

# Visual Data Mining and the MiniCAVE

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- Visual Data Mining
  - Software & Tools
  - Applications
- Immersive Projection Technology
  - CAVE & C2
  - The MiniCAVE

# Visual Data Mining

- Working Definition:
  - Find structure (cluster, unusual observations) in large and not necessarily homogeneous data sets using graphical methods and user interaction
  - Goal or expected outcome of exploration usually unknown in advance

# The Software: XGobi

Swayne, Cook and Buja

- Interactive environment for exploring multivariate data
  - \* Linked views allow “linked brushing”
  - \* Univariate, Bivariate and Multivariate views of the data
  - \* Grand tour
  - \* Wide variety of methods
  - \* Open source
  - \* Free
- Caveats
  - \* Only on UNIX and Linux platforms

# The Software: ExplorN

Carr, Wegman, Luo

- Interactive environment for exploring multivariate data (similar to XGobi)
  - \* Advanced Parallel Coordinates Displays
  - \* 3D Surfaces
  - \* Stereoscopic Displays
- Caveats
  - \* Only on SGI platforms
  - \* No interface

# The Software: ArcView

ESRI™

- Desktop GIS with wide range of viewing and data manipulation functions
  - \* Editing features
  - \* Query operations
  - \* Map display
  - \* Interactive interface
  - \* High level internal scripting language
- ArcView has a wide user base
- Caveats
  - \* Poor statistical display facilities

# The Software: XploRe

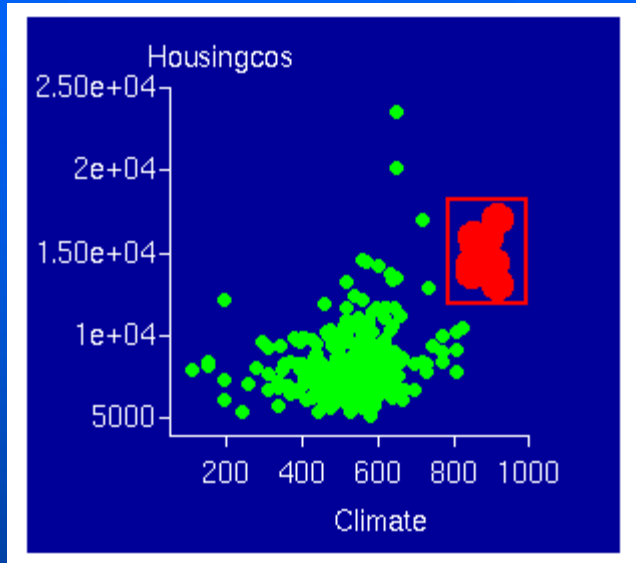
Härdle, Klinke, et al.

- Statistical Computing Environment
  - \* Built in set of statistical methods
  - \* High level programming language
  - \* Highly Interactive Graphics
  - \* Built in editors for data and programs
  - \* High level help system
- Caveats
  - Statistical views not as developed as in XGobi

# The ArcView/XGobi/XploRe Link

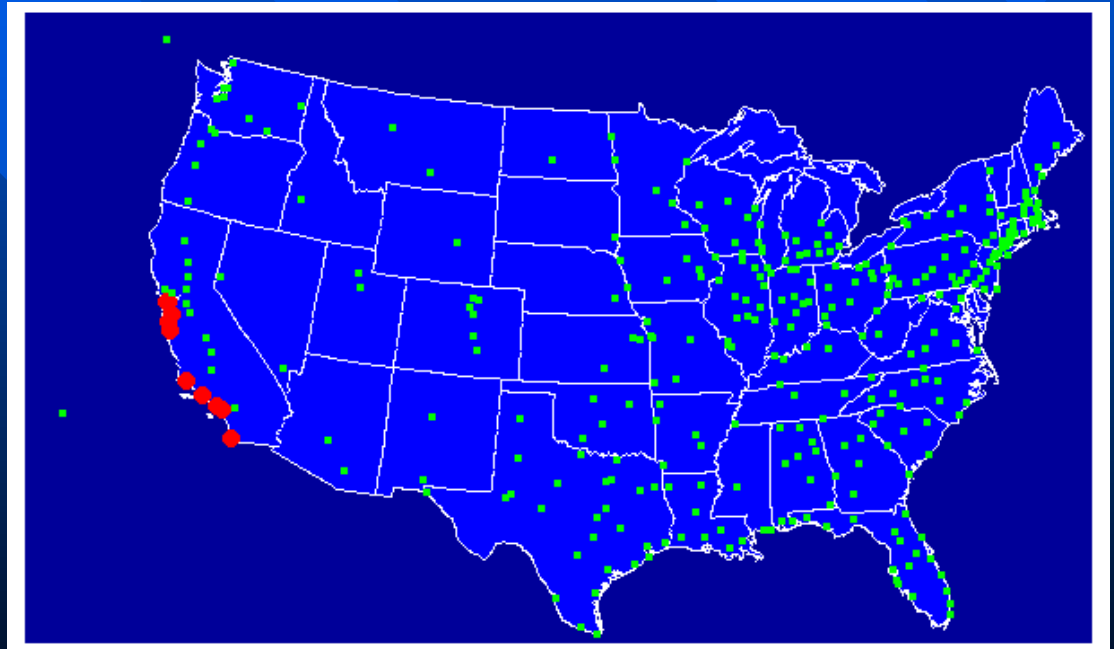
- Links these 3 packages using RPCs
- Remote Procedure Calls (RPCs):
  - Process on the local system (client) invokes a procedure on a remote system (server)
  - Request = client's desire to execute a particular remote procedure
  - Response = result produced by the remote procedure
- ArcView, XGobi, XploRe: server & client

# Tools: Linked Brushing 1

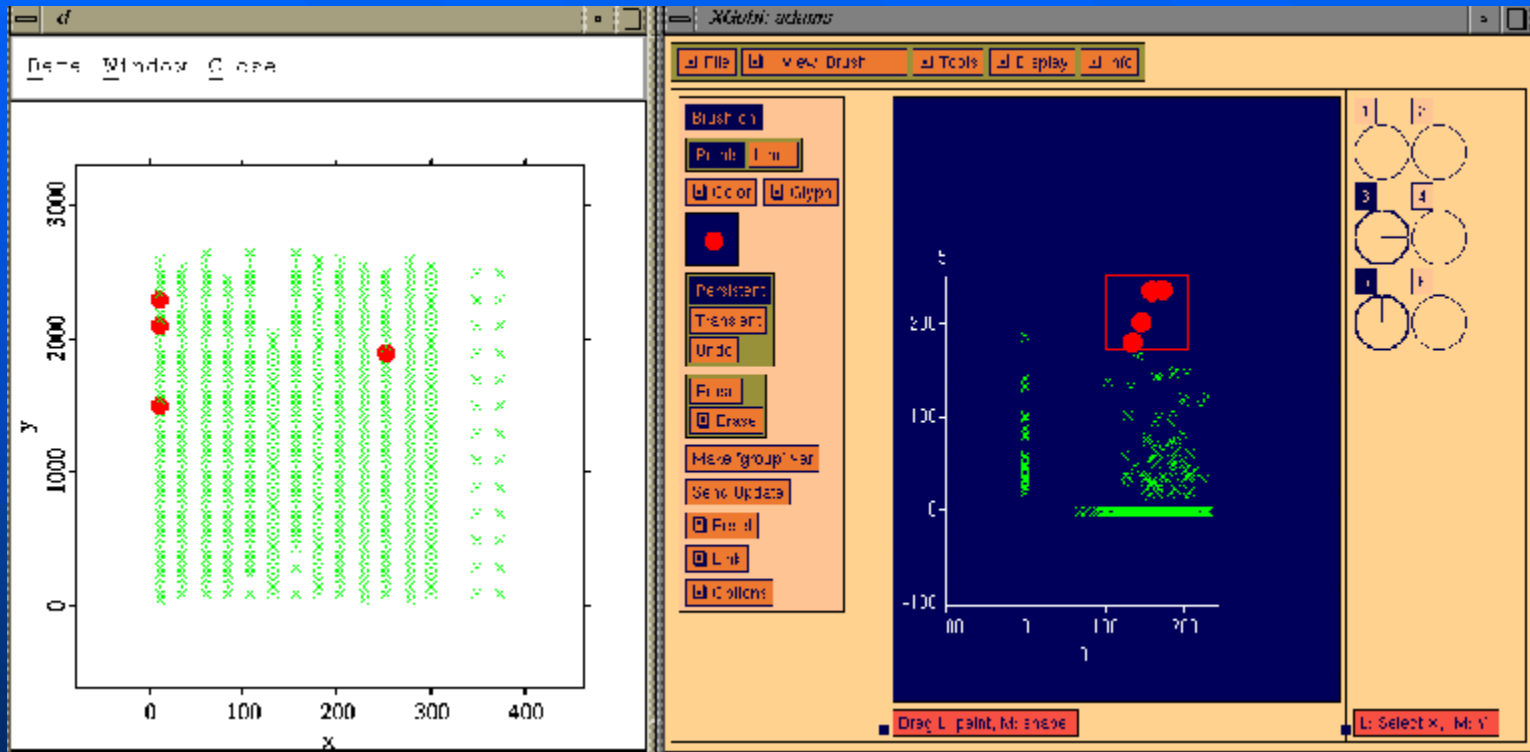


**XGobi**

**ArcView**



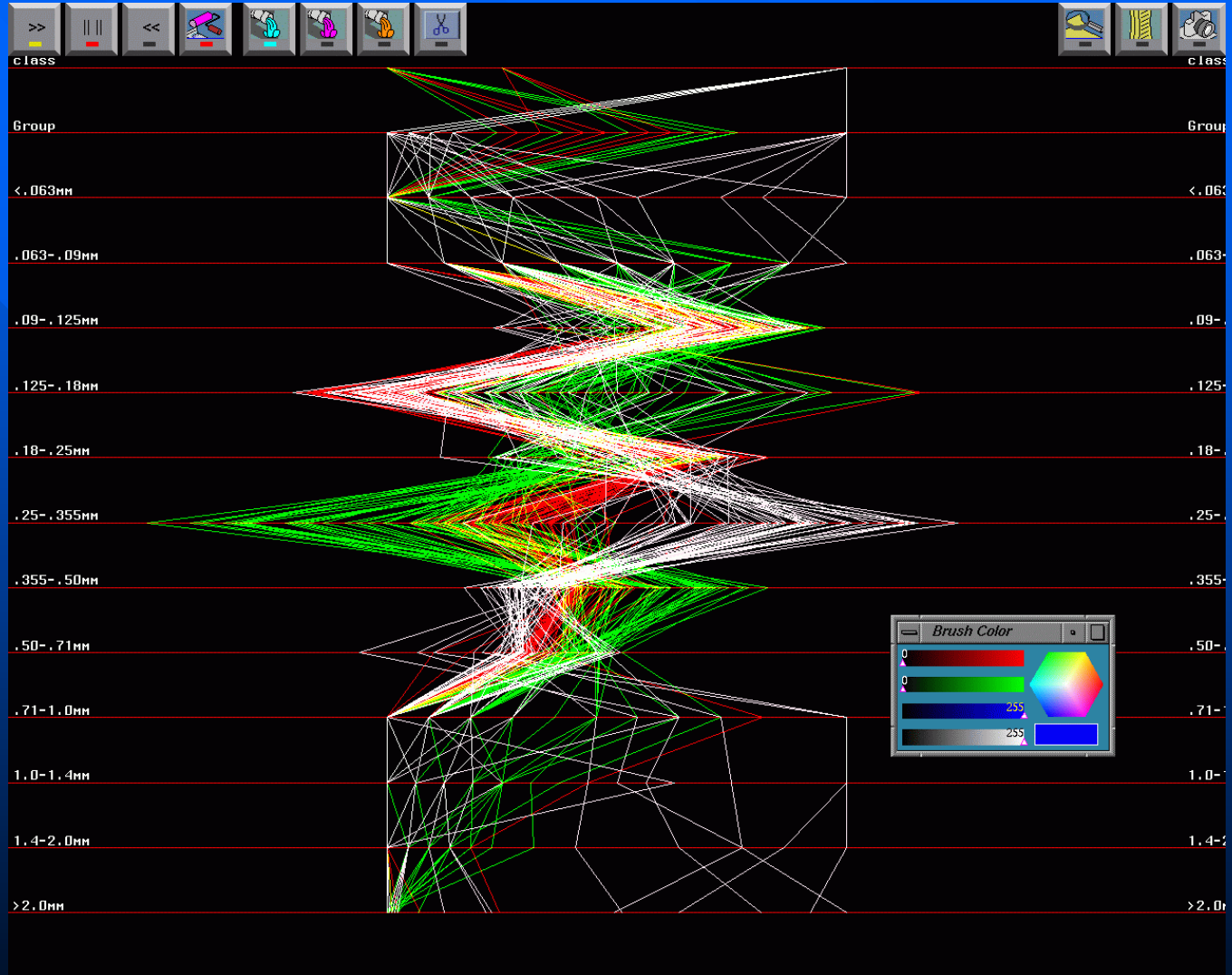
# Tools: Linked Brushing 2



XploRe

XGobi

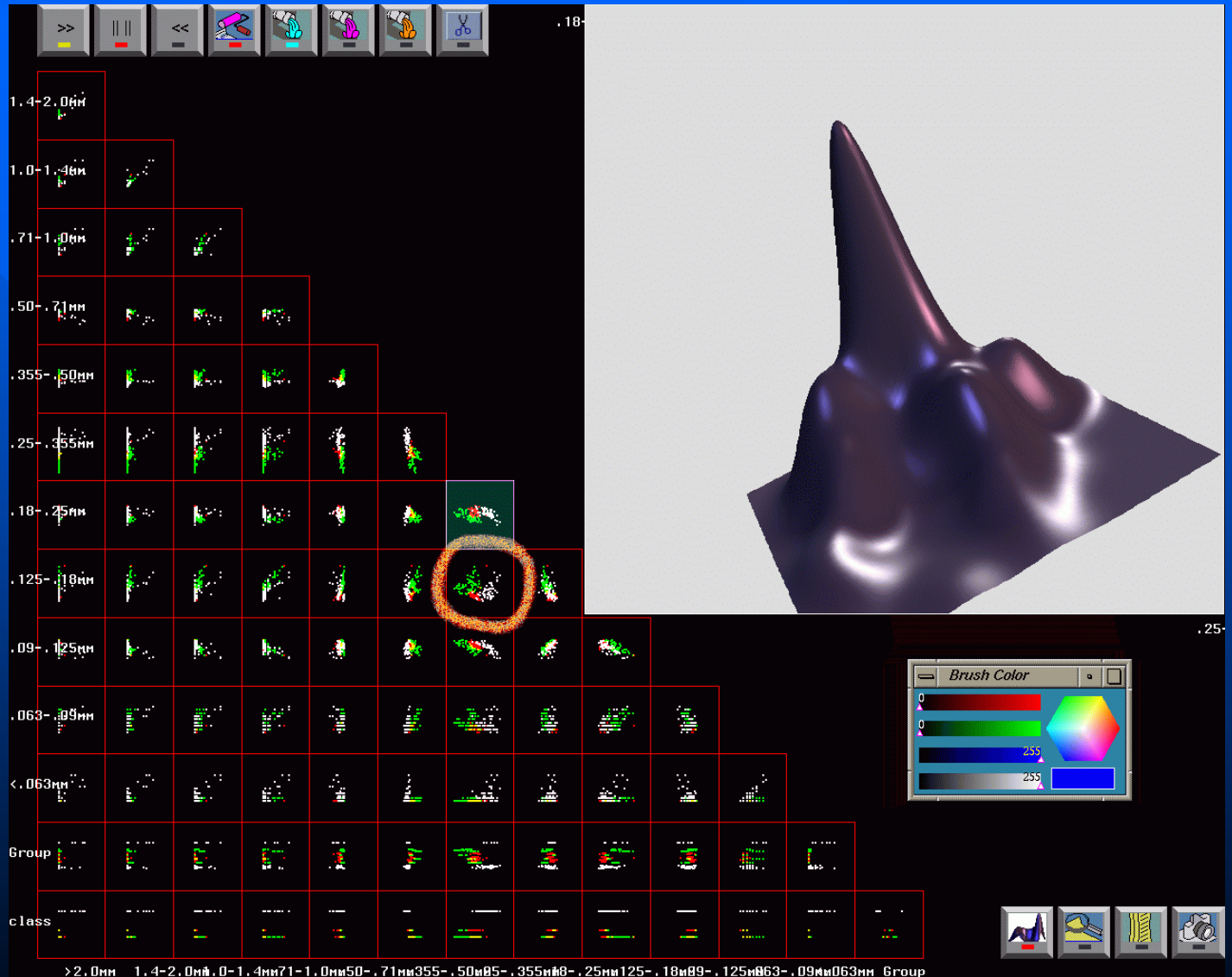
# Tools: Parallel Coordinate Plots



ExplorN

# Tools: Scatterplot Matrix

ExplorN

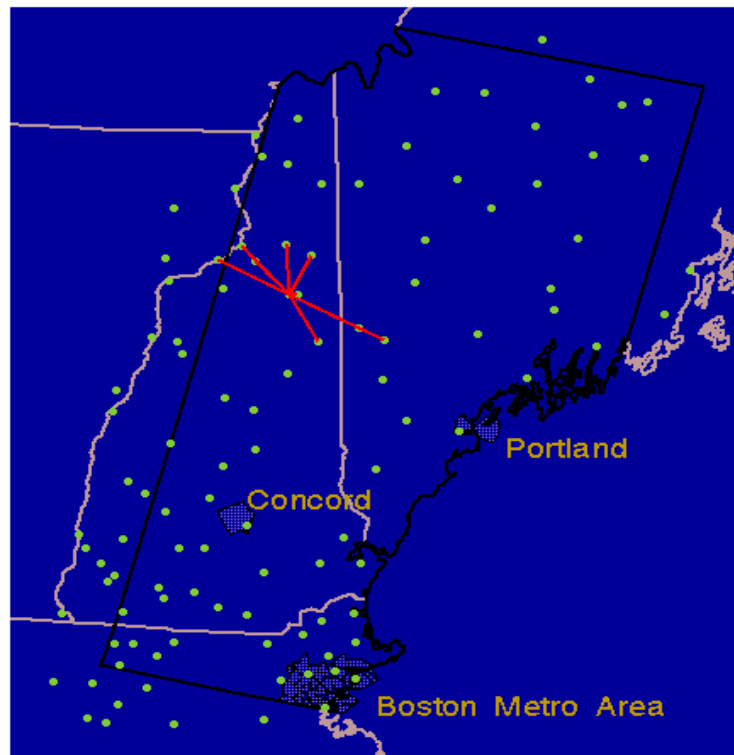
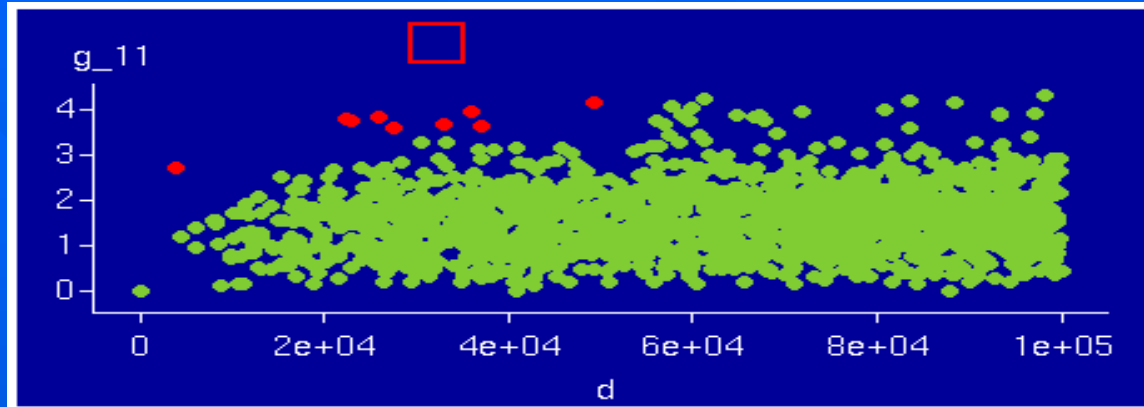


# Applications

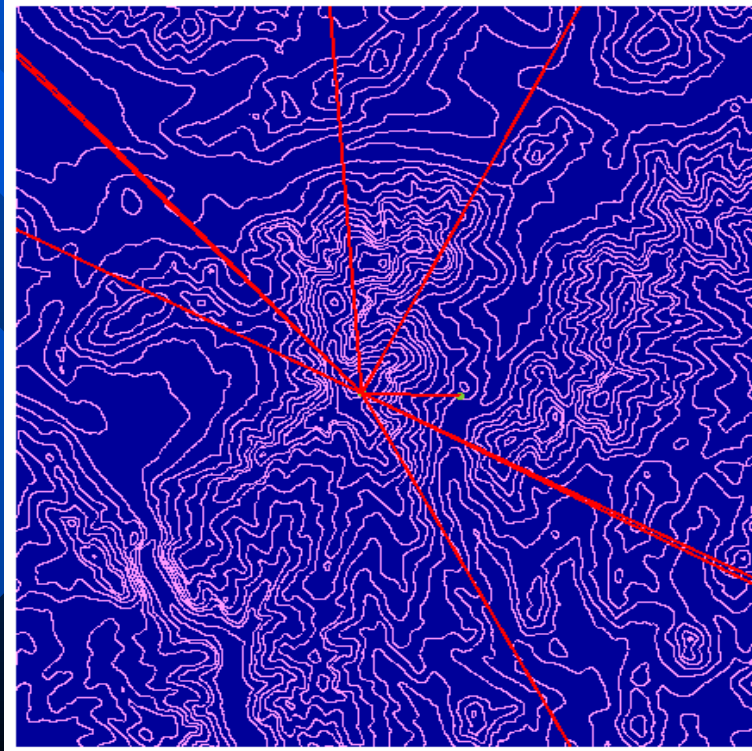
- Environmental Data
- Remote Sensing
- Archaeological Data
- Human Motion Data

# Environmental Data

XGobi



ArcView



# Remote Sensing

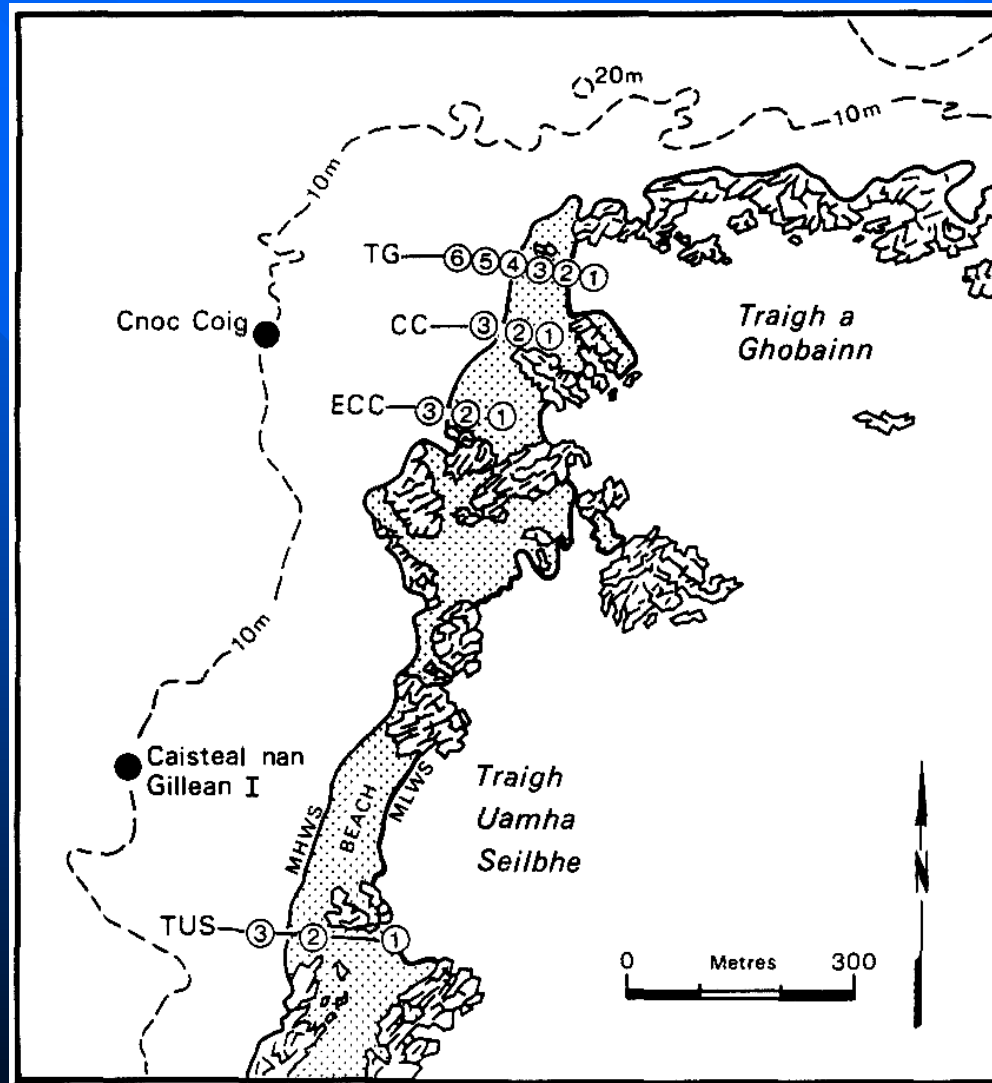
The image displays a composite of software windows used for remote sensing data analysis:

- ArcView GIS Version 3.0:** The top-left window shows the standard GIS interface with a menu bar (File, Edit, View, Theme, Graphics, Window, Color, Glyph, Size, Help, JSU) and a toolbar with various navigation and editing tools.
- XploRe:** A terminal window in the middle-left showing a series of commands for creating and configuring a data display:

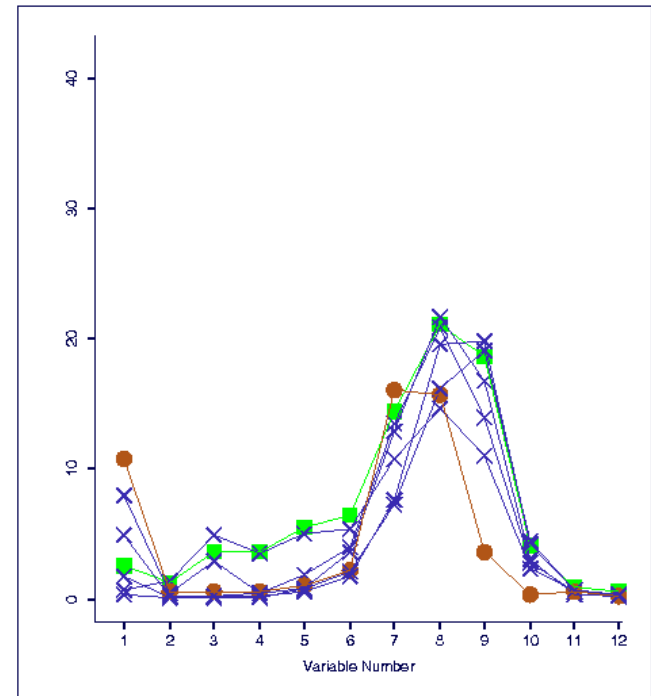
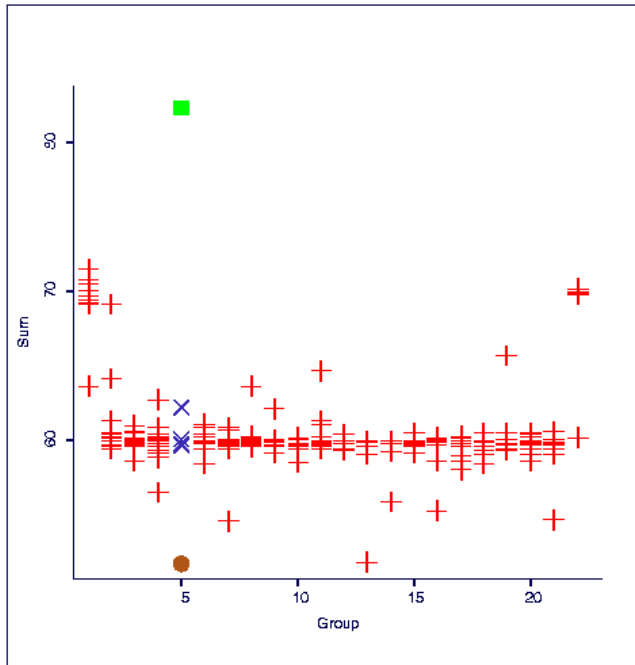
```
d = createdisplay(1, 1)
e = createdisplay(1, 1)
;
show (d, 1, 1, XGobiData)
setgopt (d, 1, 1, "brushsize", 10 | 10)
setmode (d, 1, 1, 1)
rpclink (d, 1, 1, 0, "0x42000000")
;
```

The prompt "Please enter command:" is visible at the bottom.
- XGobi: AV2-XGobi:** The bottom-left window features a control panel with buttons for "Pause", "Reinit", "Link: Unlink", "Send Tour Update", "Manip: Radial", "Path Len: 1", "Step", "Go", "Local Scan", "Backtrck 22", "F", "Hist On", "Store", "I/O", "Interp", "PC Basis", "PC Axes", "ProjPrst", "Section", "PP Indx 2.26e-03", "Optimz", "Bitmap", "TermsInExp: 1", and "PP Index". A central display area shows a scatter plot of data points in red, green, and blue. To the right of this display are six circular indicators labeled PC1 through PC6, representing principal components.
- Data Windows:** Two overlapping windows labeled "Data Window Close" show scatter plots. The larger window on the right displays a scatter plot with axes ranging from -5 to 5 on the x-axis and 0 to 5 on the y-axis. The data points are clustered into three distinct groups: red, blue, and green.
- 3D Visualization:** A large, tilted 3D plot on the right side of the image shows a grid of colored cells (blue, green, yellow, red) with small red and blue dots scattered across the surface, representing a spatial data model or classification.

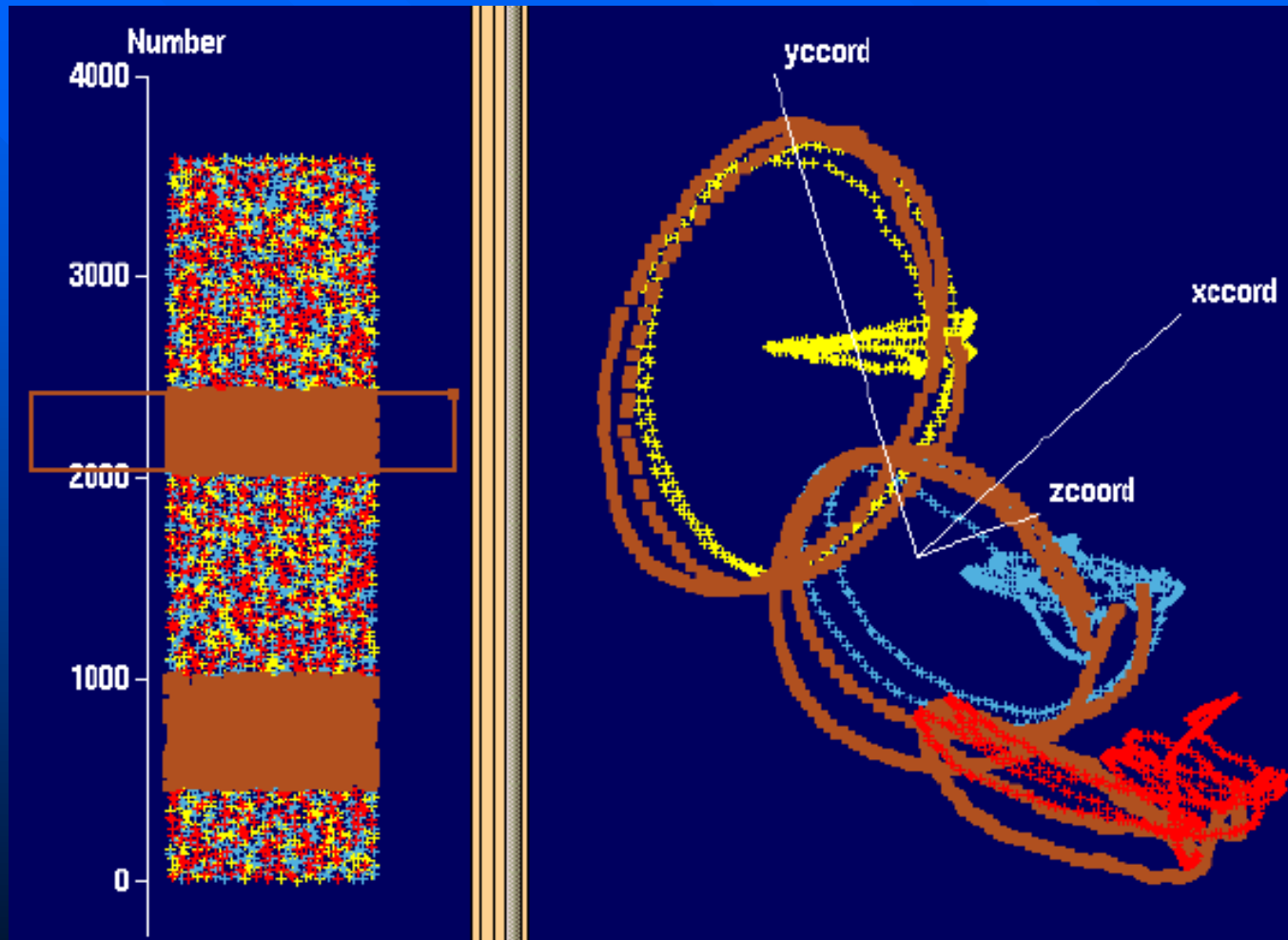
# Archaeological Data 1



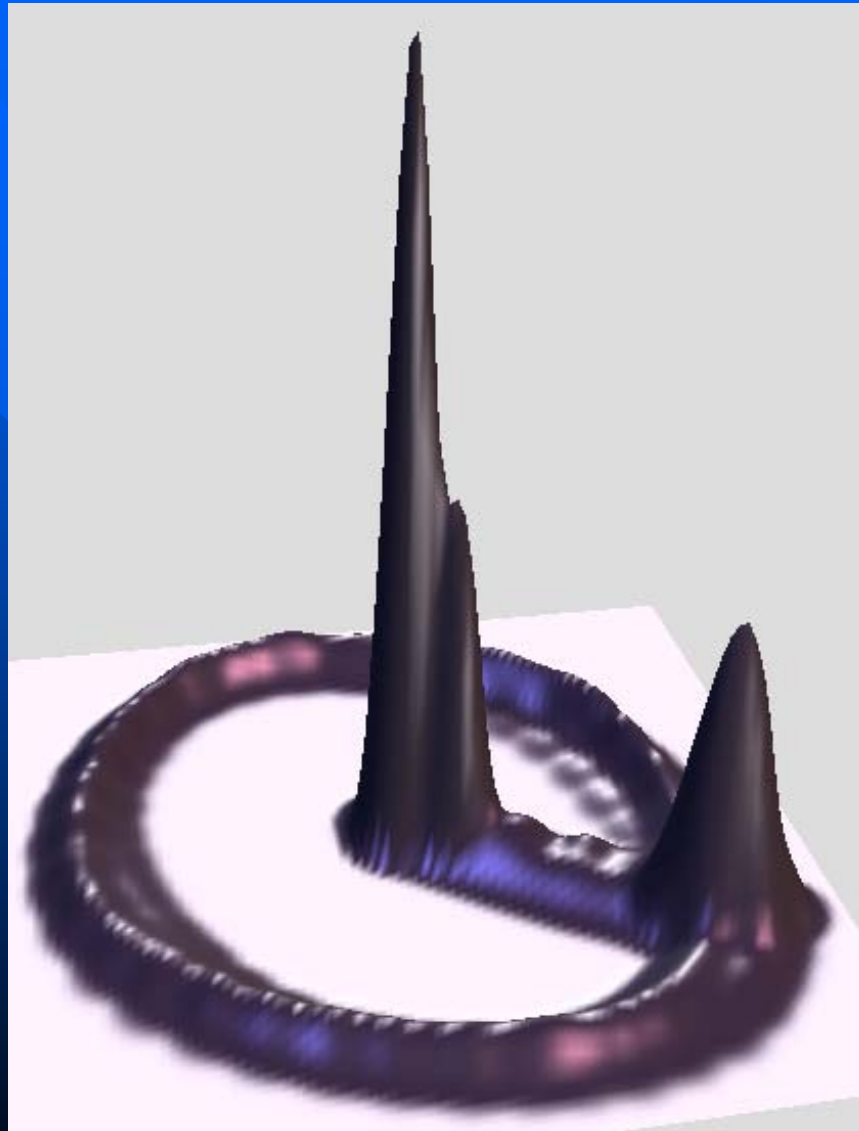
# Archaeological Data 2



# Human Motion Data 1



# Human Motion Data 2



# IPT / CAVE / MiniCAVE

# CAVE Concept

- A Projection-based Immersive VR System
  - Silicon Graphics-based with 8 to 12 processors
  - RE<sup>2</sup> or RE Infinity graphics engines
  - CRT-based projection system
  - Stereographics Crystal Eyes shutter glasses
  - Head tracking
  - Usually 3 to 5 wall cube
- Developed originally at U. Illinois, Chicago
  - Carolina Cruz-Neira

# CAVE Strengths

- Effective immersive environment
  - Lightweight non-intrusive glasses
  - Can see own hands and other participants
- Effective for group VR
  - Good tool for group collaboration

# CAVE Weaknesses 1

## ■ CRT Projectors

- Projectors not very bright
- Shock, vibration & heat, hard to keep focus
- Geometric distortion at wall interfaces

## ■ Tracking

- One user tracked, badly distorted stereo for users not at viewpoint

## ■ User Interface

- Usually 3-D extension of desktop metaphor

# CAVE Weaknesses 2

- Expensive
  - \$1,000,000 fully outfitted
  - \$600,000+ SGI computers
  - \$30,000 per projector

# Motivation for MiniCAVE

- Installed MATLAB 5 on SGI Onyx and Pentium
  - Benchmarks on 200 megahertz Pentium Pro (\$3000) and 200 megahertz SGI Onyx (\$120,000) similar
- Liquid Crystal Projectors sharp, bright, and stable under shock, vibration and temperature variation
- Stereographics Crystal Eyes technology available for Windows NT

# MiniCAVE Concept

- Windows NT/Intel Pentium II 400 mhz
- LCD-based projection systems
- 12 ft cubes scaled to 6 ft cubes
- Tracking optional, reduced latency
- Voice command metaphor
- \$100,000 entry level

# Implementation Using Monitor

- Stereo using CrystalEyes
  - Above-below stereo
  - Image resolution 1024x384 each eye
  - Vertical refresh rate 120-150 (60-75 each eye)
    - SGI monitor can handle both 120 and 150
    - CRT projector can only handle 120 refresh rate

# Speech Motivation

- User Interfaces (Van Dam)
- Shortcuts in XGobi
- User Controls in the C2 Stats Application

## MiniCAVE - Successes

- Port of SkyFly Stereoscopic Demo to NT successful with adequate frame rates on 333 megahertz machine
- CrystalEyes interface on NT successful
- Speech recognition using Dragon Dictate successful
  - but requires training of speech recognizer

# MiniCAVE - Future Steps

- NSF proposal submitted - waiting for funding of required hardware
- Use MiniCAVE for Visual Data Mining

# Contact

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