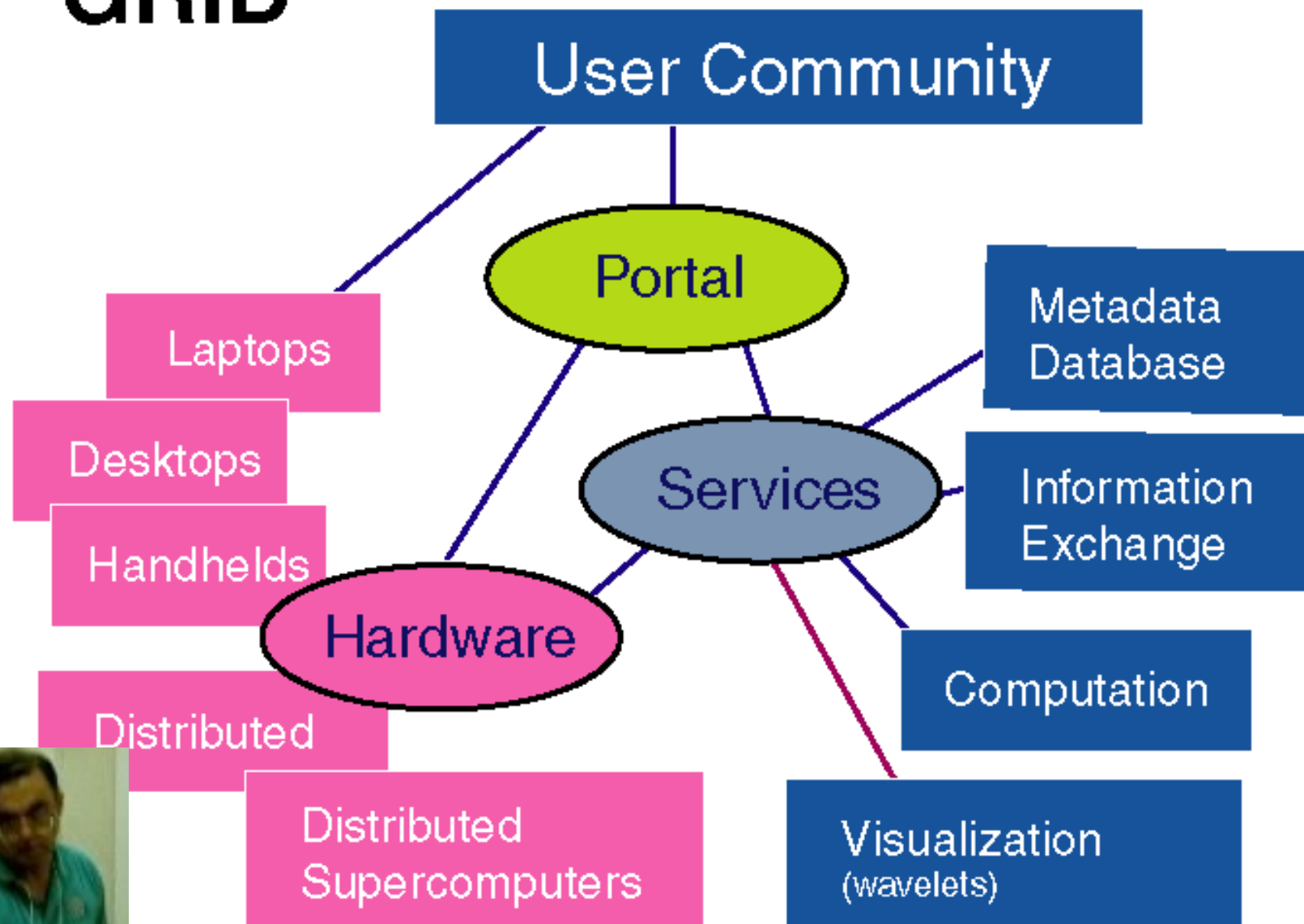
Remote Visualization

- Data could be computed, accumulated, stored, analyzed, and visualized at different locations
- Data is stored in many databases around the world
- Users collaborate
 - In the same location
 - At distributed locations
- Need toolkits to simplify access, analysis, and visualization of the data in a transparent fashion!!

Video Streaming with wavelets



GRID



Fox et al., Grid Services for Earthquake Science, ACES 2001: Special issue of *Concurrency & Practice*.

SERVICES

(slide provided by Fox)

(A) Community Contributed Services (research).

(B) EarthScope Provided Services.

EarthScope does not have to produce; can access existing (distributed) products.

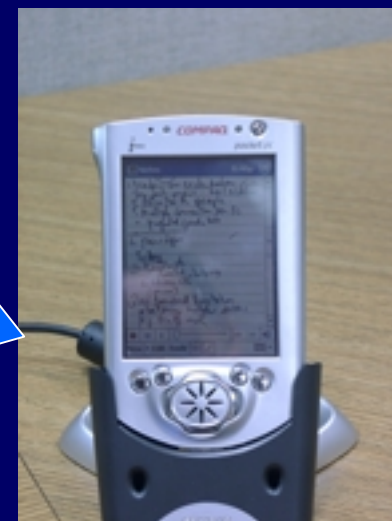
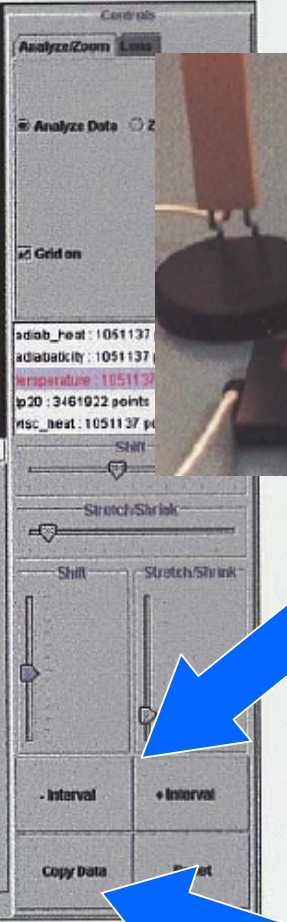
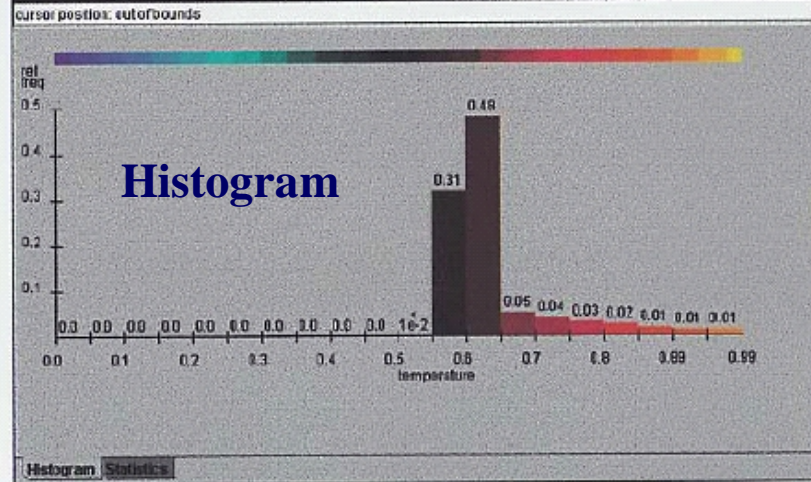
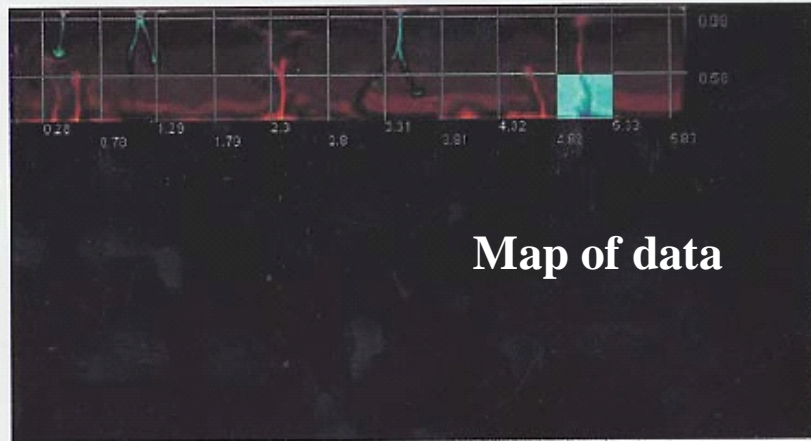


- **Visualization Service:** (commercial, open source)
Needs: 3D, 4D, overlay, georeferenced.
- **Registration Service:** different datasets into common reference system [e.g., GIS].
- **Simple data mining tools:** exist, new research mining tools will eventually become contributed as a standard service.
- **Data Aggregation Service:** combine different datasets to form meta-sets.
- **Higher level Application Data Structure Service:**
(e.g., interpolation of Finite Element mesh).

Interactive Web Querying

Another Grid Service

- Data Maps
- 3D data stored in various remote sites
- Data can be queried for
 - Statistical information of primitive or derived variables (hook up wavelet calculator to this system)
- User interface optimized for handheld devices



Two-way flow of information!!

Wireless Speeds

Present and Near Future

- Present: 802.11b
 - Range: 150 m
 - 10 Mbit/sec
- 1st quarter 2002: 802.11a
 - Range: 150 m
 - 54 Mbit/sec
 - Not compatible with 802.11b
- 3rd quarter 2002: 802.11g
 - Range: N/A
 - 54 Mbit/sec
 - Compatible with 802.11b!!

OQO: true mobile computing?

Fall 2002



- Touchscreen
- USB/Firewire
- Windows XP
- 4" screen

- ▶ Up to 1 GHz
- ▶ Crusoe chip
- ▶ 256 Mbytes memory
- ▶ 10 Gbyte hard disk



Conclusions

- Size of datasets is exploding
- Wavelets help to
 - Compress the data (1/100)
 - Visualize the data
 - Analyze the data
 - Communicate between centers
- Wireless communication promises
 - Better access to field data
 - Ubiquitous access to data using pocket devices

The End