Desperately seeking the IS in GIS

Research in Progress

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Abstract

Geographical Information Systems (GIS) are now a widespread and important form of Information Technology (IT) use. In principle, Information Systems (IS) research is concerned with all forms of IT use. Yet despite this importance, GIS remains largely invisible in IS research. This paper illustrates this separation using bibliographic data drawn from both GIS and IS. It reviews discussion within IS as to the nature of the discipline and argues for a closer coupling between IS and GIS. It discusses Spatial Data Infrastructure (SDI), mobile computing and public participation GIS as examples of spatially related fields where further IS research would be beneficial.

Introduction

The concept of Geographic Information Systems (GIS) has been around for some 50 years, at least since the Canadian Geographic Information System in the mid-1960s (Coppock and Rhind 1991). Spatial applications have always been more demanding on computer performance than traditional business applications, which are less data intensive. While technology limitations meant a slow grow of spatial systems, the concept of GIS came to a certain maturity by the 1990s with the publication of an authoritative research compilation, the "*Big Book*" (Maguire et al. 1991). While originating from outside the traditional Information Systems (IS) community, GIS began to appear in the 1990s in journals associated with IS, for instance Crossland (1995), and IS conferences such as the Hawaii International Conference on System Sciences (HICSS) and the Americas Conference on Information Systems (AMCIS). Many involved at that time expected an expansion of the role of spatial applications in IS, yet spatial applications and research related to GIS research continues to have a low profile when reading IS journals or attending these conferences. Likewise GIS journals and conferences have little obvious connection to IS other than the last two letters in the abbreviation GIS. At this point, some reflection on the connection between the IS and GIS fields is appropriate.

This can indicate the range of authors, journals and disciplines cited by particular journals and indicate the disciplinary fields which authors feel the need to cite. This form of analysis is facilitated by the availability in electronic form of citation databases and the capacity of modern computers to process these. The interpretation of analysis of journal databases is facilitated by standard visualizations of the subject space and the use of standard clustering of disciplines. One useful approach is developed by Leydesdorff, with various collaborators (Leydesdorff and Rafols 2012), (Leydesdorff et al. 2013). This visually maps all scientific disciplines, allowing particular disciplines be plotted on the same background map. Figure 1 shows a visualization of all citations in WOS.

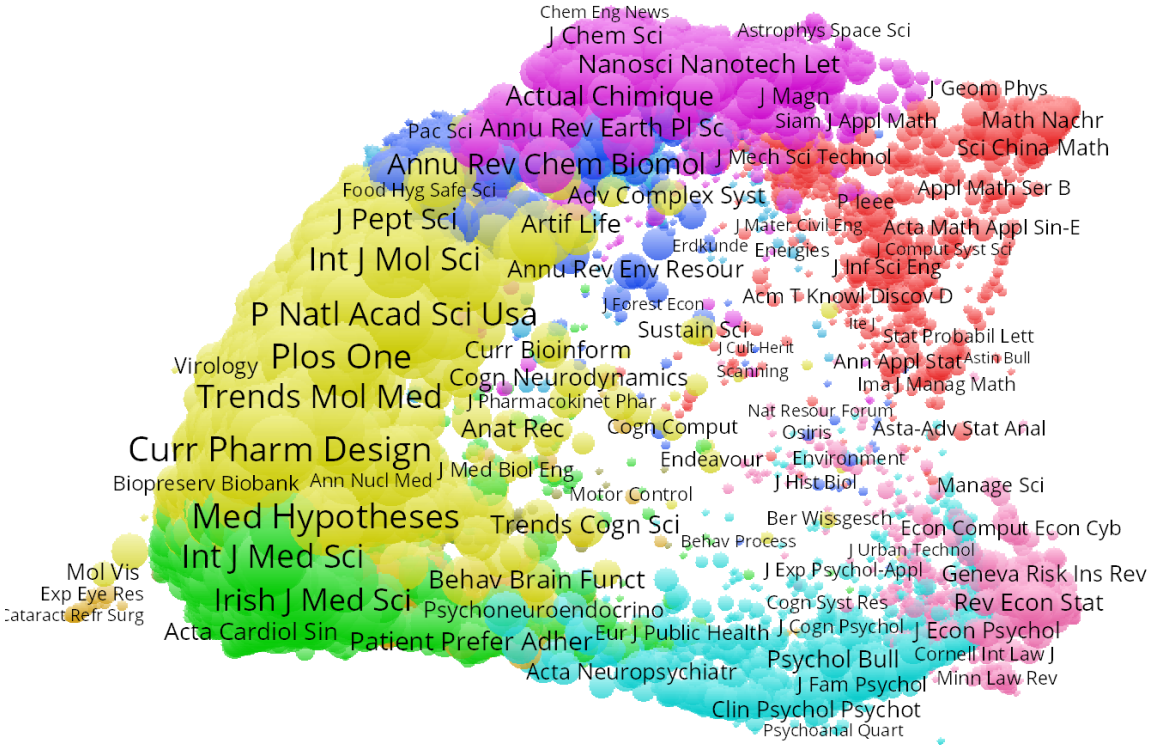

Figure 1. Visualization of all WOS citing publications (Leydesdorff http://www.leydesdorff.net/journals11/)

This visualization groups journals in clusters. The number of citations in each cluster in part reflects the different approaches to citation in different disciplines, this difference in citation rate is an issue with this form of citation analysis. The scientific disciplines are grouped to the left and top of this visualization, with the social science disciplines often cited in business publications in the bottom right. This standard visualization provides a background for the analysis of specific interdisciplinary links representing a subset of the WOS.

GIS Research visualized.

After a quarter century of widespread use, GIS is now characterized by a wide range of applications and consequently a wide range of publication outlets representing different academic disciplines. Figure 2 shows GIS publications on a similar basis to Figure 1. These represent journal articles, but not other forms of publication, selected using the topic search "*Geographical Information System*" or "*Geographic Information System*" in the WOS Core Collection. Table 1 shows the number of articles in different categories with these keywords in the 35 year period, excluding publications in journals with less than six papers in total over the period, as these do not represent usual outlets for GIS related research. Just over half the publications are in in journals in the Environmental Science area, these are colored blue in Figure 1 above. This illustrates that the bulk of GIS papers are in Environmental Science journals and related fields such as agriculture, quite removed from the typical interests of Business Schools where IS research typically takes place. There are some papers in the medical area, and some in transport or using mathematical/OR techniques. As we would expect a significant, but not dominant, proportion of publications are in planning or geography journals. However, few of the journals appearing the visualization are associated with IS, further confirmation that little is being produced in these journals relating to GIS.

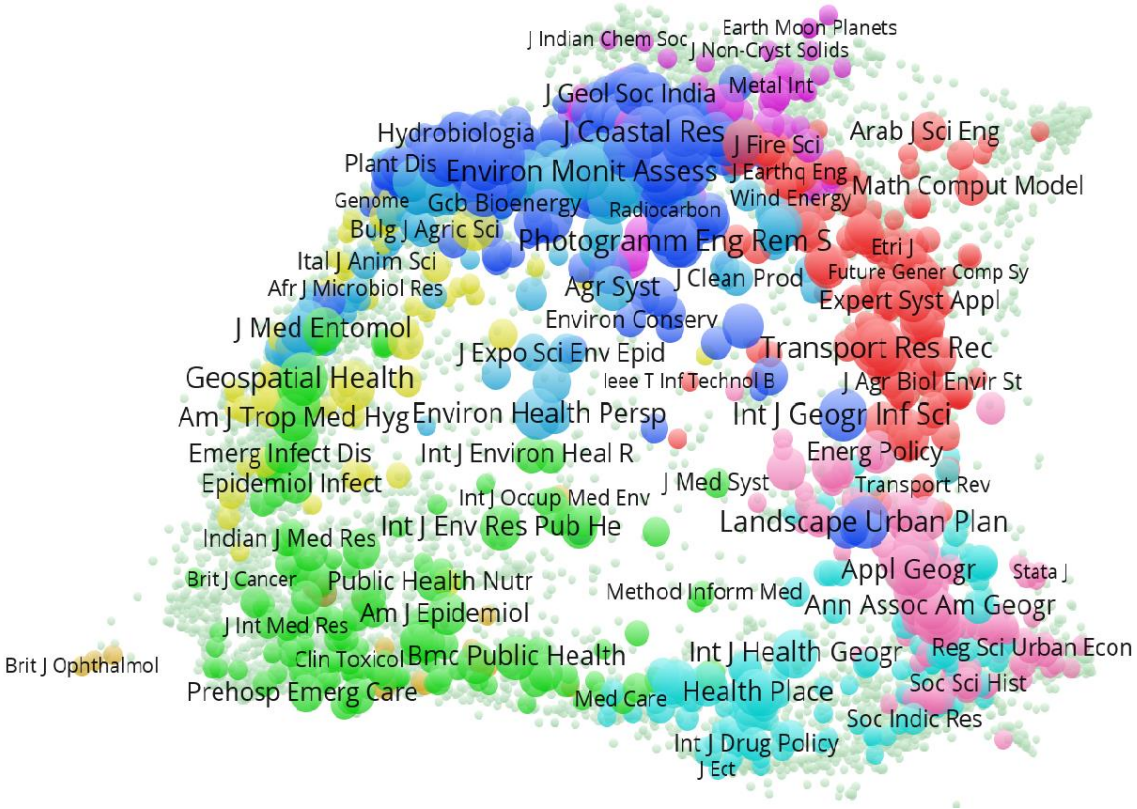

Figure 2. Visualization of publications using GIS as keyword

The above search using topic in WOS produces a very wide range of outputs, many of these papers are case studies which use GIS in some way in particular domains, but do not propose to greatly advance the GIS field as a whole. A more focused view can be achieved by looking at a more select group of journals. It isn't quite straightforward to identify such a set of journals. Caron (2008) investigated the most influential journals for geographic information science, however our focus is systems and some of publications Caron identified are more concerned with fundamental geoscience techniques than the use of

Table 1. Journal Articles in Web of Science with GIS keyword 1980-2014

Journal Domain	Number of publications	% of total GIS publications
Mathematics and Operational Research	580	6.7%
Medical, Environmental and Dental Science	577	6.7%
Environmental systems	4469	51.6%
Life Sciences	174	2.0%
Physical sciences	111	1.3%
Behavioural Science	305	3.5%
Agriculture and Environmental engineering	1932	22.3%
Geography	516	6.0%

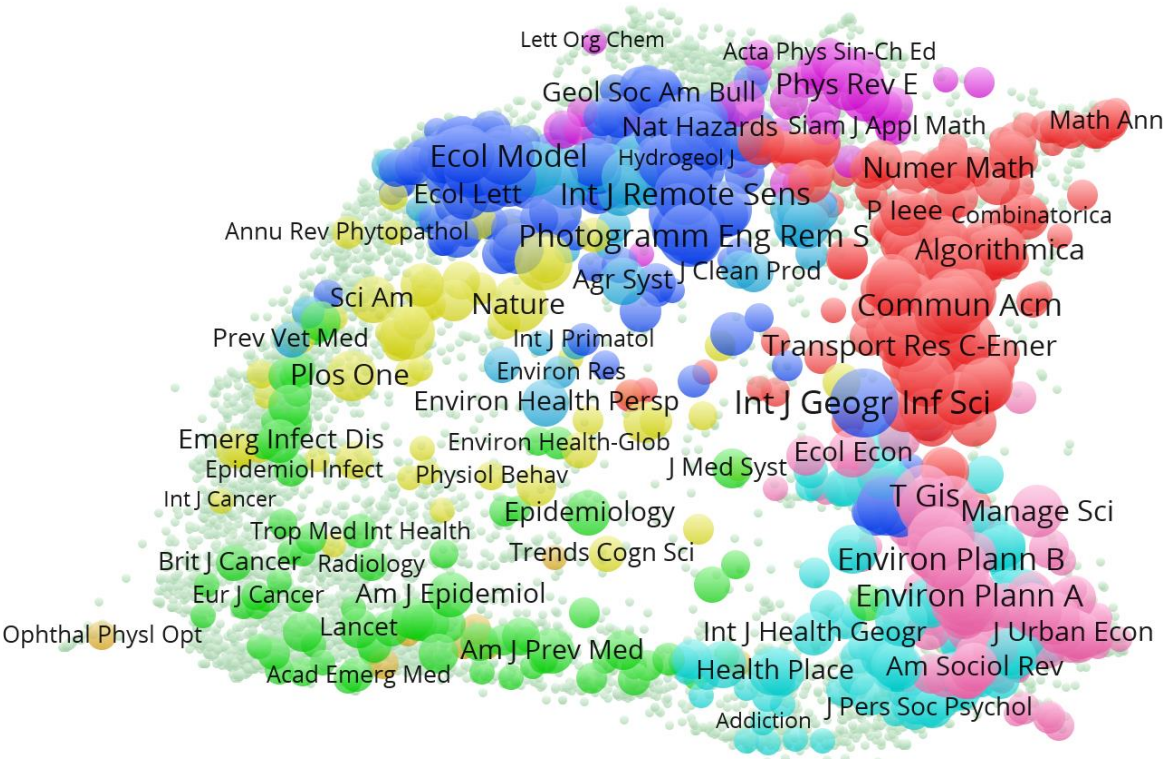

Figure 3. Visualization of citations in major GIS journals.

GIS as a completed system. Consequently, journals such as the International Journal of Remote Sensing, identified by Caron as relevant to GI Science, are less relevant to this discussion. Consequently, we feel that the most relevant papers are International Journal of Geographic Information Science IJGIS (known as International Journal of Geographic Information Systems until 1997), Transactions in GIS (abbreviated as T GIS in Figures), GeoInformatica and Computers, Environment and Urban Systems.

Figure 3 illustrates the journals cited. Figure 3 illustrates that publications in these GIS related journals are informed by citation from a range of areas, including computer science and the quantitative approaches on the right if the figure. These journals using quantitative approaches include management science journals that might be found in business schools, such as Management Science, Operations Research and Omega. It also includes computer science journals that have informed the IS discipline, but there is little evidence of direct links to IS itself.

GIS Research

GIS research has never been easily positioned in a traditional research community. This is illustrated by the disciplinary visualizations above, where the IJGIS journal sits somewhat in the middle, in a position rather difficult to classify (Wolfram and Zhao 2014). This is also illustrated by the change of name of that journal from International Journal of Geographic Information *Systems* to International Journal of Geographic Information *Science*. This change reflected a wish to concentrate more on the fundamental techniques than the systems in which those techniques were embedded. Geographic sciences have always been primarily concerned with the accurate representation of the Earth. When that accurate picture was compiled and presented, for instance in the form of maps, others made use of it for military, agricultural, natural resource exploration, and transportation purposes. GIS originated in applications largely concerned with recording geography in a more efficient way. However, when an increasing amount of spatial data has been assembled, it then is used for different purposes and it is then that researchers are challenged by disciplinary boundaries. With GIS having become established in the 1980s, the concept of Geographical Information Science as an academic concept began to emerge. Goodchild (1992) identified a

Table 2. Disciplines cognate to GIS research agenda (Adapted from Goodchild (1992))

Research theme	Cognate discipline
Data collection and measurement, Data capture	Geoscience
Display	Human Computer interaction (HCI)
Data modeling and theories of spatial data Data structures, algorithms, and processes	Computer Science
Analytical tools, Spatial statistics	Quantitative disciplines
Institutional, managerial, and ethical issues	Information Systems (IS)

research agenda appropriate at that time. The eight topics he proposed can be related to Geoscience, Computer Science, Human-computer Interaction (HCI), Quantitative disciplines and IS (Table 2). The pattern of citation in Figure 3 above reflects these relationships, with a substantial number of citations in Computer Science and Mathematical Science. Returning to the subject in a subsequent paper, Goodchild (2010) positioned these themes and some additional GIS research topics in relation the Computer, the Human, and Society. These research themes can be considered in terms of the disciplines that might inform the research (Figure 4).

The role of reference disciplines for GIS is not static. Data collection is followed by the use of computer science techniques to make it usable, followed by the processing of this data using quantitative techniques, the presentation of that information in a way comprehensible to people and ultimately its use

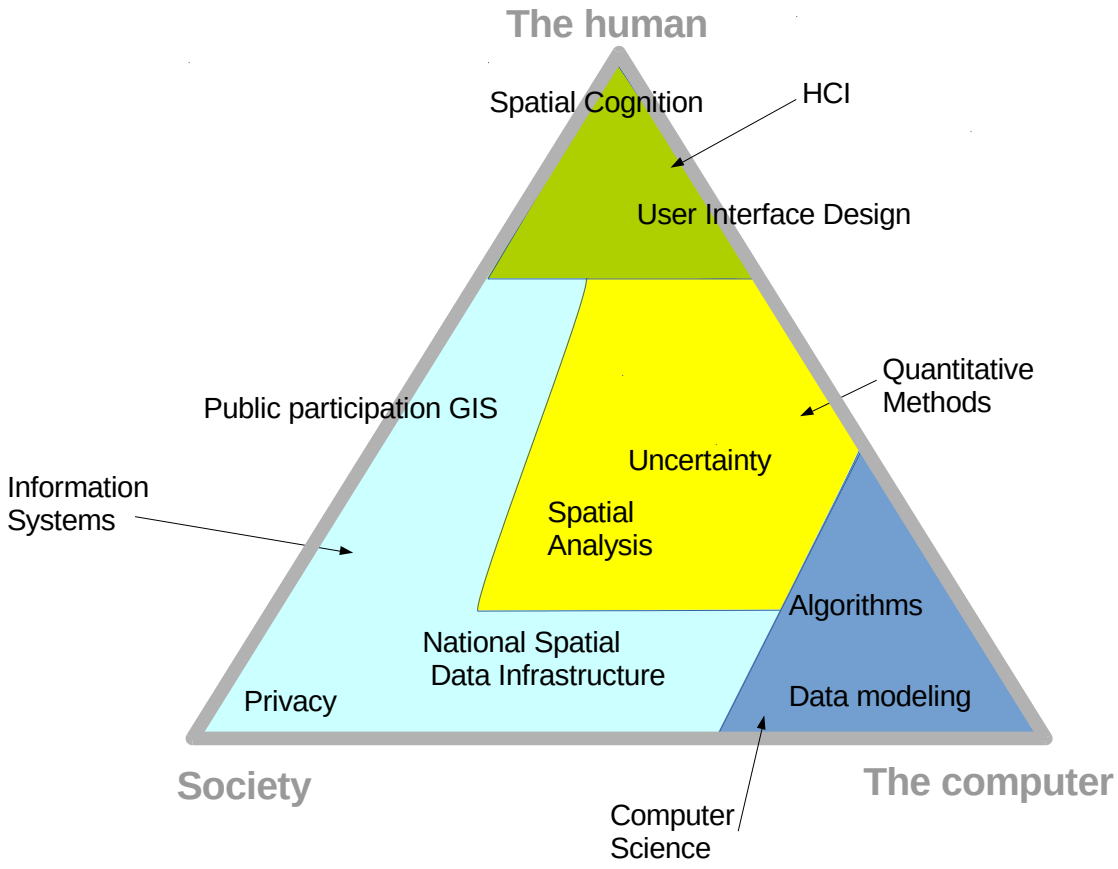

Figure 4 :GI research themes (adapted from Goodchild (2010))

in society, with associated downsides like privacy issues. While new challenges of data collection remain, and Goodchild argued for the need for continue to work on the volume and dimensionality of spatial data, spatial data already collected is in increasing use in society and IS can inform research on the issues arising from that. In a recent contribution, Goodchild (2015) noted a lack of recent academic commentary on GIS, and while this observation was largely directed at academics from geoscience disciplines it can equally be applied to those from IS.

IS Research

In order to characterize IS research, we took the AIS Senior Scholars' Basket of Journals (http://aisnet.org/?SeniorScholarBasket), other than the Journal of AIS, which is not indexed by WOS. The remaining journals were: European Journal of Information Systems, Information Systems Journal, Information Systems Research, Journal of Information Technology, Journal of MIS, Journal of Strategic Information Systems and MIS Quarterly. The citations from these journals, to the end of 2014, are shown in Figure 5 below. Citations are largely from social science journals, but with a substantial number from computer science and management science, with a much smaller proportion from the Environmental sector where GIS papers are mainly published. To some extent the IS and GIS journals draw from fundamental techniques in computer science and decision science.

The IS discipline has seen itself as being concerned with the "development, operation, use and/or impact of an information (sub)system in an organizational environment" and variations of this definition have continued to be used (Goes 2013). While in principle this should include all forms of IT, in practice some forms of IT are given more attention than others. There have been critiques of IS as having failed to fully account for the distinctive IT element that should distinguish IS from other disciplines. Orlikowski and Iacono (2001) noted that "IT artifacts in IS research tend to be taken for granted". If there is little interest in the specifics of the IT artifact, then differences in the capability of IT, for instance the addition of

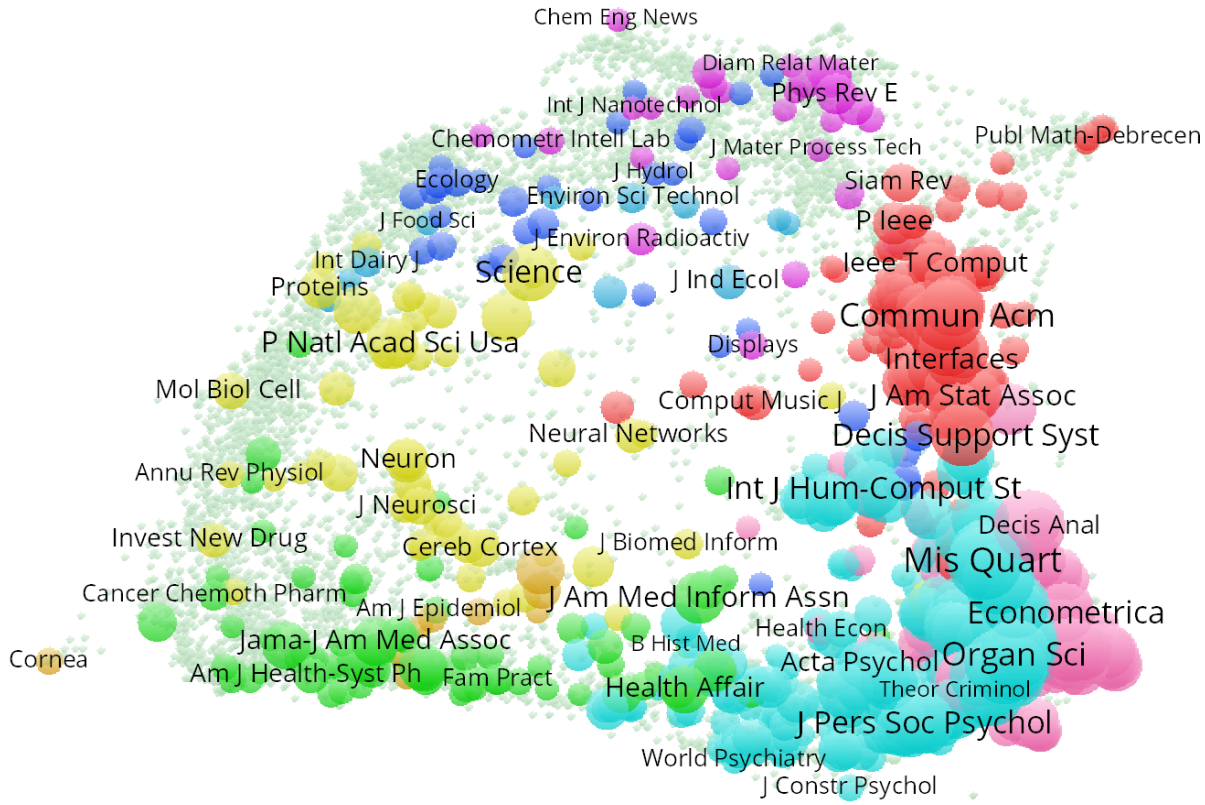

Figure 5 : Citations in top IS Journals

spatial processing capabilities, may not be given appropriate attention. Orlikowski and Iacono identified that many "IS" articles could equally be in another business school domain like logistics or marketing. This may reflect that IS academics are merging into general business school research perspectives, rather than retaining a clear focus on IT. That general business school perspective is also rather narrow in many cases, focused on a limited range of fields like Finance (Mingers 2015). In many business schools, including the authors' own, the role of the business school in the university is seen more to produce funds for research in other areas than to collaborate with them.

They used the example of IT adoption research, which they felt had become increasingly concerned with minor improvements to models rather than on how best IT should support business. They look back to an earlier period of IS research in the 70s and 80s as having had a real concern for the role of IT, a concern which had been lost. In a recent paper, Grover & Lyytinen (2015) suggest that for top IS journals that theory is a goal in itself and that researchers find it easiest to stick to a *middle of the road* approach rather than engage in novel research

A picture emerges of an IS field that had its origin in business data processing in the 1950s and 1960s, research which provided real insights at that time. However, as IT use in business matured, the IS field became increasingly concerned with the nature of its own research rather than the value of the insights provided into the role of IT. This means that IS research can ignore the distinct characteristic of technology, which is that new immature technologies arise all the time and so there are technologies at all stages of maturity. While traditional business use of IT still exists, consumer IT such as social media or personal mobile devices has now become more important as a driver of innovation. Given that various forms of IT are at different levels of maturity, it can be argued that the research approaches used for data processing in the 1960s or Management Information Systems in the 1970s are still appropriate for Location Based Systems at the present time. However, such research is likely to be assessed as much by the novelty of its research model as the novelty of the technology being discussed. While it would seem that a new area of application of IT should be more likely to inform the IS discipline than ever more detailed modeling of the same situations, not all publication outlets see it this way.

Walsham (2012) argues for that IS should concern itself with all areas where IT is used, which is now a very wide range of applications, while recognizing that individual researchers would need to specialize to some extent. Walsham gives the example of healthcare IT as a specialization, this spirit is reflected in the AIS SIGs. While Walsham's perspective is refreshing, it represents the views of a wide ranging researcher who has worked in areas like IT in developing countries, including the use of GIS. This breath of perspective is not universal in the IS community.

A research agenda for IS research on spatial topics

Goodchild's work identifies the important areas of interaction between GIS and IS, those areas of research which are not only technical but where society and organizations are involved. In 1992, spatial data was rather peripheral to society in general, and largely remained the concern of specialists. In 2015, almost everyone has an IT device in their pocket which can employ spatial data. As a consequence of developments in technology and the greater availability of spatial data, IT was become central to many sectors where it was previously less important. The IS disciple needs to research the evolution of the use of technology in these less traditional sectors as well as addressing organizational use of more mature technologies in traditional business.

Spatial Data Infrastructure (SDI) was identified by Goodchild as an important area of research. IS has long researched the integration of data within organizations, this presents an opportunity to research the integration of data across a much wider canvas. Because of the different public and private interests involved, SDI poses questions about the cost and value of data that are less explicit in traditional IS research within organizations. Spatial data also represents the ultimate in Big Data and the understanding of the spatial component of data provides some of the most interesting research questions. Likewise the combination of large amounts of spatial data and small devices using it is a good example of the power of cloud computing (Keenan 2013).

Mobile technologies represent a large and growing component of technology use today. While IS researchers do address the use of mobile devices to some extent, the research often emphasizes the 24/7 portability of mobile devices, the restrictions of the small screen and battery life, and their low cost for

less developed countries and so allowing the extension of e-commerce to a larger number of people in these countries. IS research, with some exceptions, largely ignores the location capability of mobile devices and so ignores the privacy issues arising from this. Even a review of the field calling for more research largely missed the importance of the locational element of mobile technologies (Sørensen and Landau 2015). Consequently, the locational aspect of mobile technology remains an important opportunity for IS researchers.

The combination of devices that are Internet connected and spatially located allows the collection of increasingly large amounts of spatial data. When this is done in a deliberate way it becomes volunteer geographic information (VGI) and is now an important contributor to the base of spatial data collected (Goodchild 2007). When your movements on your phone are monitored it generates ambient or "*involuntary*" VGI (Fischer 2012). When this data collection is undertaken by end users in the context of the availability of free maps and useful navigation services, a form of two-sided market is created. In this situation there may be a mutual exchange of value, but it is a far from transparent market and the nature of the exchange is clearer to one side of the transaction than the other. The routine collection of spatial data by private organizations such as Google, Apple or Twitter poses enormous challenges to privacy and this is an important area for investigation by researchers.

Public participation GIS also reflects a more diverse user base than traditional IT within organizations and represents a potentially important area of investigation for IS researchers. While Internet use is now ubiquitous, much of it is analogous to relatively low level data processing and research is required into more advanced applications just as an earlier generation of IS research looked at organizations moving from data processing to "*informating*" systems (Zuboff 1988). Spatial and locational information is one growing aspect of more advanced systems.

Given the increasing widespread adoption of GIS techniques, spatial processing becomes embedded in organizational IT infrastructure. The issues arising from the move to widespread deployment is one where the IS field, with its long record of research into issues of implementation, can usefully contribute. While there has been sporadic work published in GIS journals drawing from the IS literature, for instance Eldrandaly et al (2015), this area would benefit from greater collaboration between IS academics and those expert in GIS.

Conclusion

The disciplinary structure of research, with its consequent ranking mechanisms and academic promotion based on those rankings, can inhibit interdisciplinary research (Rafols et al. 2012). Journals often have a restricted focus and atypical research drawing from different disciplines presents problems of finding reviewers and assessing the quality of the work. The authors have had the experience of a paper arguing for the integration of techniques from GIS and OR/MS being rejected by multiple journals as being unsuitable for the journal, with referees suggesting a journal from the other discipline as being more suitable (when the reviewers in the other discipline had already suggested the journal where the paper was currently under review!). In relation to GIS and IS this fragmentation poses two dangers; that IS will not learn from GIS and that GIS will not learn from IS.

As GIS is an evolving technology which has reached considerable importance, it now represents a significant form of IT application, and one with distinct characteristics which could usefully inform the IS discipline generally. Furthermore, there is sometimes a tendency to characterize new technologies as an entirely new phenomenon, when the reality is that they have some new elements and some elements that have been seen before. So just as a new technology like cloud computing has some elements in common with timesharing mainframes a generation before, GIS is also dealing with issues which have previously arisen in IS. If the IS field is largely divorced from GIS then these similarities may not be identified and a danger of reinventing the wheel arises. Spatial technologies are now widespread and significant and the IS academic field must address their importance. IS academics with awareness of GIS must link the fields so that IS academics in other areas can fully take account of spatial systems without becoming specialists. For instance, if the locational characteristics of mobile are well documented in the IS literature than other researchers concerned with issues such as privacy can better take account of issues arising from location tracking. In conclusion, spatial systems largely remain a distant land of which little is known as far as IS research is concerned.

References

Caron, C., Roche, S., Goyer, D., and Jaton, A. 2008. "Giscience Journals Ranking and Evaluation: An International Delphi Study," *Transactions in GIS* (12:3), pp. 293-321.

Coppock, J. T., and Rhind, D. W. 1991. "The History of GIS," in *Geographical Information Systems, Volume 1 : Principles*, D.J. Maguire, M.F. Goodchild and D.W. Rhind (eds.). Harlow, Essex, England: Longman Scientific & Technical, pp. 21-43.

Crossland, M. D., Wynne, B. E., and Perkins, W. C. 1995. "Spatial Decision Support Systems: An Overview of Technology and a Test of Efficacy," *Decision Support Systems* (14:3), pp. 219-235.

Eldrandaly, K. A., Naguib, S. M., and Hassan, M. M. 2015. "A Model for Measuring Geographic Information Systems Success," *Journal of Geographic Information System* (7:4), pp. 328-347.

Fischer, F. 2012. "A New but Delicate Data-Source: VGI as Big Data. Geoinformatics, 15(3), 46-47.," *Geoinformatics* (April/May 2012), pp. 46-47.

Goes, P. B. 2013. "Editor's Comments," *MIS Quarterly* (37 No. 1/March 2013:1), pp. iii-vii.

Goodchild, M. F. 1992. "Geographical Information Science," *International Journal of Geographical Information Science.* (6:1), pp. 31-45.

Goodchild, M. F. 2007. "Citizens as Sensors: The World of Volunteered Geography," *GeoJournal* (69:4), pp. 211-221.

Goodchild, M. F. 2010. "Twenty Years of Progress: Giscience in 2010," *Journal of Spatial Information Science* (1), pp. 3-20.

Goodchild, M. F. 2015. "Two Decades On: Critical Giscience since 1993," *The Canadian Geographer / Le Géographe canadien* (59:1), pp. 3-11.

Grover, V., and Lyytinen, K. 2015. "New State of Play in Information Systems Research: The Push to the Edges " *Mis Quarterly* (39:2), pp. 271-296.

Keenan, P. B. 2013. "Cloud Computing and DSS: The Case of Spatial DSS," *International Journal of Information and Decision Sciences* (5:3), pp. 283-294.

Leydesdorff, L., Carley, S., and Rafols, I. 2013. "Global Maps of Science Based on the New Web-of-Science Categories," *Scientometrics* (94:2), pp. 589-593.

Leydesdorff, L., and Rafols, I. 2012. "Interactive Overlays: A New Method for Generating Global Journal Maps from Web-of-Science Data," *Journal of Informetrics* (6:2), pp. 318-332.

Maguire, D. J., Goodchild, M. F., and Rhind, D. W. 1991. *Geographical Information Systems: Principles, Techniques, Management and Applications*. Longman.

Mingers, J. 2015. "Helping Business Schools Engage with Real Problems: The Contribution of Critical Realism and Systems Thinking," *European Journal of Operational Research* (242:1), pp. 316-331.

Orlikowski, W. J., and Iacono, C. S. 2001. "Research Commentary: Desperately Seeking the "IT" in IT Research—a Call to Theorizing the It Artifact," *Information systems research* (12:2), pp. 121-134.

Rafols, I., Leydesdorff, L., O'Hare, A., Nightingale, P., and Stirling, A. 2012. "How Journal Rankings Can Suppress Interdisciplinary Research: A Comparison between Innovation Studies and Business & Management," *Research Policy* (41:7), pp. 1262-1282.

Sørensen, C., and Landau, J. S. 2015. "Academic Agility in Digital Innovation Research: The Case of Mobile ICT Publications within Information Systems 2000–2014," *The Journal of Strategic Information Systems* (24:3), pp. 158-170.

Walsham, G. 2012. "Are We Making a Better World with ICTs?; Reflections on a Future Agenda for the IS Field," *Journal of Information Technology* (27:2), pp. 87-93.

Wolfram, D., and Zhao, Y. 2014. "A Comparison of Journal Similarity across Six Disciplines Using Citing Discipline Analysis," *Journal of Informetrics* (8:4), pp. 840-853.

Zuboff, S. 1988. *In the Age of the Smart Machine*. New York: Basic Books.