Mathematical Genealogy & Department Prestige

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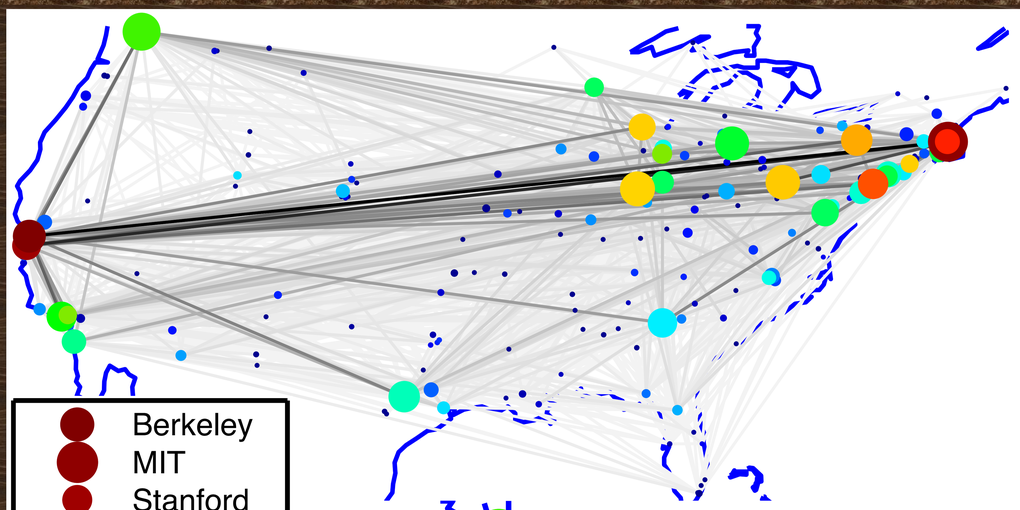
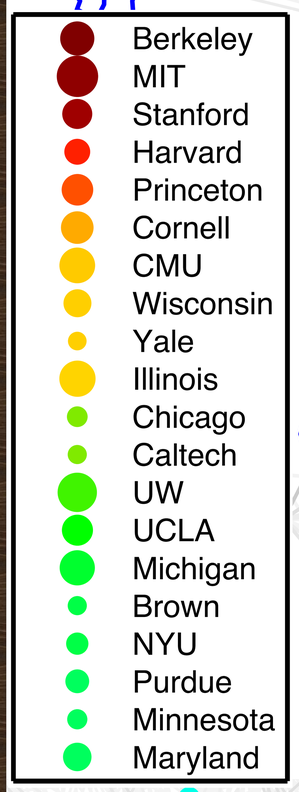
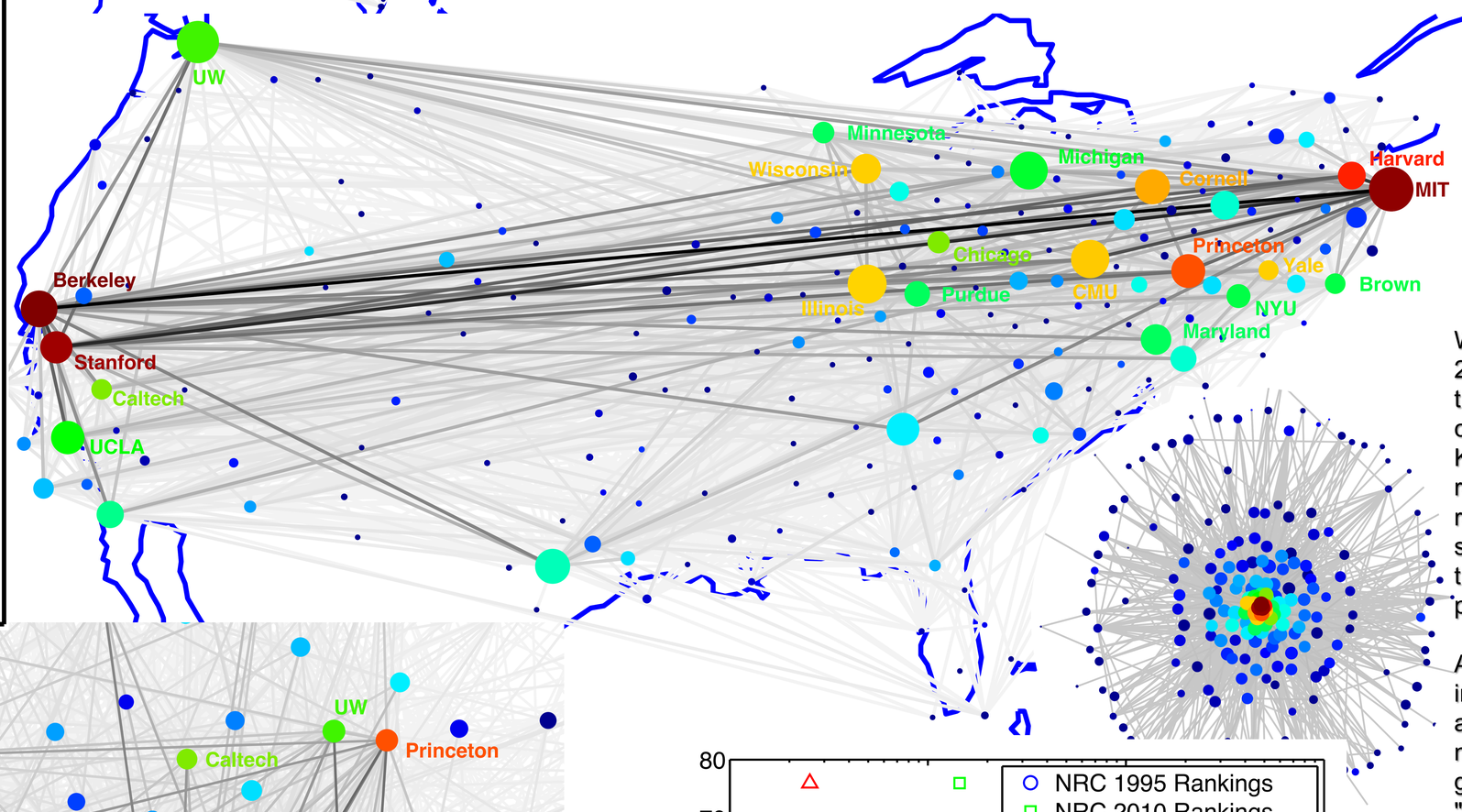
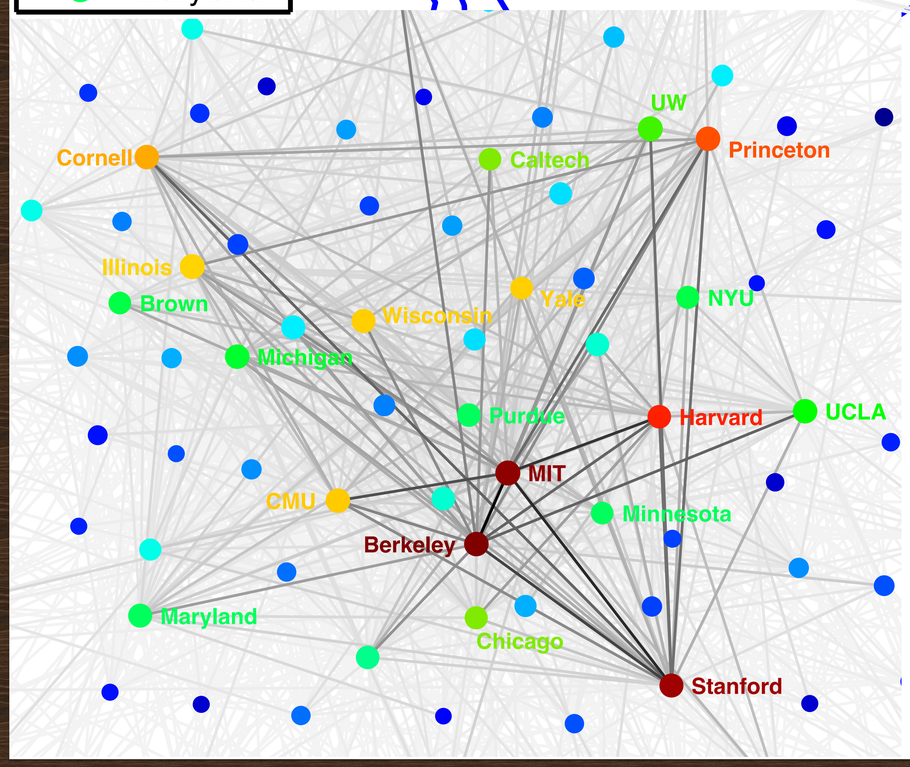


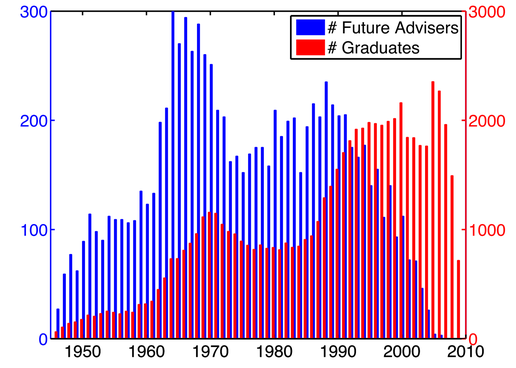






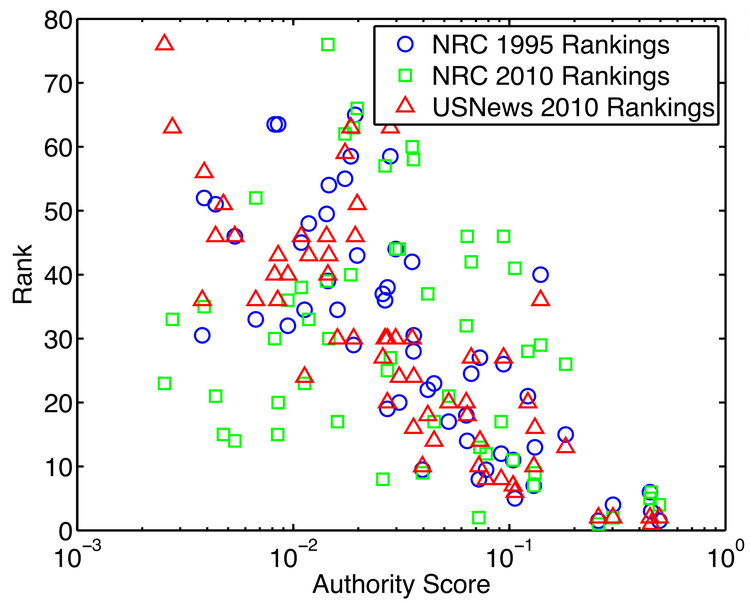
The Mathematics Genealogy Project (http://www.genealogy.ams.org/) is a searchable database of nearly 150,000 people with advanced degrees in mathematics and related fields. The data for most individuals includes dissertation title, adviser(s), graduation year, degree-granting institution, and academic descendants. The MGP is popular among mathematicians, as it allows users to trace their academic lineages back through luminaries like Richard Courant, David Hilbert, and Norbert Weiner to their historical predecessors, such as C. Felix Klein, Carl Friedrich Gauss, Jean-Baptiste Joseph Fourier, Simeon Denis Poisson, Leonhard Euler, and even Immanuel Kant.

In this work, we consider recent branches of this tree. We examine degrees granted since 1973 and project the MGP data onto a network whose nodes represent academic institutions in the United States. An individual who earns a doctorate from institution A and later advises a Ph.D. student at institution B is represented by a directed edge of unit weight that points from institution B to institution A. The total weight of the directed edge from B to A is the number of people who advised a doctoral student at B after obtaining a doctoral degree from A. This gives information about the academic output of institution A. One can estimate the mathematical prestige of a university by computing "centrality" scores that quantify the node locations in this academic-lineage network.



We show several visualizations of this 1973–2010 academic-lineage network. We quantify the positions of universities in the network by calculating "hub" and "authority" scores using Kleinberg's HITS algorithm [3] (which we represent visually by node size and color, respectively). Institutions with high authority scores have high-valued hubs pointing to them, and institutions with high hub scores point to high-valued authorities.

A Kamada-Kawai visualization [2] (to the immediate left of this text) places the high-authority universities in the center of the network. We also visualize the network using geographic placement (upper left) and a "geographically-inspired" representation (center). We highlight the core of the network using a Fruchterman-Reingold [1] force-directed layout (lower left).



In the legend, we list the top 20 institutions in order of their authority scores. We compare the network authority scores with various rankings of mathematics departments [6,7,8] (scatter plot) for the 58 universities that appear in the top 40 of at least one of the published rankings or have one of the top 40 authority scores. As expected, higher authority scores correlate with higher prestige in the rankings (smaller rank numbers). However, scatter is obviously present, particularly with the 2010 National Research Council (NRC) rankings.

References

[1] T. M. J. Fruchterman & E. M. Reingold [1991], Graph Drawing by Force-Directed Placement, *Software, Practice and Experience* **21**: 1129-1164.
[2] T. Kamada & S. Kawai [1988], An Algorithm for Drawing General Undirected Graphs, *Information Processing Letters* **31: 7-15.**
[3] J. M. Kleinberg [1999], Authoritative Sources in a Hyperlinked Environment, *Journal of the ACM* **46(5)**: 604-632.
[4] R. D. Malmgrem, J. M. Ottino, & L. A. N. Amaral [2010], The Role of Mentorship in Protégé Performance, *Nature* **465**(7298): 622-626.
[5] M. E. J. Newman [2010], Networks: An Introduction, Oxford University Press.
[6] National Research Council 1995 rankings, http://www.ams.org/notices/199512/nrctables.pdf.
[7] National Research Council 2010 rankings (rank order of medians of the S-ranking ranges), from http://graduate-school.phds.org/rankings/mathematics.
[8] US News & World Report 2010 rankings, http://grad-schools.usnews.rankingsandreviews.com/best-graduate-schools/top-mathematics-programs/rankings.

Network methods have the potential to be very valuable for quantifying the temporal development of institution prestige and the relationships between institutions.

Acknowledgements

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