

Difference Map Readability for Dynamic Graphs

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Outline

- Introduction
- Previous Work
- Experiment
- Results
- Conclusion and Future Work

Research Questions

- User study for difference maps across interfaces
 - animation, slide show, and small multiples
- Primary research question:
 - 1 Do difference maps help improve the readability of dynamic graphs?
- Secondary research question:
 - 1 Under what interface do they help the most?

What are Dynamic Graphs?

K. Boitmanis et al., Visualizing Internet Evolution on the Autonomous Systems Level. (GD '07)

- Graph series that evolves over time
- Each snapshot of the graph at a given time is a **timeslice**
- Quite frequently shown as an **animation** in graph drawing

What is a Slide Show Approach?

- Like a PowerPoint presentation
- No smooth interpolation between frames

What is a Small Multiples Approach?

MainWindow

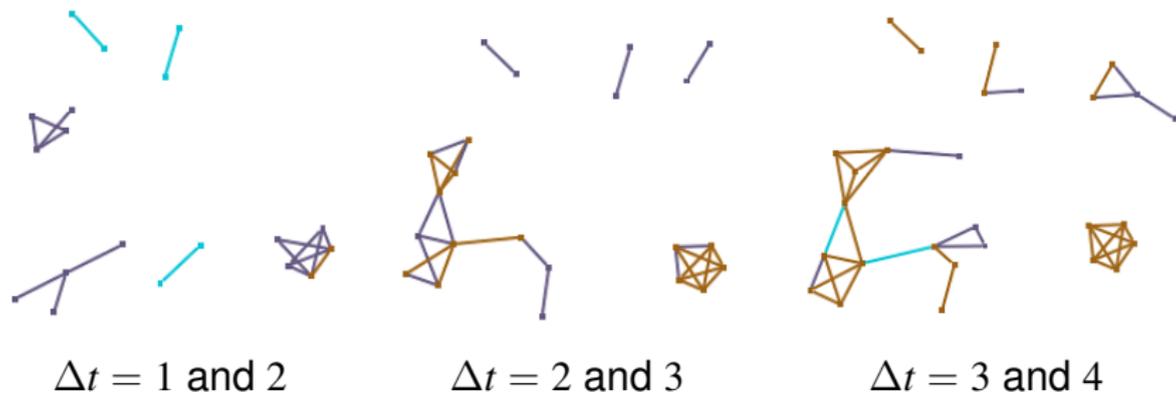
In this data set, does the **number of edges** increase, decrease, remain constant, or fluctuate?

increase
 decrease
 constant
 fluctuate

Submit Answer

- Each timeslice in its own window and scan windows for evolution
- Not all that prevalent for dynamic graph drawing

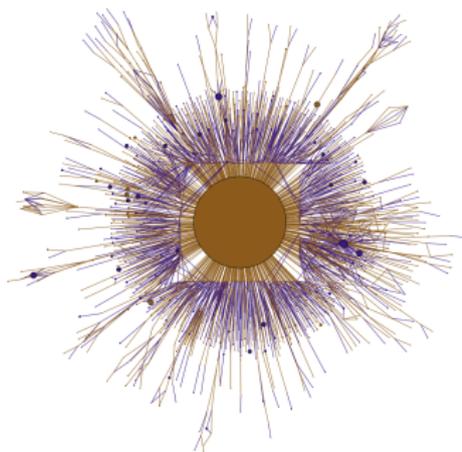
What is a Difference Map?



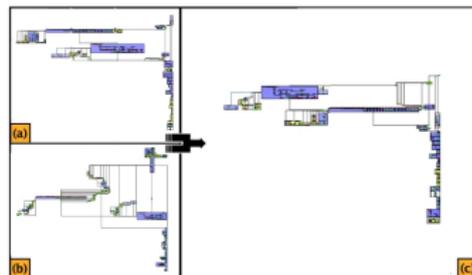
Archambault 2009

- Union of each pair of adjacent timeslices
- Colour nodes by addition, use small multiples
- Is this interface effective?

Previous Work Uses Difference Maps



(a) Archambault 2009



(b) Bourqui and Jourdan 2008

- Mostly small multiples used for difference maps
- Show difference between graphs/timeslices using colour and position

Mental Map Preservation Techniques and Experiments

- Extensive research in mental map preservation
 - Moen '90, Cohen *et al.* '92, Brandes *et al.* '97, Diehl *et al.* '02
 - Görg *et al.* '04, **Erten et al.** '03, Frishman and Tal '08
 - Boitmanis *et al.* '07
- Many experiments to test readability
 - Purchase *et al.* '06 and '08, Saffrey *et al.* '08, Archambault *et al.* '10
- Mental map controlled in experiment
 - our implementation of GraphAEL algorithm with low mental map

Animation and Small Multiples for Data Visualization

- Animation vs small multiples for dynamic data
 - Griffen *et al.* 2006
 - field of coloured hexagons
 - animation is both faster and more accurate
 - Robertson *et al.* 2008
 - animated scatter plots
 - small multiples is significantly faster and more accurate
- What about for graphs?
 - Archambault *et al.* 2010 TVCG
 - small multiples significantly faster
 - animation significantly more accurate on appearance
 - Farrugia *et al.* 2010 InfoVis Journal
 - small multiples significantly faster
- Results seem to depend strongly on data type

Experiment Outline

- Two research questions:
 - 1 Do difference maps help improve the readability of dynamic graphs?
 - 2 Under what interface do they help the most?
- Test three interfaces
 - animation, slide show, and small multiples
- On two data sets
 - `threads2` and `van de Bunt`
- Four questions that are both local and global

Data Sets

- `threads2`, Frishman and Tal 2008
 - network of users on newsgroup
 - edge if one replies to another's post
 - network only grows as no posts deleted
 - average 70 nodes and 83 edges
- van de Bunt, van Duijn *et al.* 2003
 - social network of undergraduate dorm
 - edge is a friend relationship
 - network fluctuates in size
 - average 23 nodes and 32 edges

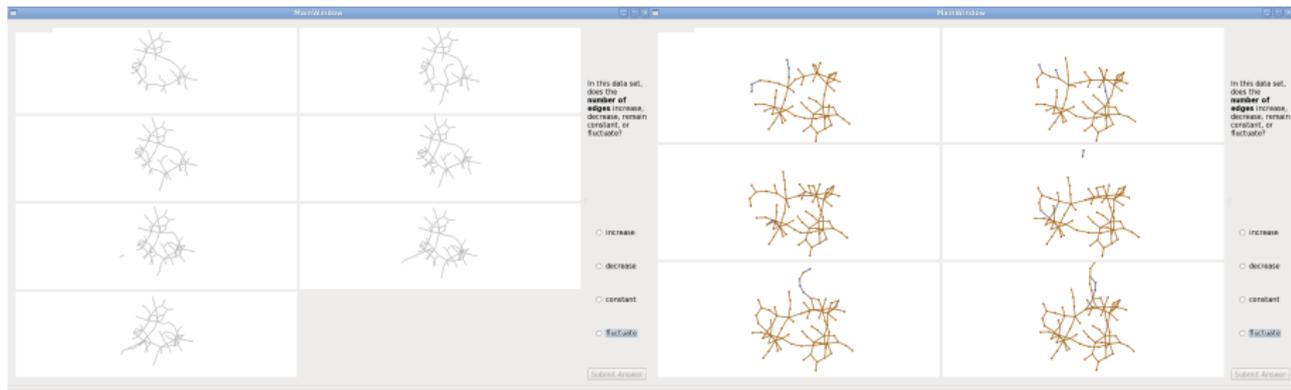
Animation

- Animation interface just like a movie player
- Added/removed edges are faded in/out
- Node positions smoothly interpolated
- Control through slider or watch movie

Slide Show

- Slide show interface just like a PowerPoint presentation
- No smooth transitions between frames
- Arrow keys advance from one frame to the next
- Bottom of screen indicates frame number and total frames

Small Multiples



- Each timeslice in its own window
- No transitions between time steps at all
- User scans the windows to read the dynamic graph series

Question 1: Degree

- A local, topology-based question
- Which vertex **increases** its **degree** over time?

Question 2: Appearance

- Local question related to dynamism
- Which **edges** appear together **exactly once** over all timeslices?

Question 3: Number of Edges

In this data set, does the **number of edges** increase, decrease, remain constant, or fluctuate?

increase
 decrease
 constant
 fluctuate

Submit Answer

- Global question related to dynamism
- In this data set, does the **number of edges** increase, decrease, remain constant, or fluctuate?

Question 4: Paths

- Global, topology-based question
- When a path exists between the black node and a node of each of the four colours, which path **only decreases** in length?

Do Difference Maps Help Overall?

- No significant difference overall
- Question 3: Number of Edges
 - difference map significantly more accurate than no difference map
 - no significant difference in response time

Question 2: Appearance

The screenshot shows a user interface for a multiple-choice question. It is divided into two main sections: 'Map 1 (small)' on the left and 'Map 2 (difference map)' on the right. Each section contains a 4x2 grid of map images. The question asks: "Which edges appear together exactly once over all trees?" Below the question are four radio button options: blue, red, grey, and yellow. A "Submit Answer" button is located at the bottom of each panel.

- Appearance question on small multiples
 - no difference map significantly faster than difference map
 - no significant difference in error rate
- Two colours in difference map case

Question 3: Number of Edges

In this data set, does the number of edges increase, decrease, remain constant, or fluctuate?

increase

decrease

constant

fluctuate

Submit Answer

In this data set, does the number of edges increase, decrease, remain constant, or fluctuate?

increase

decrease

constant

fluctuate

Submit Answer

- Number of edges on slide show and small multiples
 - difference map significantly more accurate than no difference map
 - no significant difference in response time
- No significant difference for animation response time/accuracy

Difference Maps Significantly Preferred

	Degree		Appearance		Number of Edges		Paths	
	ND	WD	ND	WD	ND	WD	ND	WD
Mean	12.96	8.08	11.16	9.64	13.40	7.40	12.04	8.96
Std. Deviation	2.61	2.63	2.93	3.15	2.50	2.58	3.27	3.27

WD - Difference Map, ND - No Difference Map

- Difference maps significantly preferred
 - questions degree, number of edges, and paths
- Users may be more confident with this representation

Conclusions

- 1 Do difference maps help improve the readability of dynamic graphs?
 - they help in determining trends in the number of edges
- 2 Under what interface do they help the most?
 - they help mostly under slide show and small multiples

Future Work

- Do cluster trees/graph hierarchies help in this setting?
- What about mental map preservation?
- Comparison tasks between static graphs.

Questions?