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The use of Social Network Analysis to explore relationships between the Medical Informatics and Information Systems literature

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ABSTRACT

Health informatics (HI) research has evolved over several decades from its roots in computer science (CS) and artificial intelligence in medicine (AIM). Information Systems (IS) evolved independently, but recently IS within health environments are being embraced as a new test bed for Information Systems theories. The purpose of this paper is to present an objective view of the level of cross reference between the IS and MI bodies of literature, and to either provide evidence of uptake of IS theories in HI or of outlets that would provide appropriate targets for such work due to their antecedents and influence. The extent of the cross fertilization between the two disciplines is still thought to be low. Using social network analysis (SNA) we present an exploratory study which identifies the bridges and cutpoints within a basket of 44 key journals and identify the impact of Information Systems research on the Health Informatics discipline. This work is informed by a number of recent studies using this approach.

Keywords

Social network analysis, journal citation networks, IS research, Cogent discipline

INTRODUCTION

This article presents the results of an exploratory social network analysis of 44 journals from MI and IS based on citation data from Web of Science. Our objectives are twofold. First to apply SNA to reveal the structure of the relationship between MI and IS as shown through citation reports to address the following research questions:

What is the impact of information systems research on the Health Informatics discipline?

Can we identify cut point and bridge journals that relate MI to IS?

Prior SNA studies focus on top journals rated via well accepted ranking studies. The motivation for this approach is clear; any assertion we make about impact only applies in the basket of journals we select for such studies. It makes sense therefore to select those journals that are of interest and value to scholars in the field. There is a risk of missing some important work via this approach, in particular citations of Information Systems work in less well known journals. It is interesting to explore the degree to which Health Informatics researchers are drawing on mainstream Information System theory. Our article is structured as follows we begin with a review of previous studies of this nature and particularly those using SNA, next we describe the journal selection, data collection and data analysis processes used. We then describe in detail the impact of specific journals in the network and analyse the information flows between the two disciplines. In the final section we discuss our results and

BACKGROUND

Development efforts on systems to support clinical care have been underway for almost half a century (Kaplan 2001) and the use of computers in health care settings is well established. Originally computer based information systems in health care were designed primarily for administrative functions, especially financial and scheduling domains. It is only since the early 1990s that a shift has occurred from administrative information systems to clinical ones with systems being applied to diagnostic situations. During this period a number of significant lines of development have occurred in particular there has been a shift from, from local to global information system architectures, and a shift of focus from health care professionals to patients and consumers, and from using data only for patient care to research/ Further focus has shifted from technical to strategic information management priorities, and inclusion of new types of data, inclusion of new technologies (e.g. wearable

devices). It is of interest to explore how mainstream IS theories might assist in the development and use of health information systems in this changing environment. This viewpoint was described in detail in Chiasson and Davidson (2005).

PREVIOUS JOURNAL STUDIES USING SNA

Some prior studies of this nature have been carried out. Morris, (1998, 2000, 2001) used SNA to identify the core literature in health informatics and the boundaries of the discipline. Shuemie et al (2009) built on this research using a semi automated analysis to identify subdomains within health informatics. In 2004 Otero et al carried out a longitudinal study to examine the evolution of HI citations. More recently Raghupathy and Nerur (2009) identify emerging subfields via author co-citation analysis in health information systems research. Polites and Watson (2009) presented a thorough review of previous mainstream SNA studies. They drew particular attention to the very extensive SNA studies by Leydesdorff (2004 a,b)

UPTAKE OF MI THEMES IN MAINSTREAM IS

There have been a number of papers in recent years calling for the IS and HI communities to explore the synergies open to them in cross-disciplinary research (Chiasson and Davidson 2002, 2005; Chiasson et al 2007) and more recently a number of special issues have emerged exploring this area (See Table 1)

Date	Journal Name	Tag line
2007	E-service journal	Special issue on healthcare information
2006	Decision support systems	Decision support in medicine
2007	Decision Sciences	Decision making in the health sector supply chain
2007	European Journal of Information Systems	Health Information Systems Research, Revelations and Visions
2005	International Journal on Semantic Web and Information Systems	Special issue on healthcare information
2006	Communications of the AIS	Ongoing Series
2010	ISR	Role of IS in Healthcare Organisations
2010	JAIS	Healthcare IT Process, People and Patients

Table 1. Special Issues on Healthcare IS

SOCIAL NETWORK ANALYSIS

Social network analysis refers to the analysis of social networks utilizing graphical methods. Today, network analysis usually refers to quantitative analysis of relationships among nodes (actors or objects) based on mathematical graph theory. The main purposes of this quantitative approach are (1) generation of various coefficients of the centrality or non-centrality of nodes; and (2) visualization of the connectedness of nodes in graphical form. UCINET is currently the leading software package for network analysis.

SNA has its origins in the Sociometry which was often used in small group research with a focus on interpersonal choices. In that context it was a largely subjective but empirical, phenomenological approach to the study of group structure. It is appropriate for the study of relationships between journals due to the analogous relationship between journals and the flow of information between them.

The different roles adopted by journals within the network

Following Polites and Watson (2009) we acknowledge a number of distinct roles in a network these are summarized in Error! Reference source not found..

Role	Description
Source	Journals that receive more citations than they cite themselves
Sink	Journals that make citations to many different journals but are not cited by as many in return
Bridge	Connections that hold otherwise unconnected sets of journals together
Cutpoint	Journals that, if removed would cause the structure to be divided into unconnected blocks

Table 2. Journal roles

Relatedness

When developing models of information flow results can be skewed by issues such as the number of issues published per year and self citation. To overcome this all self citations were removed from the data and the relatedness value was calculated using an established measure. We use an algorithm for calculating relatedness based on Pudovkin and Garfield (2002) see Figure 1.

CALCULATING RELATEDNESS COEFFICIENT OF JOURNAL₁ AND JOURNAL₂

$$R_{1>2} = \frac{C_{1>2} \times 10^6}{\text{Ref}_1 \times \text{Pap}_2}$$

$$R_{1<2} = \frac{C_{1<2} \times 10^6}{\text{Ref}_2 \times \text{Pap}_1}$$

$$R_{\text{coeff}} = \sqrt{R_{1>2} \times R_{1<2}}$$

C = Citations

Ref₁ is the number of references cited in Journal 1.

Pap₂ is the number of papers published by Journal 2.

Ref₂ is the number of references cited in Journal 2.

Figure 1 Formula used to calculate relatedness

METHODOLOGY

Journal selection

There is a certain amount of controversy about ranking studies in general and which journals should be included in particular. Arguments centre around US vs European centered approaches, the confining nature of restricting a selection and, from the

point of view of ranking the fear that identifying a set of journals will be a self-perpetuating process. In this study *Ranking* is not the major aim. However whatever conclusions we draw can only apply to the basket of journals selected and for this reason it is appropriate to start with a set that will encompass the interests of the target audience(s).

Consistent with our objective of sampling the literature not constrained by recourse to the so called Top Journals we rejected the use of such a “lens” and took a more broad brush subject driven approach. Thus we began the study with an initial search of the 20 journals that resulted from an ISI search using “medical informatics” as a subject area. We then captured all the related journals and filtered for any core to the IS, CS or AIM disciplines. This resulted in a basket of 44 journals illustrated in below (standard ISI abbreviations). Communications of the AIS might seem a significant omission given its identification in Table 2. It is however not available in the journal citation reports of Web of Science.

J AM MED INFORM ASSN	EXPERT SYST APPL
J MED INTERNET RES	J TELEMED TELECARE
MED DECIS MAKING	COMPUT METH PROG BIO
J BIOMED INFORM	DATA KNOWL ENG
ARTIF INTELL MED	EUR J OPER RES
INT J MED INFORM	J MED SYST
J EVAL CLIN PRACT	INFORM PROCESS MANAG
STAT MED	J AM SOC INF SCI TEC
STAT METHODS MED RES	BIOINFORMATICS
METHOD INFORM MED	BMC BIOINFORMATICS
IEEE T INF TECHNOL B	COMPUT J
EUR J INFORM SYST	IEEE T ENG MANAGE
INFORM SYST J	MED BIOL ENG COMPUT
INFORM SYST RES	BIOMED TECH
J ASSOC INF SYST	INFORM SYST
J MANAGE INFORM SYST	INFORM SYST MANAGE
MIS QUART	IEEE INTELL SYST
J STRATEGIC INF SYST	INFORM MANAGE-AMSTER
J INF TECHNOL	ARTIF INTELL
COMMUN ACM	IEEE T KNOWL DATA EN
DECISION SCI	BRIT MED J
DECIS SUPPORT SYST	JAMA-J AM MED ASSOC

Table 3 The Journals in this study

SNA Process

Citation data was collected from JCR links in Web of Science for the journals identified. The related citations were harvested and put into 44 related worksheets. The data was checked for anomalies and then imported into UCINET. All self citations were removed from the UCINET file. The file was then analysed using NETDRAW.

Results

Fig 2 shows the information flows in the journal network its layout is less polarized than one might expect but shows MI journals on the right and IS journals on the left with computer science journals centrally above the network and down the middle. The thicker lines indicate stronger ties within the IS cohort than in the HI cohort.

The information flow (an arrow from A to B means that A cites B) shows a number of highly cited journals around the middle of the network specifically including the journal of the American society for science and technology, Decision Support Systems and IEEE transactions on Knowledge and data Engineering. Communications of the ACM was also a bridge journal between the two disciplines. This confirms the role it occupies noted in previous studies (Polites and Watson, 2008) There was only one cutpoint in the model indicated by the relationship with BIOMED TECH.

When investigating information flow it is also interesting to identify who generates, digests and transmits, and merely uses this information. These three roles are referred to as sources, transmitters and sinks. Fig 3 illustrates the relative sources (in red) and sinks in the network.

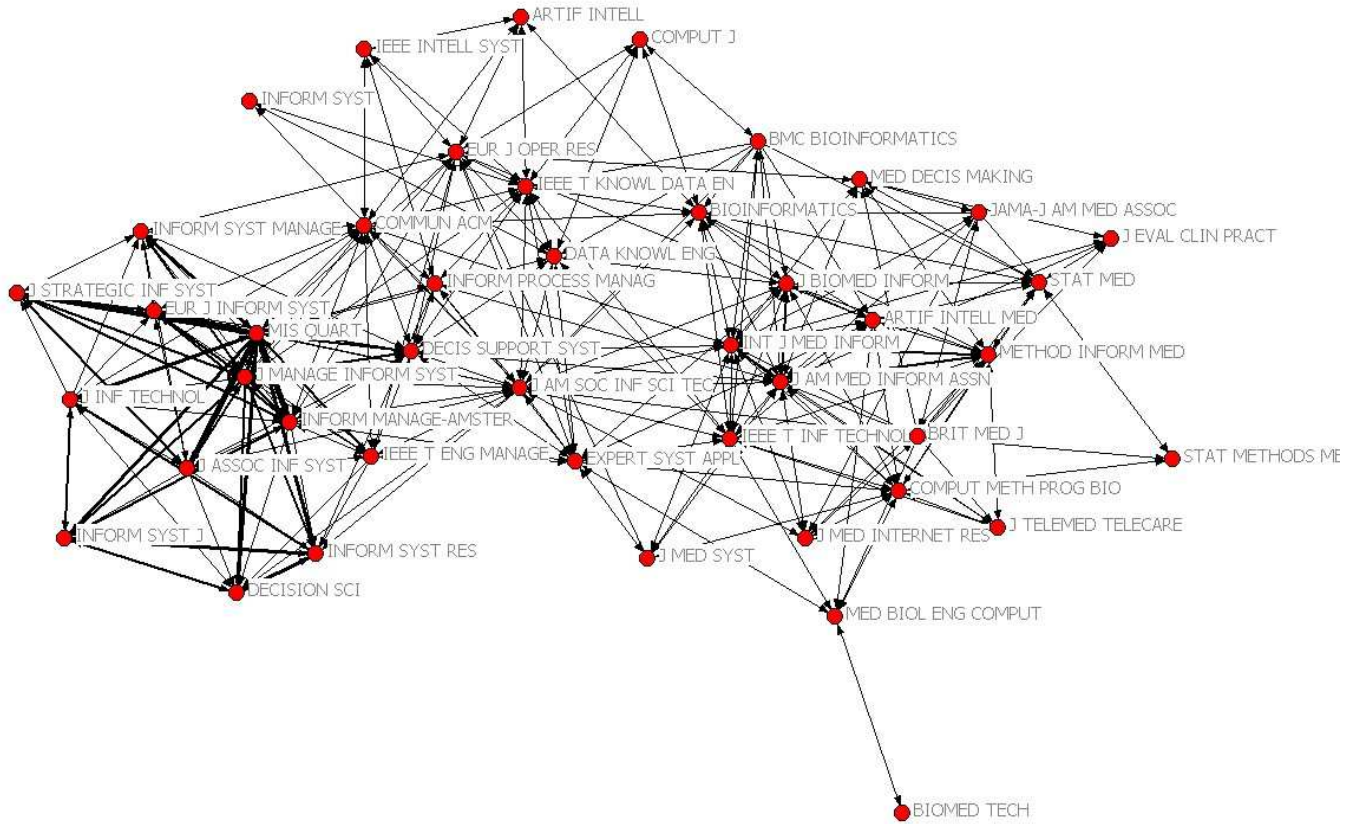


Figure 2 Output of SNA analysis

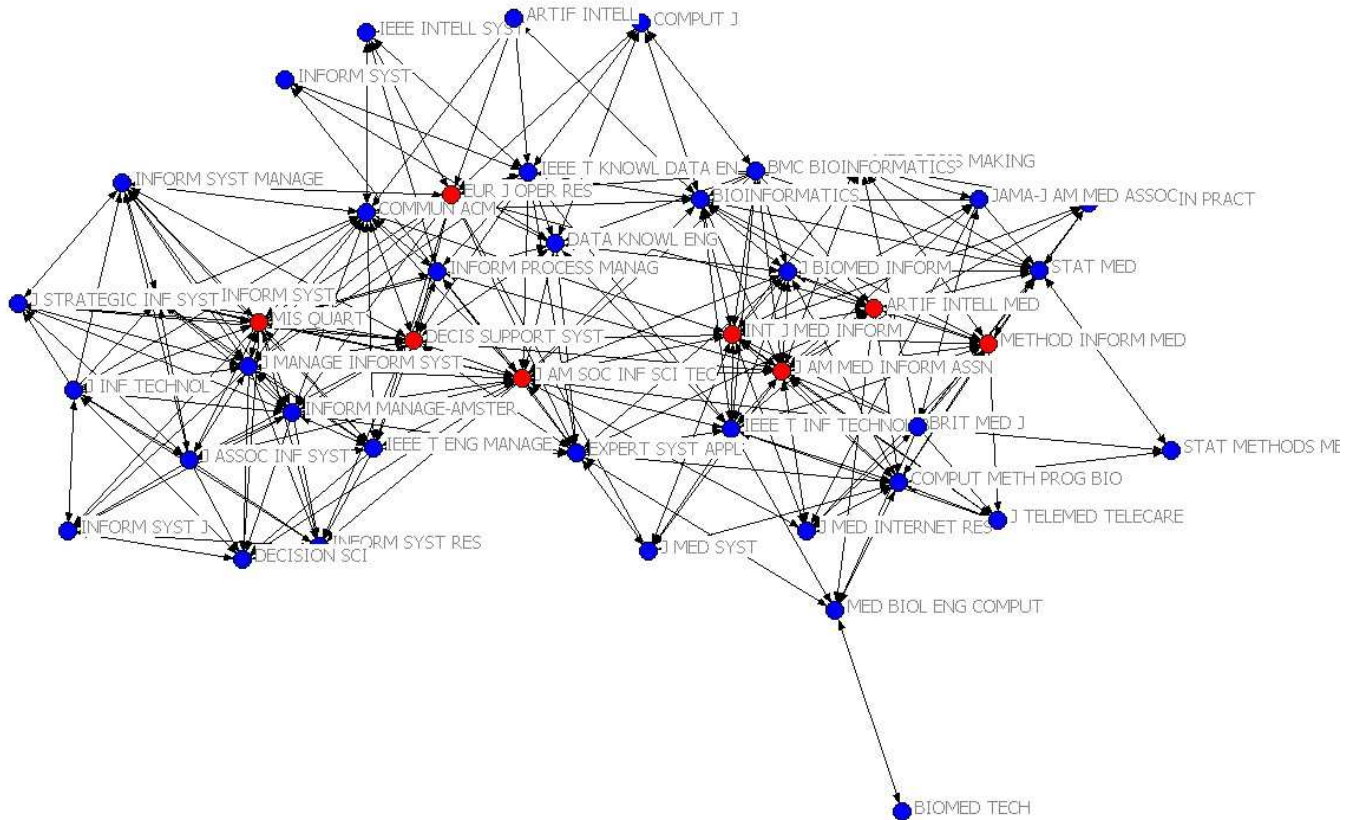


Figure 3 Relative sources and sinks

CONCLUSION

Consistent with the findings of Raghupathy and Nerur (2009), the formation of our network indicate the presence of several strong sub-fields, including HIS evaluation, and clinical DSS. The presence of the journal of the American Society for Information Science and Technology as a relative source in the network was a surprising finding as being an Information Science journal it was not expected to have links to both fields.

LIMITATIONS AND FUTURE WORK

A simple visualization of the information flows within this journal basket has revealed the key bridging journals between the two disciplines, however further work is needed to examine the exact nature of these publications and whether IS theory is filtering through. This work has enabled this task by providing an objective analysis of the relatedness of cross disciplinary research and the journals in which it potentially appears. We will extend the analysis to examine the exact nature of the publications in these bridge journals.

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