

Interaction Technique for Selecting and Manipulating Subgraphs in Network Visualizations

Authors:

Michael McGuffin and Igor Jurisica

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Presenter: Charles Blatti

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- Presented at IEEE Information Visualization Conference (InfoVis) 2009
- Awarded Honorable Mention

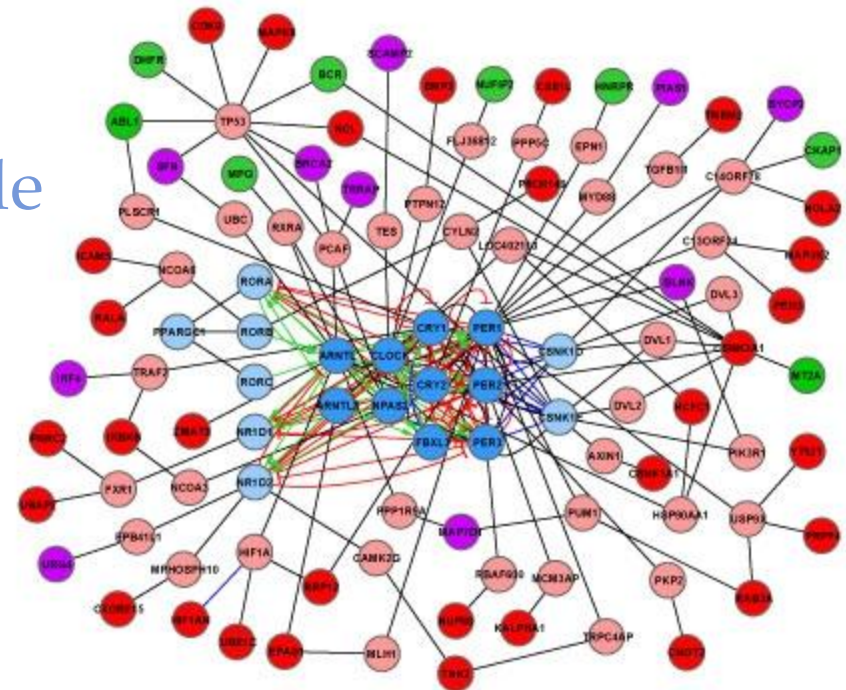
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- Michael McGuffin
 - Assistant Professor at University of Quebec
 - Research interests in HCI
 - Post-Doc at Jurisica Lab
- Igor Jurisica
 - PI in lab that focuses on Cancer Informatics involving representation, analysis and visualization of high dimensional data generated by high throughput biology experiments
 - University of Toronto and Ontario Cancer Institute, Princess Margaret Hospital



Focus on User Interaction

- Tasks
 - Adjust Layout
 - Change display options (color, shape, label)
 - Make changes at the subgraph and single node level



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As

- Ma
- Me

Untitled - Paint

File Edit View

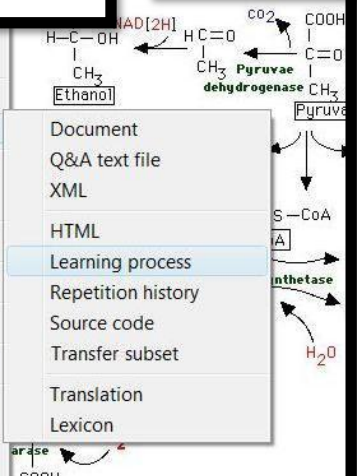
Desktop widgets and applications include:

- Four analog clocks for Los Angeles, St. Louis, Miami, and Paris.
- A length conversion utility (Yard to Meter).
- A calculator.
- A weather widget for Paris showing 18°C.
- A large date widget showing Tuesday, February 28, 2006.
- A calendar for February 2006.
- A numeric keypad.
- A Dictionary/Thesaurus window.
- A Translate window showing French to English translation: "une tartine" to "a slice of bread".
- A file utility window showing file types like JPEG, TIFF, PNG, etc.
- A Buddy List and Jabber List window.

Remember: (apple) Q to quit programs completely.
 Merci ma cherie.
 bisounours a toi

File Edit Search Learn

- Open collection
- Reopen collection
- New collection
- Copy collection
- Delete collection
- Repair collection
- Merge collection
- Import
- Export
- Tools
- Properties
- Installation
- Level
- Process collection >
- Exit Alt+F4
- 1 ALL d:\sm2008\systems\
- 2 PHOTOS d:\sm2008\systems\
- 3 YOUTUBE d:\sm2008\systems\



Close

Human Computer Interaction Fixes

- Designed to:
 - Enable Rapid Access
 - Reduce Screen Space
 - Reduce Errors
- Popup and Gestural Types
 - Marking menus
 - Hotboxes
 - Control menus
 - Flow menus
 - FaST sliders
- Typically not incorporated in interactive graph layout



Marking Menus

The Limits Of Expert Performance Using Hierarchic Marking Menus

Gordon Kurtenbach and William Buxton

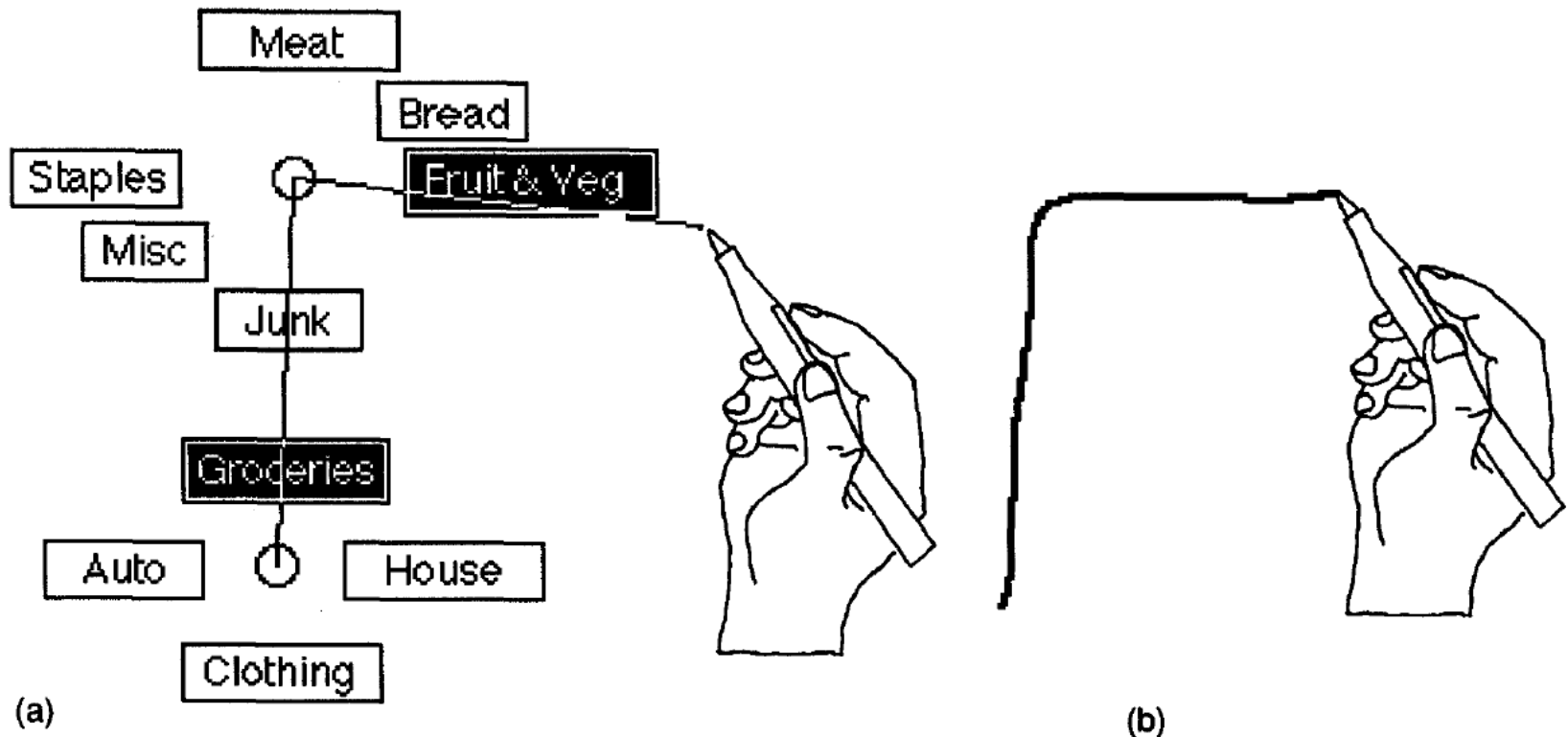


Figure 1. Hierarchic marking menus can be selected from using two different methods. Using method (a), radial menus can be sequentially displayed and selections made. Method (b) uses a marking to make the same selection. Method (a) is good when the user is unfamiliar with the menu. Method (b) is good when the user is familiar with the menu and wants to avoid waiting for the display of each menu.

Hotboxes

- Original hotbox (1999)



Figure 1: Maya application with Hotbox widget in the center

The Hotbox: Efficient Access to a Large Number of Menu-items

*Gordon Kurtenbach, George W. Fitzmaurice, Russell N. Owen and Thomas Baudel**

Control Menus

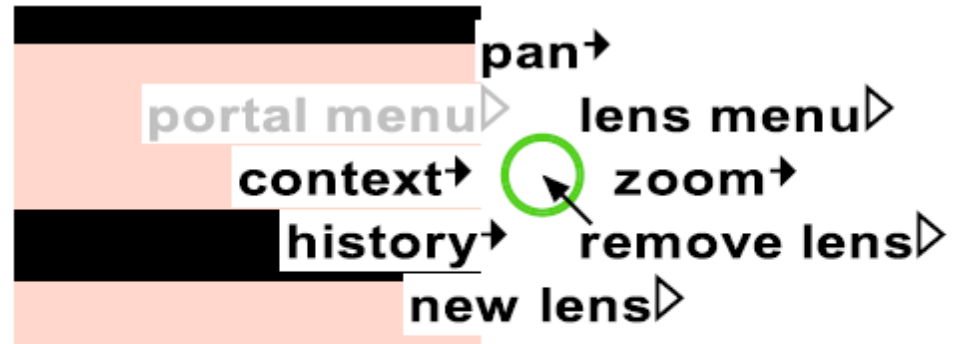


Figure 1: the control menu in our ZUI

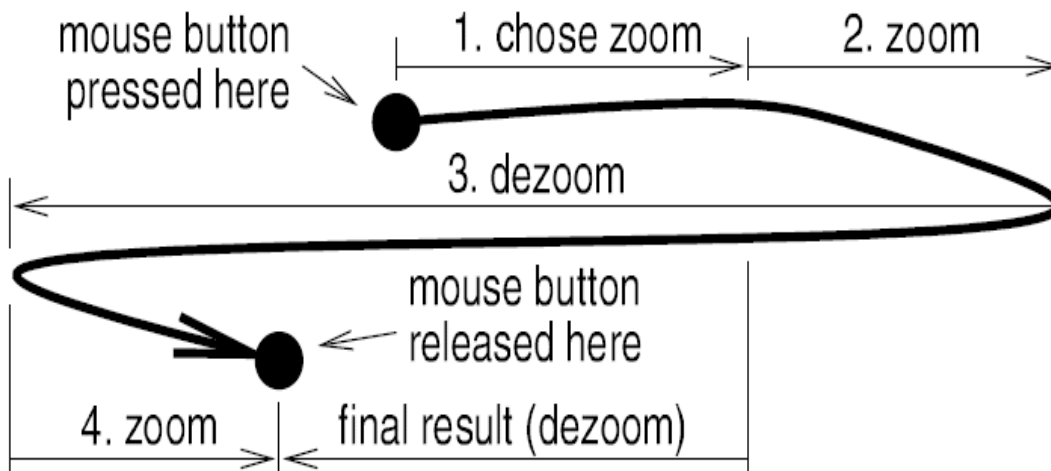


Figure 2: zooming with a control menu

Control Menus: Execution and Control in a Single Interactor

Flow Menu

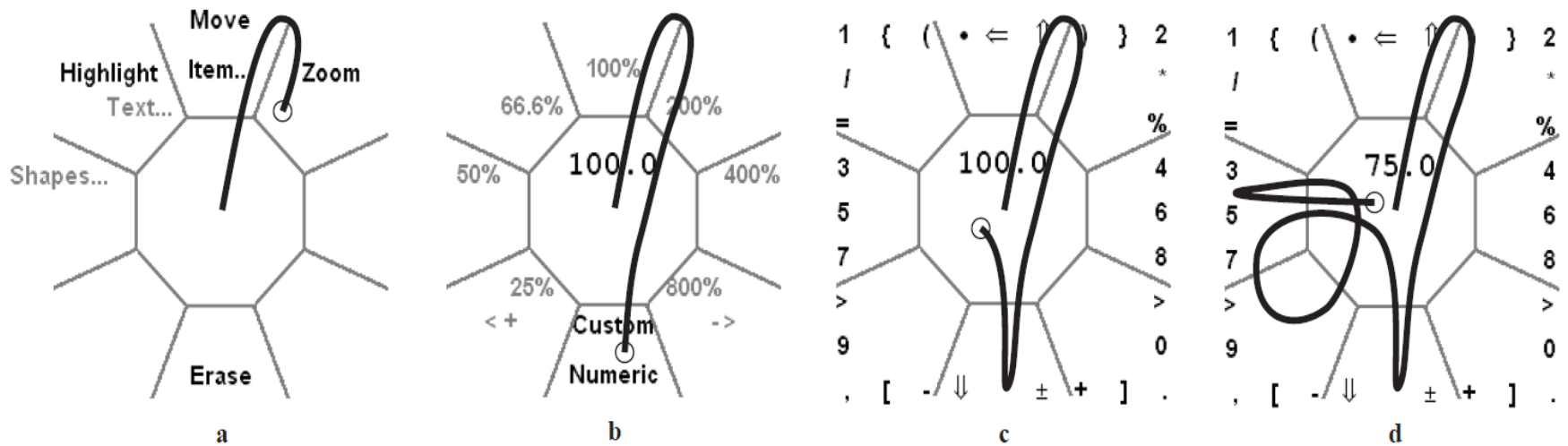


Figure 2: After selecting *Item...* → *Zoom* from the root menu (a), the user selects *Numeric* to enter the new zoom value as a sequence of digits (b). The zoom menu is dismissed and the Quikwriting system is brought up (c) so that she can enter the zoom value (d).

FlowMenu: Combining Command, Text, and Data Entry

FaST Sliders

FaST Sliders: Integrating Marking Menus and the Adjustment of Continuous Values

Michael McGuffin², Nicolas Burtnyk², and Gordon Kurtenbach^{1,2}

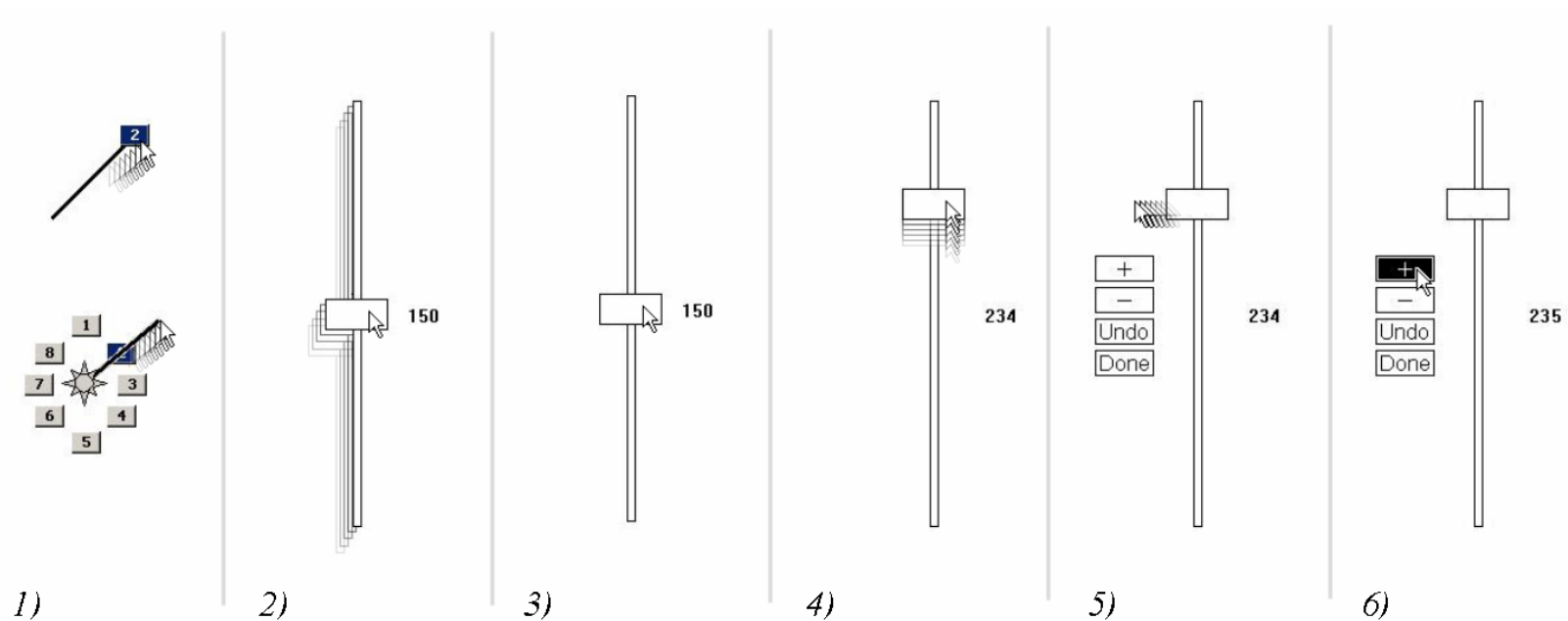


Figure 2: FaST Slider interaction 1) The user does a drag-release using either a menu or a quick “flick” gesture. This displays a slider. 2) With the mouse button released the entire slider follows the cursor. 3) When the mouse button is pressed the slider is “glued” to the screen. 4) Dragging adjusts the wiper (releasing at this point would dismiss the slider). 5) Dragging perpendicular to the slider posts the slider and some additional controls 6) these controls can then be used. Clicking on “Done” completes the interaction.

NAVIGATOR

- Network Analysis, Visualization, & Graphing TORonto
- <http://ophid.utoronto.ca/navigator/index.htm>
1

NAViGaTOR

- Network Analysis, Visualization, & Graphing TORonto
- Nodes usually represent proteins, edges are interactions
- Usually hundreds to ten thousands of nodes
- Force directed methods to establish initial layout
 - User can optionally fix a node into place (works simultaneously with force directed)
- Graphical attributes of edges and nodes
 - Label, shape, color, opacity
 - Modified manually or automatically based on associated metadata

Function Types

- Selection
- Commands
 - Perform operations
- Global

Selection Functions

- Select and deselect nodes
- Rectangle and lasso selection
- Select subgraph using edge connectivity

Command Functions

- Change shape
- Adjust opacity
- Show/hide labels
- Fix/unfix node positions
- Adjust force parameter and weights
- Collapse/expand metanodes
- Delete

Layout Commands

- Linearize or circularize nodes
 - Precede with a command to fix
 - Linearize
 - Fits a straight line through the initial points
 - Nodes are projected onto the straight line
 - Nodes are shifted to be evenly spaced
 - Circularize
 - The centroid of the initial position is the center of the node
 - The radius of the circle is the average distance from the centroid and initial positions
 - Nodes mapped to circle and then evenly spaced
 - Can then apply combinations of translations, scalings, rotations while preserving layout

Global

- Select/deselect all
- Invert selection
- Turn force directed on/off
- Undo

While Adding Functions

- Temptation to add
 - Menu items
 - Short cuts
 - Modes
- HCI Rule of Thumb
 - Avoid Persistence Modes
 - Modes involving no kinesthetic feedback or little visual feedback

Modeless Interfaces

- Only have transient modes
 - modes with strong visual or kinesthetic feedback that user is in a special temporary mode
- Original NAViGaTOR
 - Used shortcut keys + mouse button to invoke transient modes
 - Only useful to experts
 - Does not scale up
- Improved NAViGaTOR
 - Desires fast access and scalability
 - Avoids persistent modes, using menus and panels

Solution

- Popup widgets
 - Invoked with holding down key or button
 - Do not use screen space when not in use
 - Bring interface to user
 - “Object oriented manner”
 - Selected data “noun” and command “verb”
 - Enable fast gestural input and occasionally allow 1D and 2D arguments
 - Scale up with hundred of commands
- <http://profs.logti.etsmtl.ca/mmcguffin/research/hotterBox/>

Selection Techniques

- Selecting a subgraph of nodes
 - Rectangle vs. lasso
 - Combining and eliminate two different modes
 - During dragging, system tracks the length of drag vs the change in distance between starting location and ending location
 - If ratio exceeds threshold (2.5), interpret as mostly closed and lasso else interpreted as diagonal of rectangle
 - Adding to selection
 - Removing from selection
 - Selecting only nodes
 - Must use cancel if done accidentally

Selection

- Selecting a single node
 - Toggle node
 - Default action
 - Must use the cancel to prevent if done accidentally
 - Select only single node
- Selection based on connectivity
 - Selecting neighborhood with radius N
 - Selecting Connected Component
 - When the neighborhood and component are the same, options co-highlight (co-highlight)

Selection with Radial Menus

- Radial menus and marking menus (equivalent when one level deep)
 - Selected ballistically with rapid flicking motions
 - Only need to flick within forty five degrees of sector
 - Advantage: Faster than linear menus
 - Disadvantage: can have small labels
 - Neighborhood selector requires that you stop on label
 - Same as a 1D slider that has the advantage of appearing at the most click cursor location
- All is implemented with one button on the mouse
 - Click on whitespace: lasso/rectangle selection
 - Click on node: node specific menu

Commands with Hotboxes

- Original hotbox popped up when holding space bar
 - Mouse used to select labels and popup smaller menus
 - Release of spacebar, closes hotbox
 - Pop ups centered at cursor, allow memorization of relative movements
 - Scales up

Commands with Hotboxes

- Implementation contains
 - Push buttons
 - Checkbox items
 - 1D and 2D “sliders”
 - Allow user to press down on and drag to specify arguments
 - No slider “wiper”, show feedback by changing the network
 - About 30 commands
 - No submenus, but easy to incorporate
 - Ctrl is the non preferred hand keyboard key

Sliders

- Move (2D)
 - 2D slider at the center of hotbox because it pops up at cursor location
 - Default option
- Scale and rotate (2D)
 - 2D slider that
 - Uniform Scales around centroid in response to vertical dragging
 - Rotates around centroid by horizontal dragging
- Scale (2D)
 - Non-uniform scaling
- Move and rotate (2D)
 - Allows nodes to be translated and rotated around centroid
- Opacity (1D)
- Per-node force-parameter (1D)
- Hotbox opacity (1D)

Buttons and Checkboxes

- Checkbox to turn on or off tooltips
- Buttons for the labels and shapes
- Buttons for global operations
- Buttons for selection
 - Grow or shrink by one edge
 - Not reversible actions
- Buttons of layout patterns
 - Fix before circularize
 - Concentric circles
 - Nodes are circularized
 - As drag to right, additional circles of nodes 1, 2, or more edges are added
 - Can reverse by dragging to the left

Shortcuts and Features

- Activation circle shortcut for the two most common commands
- Ctrl + click...
 - inside activation circle
 - on node selection moves one node
 - on white space section moves all selected nodes
 - outside activation circle
 - Hotbox
- Hotbox commands can be performed in succession without releasing ctrl

Globals

- White space click with no drag
 - Follows until user presses second time
 - Allows user to reposition if necessary
 - Also creates a visual cue that there are in a special mode
 - Then locks in place and interprets drag

Summary of Operations

Left-press-release on node: toggle selection state of node
Left-press on node: popup node-specific radial menu (then drag-release to select item, or release in centre of menu to select default item)
Left-press-release on whitespace: popup global radial menu (then press-drag-release to select item, or press-release in centre of menu to select default item)
Left-press-drag on whitespace: rectangle/lasso selection (then release to complete)
Ctrl-Left-press-drag on node: select and move one node (other nodes already selected remain selected but are not affected)
Ctrl-Left-press-drag on whitespace: move all selected nodes
Ctrl-move: popup hotbox

Table 1. Seven key actions in the new user interface. Only one mouse button, and one keyboard key, are used. The first four use all combinations of {press-release, press-drag} \times {on whitespace, on a node}.

Building Selections

- One by one selection with ctrl is problematic when invalid selection deselects all
- Need set operations when dealing with large network with thousands of objects
 - Add to current selection ($S \leftarrow S \cup S'$)
 - Deselect this ($S \leftarrow S \setminus S'$)
 - Select this only ($S \leftarrow S'$)
- Hotbox the maintenance of the selection while moving only a single element of it

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Command Diagram

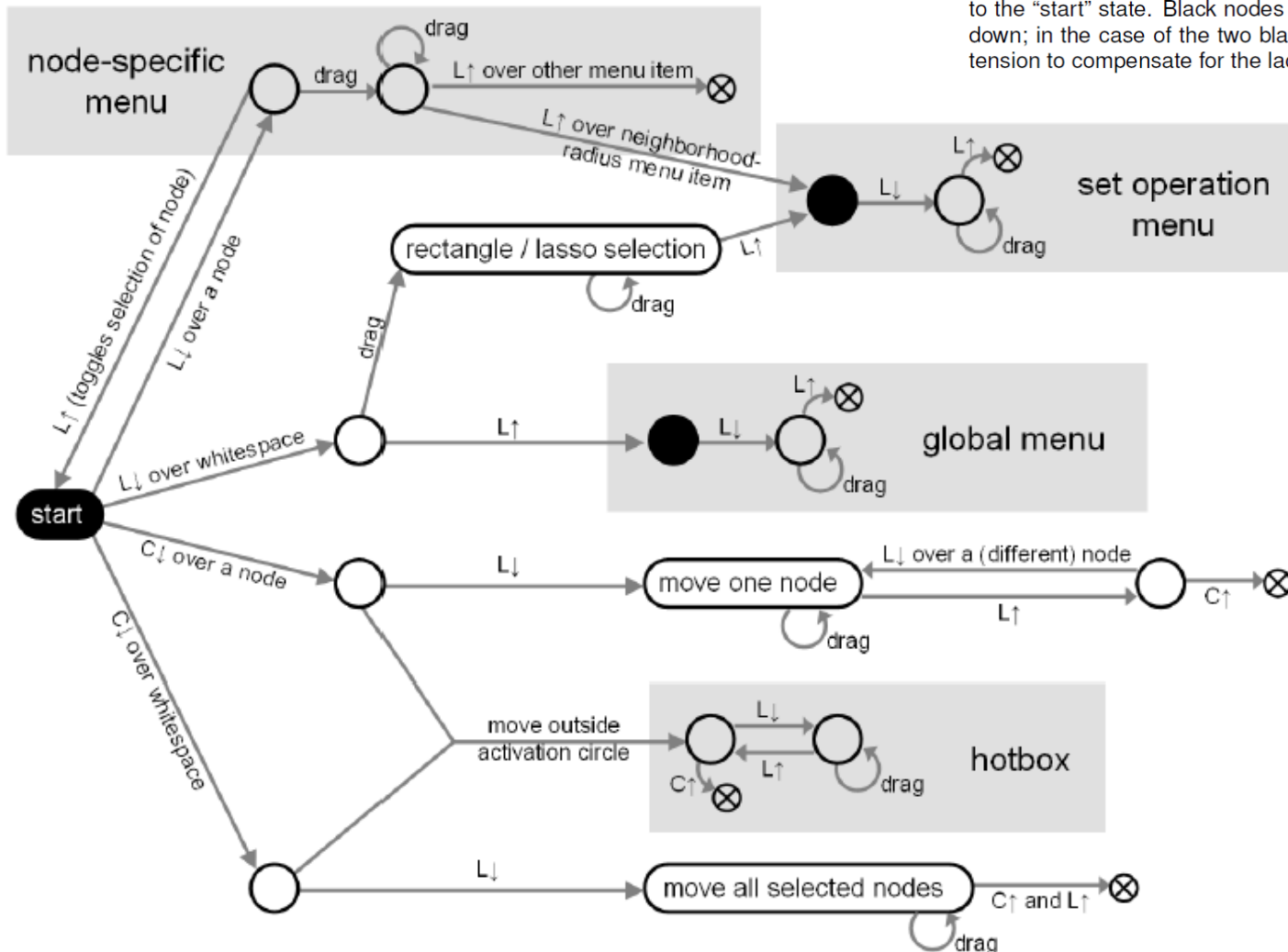


Fig. 9. A state-transition diagram of the integrated set of interaction techniques. L and C refer to the Left mouse button and the Ctrl key, respectively, and the symbols \downarrow and \uparrow refer to press and release events. The shaded rectangles correspond to the hotbox and each of the radial menus. The terminal state symbol \otimes simply means that the user returns to the "start" state. Black nodes are where neither button is being held down; in the case of the two black nodes within menus, there is visual tension to compensate for the lack of kinesthetic tension.

Novelty

- 1D and 2D sliders in Hotbox with immediate effect shown
- Use of linear menu items in radial menu for controlling discrete parameters
- Default of radial menu associated with center
- Co-highlighting of equivalent operations

Discussion of Other Options

- Considered bimanual input methods with two pointing device, but not widely accessible
- Hotbox is “Poor man’s ” bimanual interface since Non-preferred hand is requires kinesthetic feedback (avoids persistent modes)
- Multiple clicks in drags preferable to single drag flowmenu pig tails because precise cursor position required in large graphs for selection

Extensions

- Although everything is two keys, can implement Ctrl-A or Ctrl-D
- New commands
 - Panning, zooming
 - Intersection and symmetric difference
 - Additional layout patterns
 - Add undo
 - Many others...

User Testing

- 8 testers
- 1 regular user of NAViGaTOR
 - Pre-Questionnaire
 - Discovery phase
 - 5 minutes of discovery using only Ctrl and left mouse button
 - No one found all 7 actions
 - Instructional phase
 - Instruction on how to perform the 7 actions



User Testing

▫ Layout Tasks

- 6 layout tasks

- Given a network (size 30-111 nodes) of 4 connected components and a final layout and asked to reproduce it
- Given many hints for first two tasks
- Allowed to ask questions on later ones
- Corrected if grossly inefficient (e.g. moving nodes one by one)

- Not all users completed all six due to time constraints

▫ Post-questionnaire



Tasks #3 and #4

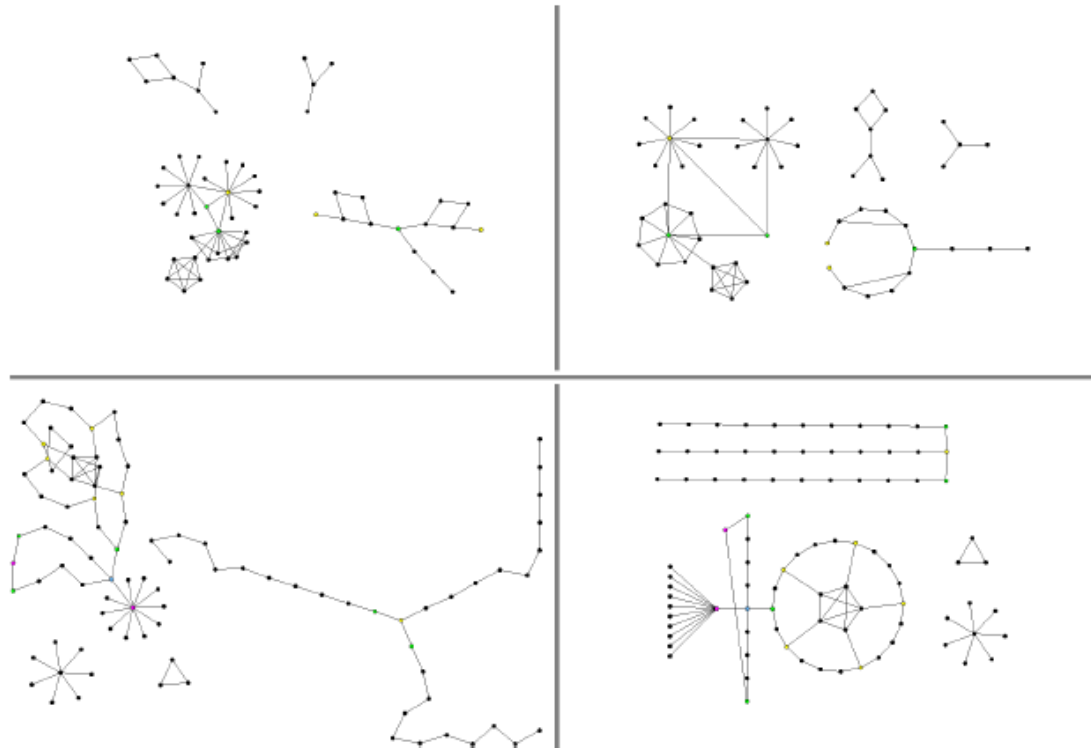


Fig. 11. *Upper and lower left*: initial layout of the network in tasks #3 and #4, respectively, as determined by force-directed layout. *Upper and lower right*: target layout that users had to achieve, in the same tasks.

Results



- Interface somewhat intuitive
- Instructional phase took 15-45 minutes
- 15 minutes for first two tasks
- 20 to 50 minutes to perform tasks 3 and 4
- Hardest aspect is remembering how to operate interface
- Tasks were also inherently difficult
- Overall received generally positive reviews and comment ~4.1/5