Uncertainty-Aware Visual Analytics

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Project Overview

- Two years (2008 – 2010)
- PI: Kwan-Liu Ma
- Participants:
  Dr. Carlos Correa, postdoctoral researcher
  Yu-Hsuan Chan & Tarik Crnovrsanin
    PhD students
- Research results include publications and software
- Participated in two VAST contests
- Press presence

Objectives

- Develop mathematical foundation for uncertainty quantification, propagation and aggregation in visual analysis
- Visual mapping of uncertainty to enable analysts to gain insight from the data with correct confidence level
- Support collaborative reasoning
  - Incorporating and conveying uncertainty
  - Increasing confidence level (i.e., certainty) with collective knowledge and findings

# A Framework for Uncertainty-Aware Visual Analysis
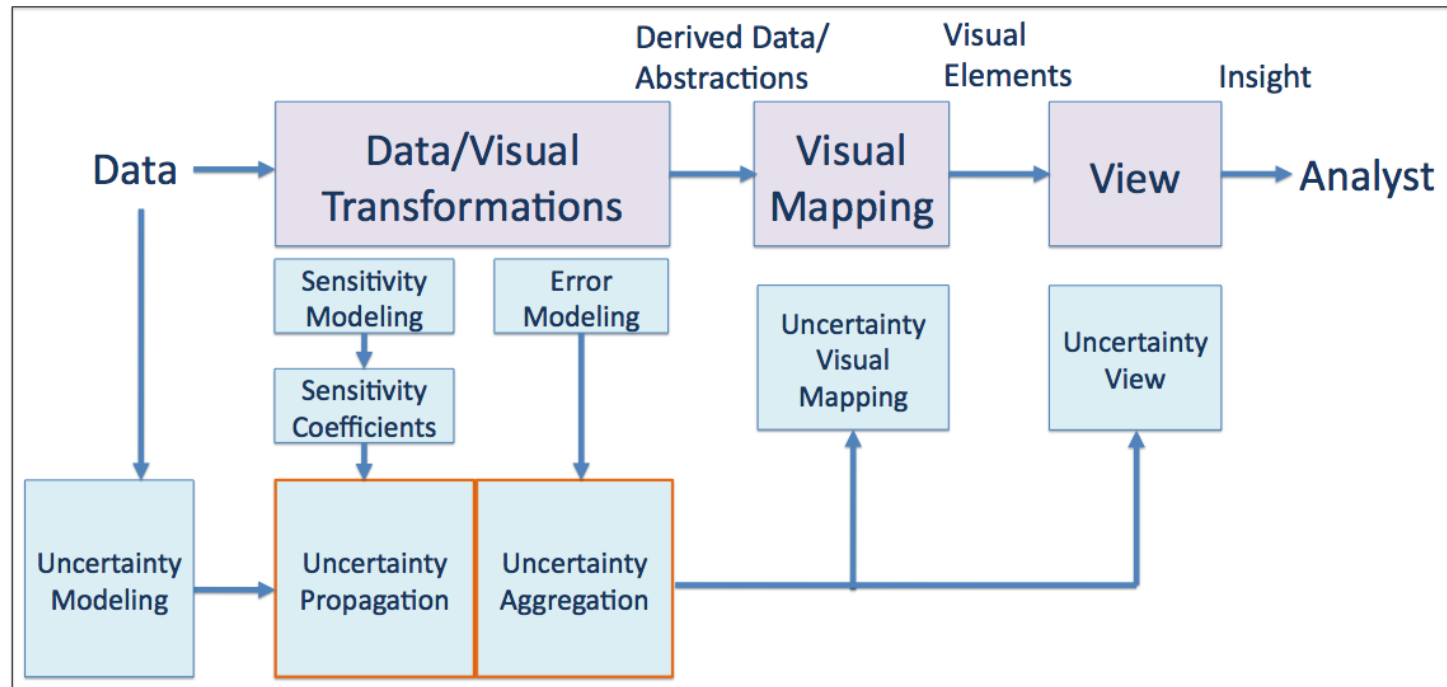
- Formalize the representation of uncertainty & basic operations
- Quantify, propagate, aggregate, and convey uncertainty introduced over a series of data transformations
- Enhance and evaluate visual reasoning in an uncertainty aware manner with this framework

Network Analysis using Centrality Sensitivity

- Analyze a network by studying its *sensitivity* and *stability* in terms of different centrality metrics
- Compute sensitivity as the derivative of the centrality function
- Visually reveal global distribution of influence, friendship and enmity
- Filter or simplify a network

  e.g., Centrality-preserving simplification

- Search and explore by navigating in the context of relative importance with respect to a selected node
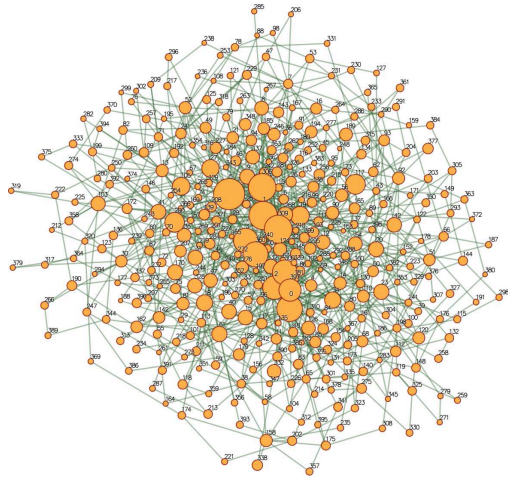
Network Characterization
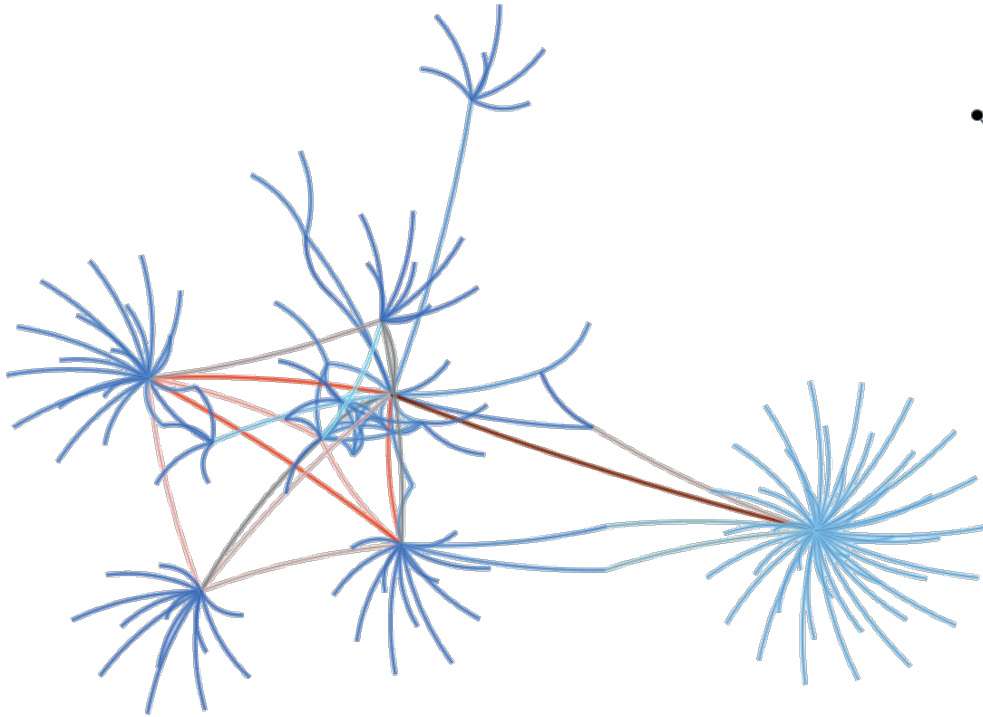
Friendster social network
Links exhibit negative sensitivity
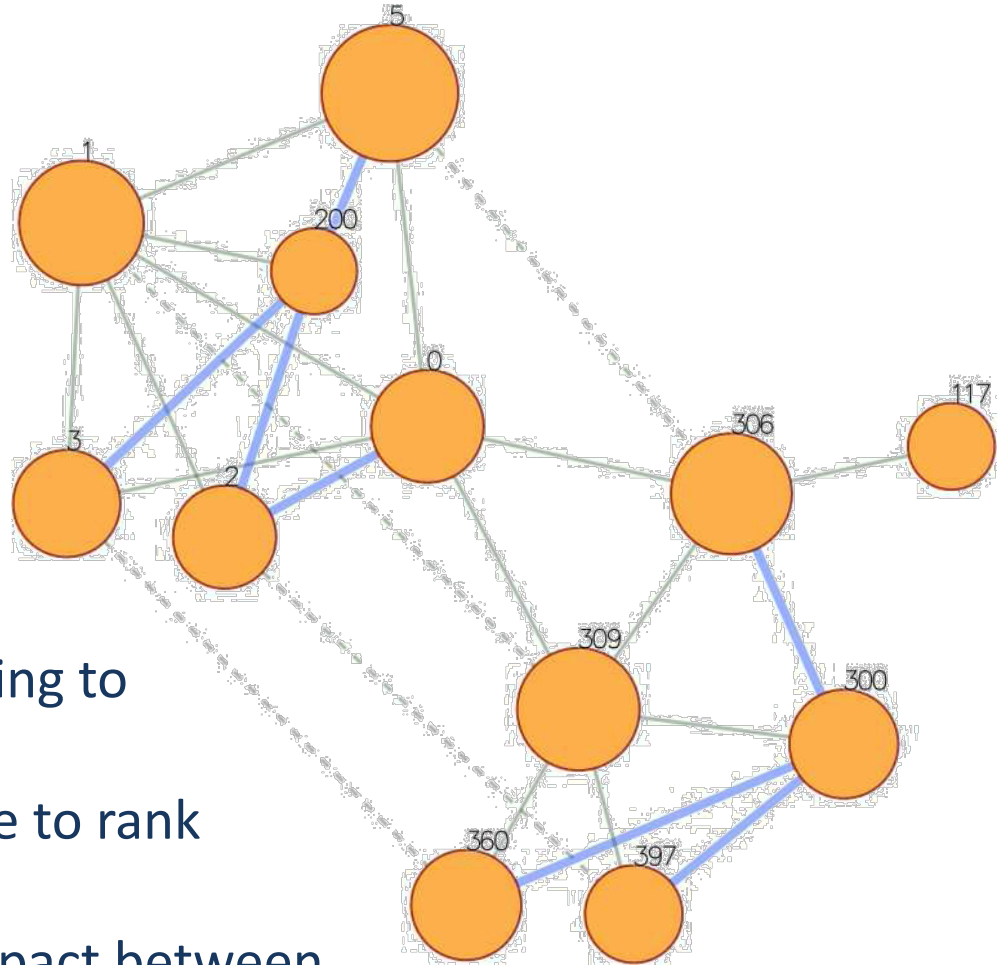between cluster centers
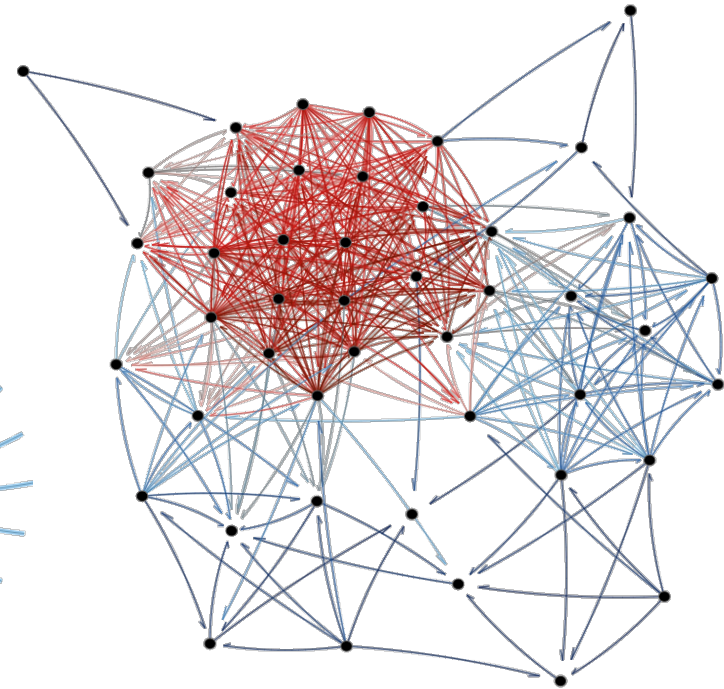
Astrophysics co-author network
One competitive network and
one collaborative network

Uncovering Hidden Relations

A VAST challenge dataset
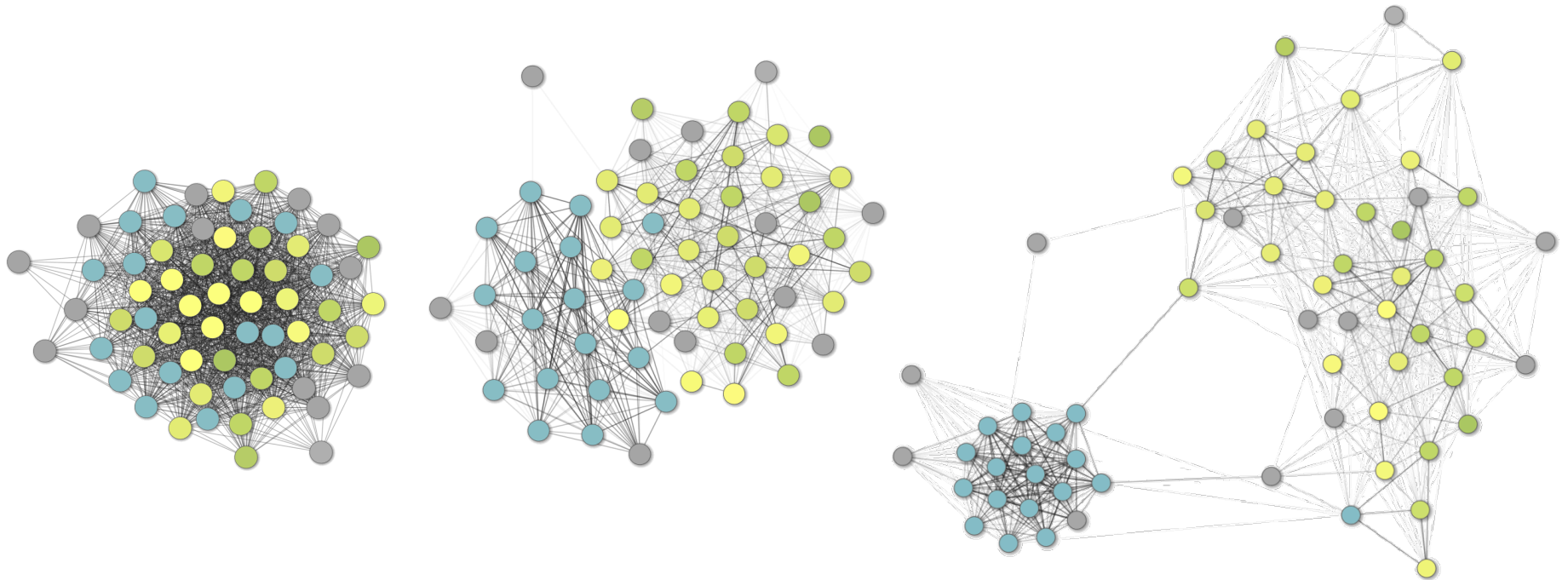400 cell phones

1. Nodes are filtered according to
   Markov importance
2. Sensitivity analysis is done to rank
   the edges
3. Identify strong mutual impact between
   unconnected nodes

Network Filtering/Simplification

MIT Reality dataset (Proximity)

Blue: Sloan school   Green: Media Lab   Gray: Unidentified
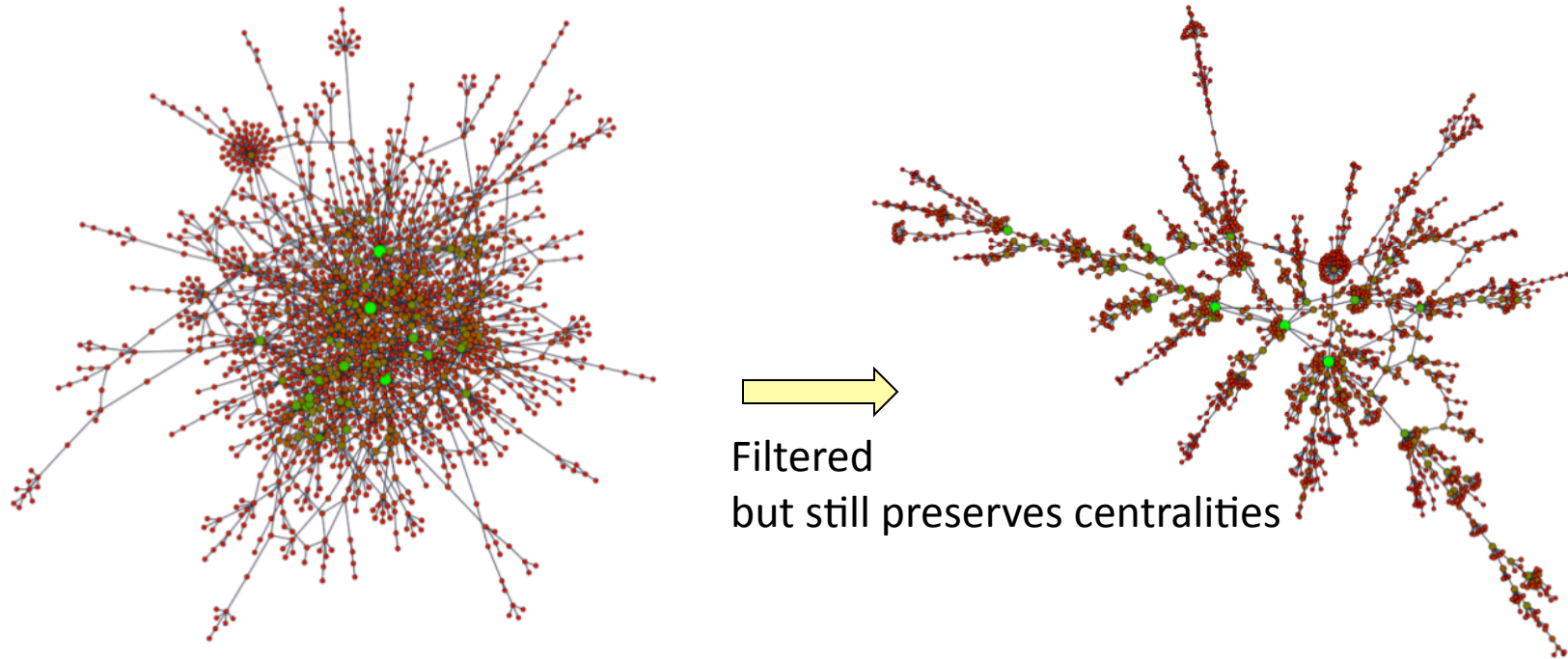

Force directed layout

with positive sensitivity

Filtered with sensitivity magnitude

Most users were in
close proximity to each other!!

Network Filtering/Simplification

Filtered
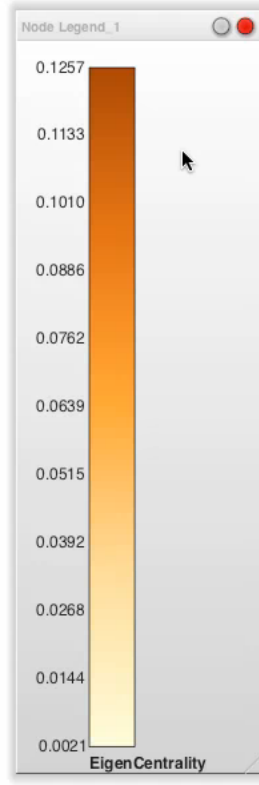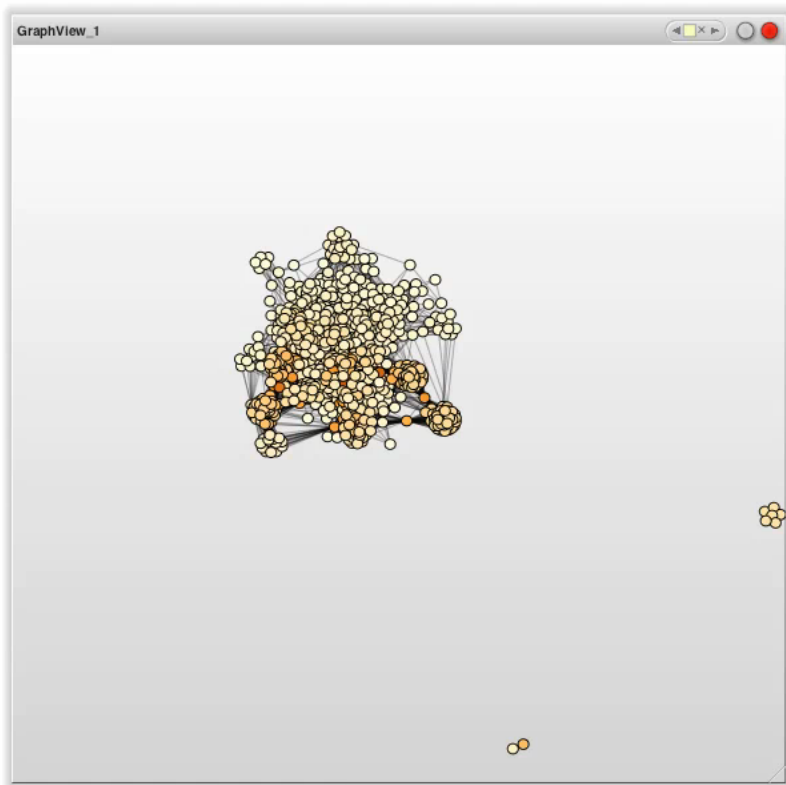but still preserves centralities

Network of protein-protein interaction (~1500 nodes)

1. Find the minimum spanning tree weighted by the derivatives
2. Add back a certain number of highly weighted edges to retrain a core network

***Validation: Nodes are central should remain central.

NetZen v0.1

Search :

GraphView_1

Node Legend_1

0.1257

0.1133

0.1010

0.0886

0.0762

0.0639

0.0515

0.0392

0.0268

0.0144

0.0021

EigenCentrality

Info   Inspector   Mapping   Analysis Tools   Layouts
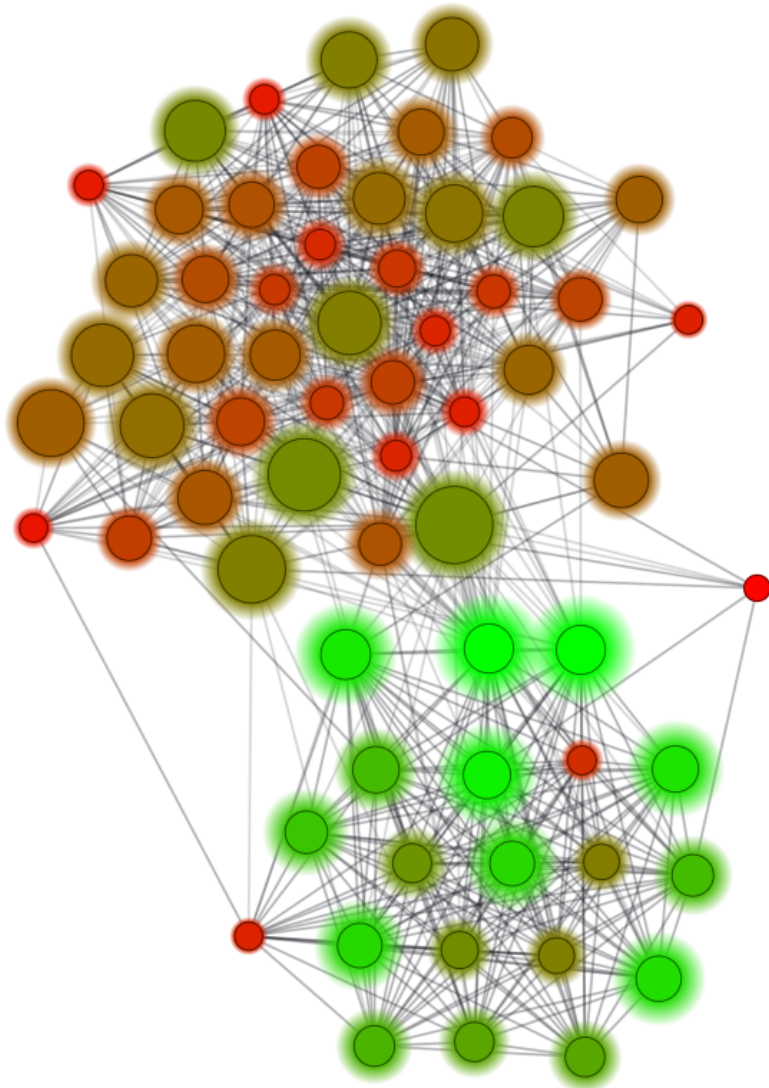
Summary

Sources:
...amples/astro/astroDerivs.nodes
...amples/astro/astroDerivs.edges

Num. nodes   955
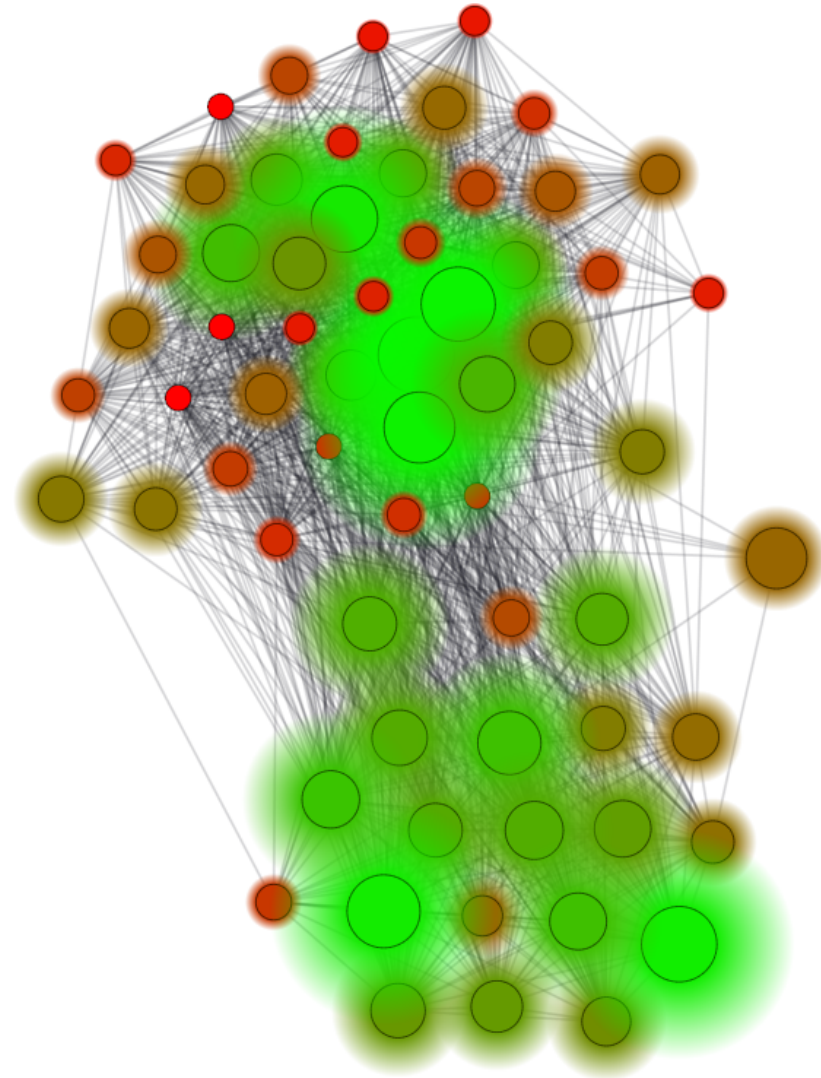**Num. edges**   75110

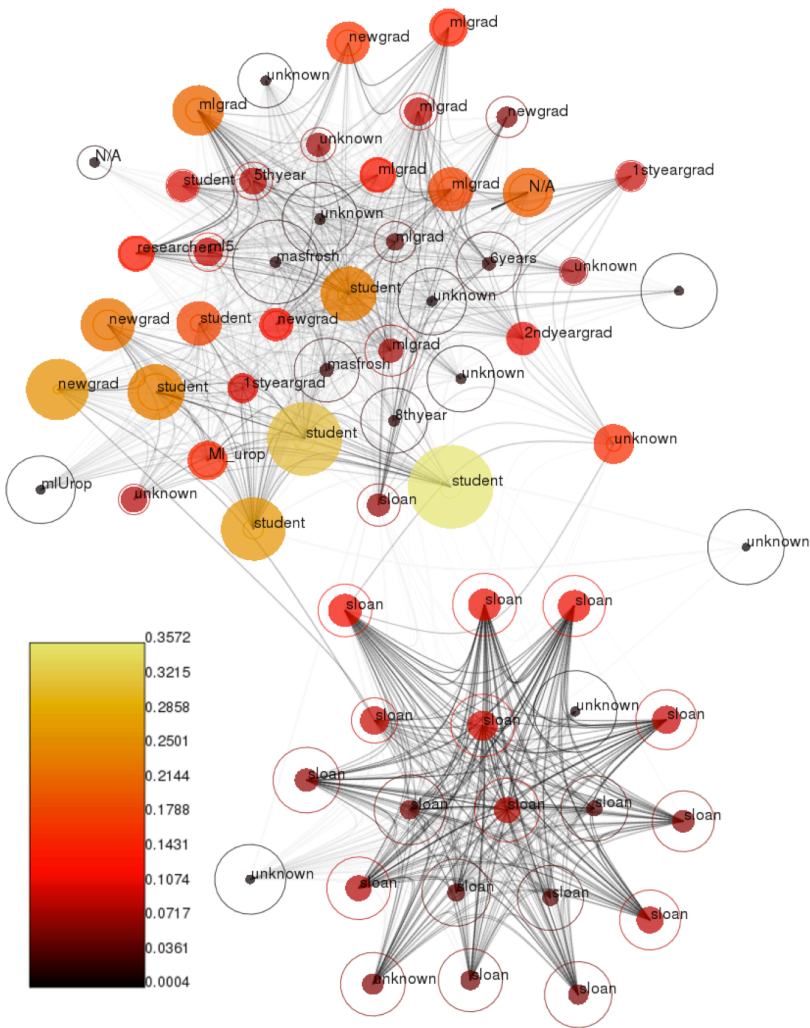NetZen v0.1

Visualizing Teen Aggression
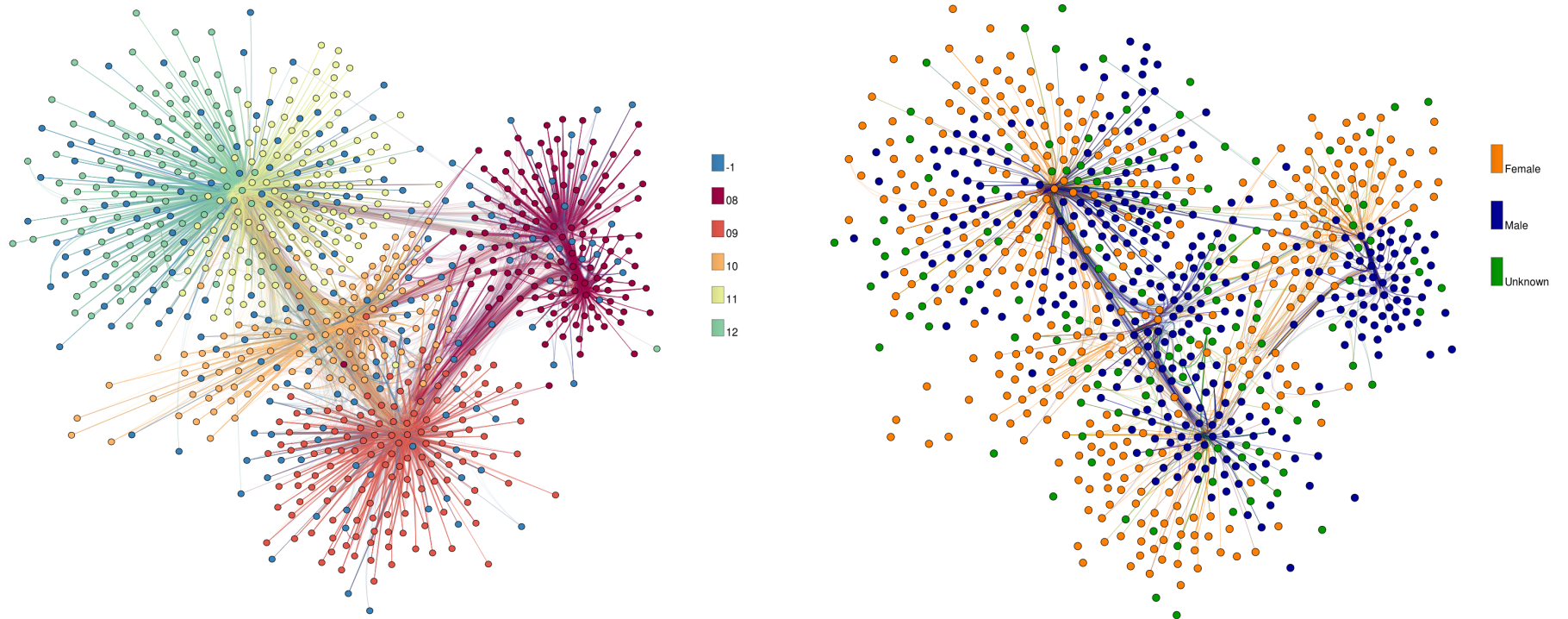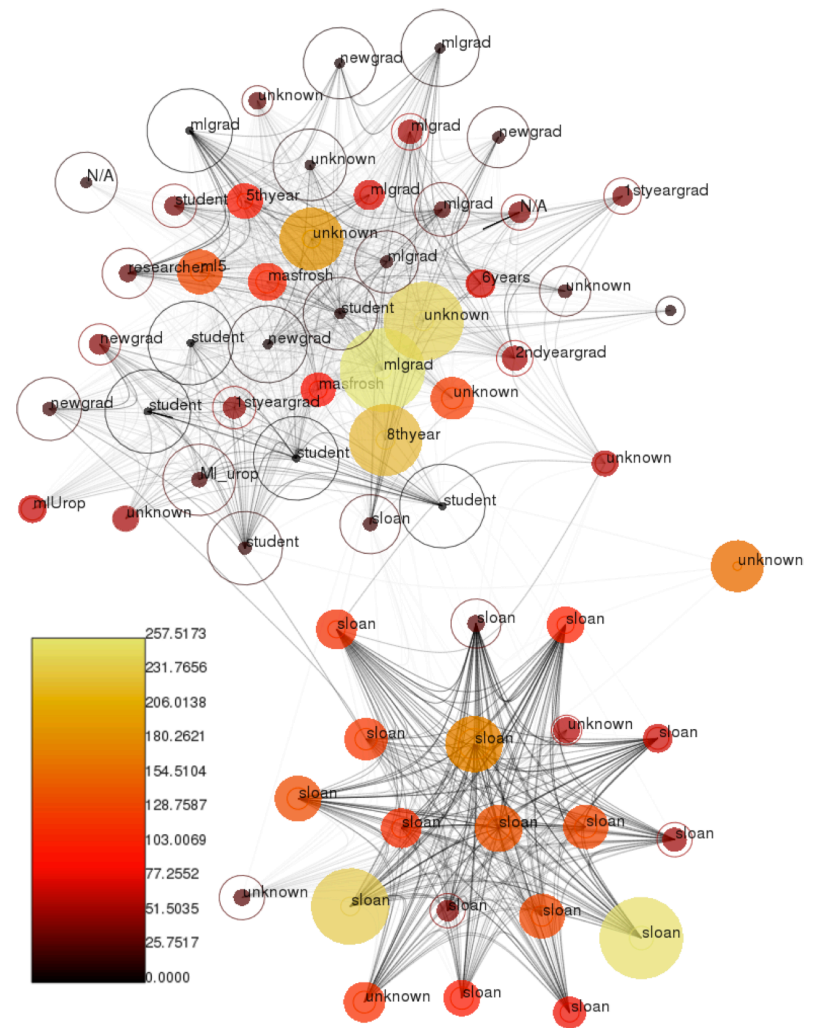
Visual Mapping of Uncertainty

Eigen

Betweenness

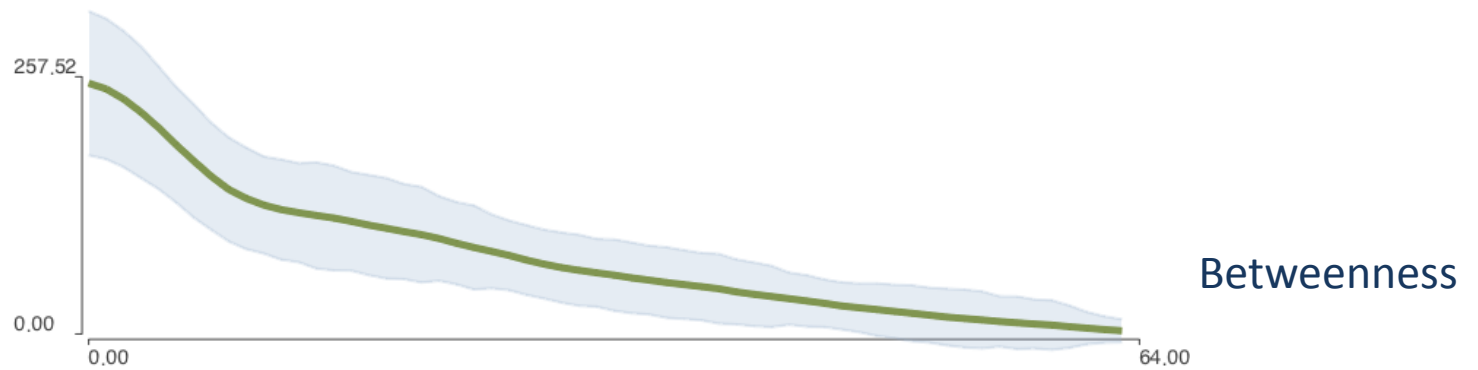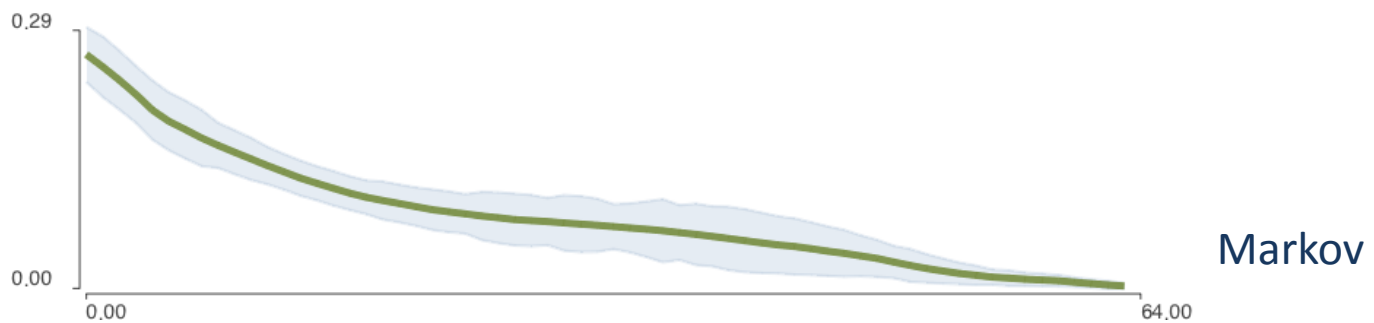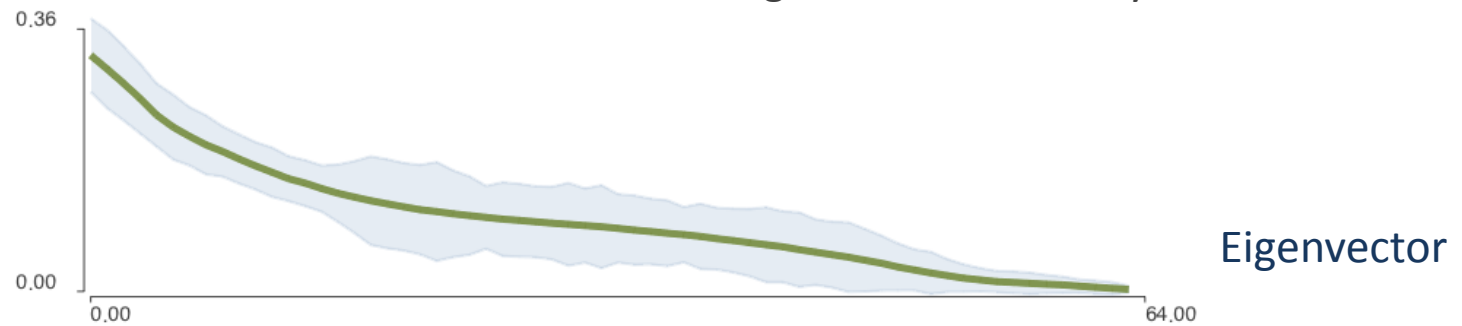# Visual Mapping of Uncertainty

Eigen

Betweenness

Summary View of Uncertainty

Nodes in descending order of centrality

Publications

- Tarik Crnovrsanin, Carlos Correa, and Kwan-Liu Ma. *Social Network Discovery Based on Sensitivity Analysis*. In Proceedings of the 2009 International Conference on Advances in Social Networks Analysis and Mining (**ASONAM 2009**), July 20-22 2009, pp. 107-112.

- Carlos Correa, Yu-Hsuan Chan, and Kwan-Liu Ma. *A Framework for Uncertainty-Aware Visual Analytics*. In Proceedings of Visual Analytics Science and Technology 2009 Conference (**VAST 2009**), October 2009, pp. 51-58

- Tarik Crnovrsanin, Chris Muelder, Carlos Correa, and Kwan-Liu Ma. *Proximity-based Visualization of Movement Trace Data*. In Proceedings of Visual Analytics Science and Technology 2009 Conference, October 2009 (**VAST 2009**), pp. 11-18.

- Yu-Hsuan Chan, Carlos Correa, and Kwan-Liu Ma. *Flow-based Scatterplots for Sensitivity Analysis*. In Proceedings of the Visual Analytics Science and Technology 2010 Conference (**VAST 2010**).

- Yu-Hsuan Chan, Kimberly Keeton, and Kwan-Liu Ma. *Interactive Visual Analysis of Hierarchical Enterprise Data*, In Proceedings of the 12th IEEE Conference on Commerce and Enterprise Computing (**CEC 2010**), November 10, 2010

- Tarik Crnovrsanina, Isaac Liao, Yingcai Wu, and Kwan-Liu Ma. *Visual Recommendations for Network Navigation.* **Computer Graphics Forum** (EuroVis 2011), 30(3), June 2011.

- Carlos Correa and Kwan-Liu Ma. *Visualizing Social Network*. **Social Network Data Analytics** (Ed. C. Aggarwal), 2011**.**

- Carlos Correa, Tarik Crnovrsanin, and Kwan-Liu Ma. *Visual Reasoning about Social Networks using Centrality Sensitivities*. **IEEE Transactions on Visualization and Computer Graphics**, 18(1): 106-120, January 2012

Ongoing Projects & Further work

- Sensitivity scatterplots (tomorrow's presentation and poster)

- Interactive network navigation based on relative importance (in poster)

- UQ and aggregation for data reduction

- The development of a unified uncertainty framework

- Uncertainty-aware collaborative analysis

Software

- NetZen

- An open-source software tool for the analysis and visualization of social and other scale-free networks

- Providing a general framework for studying uncertainty in network-based analytics

- http://vis.cs.ucdavis.edu/NetZen

- Version 1.0 is available