Eye Tracking Metrics and Studies

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User Study Performance Measures

- Response times
- Error rates

→ Typically statistically evaluated
→ Hypotheses confirmed/rejected
Eye Tracking Metrics

- Gaze points
- Fixations
- Gazes
- Areas of Interest
- Saccades
- Transitions
- Scanpaths

→ Inherent spatio-temporal nature
Eye Tracking Metrics

- Gaze points are spatially and temporally aggregated into fixations.
Eye Tracking Metrics

- Fixations are connected by saccades and have a certain duration represented by the radius.
Eye Tracking Metrics

- A temporal order of fixations is a gaze, however, only if the fixations are within an AOI.
Eye Tracking Metrics

- An AOI is a region of specific interest on the stimulus.
Eye Tracking Metrics

- A saccade from one AOI to the next is called a transition.
Eye Tracking Metrics

- A complete sequence of fixations and saccades is called a scanpath.
Eye Tracking Metrics

- Space and time dimensions make statistical evaluation of the data more complicated
Three Eye Tracking Studies

- Michael Burch, Julian Heinrich, Natalia Konevtsova, Markus Höferlin, and Daniel Weiskopf. Evaluation of Traditional, Orthogonal, and Radial Tree Diagrams by an Eye Tracking Study. IEEE VIS 2011
- Rudolf Netzel, Michael Burch, and Daniel Weiskopf. Comparative Eye Tracking Study on Node-Link Visualizations of Trajectories. IEEE VIS 2014
Node-Link Tree Diagrams

- Michael Burch, Julian Heinrich, Natalia Konevtsova, Markus Höferlin, and Daniel Weiskopf. Evaluation of Traditional, Orthogonal, and Radial Tree Diagrams by an Eye Tracking Study
IEEE VIS 2011

Goal

Understand how people read node-link tree diagrams
Node-Link Tree Diagrams

- Stimuli: Traditional, orthogonal, and radial node-link tree diagrams
Node-Link Tree Diagrams

- Stimuli: Traditional, orthogonal, and radial node-link tree diagrams
- Independent variables: Layout and orientation, Number of highlighted leaf nodes
Node-Link Tree Diagrams

- Stimuli: Traditional, orthogonal, and radial node-link tree diagrams
- Independent variables: Layout and orientation, Number of highlighted leaf nodes
- Task: Find the least common ancestor in the displayed tree
Results on completion times and error rates

- Significant effect of diagram orientation on completion times by post-hoc pairwise t-test between l/b, l/t, r/b, r/t
- Significant effect of tree layout on completion times by pairwise t-test between radial and non-radial
- Significant effect of number of highlighted leaf nodes on completion time by pairwise t-test between 3 and 9
Node-Link Tree Diagrams

- Results on reading strategies
Node-Link Tree Diagrams

- Results on reading strategies
Node-Link Tree Diagrams

- Results on reading strategies

- Cross checking behavior in the radial diagrams
- Twice as long until confirmation of task solution
- Clearer visual task solution strategies in non-radial diagrams
Metro Maps

- Michael Burch, Kuno Kurzhals, and Daniel Weiskopf
  Visual Task Solution Strategies in Public Transport Maps
  Eye Tracking for Spatial Research 2014

Goal

Understand how people read metro maps
Metro Maps

- Stimuli: Public transport maps/Metro maps
- Independent variables: Map complexities/station highlights
- Task: Find a route from a start to a destination station
Metro Maps

- Results on completion times and error rates
Metro Maps

- Results on reading strategies
Metro Maps

- Identified visual task solution strategy
  - 1.) Searching and locating start and destination stations
  - 2.) Finding a geodesic path between start and destination stations
  - 3.) Building a set of possible metro lines
  - 4.) Estimating possible interchange points
  - 5.) Partially solving the route finding task between interchange points
  - 6.) Cross checking the complete found route
Trajectory Visualizations

- Rudolf Netzel, Michael Burch, and Daniel Weiskopf
  Comparative Eye Tracking Study on Node-Link Visualizations of Trajectories
  IEEE VIS 2014

Goal

Understand how people read trajectory visualizations
Trajectory Visualizations

- Stimuli: Node-link diagrams from movement ecology
- Independent variables: Standard arrow, tapered, equidistant arrows, equidistant comets
- Tasks: (1) Follow path, (2) Longest link, (3) Number of nodes in clusters

(a) standard arrows  
(b) tapered links  
(c) equidistant arrows  
(d) equidistant comets
Trajectory Visualizations

- Results on completion times and error rates

Task 1

(a) Average time

(b) Average correctness
Trajectory Visualizations

- Results on completion times and error rates

Task 1

![Chart showing average completion times and correctness for different visualizations. The chart compares Arrows (A), Equid. Arrows (EA), Cornets (C), and Tapered (T).]
Trajectory Visualizations

- Results on reading strategies and eye tracking metrics

Task 1

(a) Average fixation duration

(b) Average saccade length
Trajectory Visualizations

- Results on reading strategies and eye tracking metrics

Task 1

![Diagram showing trajectory visualizations with data points and error bars for different conditions: Comets (C), Tapered (T), Equid. Arrows (EA), and Arrows (A). The x-axis represents average saccade length (pixels), and the y-axis represents average fixation duration (ms).]
Major result of the eye tracking study

- Tapered link style performed well for the tasks with respect to
  - error rates and completion times
  - eye tracking metrics saccade lengths and fixation durations
Challenges in Eye Tracking Studies

- Eye movement data has a spatio-temporal nature
- Finding visual task solution strategies is difficult
  - Even more complicated for dynamic stimuli
  - Combination/aggregation of several stimuli problematic
- Visual Analytics may be a useful concept
  - Combination of algorithms, visualization, and the human user
  - We need more eye tracking studies to understand problems
Literature


