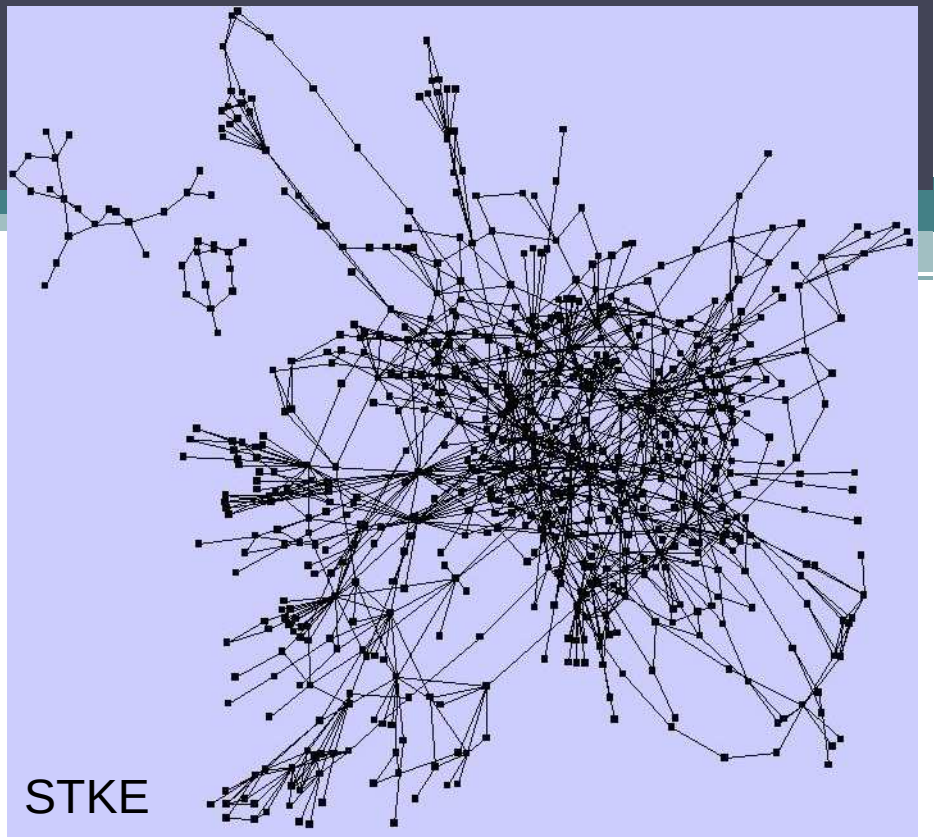
The Effects of Immersion and Navigation on the Acquisition of Spatial Knowledge of Abstract Data Networks

James Henry, M.S.
Nicholas F. Polys, Ph.D.

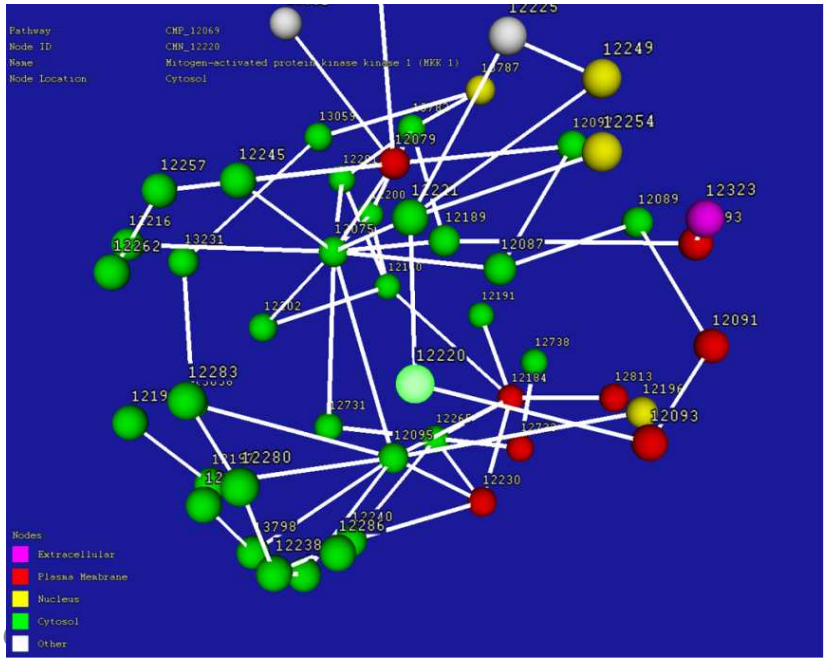
Virginia Tech



Network Topology

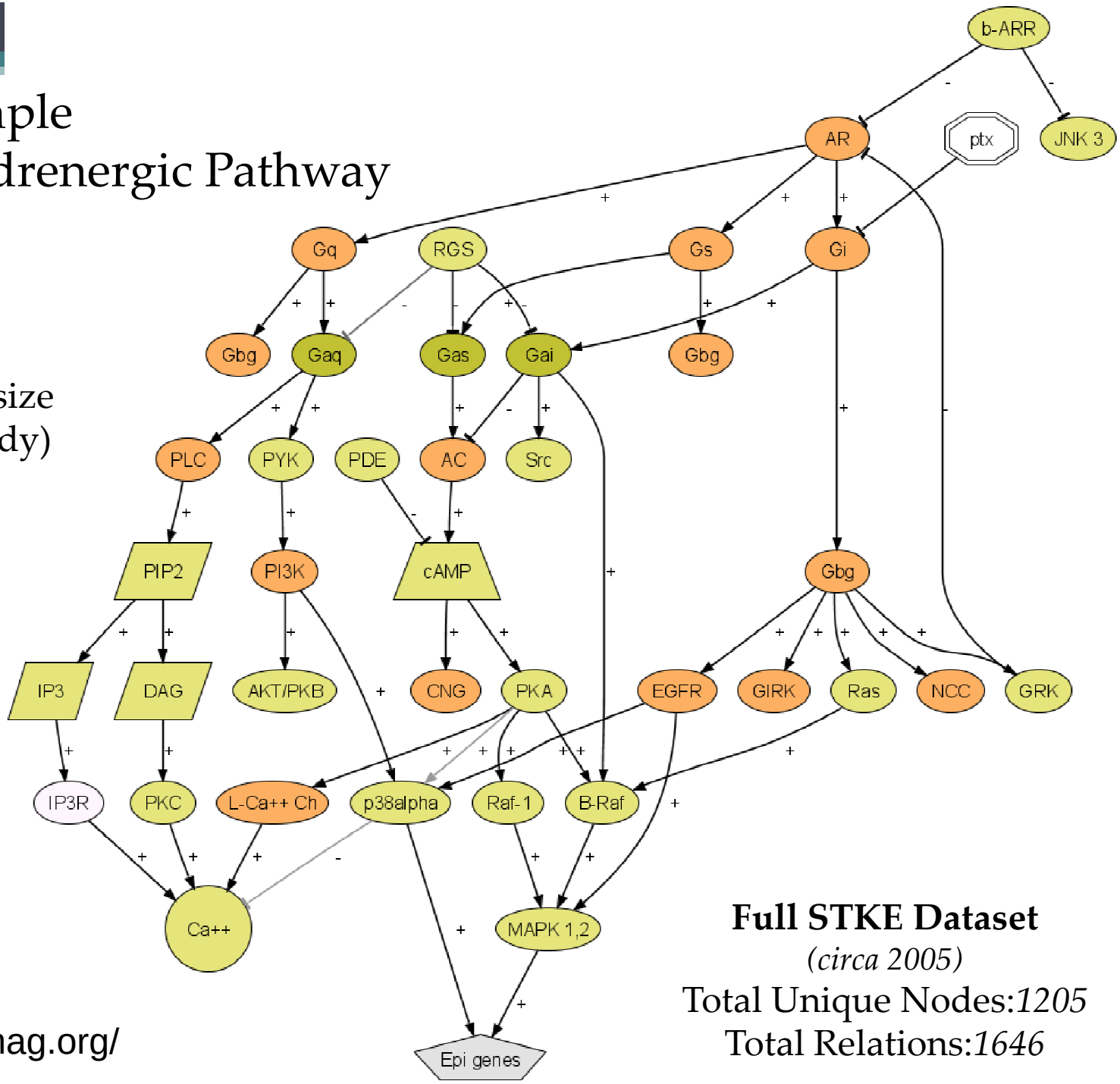
Knowledge about how a network is connected and organized. In STKE's case:

- **Landmarks** (hubs and outliers)
- **Routes** (signaling pathways between biochemical compounds)
- **Survey**
  (organization, neighbors and groups)



STKE Example
Myocyte Adrenergic Pathway
(CMP_9043)

(Typical of the size used in this study)



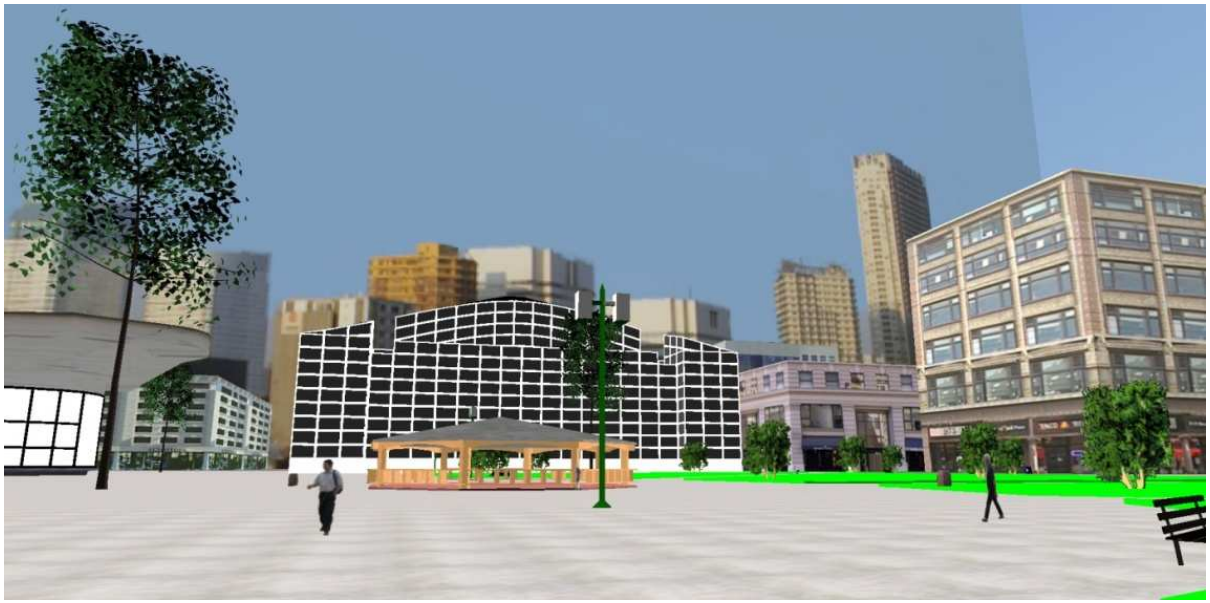
Full STKE Dataset
(circa 2005)
Total Unique Nodes:*1205*
Total Relations:*1646*

http://stke.sciencemag.org/

Acquisition of Spatial Knowledge

Virtual Reality

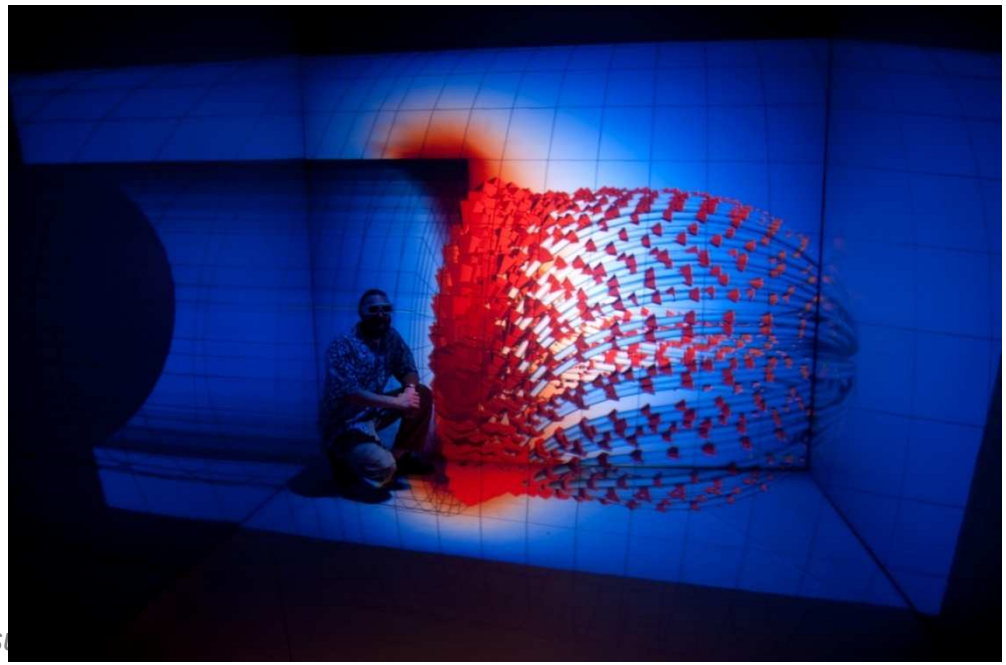
- Immersion: display, tracking and input technology
- Techniques for Navigation, Selection, Manipulation
- Typically focused on wayfinding in **realistic** environments



The Benefits of Immersion

Immersion is the technology that enables 'Presence'; increasing by sensory substitution. For example:

- Field-Of-Regard (FOR)
- Field-Of-View (FOV)
- Head tracking
- Input devices
- Stereo rendering
- Display resolution



User Study

Goals

- Explore new methods of visualizing network data
- Test evaluation method for spatial knowledge of abstract graphs

Data & Platform

- STKE pathways viewed as a 3D network
- Stereo rendering (active), 6-DOF head and wand

Evaluation

- Immersive environment (FOR: 1 wall vs. 4 wall)
- Egocentric vs. Exocentric navigation

User Study Design

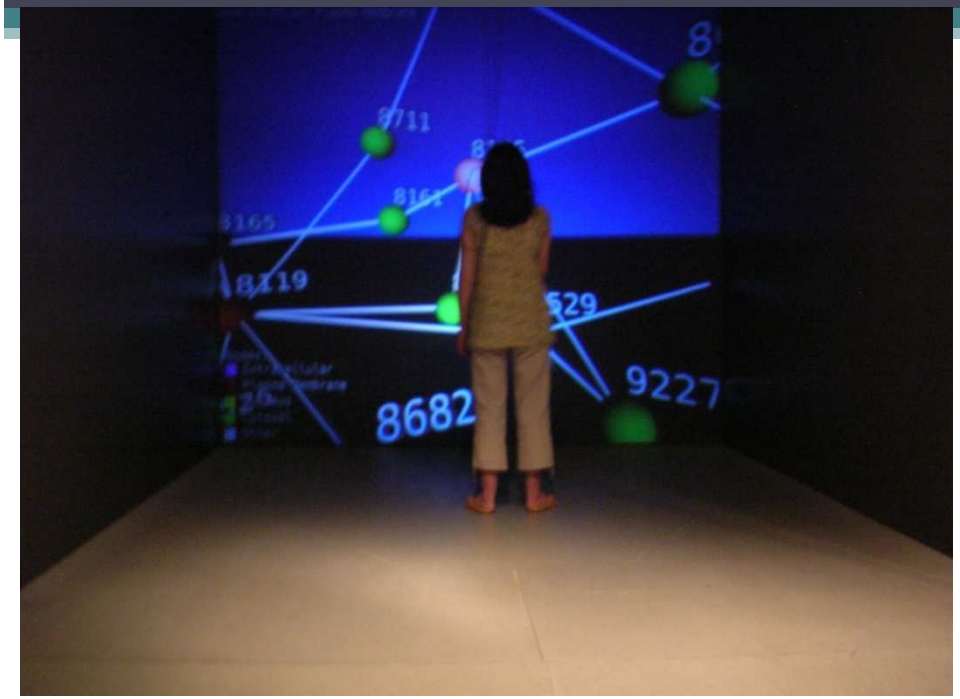
- BIBD

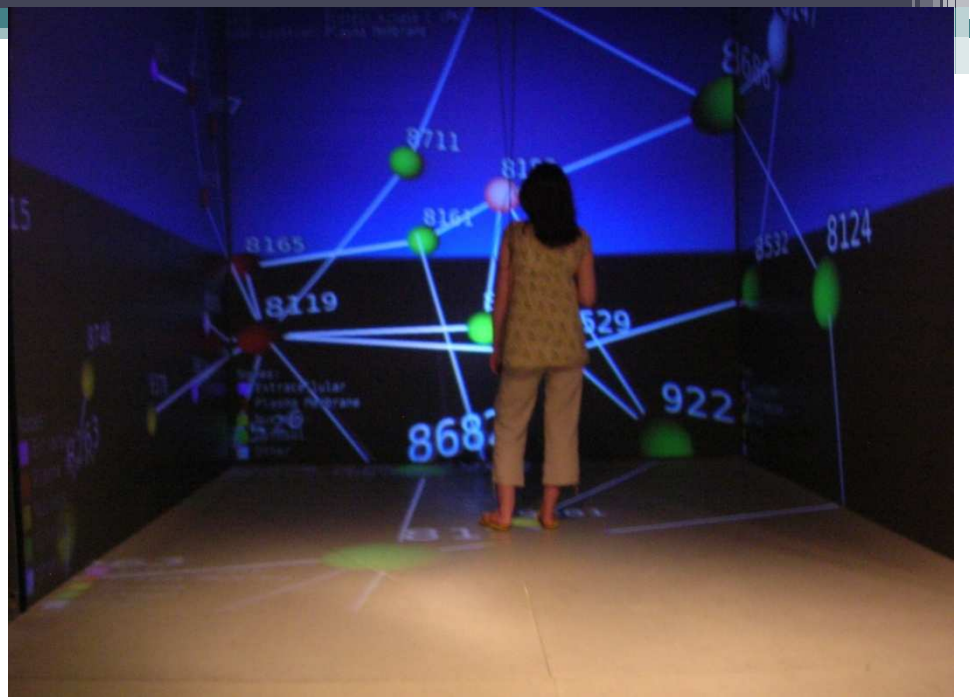
1	A	B	C
2	A	B	D
3	A	C	D
4	B	C	D

- Combination of phases

	Fly	Orbit/Rotate
1 wall	Scenario A	Scenario B
4 wall	Scenario C	Scenario D

- 4 question types:
  - **Survey** - Identify all of the neighbors of node *X*
  - **Route** – How many nodes are between nodes *X* & *Y*
  - **Landmark** - Which is the most connected node?
  - **Survey** – How many nodes of type Z are in the graph?



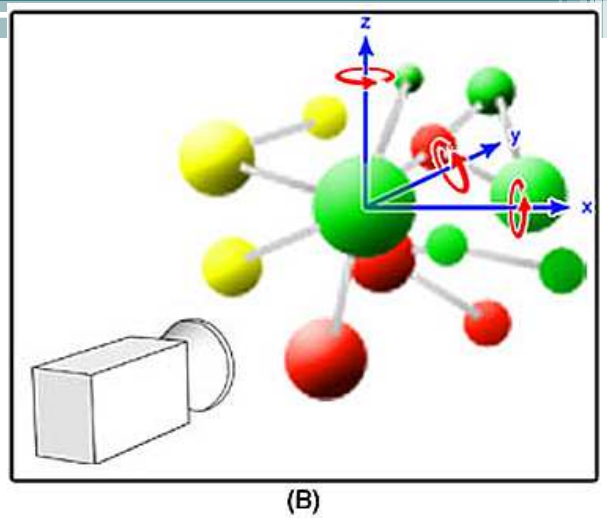


Run in the VT CAVE (IS – 900 tracking) on one wall or three walls + floor

Stimuli: STKE pathways (33-42 nodes in each trial)

Built using DIVERSE and OpenSceneGraph

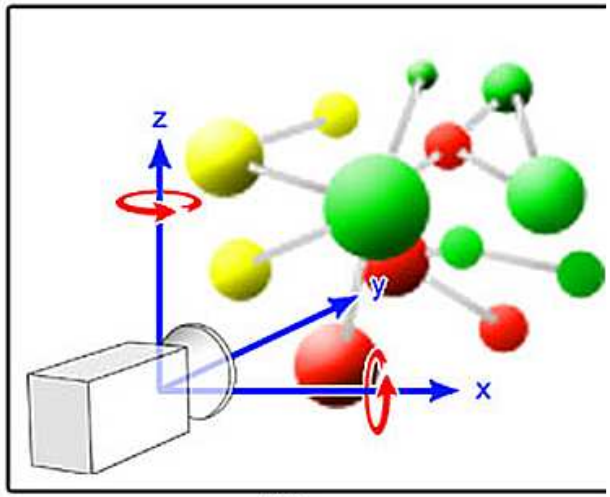
Navigation Techniques



(B)

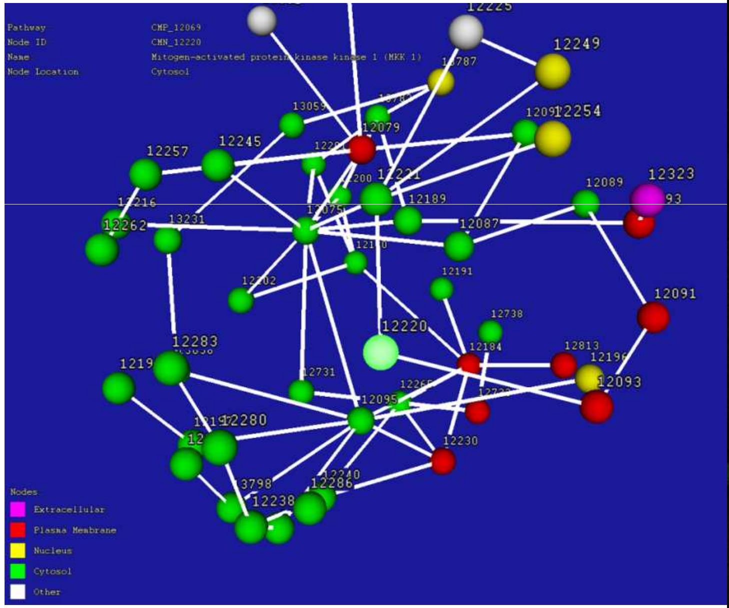
- What is **Rotation / Orbiting**?
  - *Exocentric*
  - Rotate world around selected Pivot node with thumb joystick
  - Separate buttons for zoom-in & zoom-out

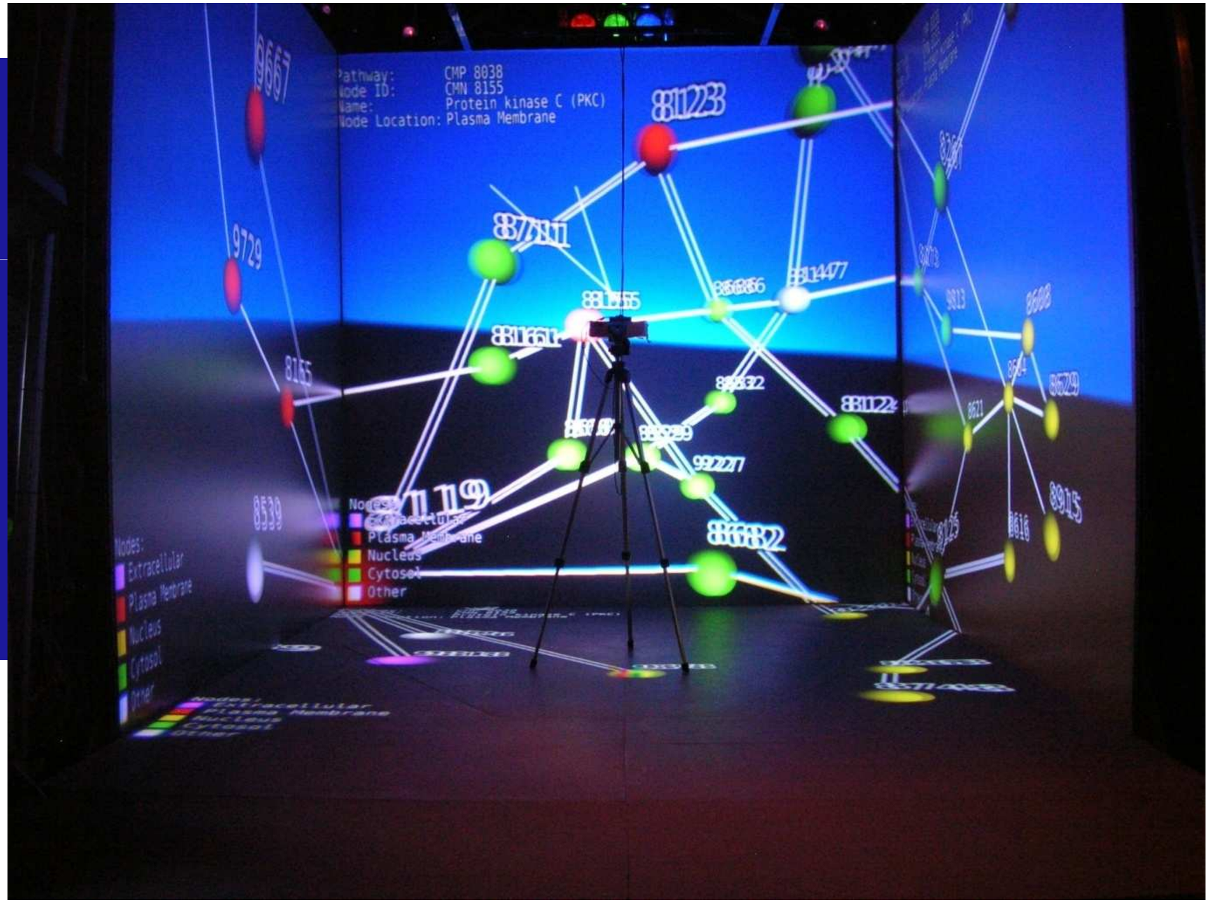
- What is **Flying**?
  - *Egocentric*
  - Point wand and press thumb joystick to move the view in world, changing Heading and Pitch



(A)

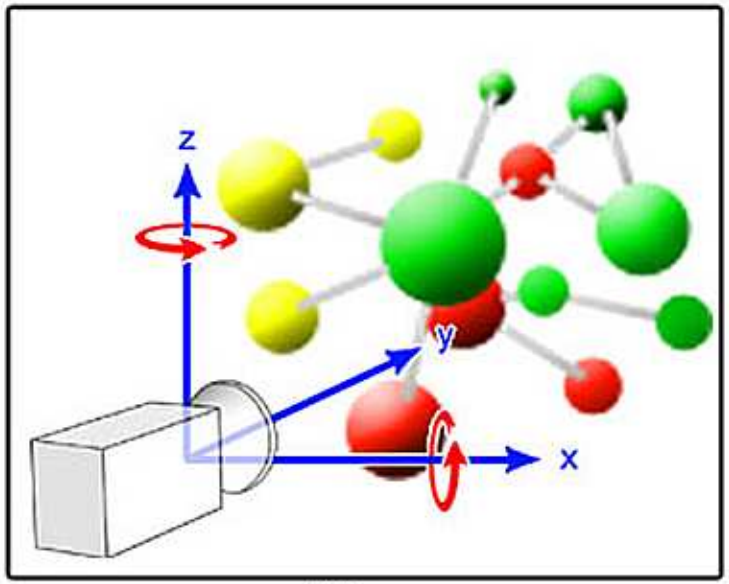
Demo


Pathway CMP_12069
Node ID CMN_12220
Name Mitogen-activated protein kinase kinase 1 (MKK 1)
Node Location Cytosol
Nodes
Extracellular
Plasma Membrane
Nucleus
Cytosol
Other


Pathway: CMP 8038
Node ID: CMN 8155
Name: Protein kinase C (PKC)
Node Location: Plasma Membrane

Flying by Pointing (Egocentric)

- *Movie: for film mono rendering was used; rendering projected for physical camera*



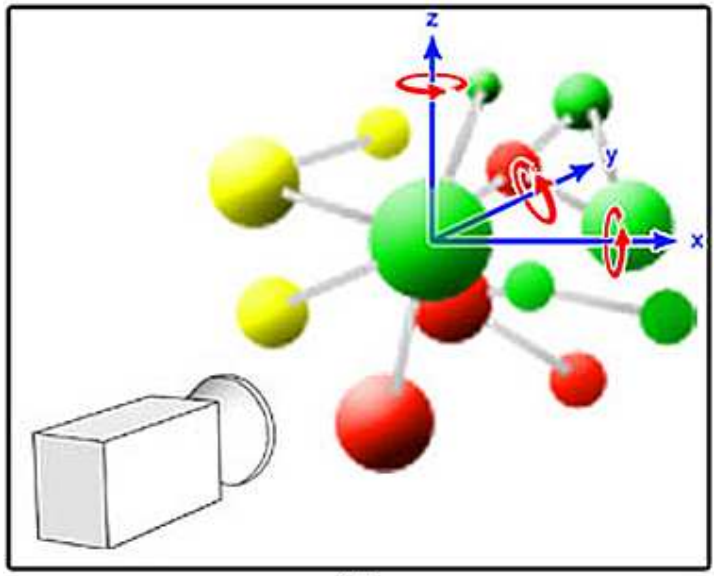
(A)

Navigation Mapping:

- has no roll
- requires ratcheting to see back side

Rotation (Exocentric)

- *Movie: for film mono rendering was used; rendering projected for physical camera*

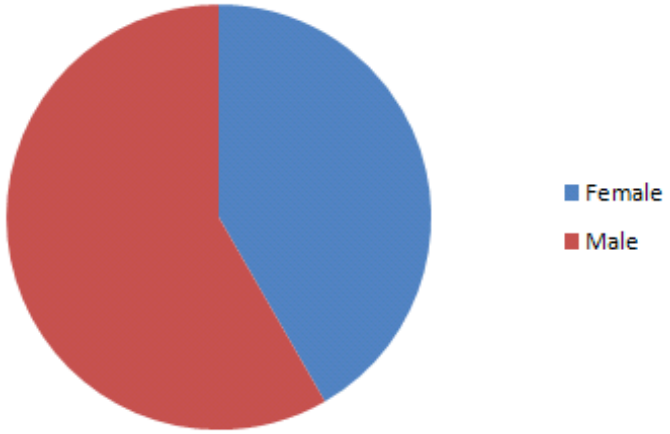


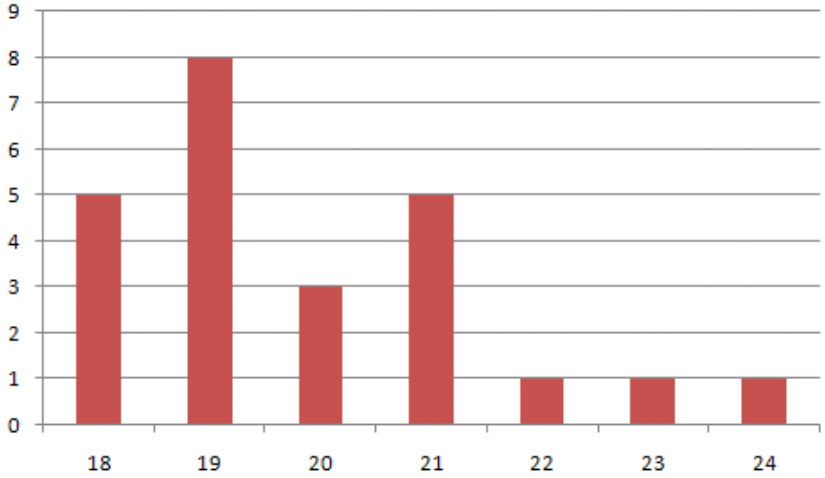
(B)

Navigation Mapping:
• has roll
• no ratcheting to see back side
• Zoom in/out uses two additional buttons

Participants in User Study

- Number of participants (n) = 24
- Participant demographics
  - Gender, Age
  - Computer and Gaming Experience



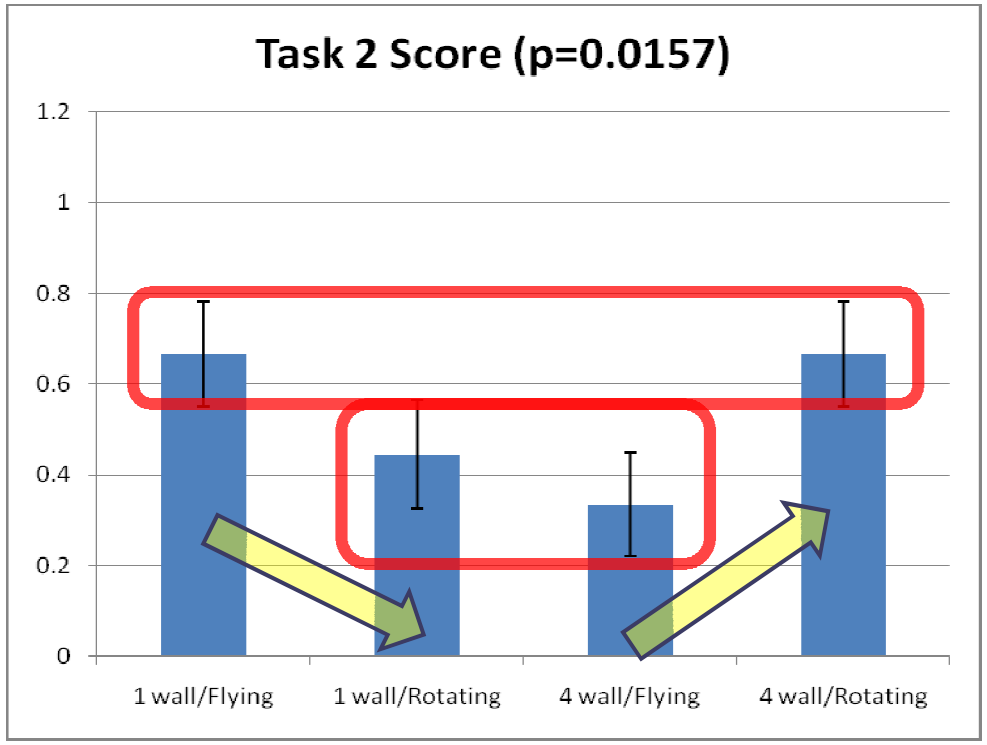


Significant Results

- PC experience (Correlation)
  - Prefer 4 walls
  - Prefer Rotation
- Task Performance (ANOVA)
  - Acquisition of Route Knowledge
    - Interaction of Navigation and FOR for accuracy
  - Acquisition of Survey Knowledge
    - Egocentric performs significantly better for accuracy

Route Knowledge: How many nodes between *X* & *Y* ?

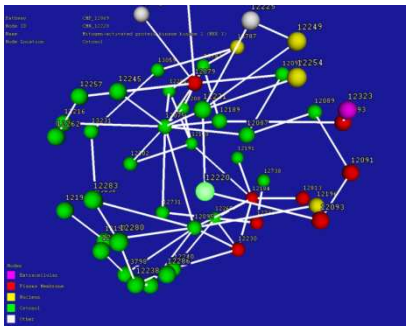
Interaction Effect



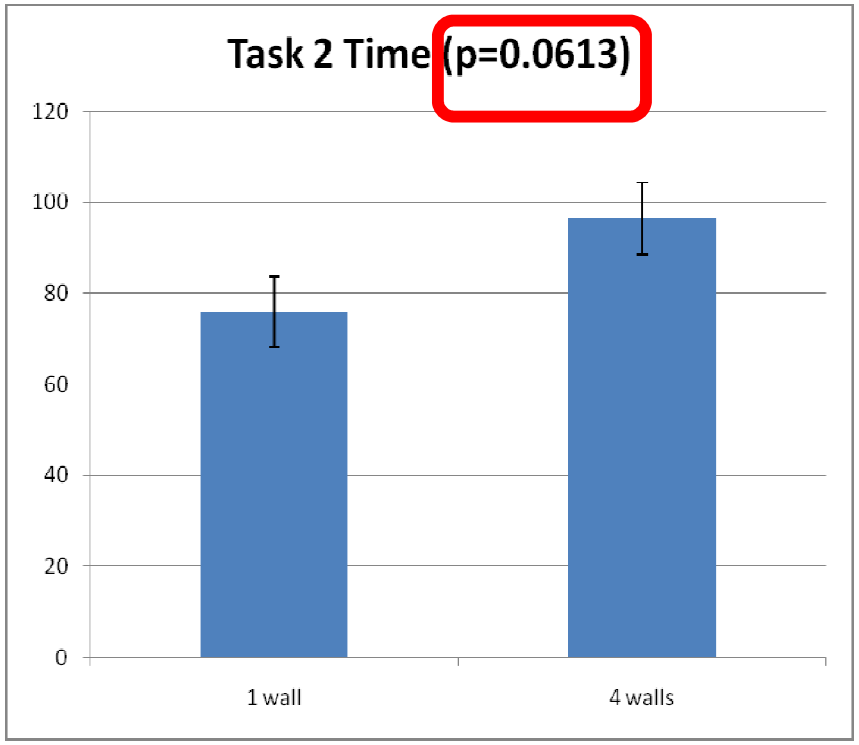
Parity of opposite conditions!

Tradeoff in **counting hops** between nodes:

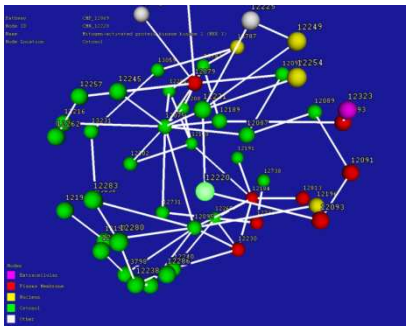
- On One wall, Flying enables better accuracy;
- On Four walls, Rotation enables better accuracy.



Route Knowledge: How many nodes between *X* & *Y* ?

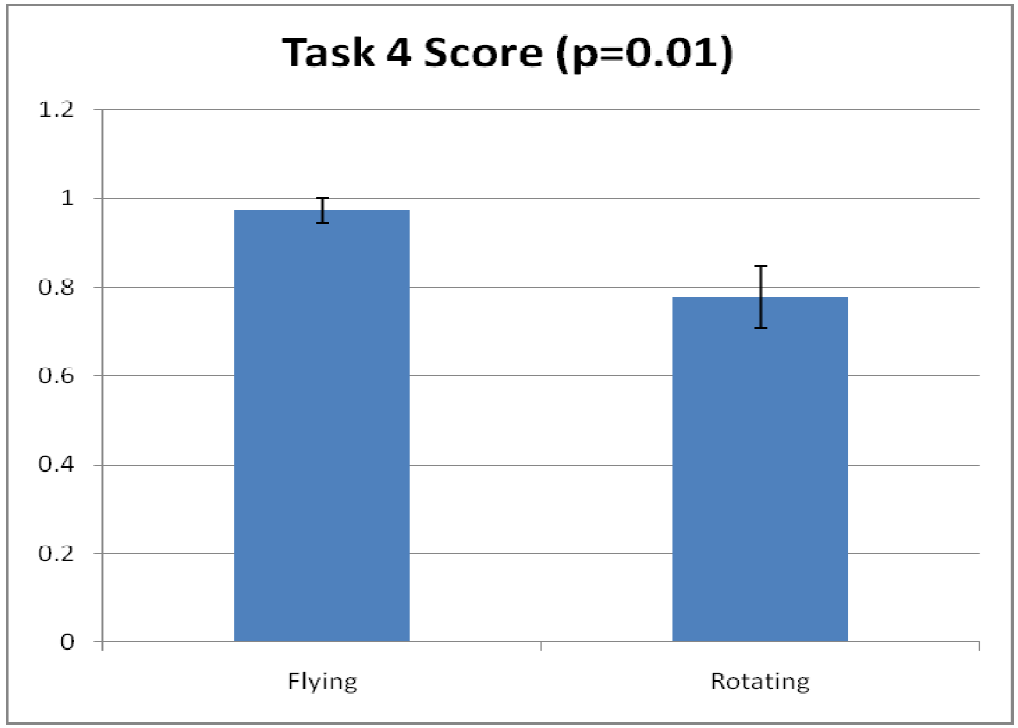


Not quite significant, but points out the challenges (time to completion) to usability of more immersive (higher FOR) display environments…



Survey Knowledge: Count the number of type *X* nodes

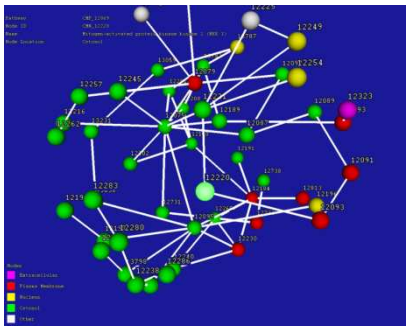
Egocentric advantage



Counting nodes of a certain type (e.g. membrane) -

Accuracy is significantly lower With the exocentric rotation technique.

When rotating the world, it seems difficult to keep track of which nodes have been counted.



Interpretations

- No clear winners overall
- Route and Survey counting tasks are especially susceptible to navigation and FOR manipulations
- Navigation and FOR interact and should be considered together

Implications

- Displays – we need better interaction techniques to reduce time to completion in high FOR
- Navigation type – we need to improve techniques for counting hops and groups
- Interaction of variables - users rely on different perceptual cues depending on the size / surround of the display (FOR). We are not sure where these tradeoff thresholds might be!
- More research required!

Next Steps

- Apply this experimental method to different classes of network layout algorithms, display venues
- Test a combination navigation technique:
  - if there is no selected node, fly;
  - if a node is selected, rotate
- Assess significance of including a horizon line when the data does not imply one… and navigation mapping includes roll

Questions & Ideas ?

npolys@vt.edu

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