# Collaboration in Directly Mediated Interaction Environments

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Workshop on Advanced Collaborative Environments

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Battelle

Pacific Northwest National Laboratory
Operated by Battelle for the U.S. Department of Energy

# Overview

- Introduction to HI-Space
- Examples of Public Demonstrations
- Measuring Performance: Lag
- Some other game types of examples
- Measuring Performance: Fitts' studies
- BioApp: a more complex interface
- Introduce Visual Analytics
- Developing Visual Analytics for Collaborative Mobile Use

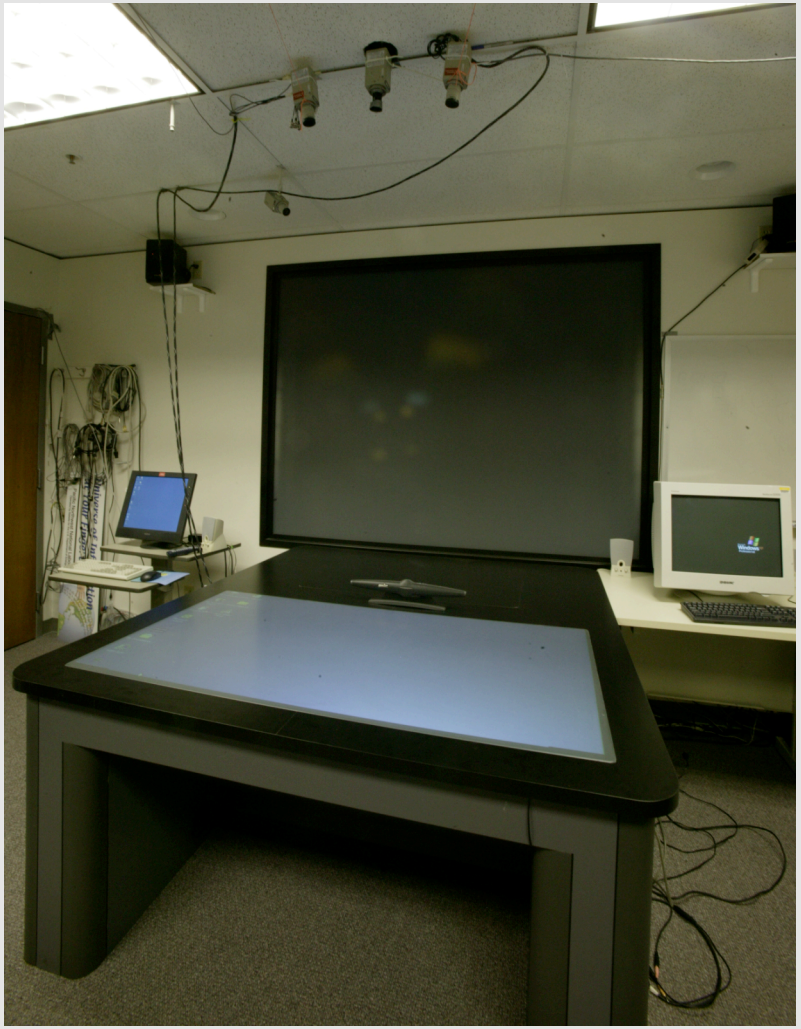
# Pacific Northwest National Laboratory

**Mission: Perform basic and applied research to deliver energy, environmental, and national security for our Nation.**


- Managed by Battelle since 1965
- $638 million FY04 business volume for government and private industry
- ~3,900 staff
- National user facilities
- More than 1,200 patents and 200 active licenses

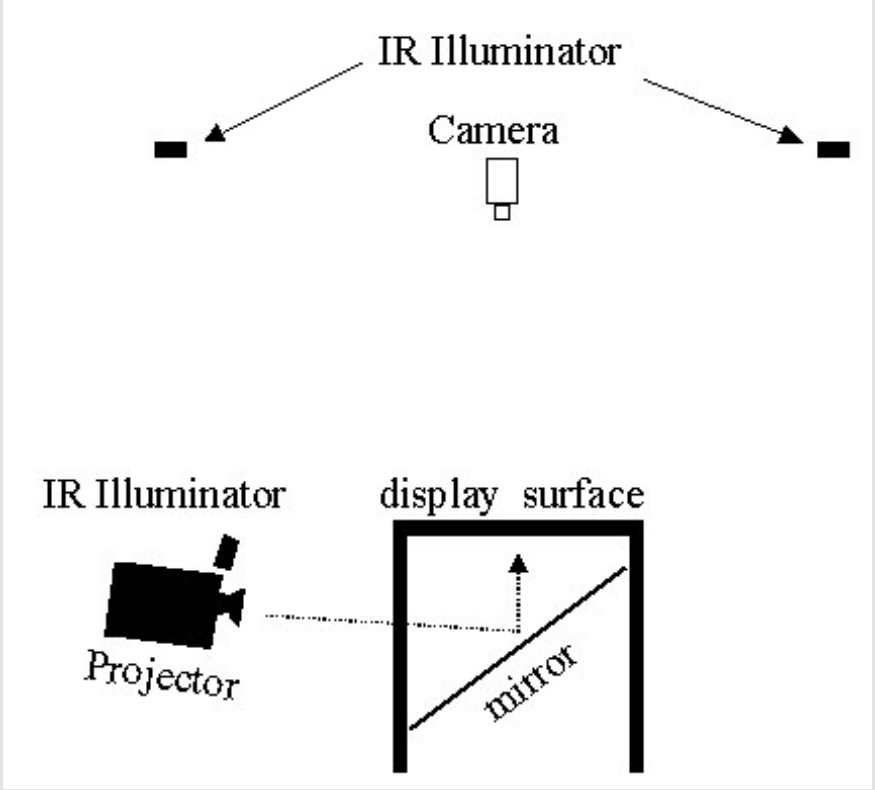
# Directly Mediated Interaction Concept

- Mixed reality interaction workspace
- Support multiple users
- Designed to use multi-modal *natural* interaction techniques
- Minimize user encumbrance and entrance costs
- Requires support for new interaction types



# Human Information Workspace (HI-Space) Basic Configuration

- Projector & IR Sources under table
- Projector & mirror orientations optimized to screen
- Video camera & IR Sources above the table
- Off-the-shelf hardware with custom software
- Turns hand and objects into input devices



# Public Settings

- Supports multiple users
- No user  worn devices
- No calibration of users
- No exposed equipment

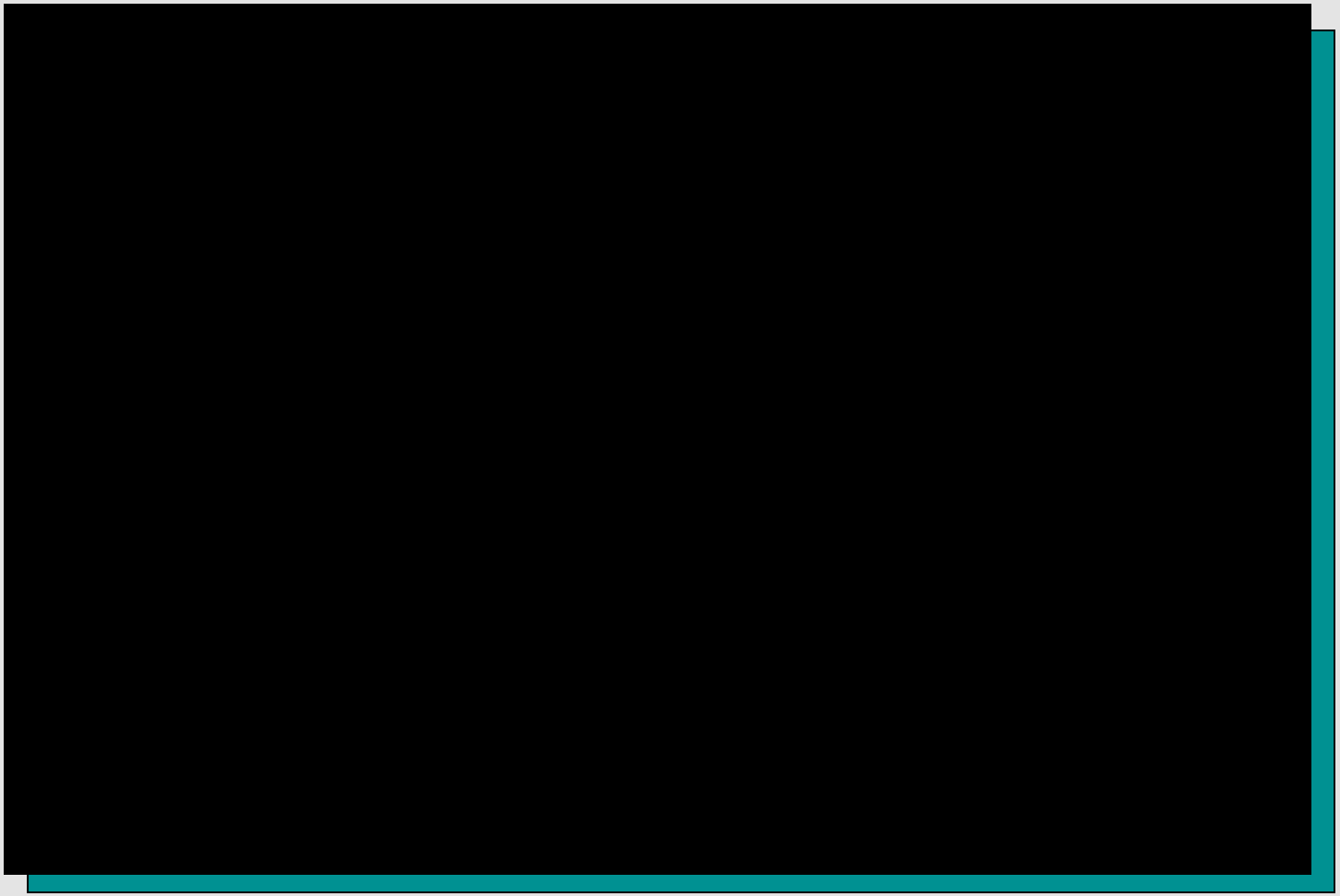
# Virtual Dig

**Seattle Art Museum**

**3 month exhibition**

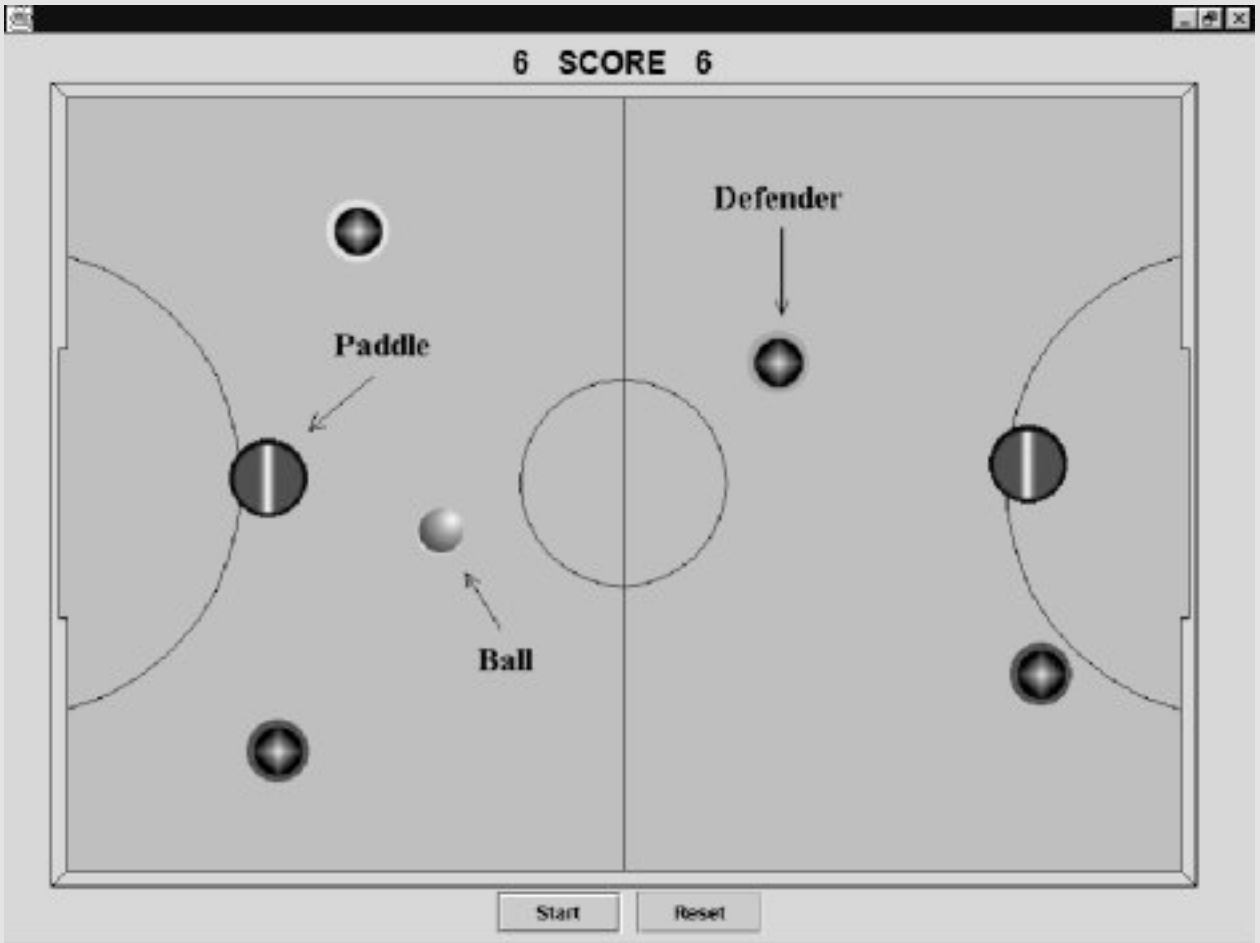
**25,000 Visitors**

# Virtual Dig Brushing Video

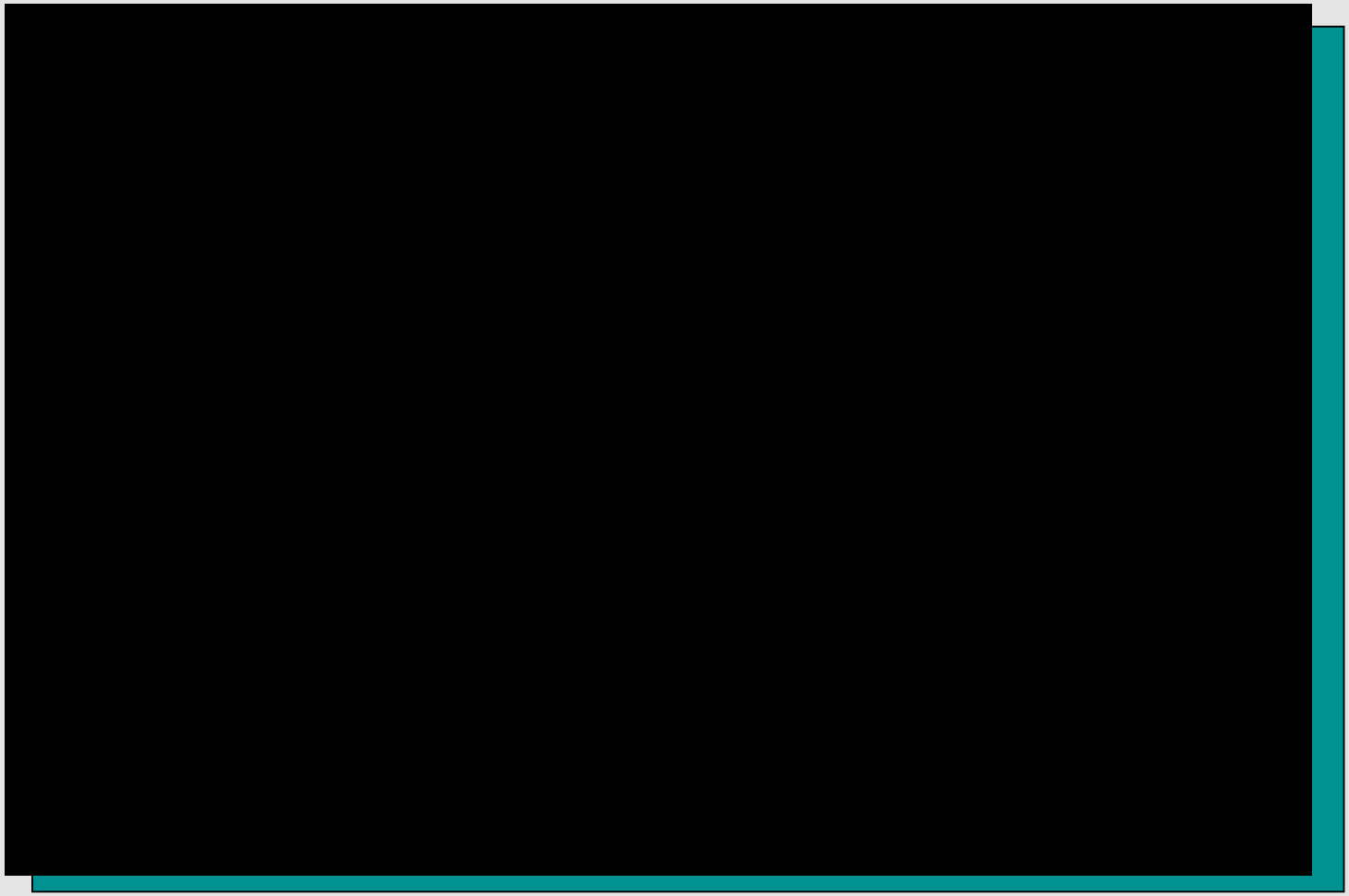


# Virtual Hockey

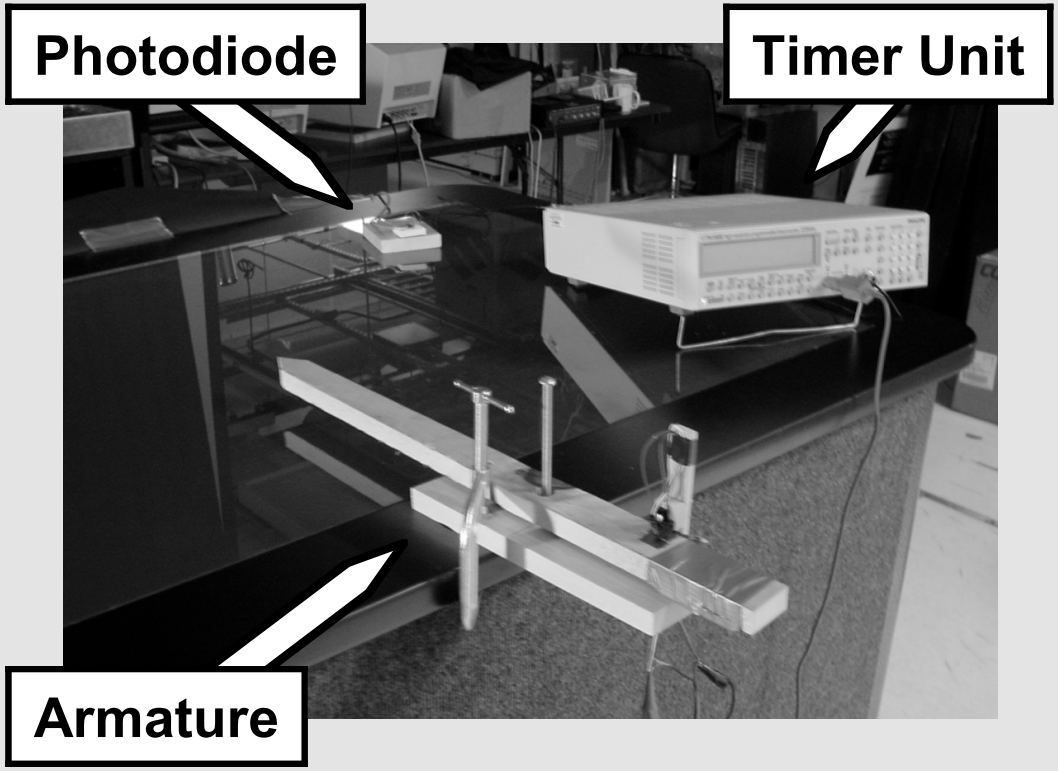
- Two Players
- Air Hockey
  - Puck/Ball
  - Paddles
- Pinball
  - Defenders



# Virtual Hockey Video



# Total System Lag Determination




Based on a technical paper from UNC [Mine 1993]

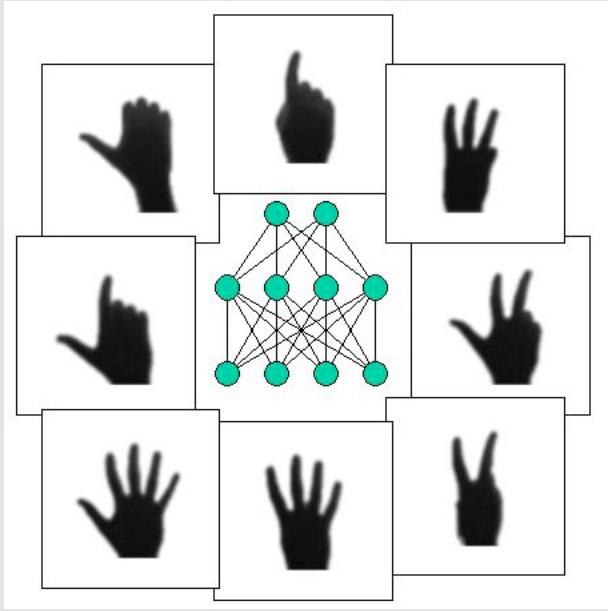
# Total System Lag Results

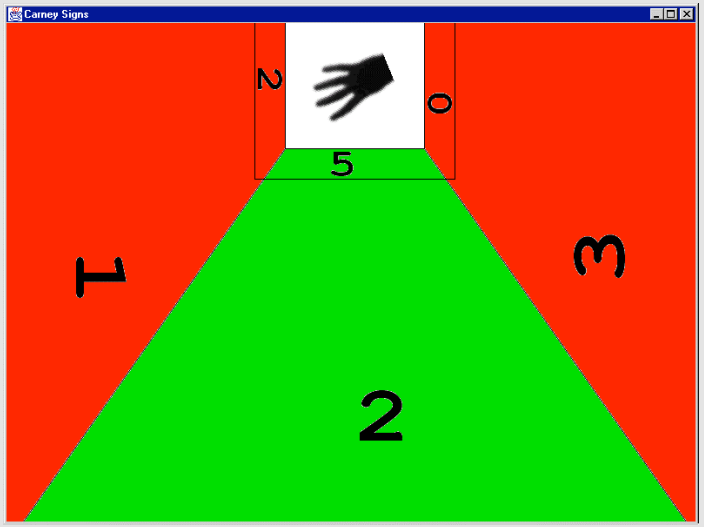
| | | | Mean Time (ms) | Standard Deviation (ms) | 95% Mean Error (ms) |
|---|---|---|---|---|---|
| 30 fps | Normal | Set 1 | 71.13 | 11.059 | 1.533 |
| | | Set 2 | 70.39 | 11.038 | 1.530 |
| | | Set 3 | 71.48 | 11.025 | 1.528 |
| 10 fps | Reduced Image Processing | Set 1 | 215.20 | 31.105 | 4.311 |
| | Reduced Application Processing | Set 1 | 116.67 | 32.280 | 4.474 |
| | Skipped Frames | Set 1 | 99.87 | 28.607 | 3.965 |

All sets consist of 200 trials

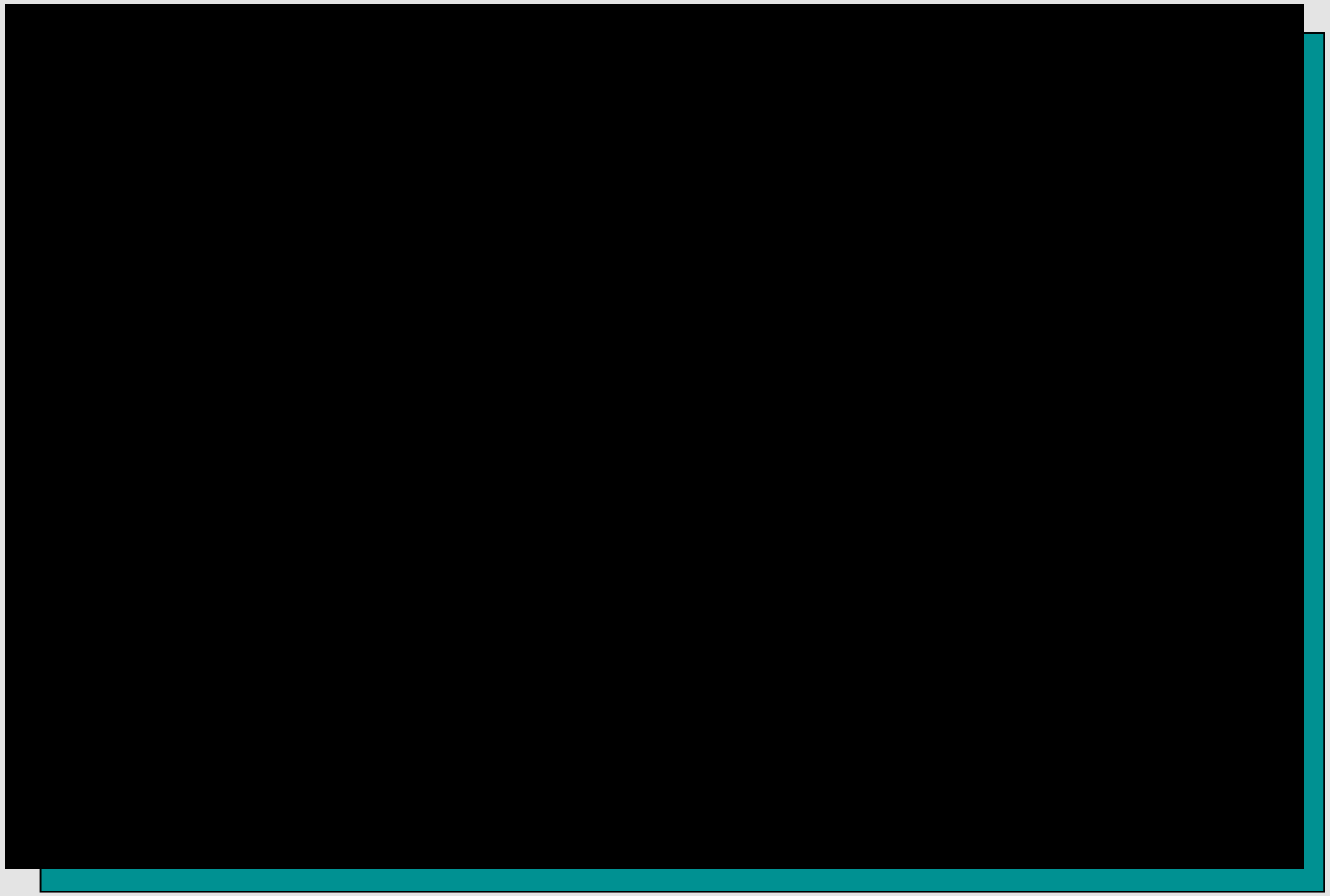
# Carney Signs

Rock, paper, scissors is simple kids game that uses hand pose to determine a winner between two players. Carney Signs is similar in context. In Carney Signs, three players (numbered 1, 2, and 3) each try to match a hand pose presented to them by the computer.

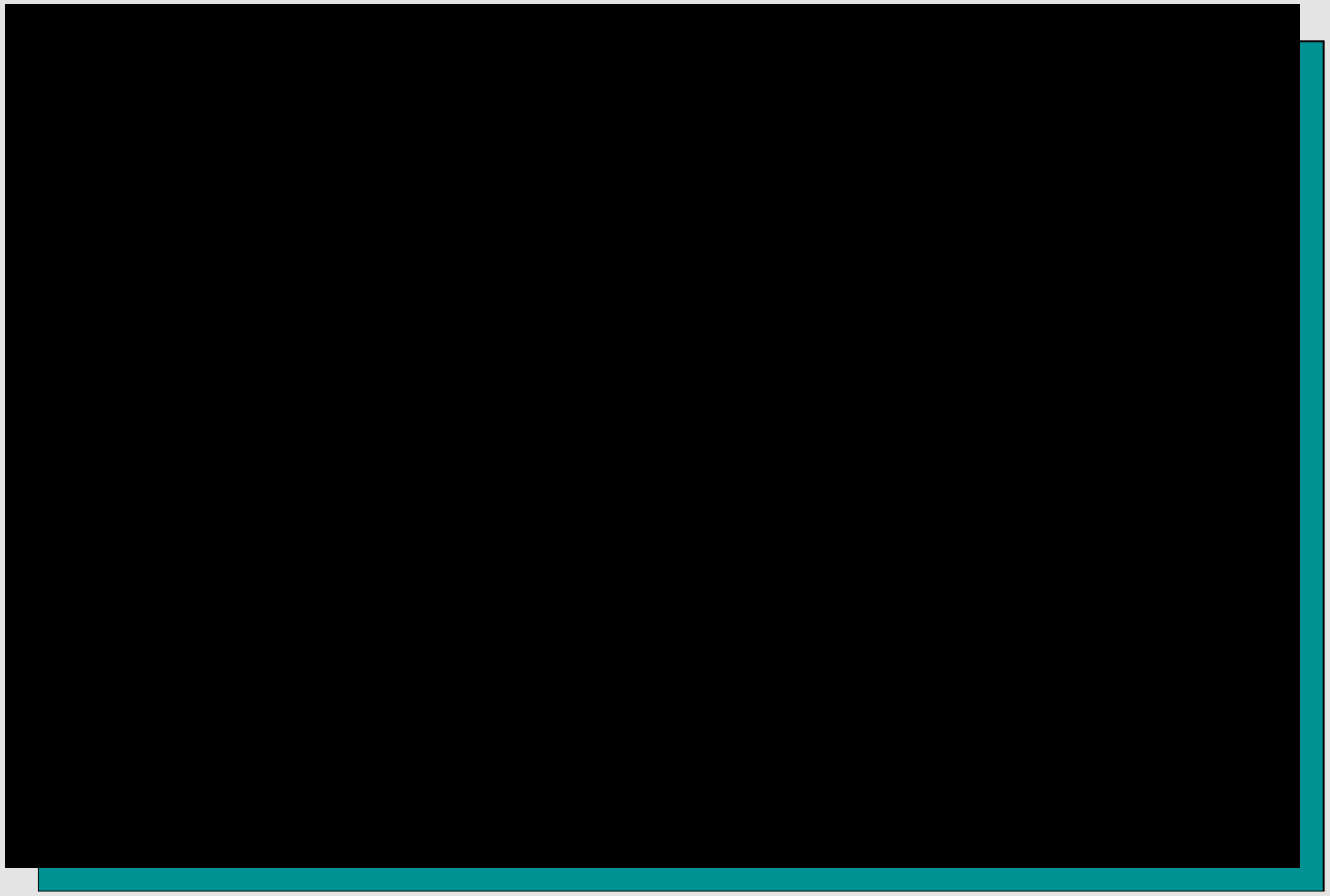




# Carney Signs Video



# Sample Games



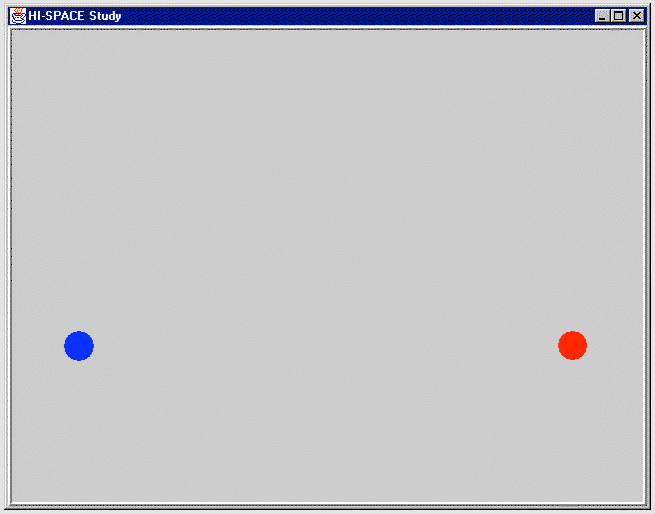
# Performance Studies

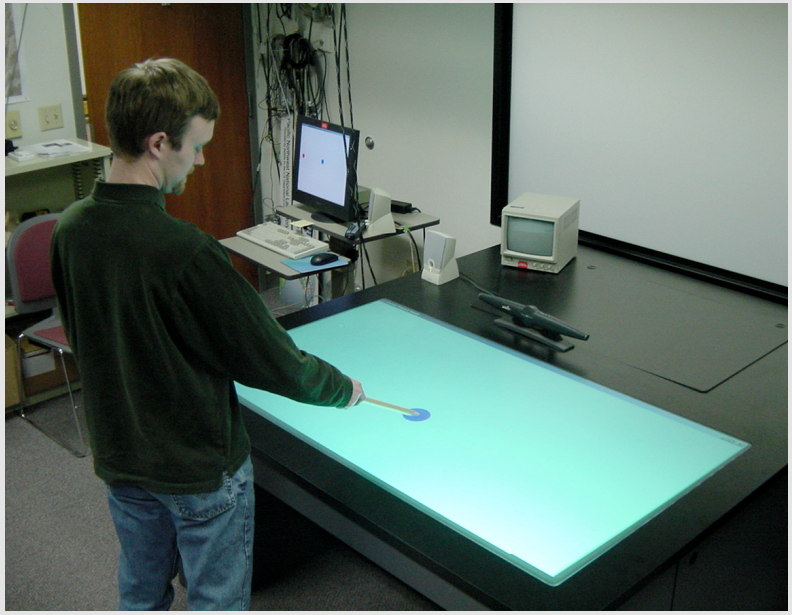
- Does using HI-SPACE type technology in a DMI environment perform any different than using a mouse on a desktop system?
  - Does cursor feedback change performance?
  - Does How does system lag impact performance?
- Decided to run Fitts' studies

$$ID = \log_2 \frac{2A}{W} bits / \sec$$

# Fitts' Model Study Example

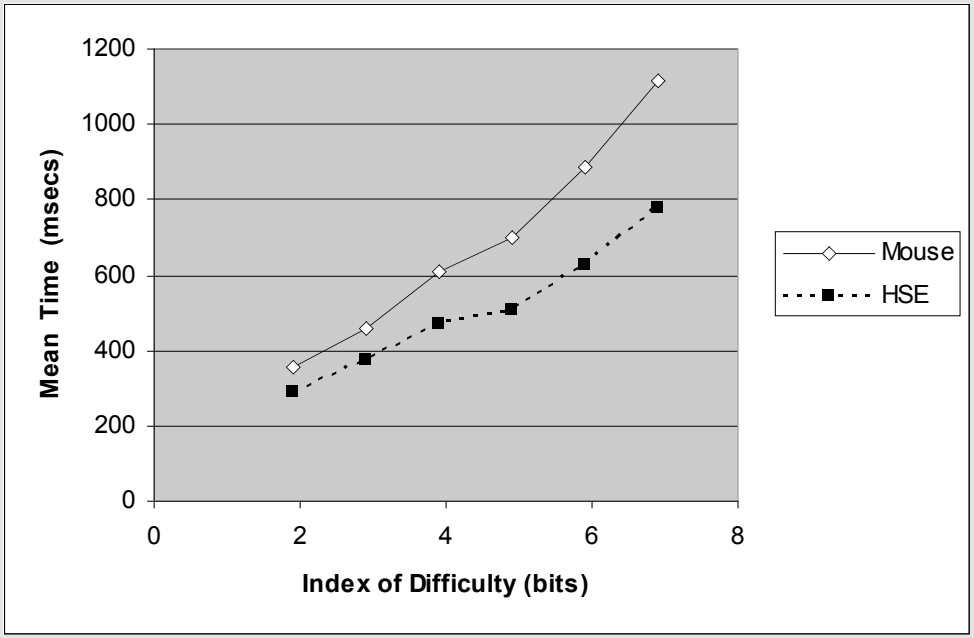
- Discrete ***tapping*** task
- Left / Right motion only
- Subjects
  - Under 40 years old
  - Right handed
- Used a 12 inch hand held stylus



# Direct Comparison Study

- The mouse was slower and had a worse IP.
- No difference in error rates. However …

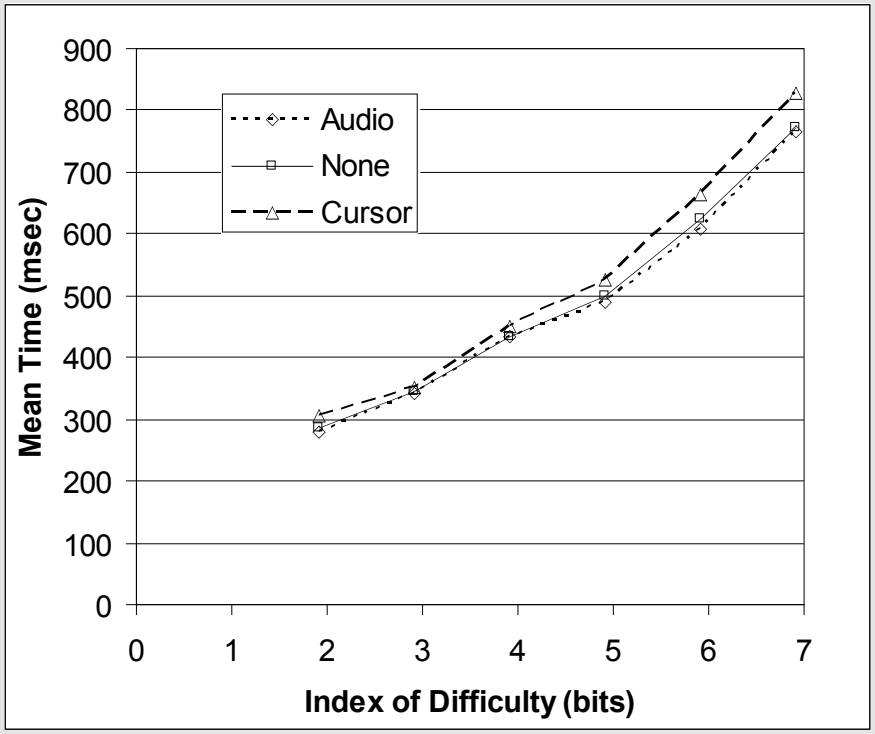


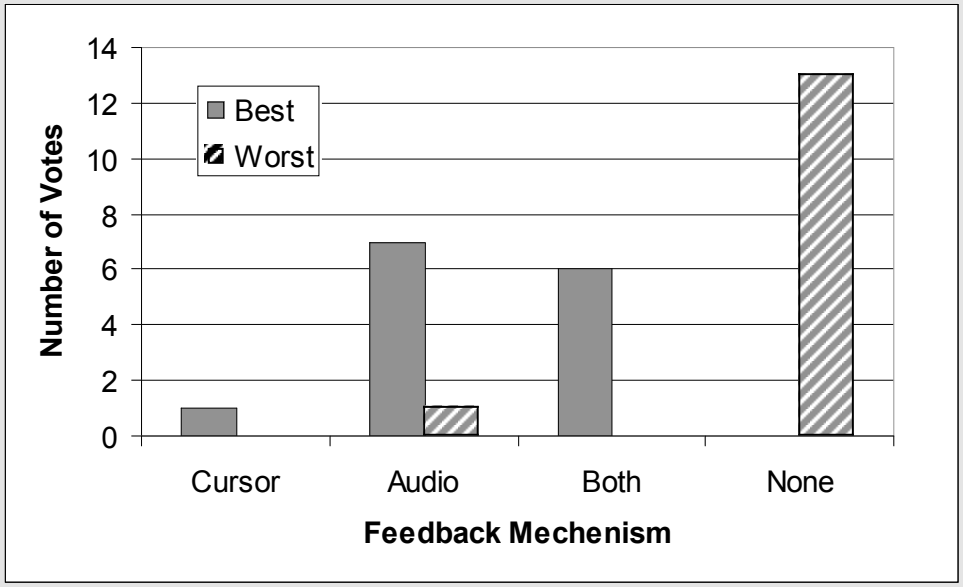

| | Interaction Type | |
|---|---|---|
| | Mouse | HSE |
| Mean Time (ms) | 667 | 505 |
| Error Rate | 4.2% | 3.2% |
| Index of Performance (bits/s) | 7.1 | 10.4 |
| Y intercept (ms) | 45 | 81 |

| | % misses by target Width (pixels) | | | |
|---|---|---|---|---|
| | 14 | 28 | 56 | 112 |
| Mouse | 9.38% | 4.37% | 2.39% | 0.51% |
| HSE | 10.85% | 1.51% | 0.34% | 0.00% |

# Feedback Study

The cursor and combined conditions took more time (~6%) but resulted in less errors (~30% for high ID only).

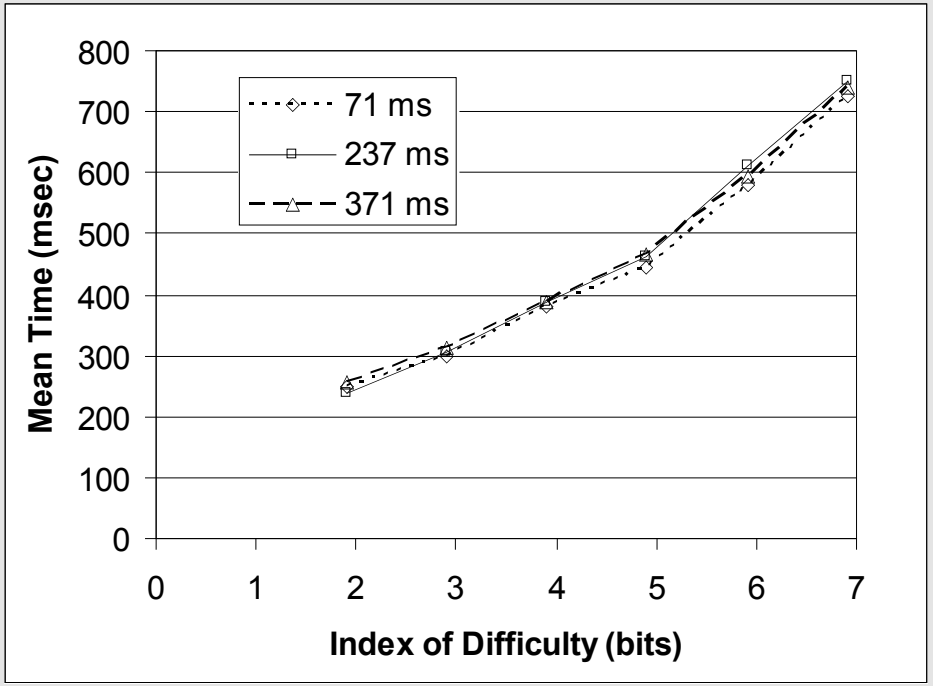



Interface design could reduce the role of the cursor for some tasks.

# Lag Study

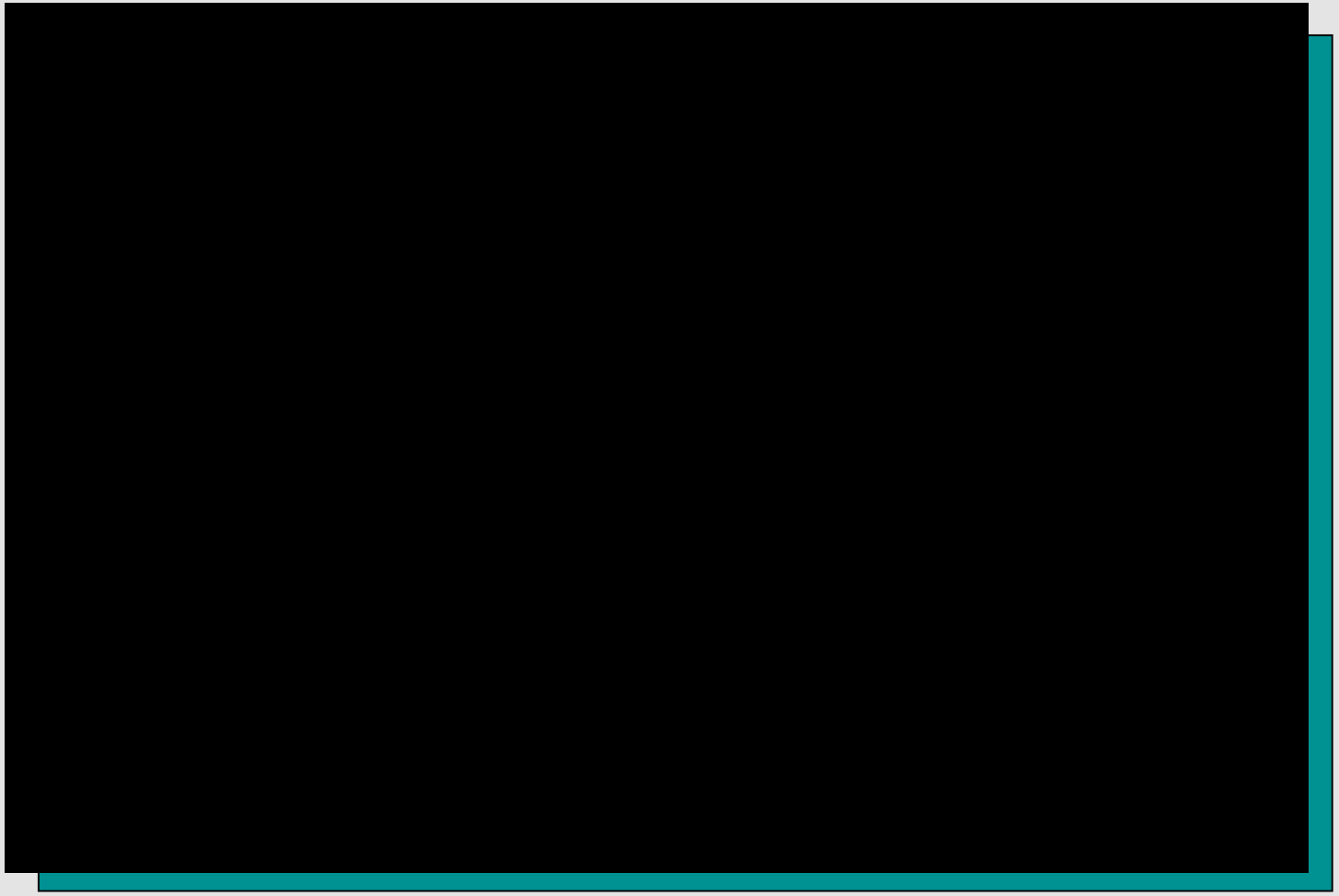
No significant performance change caused by lag.



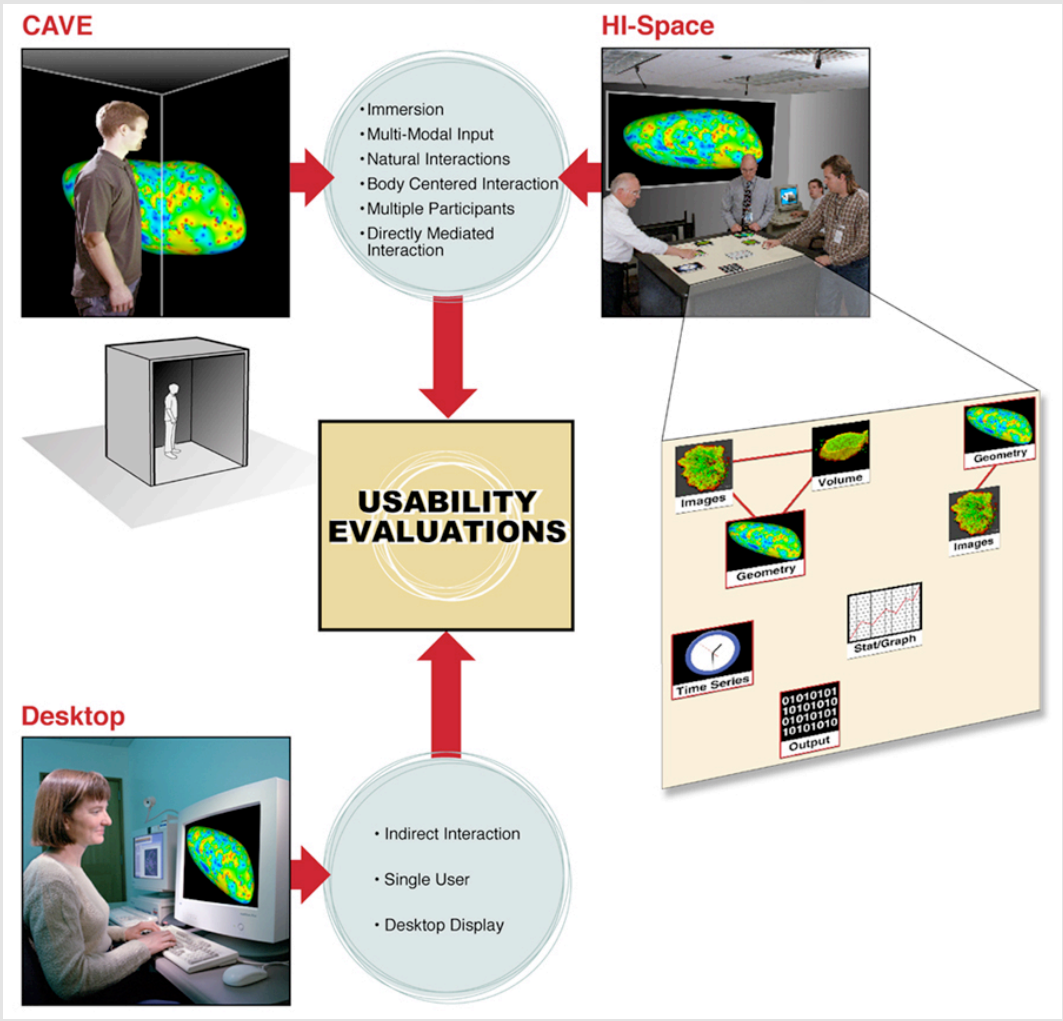

| | Lag (ms) | | |
|---|---|---|---|
| | 71 | 237 | 371 |
| Mean Time (ms) | 433 | 448 | 448 |
| Error Rate | 4.4% | 3.5% | 4.0% |
| Index of Performance (bits/s) | 10.8 | 9.9 | 10.6 |
| Y intercept (ms) | 24 | 5 | 32 |

- Input no longer dependent on timely output.
- Could allow users to function when system is slow.

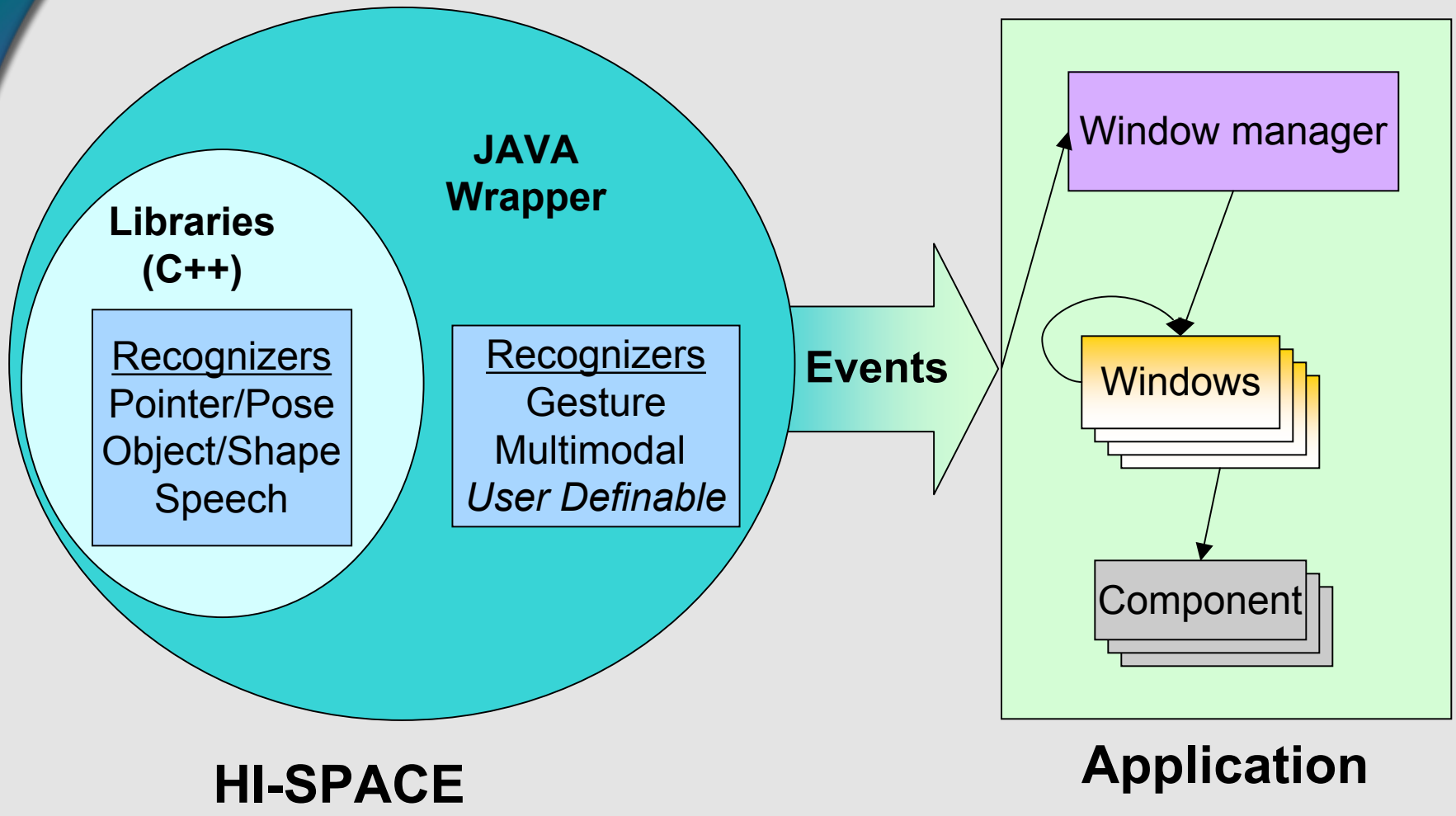
# Simple Paint Program



# Interactive Scientific Visualization Techniques Project

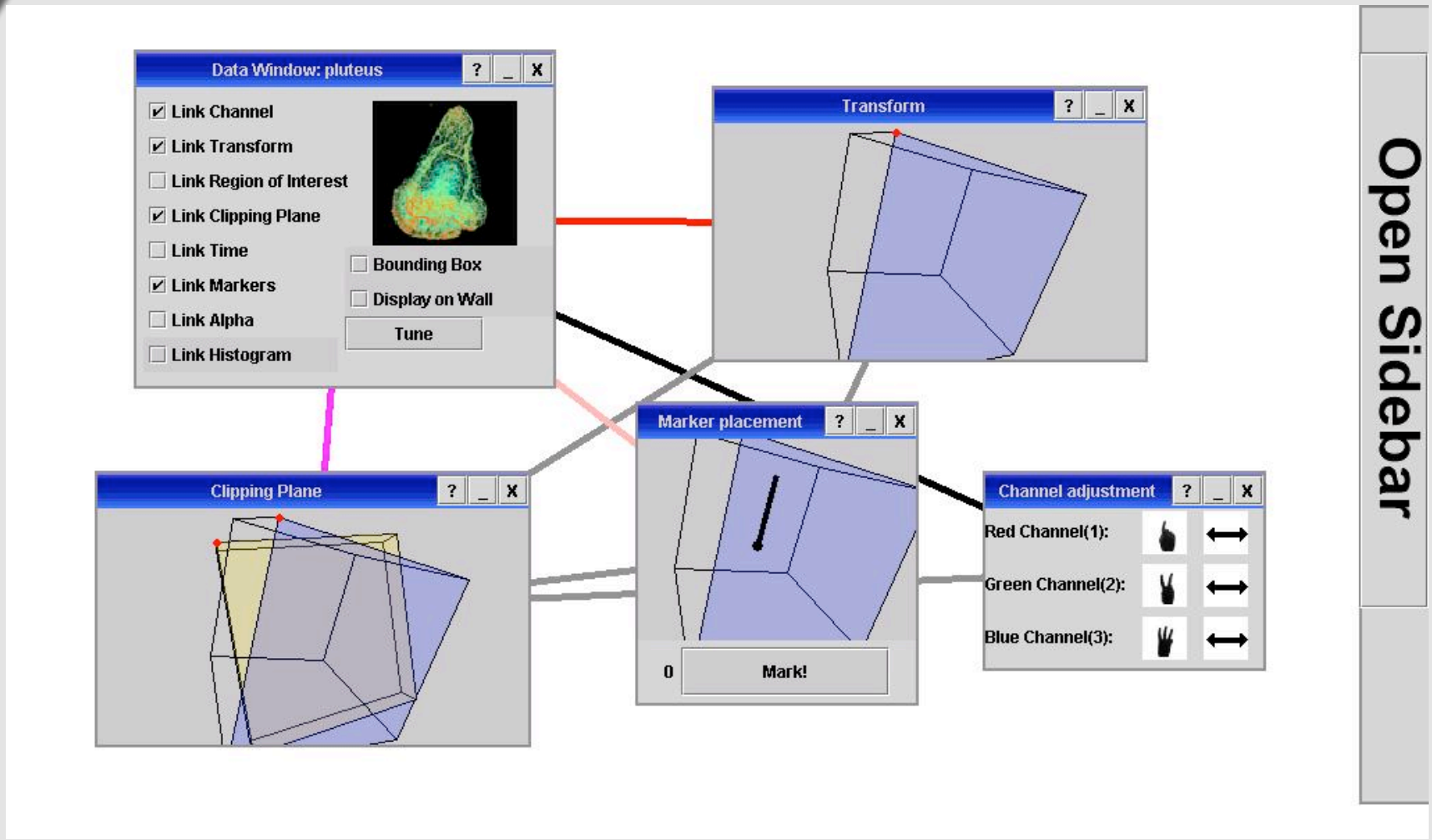


# HI-Space System Architecture

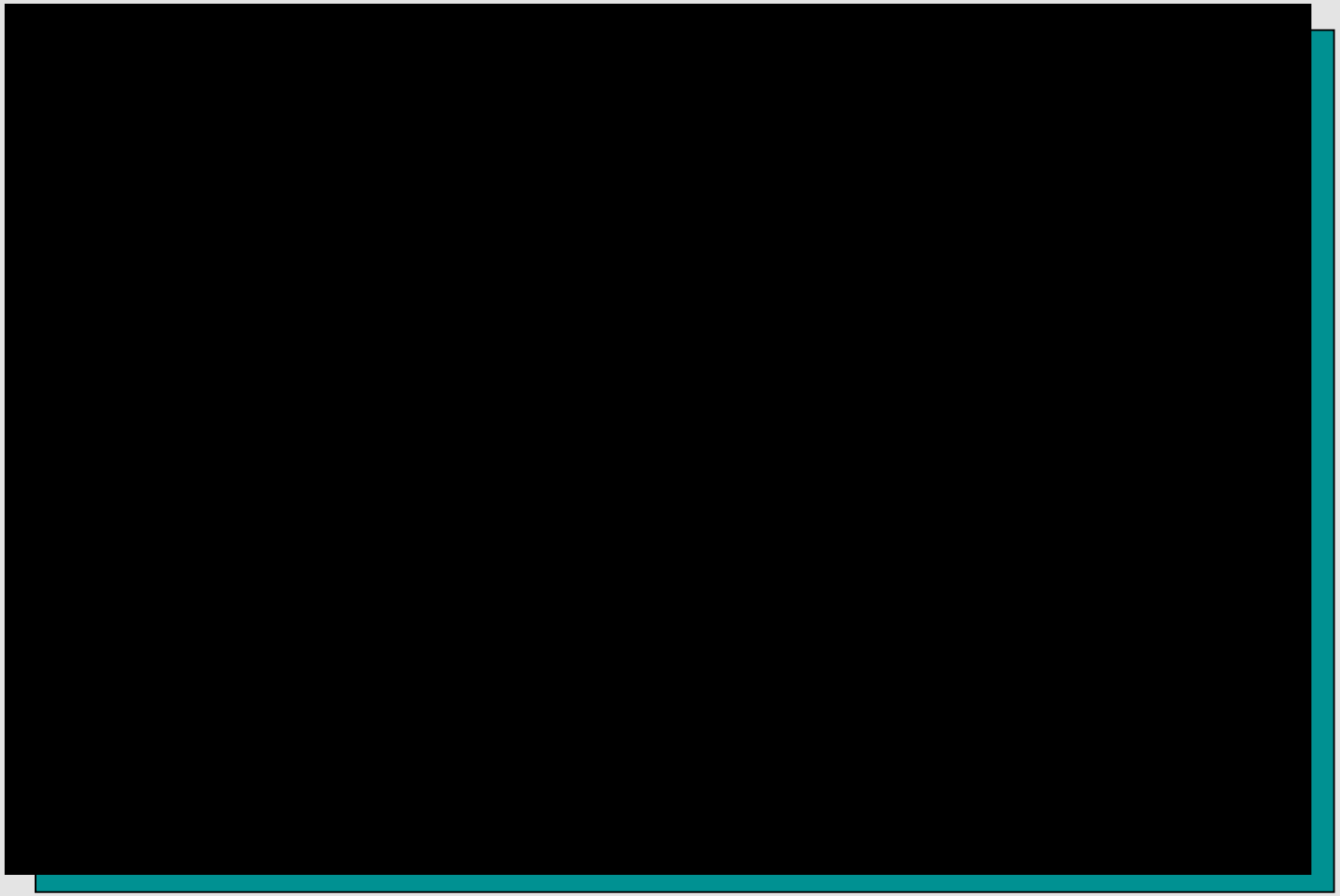


# Interface Example

## Interactive Scientific Visualization Techniques Project

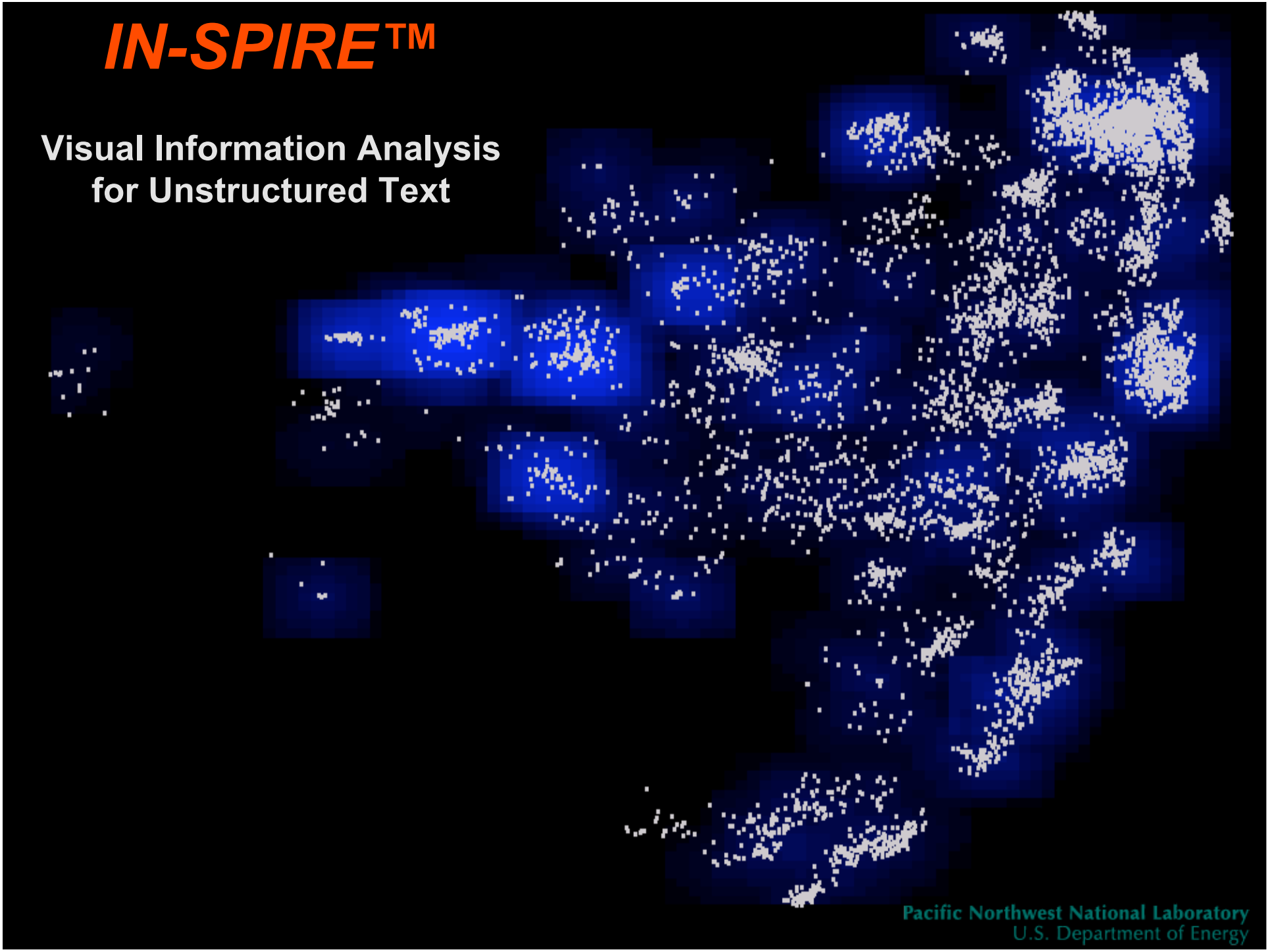


# ISVT Video



# IN-SPIRE™

## Visual Information Analysis for Unstructured Text



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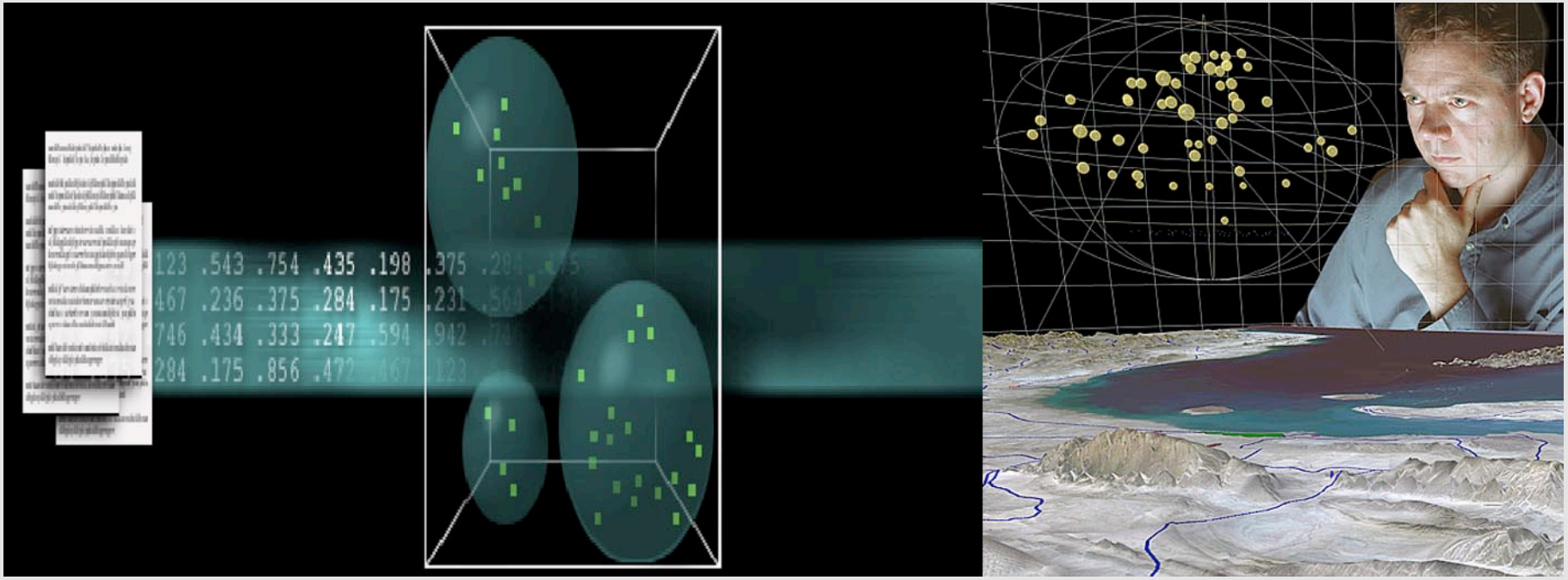
# Visual Analytics

**Visual analytics is the science of analytical reasoning facilitated by interactive visual interfaces.**




Data Representations & Transformations

Visual Representations & Interaction

Analytic Reasoning & Discourse

# Why Mobile Devices?

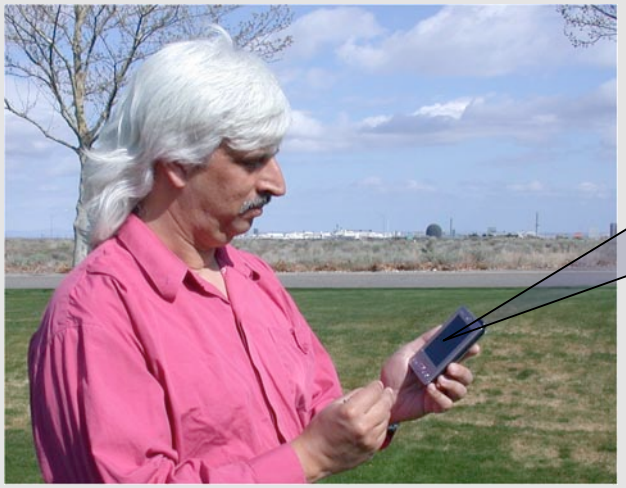
- There are currently 1.5B mobile devices in the world today. This number is expected to reach 3.0B by 2010
- Sensors, mobile and fixed, will become ubiquitous
  - Today cell service providers get constant signal strength readings from every cell phone in the world
  - In the future every cell phone will be an RF reader
  - RF tags will cost $0.10 each or less

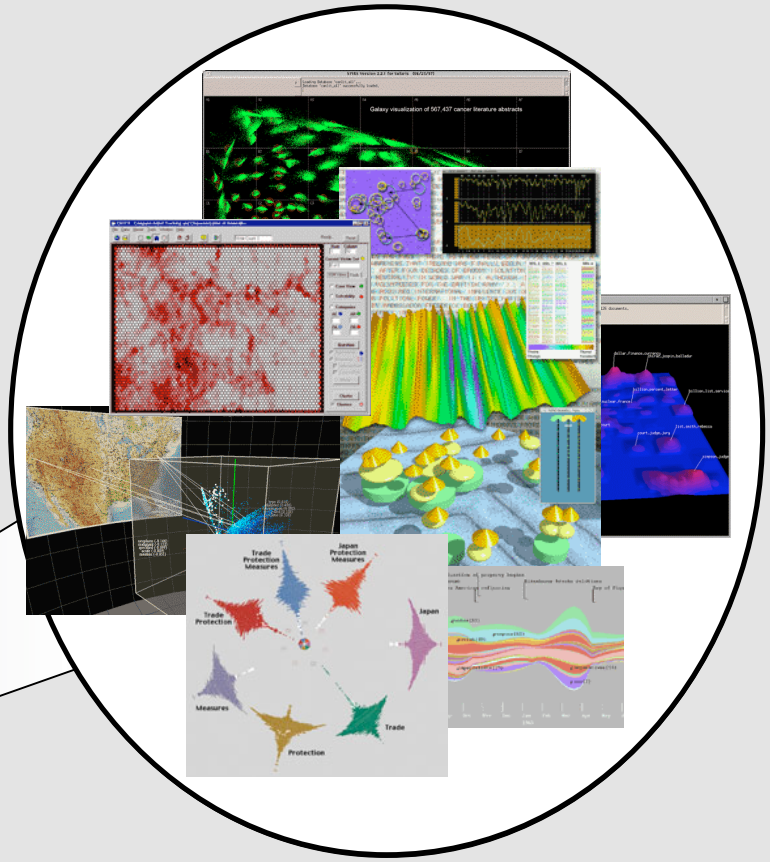
**"If you are looking to the future and what you see looks like sci-fi it might be wrong. But if it doesn't look like sci-fi it is definitely wrong"**
**~Christine Peterson**

# How would VA be used on mobile devices?

- We see several possible roles:
  - First responders
  - Agents in the field
  - Analysts on travel
  - Supervisor tasks
- What would they want to do?
  - Move analytic functionality outward
  - Incorporate streaming updates in to an analysis
  - Matching geospatial location to information
  - View work by others
- Use of VA in a mobile environment
  - What role would visualization play?
  - Are any of the current VA tools useful?
  - What devices would they use?

**Cannot directly port visual analytic tools to the mobile environment.**

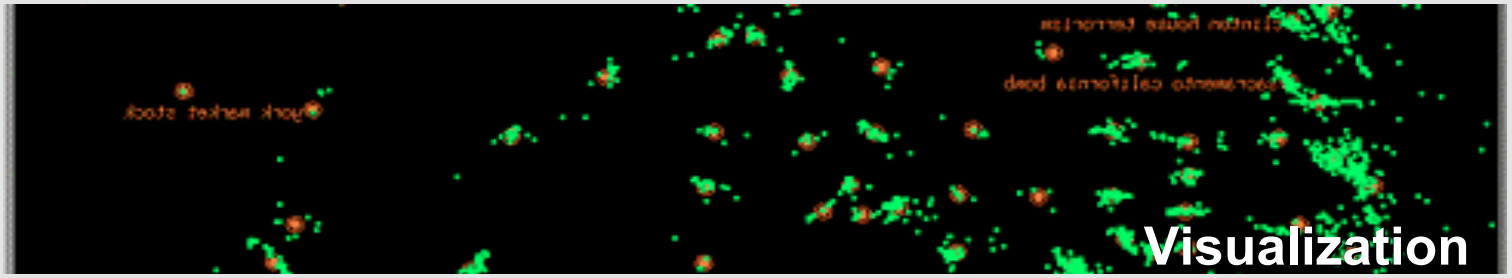




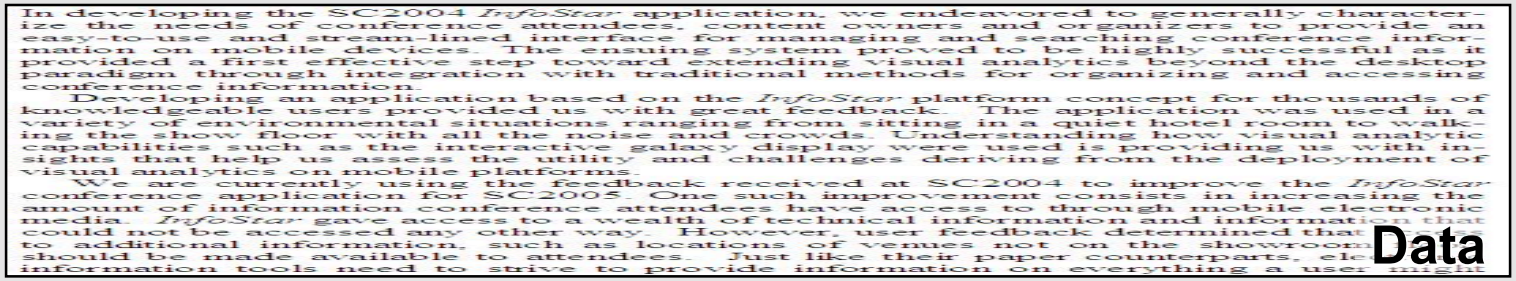

**Display**
**Input**
**Environment**
**Focus of attention**

# Scalable Progressive Disclosure

**Simple** ⟷ **Complex**



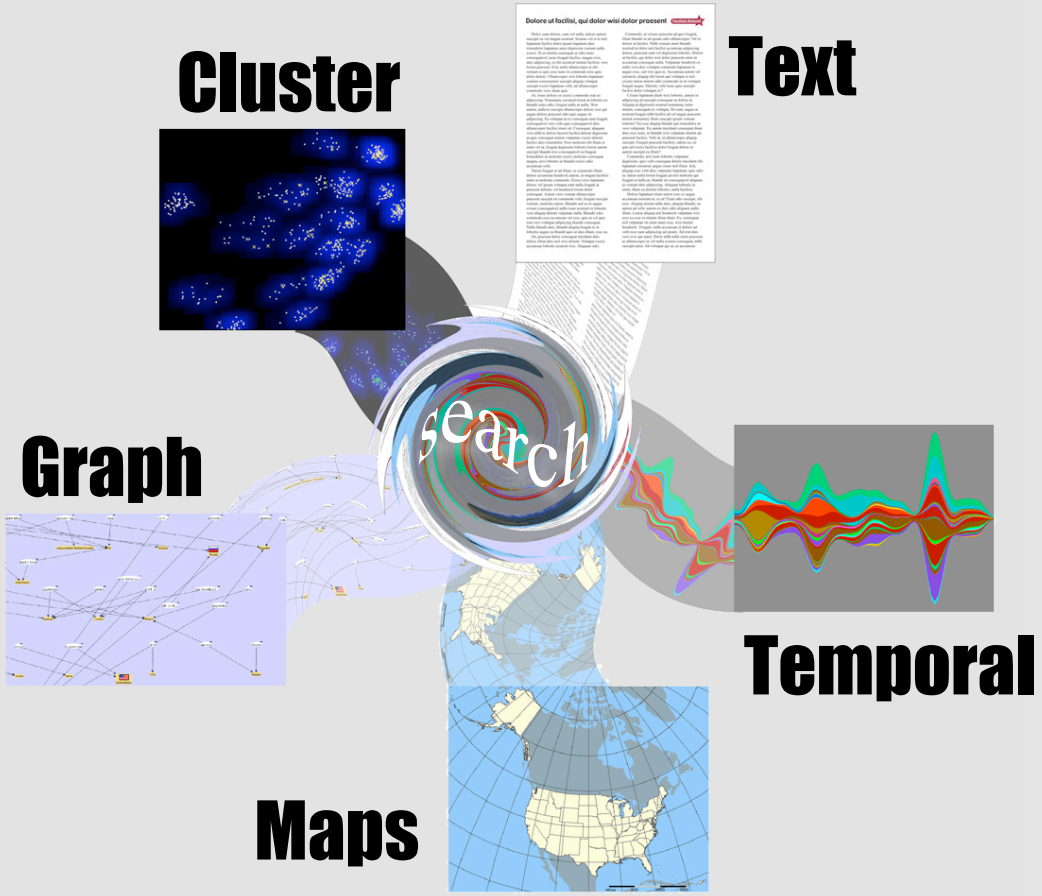



In developing the SC2004 *InfoStar* application, we endeavored to generally characterize the needs of conference attendees, content owners and organizers to provide an easy-to-use and stream-lined interface for managing and searching conference information on mobile devices. The ensuing system proved to be highly successful as it provided a first effective step toward extending visual analytics beyond the desktop paradigm through integration with traditional methods for organizing and accessing conference information.

Developing an application based on the *InfoStar* platform concept for thousands of knowledgeable users provided us with great feedback. The application was used in a variety of environmental situations ranging from sitting in a quiet hotel room to walking the show floor with all the noise and crowds. Understanding how visual analytic capabilities such as the interactive galaxy display were used is providing us with insights that help us assess the utility and challenges deriving from the deployment of visual analytics on mobile platforms.

We are currently using the feedback received at SC2004 to improve the *InfoStar* conference application for SC2005. One such improvement consists in increasing the amount of information conference attendees have access to through mobile electronic media. *InfoStar* gave access to a wealth of technical information and information that could not be accessed any other way. However, user feedback determined that access to additional information, such as locations of venues not on the showroom floor, should be made available to attendees. Just like their paper counterparts, electronic information tools need to strive to provide information on everything a user might

# Primary Types of Visualizations



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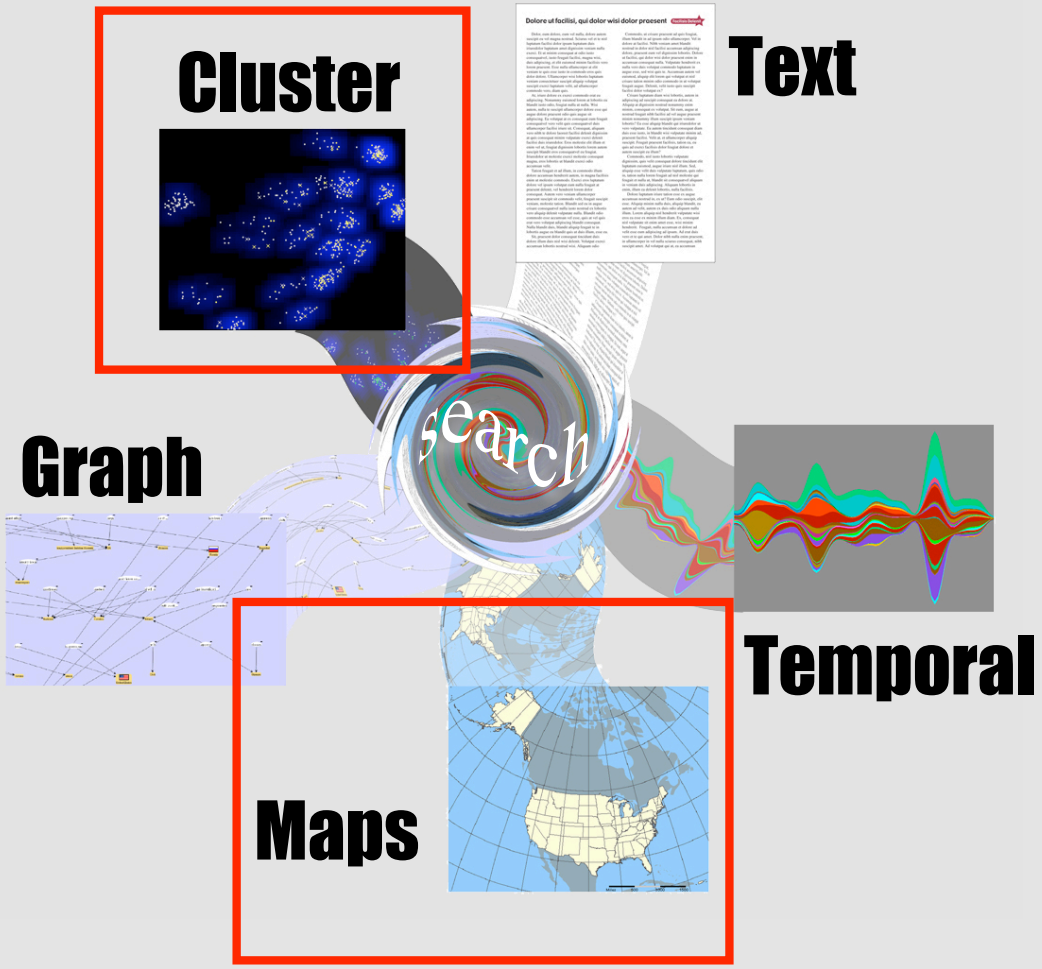
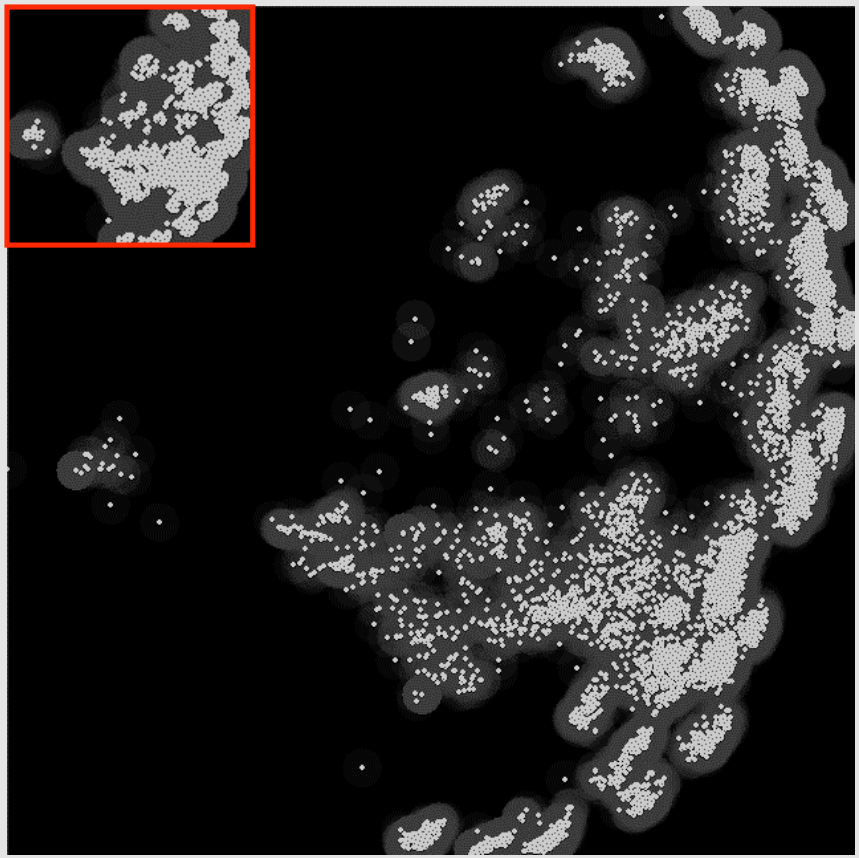


# Cluster Visualization: The Problem

- On mobile devices, this display:
  - does not communicate information quickly or easily
  - is difficult to interact with
- We need to:
  - maintain spatial information
  - develop a simple interaction technique



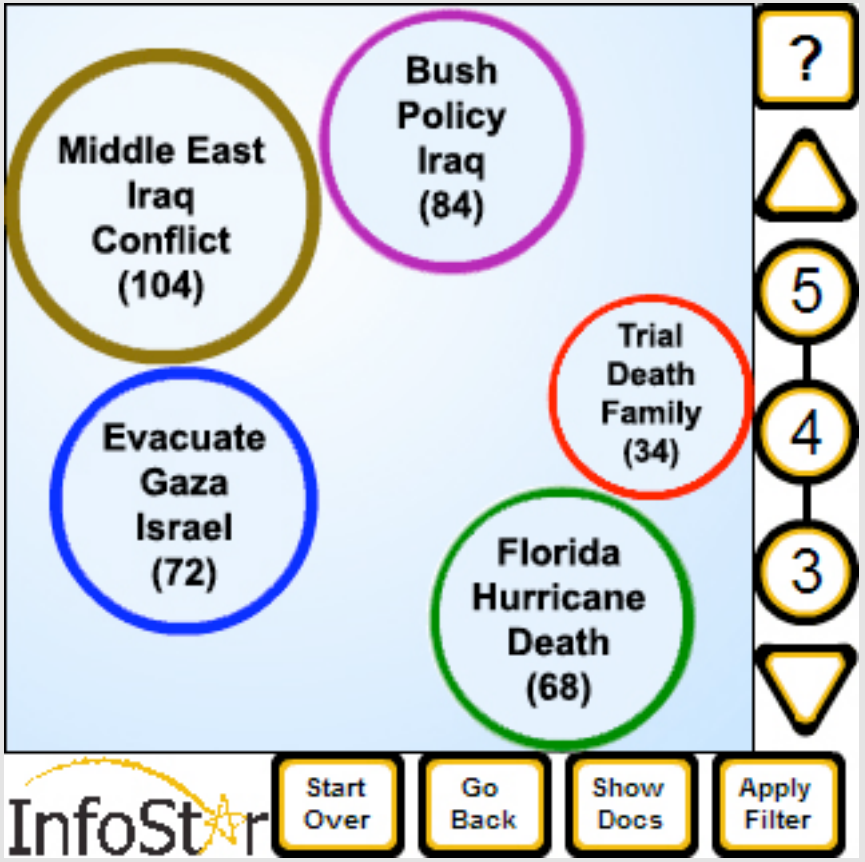
# Cluster Discourse for Mobile Devices

User Controlled Cluster Density

Drill Down Through Bubbles

Filter Documents Represented

Access to Document Content




[Current working prototype for SC05]

# Map Interactions for Mobile Devices


- Combining speech and pen input
- Writing recognized by devices and people
- Fast access to geospatial encoding
- Annotation

# Questions?