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Nodes in Evolving Networks – Scientific Journals as a Case of Dynamic Animation

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Introduction

Following the recently emerging paradigm of complex evolving networks this paper is located at the crossing point between empirically tracing networks in massive data, visualizing evolving networks over time, and thinking about structure and structural changes of networks in terms of mathematical models. Taking scientific communication as case we analyze evolving networks of journal-journals citations. The Journal Citation Reports of the (*Social*) *Science Citation Index* contain structural information about citation-relation patterns of journals at the aggregated level for each year. The aggregated journal-journal citation matrices based on this data can be analyzed in terms of their structural dimensions using, for example, factor analysis and multi-dimensional scaling (MDS). In the case of journal maps, the clusters can be designated in terms of scientific specialties (Boyack *et al.*, 2005).

Hitherto, changes in observable variation have been difficult to distinguish from changes in latent structures. Most techniques for dynamic visualizations are based on smoothing the transitions by linear interpolation between static representations in order to optimize the conservation of a mental map (Moody *et al.*, 2005; De Nooy *et al.*, 2005; Bender-deMoll & McFarland, 2006). In this study, we use an MDS-based algorithm to layout time series of network data dynamically by optimizing the stress both within each year and over consecutive years, that is, by optimizing in three dimensions of the data (Erten *et al.*, 2004; Gansner *et al.*, 2004; Schank, 2008). The new algorithm was recently implemented in *Visone*. *Visone* is a software package for the visualization of network data and is freely available at <http://visone.info/> (Baur *et al.*, 2002; Brandes & Wagner, 2004).

We apply the new algorithm to three evolutions of citation impact environments of journals for which an expectation about interdisciplinary developments can be specified on the basis of previous research: *Cognitive Science* (Goldstone & Leydesdorff, 2006), *Social Networks* (Leydesdorff, 2007), and *Nanotechnology* (Leydesdorff & Zhou, 2007).

Results

Cognitive Science provides an example of a journal that deliberately searches its relevant environments for potential audiences for new knowledge claims that are obtained mainly from new developments in cognitive psychology. The interface with education research was firmly stabilized during the last decade, and the journal receives a sufficiently large number of citations from outside its original discipline to maintain high betweenness centrality in its relevant citation environment.

The journal *Social Networks* first crystallized as a methods journal in sociology during the 1980s, but then experienced the Internet revolution during the 1990s. The relationship with management journals was firmly established on the side of the social sciences involved, but the physics journals involved in Internet research (e.g., *Physics Review E*) do not cite this

journal regularly enough for it to become an interdisciplinary node between the natural and social sciences. Instead, the citation pattern in most of the years has remained encapsulated in sociology as the mother discipline.

In the case of nanotechnology, the intellectual fields of applied physics and relevant chemistry have undergone reorganization during the period under study. The journal *Nanotechnology*, which existed before this “revolution” played a role among other journals in applied physics first by catching the attention to the nano-field among physicists and then in forging a relationship with chemistry. The latter relationship transformed the field of advanced material sciences into a citation cluster at the interface of applied physics and physical chemistry.

Discussion

In this paper we show in three cases how the development of a speciality can be visualized looking at the citation environment of key journals. This also entails a node-centered perspective. Our results suggest that the claim of “interdisciplinarity” eventually seems in practice to lead to the emergence of a specific interface between two existing specialties and the potential reorganization of that interface into a co-evolution. At this interface the “key journal” changes its structural position measured in terms of centrality. With such insights into changing functions of nodes (and links) as they appear empirically we can ask further questions about inherent mechanisms behind the growth, role and function of scientific journals in scientific communication in different stages of the developments of paradigms.

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