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Preface

The GIScience conference series (www.giscience.org) was created as a forum for all researchers who are interested in advancing research in the fundamental aspects of geographic information science. Starting with GIScience 2000 in Savannah, Georgia, USA, the conferences have been held biennially, bringing together a highly interdisciplinary group of scientists from academia, industry, and government to analyze progress and to explore new research directions. The conferences focus on emerging topics and basic research findings across all sectors of geographic information science. After three highly successful conferences in the United States, this year's GIScience conference was held in Europe for the first time.

The GIScience conferences have been a meeting point for researchers coming from various disciplines, including cognitive science, computer science, engineering, geography, information science, mathematics, philosophy, psychology, social science, and statistics. The advancement of geographic information science requires such interdisciplinary breadth, and this is also what makes the conferences so exciting. In order to account for the different needs of the involved scientific disciplines with regard to publishing their research results, we again organized two separate stages of paper submission: 93 full papers were each thoroughly reviewed by three Program Committee members and 26 were selected for presentation at the conference and inclusion in this volume. Then, 159 extended abstracts, describing work in progress, were screened by two Program Committee members each. Subsequently, 42 of them were selected for oral presentation, and 46 for poster presentation at the conference. All extended abstracts were published in a separate book in the Institute for Geoinformatics, University of Münster-Prints series.

The proceedings of GIScience 2006 provide ample evidence that the field of geographic information science is both maturing and growing. This year's number of full-paper submissions marked a record, topping the previous submission rate by more than 30%. Another important trend is the increasing competitiveness for entering the LNCS proceedings. The acceptance rate for full papers was below 28%, a clear indication of the quality of the papers in this book. The mixture of topics demonstrates that the field is still exploring classic topics, but also moving into novel directions. Among the traditional topics we find spatial representations and data structures, spatial and temporal reasoning, computational geometry, spatial analysis, and databases. A significant number of papers deal with navigation, interoperability, dynamic modeling, ontology, and semantics. Geosensors, location privacy, social issues and GI research networks rank among the important and exciting new directions.

In addition to the paper sessions, GIScience 2006 included four keynote addresses, five pre-conference workshops, an interactive poster session, and social

events. The water castle of Nordkirchen, one of the most beautiful sights in the area, served as the location for the gala dinner. The conference itself was held at Münster Castle—built from 1767 to 1787, formerly the Prince Bishop's residence, now part of the University—and located in one of the most livable cities in the world. In October 2004 Münster became the first German city to win the Gold LivCom Award (www.livcomawards.com) in the category of cities with 200,000 to 750,000 inhabitants. This year's conference turned out to be yet another highlight of the series combining excellent research with a picturesque background.

As Program Co-chairs, we thank the many people who helped to make GIScience 2006 a success: those who submitted their work and participated in the conference, the co-organizers, the General Chair, the Program Committee and additional reviewers, the Local Organizing Committee, the Web team, the staff of the Institute for Geoinformatics and the University of Münster, and last but not least our sponsors. Special thanks go to Carsten Keßler for his help with these proceedings.

July 2006

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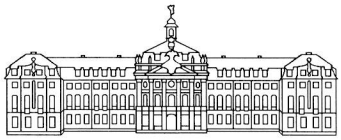

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A Social and Spatial Network Approach to the Investigation of Research Communities over the World Wide Web

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Abstract. The research presented in this paper introduces a graph-based and computational modelling approach that derives a social network and computes its emerging spatial and thematic properties from the semantics embedded in a series of Web pages. We apply several local and global graph-based operators, and complement them with thematic, spatial and similarity operators. This allows us to infer the degree of correlation between the different properties of the network. The approach is applied to the study of the GIS research communities as exemplified by the International COSIT and GIScience conferences.

Keywords: graph analysis, semantic space, social networks, GIScience, web communities.

1 Introduction

A social network is commonly defined as a set of people who share a common interest and have connections of some kind (Wasserman and Faust, 1994). Social networks provide useful insights into ways that the social communities are formed and interact. They have been widely studied over the past years, particularly in mathematical and statistical research (Strogatz, 2001; Newman, 2003), but have also been applied in many application domains such as epidemiology (Moore and Newman, 2000), environment (Dunne *et al.*, 2002) and scientific citation (Redner, 1998).

Social networks have been preferably studied using surveys, but these have certain limitations as connections are not always recorded in questionnaires. Surveys are also time consuming, can be subjective, costly and error prone. In order to address these limitations, new forms of studies have recently emerged to derive and compute social networks. In particular, the World Wide Web provides many opportunities for inferring and analysing social networks as web sites often embed information with respect to a specific domain of interest, and the actors that are part of it (Berners-Lee *et al.*, 2001; Greco *et al.*, 2002; Hou and Zhang, 2002; Bekkerman and McCallum,

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2005). Derivation of a social network becomes a modelling and parsing problem where members of a group of interest and connections between them should be inferred from the information embedded on the web.

The research presented in this paper introduces a social and spatial network approach to infer and analyse the structure and properties of a semantic network derived from the relationships embedded and hidden in a subset of the World Wide Web. Our objective is to complement graph-based operators with spatial, thematic and network correlation measures that cannot be easily expressed by a graph layout, but can be virtually derived from the relationships embedded and hidden on the Web. This will help us in understanding the role of space and thematic classifications in a given social network, for instance, the degree to which network properties are correlated to other properties.

The domain used for our study is the semantic network formed by the scientific community closely related to Geographical Information Science. Network and graph-based analysis support exploration of patterns of collaborations in this field, and reveal to what degree trajectories of researchers impact the formation of a network of communities. The motivation for examining research networks is twofold. First, as members of this community, we are curious about the elaborations and extent of the field. Second, in a more general sense, the emergence of GIScience research is an instance of the broader phenomenon of new disciplines forming at the intersection of existing fields, and this research will lead the way forward for assessing how this community composes over time. To illustrate the approach we consider two major international conferences of the field: the Conference on Spatial Information Theory (COSIT) and Conference on Geographical Information Science (GIScience) that present the advantage of reflectingthe key players of the GIScience community. These two conferences appear relatively central in the field of Geographical Information Science, and are well documented on the Web. The main information inputs are sourced from the web sites of the last organised sessions of these conferences in 2004 and 2005, respectively, along with previous years to some degree. The components constituting the elements of the network are researchers that had papers accepted at these conferences, and connections given by their academic trajectories along universities. The objective of the study is not to study individuals and their networks, but rather to analyse the affiliation network of the universities and research centres that have supported the careers and progression of these researchers. The expected output is a network of universities active in this particular research field. We also assume that the trajectory of a given researcher from one university to another represents an implicit connection between these two universities. This information is derived and computed from the short biographies as they appear on the web pages of the researchers hyperlinked to the conference web sites. This supports derivation of a semantic network whose properties are analysed using graph measures, thematic and geographical-based correlations, and similarity measures.

In a preliminary study, we analysed the properties exhibited by these scientific network using graph-based measures and their distribution in space (Béra and Claramunt, 2005). This allowed us to infer the hubs and authorities of the social network, centrality patterns, and the distribution of these properties in space. This paper extends our previous work by enlarging the analysis in several directions. First, we generalise the measure of geographic dispersion to the thematic dispersion.

Secondly, we integrate a hierarchical component in the analysis in order to take into account several levels of abstraction in the thematic and spatial dimensions. Last, we apply a similarity measure to evaluate the dependencies between the two scientific networks. The remainder of the paper is organised as follows. Section 2 introduces the principles of our modelling and computational approach. The case study is developed in Section 3, and major results presented. Finally, Section 4 draws some conclusions and outlines future work.

2 Semantic Network Modelling

A semantic network is modelled as a hypergraph $G\ (N,E)$ where N is a finite set of nodes, and E is a finite set of links between these nodes. A node is denoted as n_i, a link between two nodes $n_i, n_j \in N$ as a pair (n_i, n_j).

Network analysis combines global measures that outline the emergent structure of the represented graph, with local-based measures that characterise particularities in the graph. The most popular local measures are the degree (i.e. number of nodes connected to a node) and the clustering coefficient of a node. The clustering coefficient evaluates the extent to which the neighbours of a node i are also linked one to another. Global measures evaluate the centrality of a node in the graph. These include for example the average distance between nodes, the ratio of shortest paths a node lies on (Sabidussi, 1966), and accessibility of a node (Batty, 2004; Béra and Claramunt, 2003, White and Smyth, 2003). An essential measure of centrality is the *betweenness centrality* $C_b(i)$ that gives the fraction of shortest paths between node pairs that pass through a given node (Freeman, 1977; Brandes, 2001), and is defined as

$$C_b(i) = \sum_{k \neq j \neq i} \frac{S_{jk}(i)}{S_{jk}}\ , \tag{1}$$

where S_{jk} denotes the number of shortest paths from j to k and $S_{jk}(i)$ is the number of shortest paths from j to k that i lies on. The *betweenness centrality* can be generalised to multiple component graphs, as well as for directed graphs.

Although these graph-based measures are expected to exhibit local and global properties of a given network, they do not take into account the spatial and thematic dimensions. This leads us to introduce some additional geographically-related measures that correlate the structural and geographical properties of the semantic network. From a given semantic network *G(N, E)*, we consider the geographically-based subsets of N that group the nodes of N according to their membership to a given classification and partition of the underlying space (the same principles can be applied to a thematic classification and a measure of thematic dispersion). The objective is to analyse to which degree the structure of a network is correlated to a given classification. Let us consider a classification $C = \{c_1, c_2, \ldots, c_j, \ldots, c_p\}$ that forms a partition of N with $p > 1$. For a given node n_i of a class c_j of N, we define the geographic dispersion value $\mathrm{disp}(n_i)$ as follows:

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