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Joint 4S/ISSI Panel on Mapping Science
Organized by Henry Small

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Maps of science as visual representations of scientific activity have become commonplace in information science and scientometrics over the last decade. This development has paralleled the advent of large scale data files, and the emergence of numerous algorithms for the reduction of dimensions of inherently hyper-dimensional systems. Whether based on citation data, co-authorship, co-word patterns, social contacts, web links, etc. such analyses are often invoked to demonstrate the structure and evolution of scientific fields, and that all researchers or ideas are separated by only a few steps, i.e., the small-world of science and scholarship.

This panel will explore the state-of–the-art for creating and interpreting maps of science. Are maps valid representations of scientific fields or of science as a whole, and what are the viable approaches to validation? What social and intellectual realities do they capture, or fail to capture? What metaphors are most effective for explaining maps? Is readability an issue? What is the influence of self-citations, or citation cliques on these structures? Can scientific controversies be represented by maps and what do they look like? Can maps inform us about the history of a field? Do they reflect a "collective mind" of science, or are they merely artifactual aggregates of particularistic behavior? Finally, what is the audience for such maps: the scientific elite or the masses?

Combined Mapping of the Science and Technology Literature at the Structural and Detailed Levels
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Sandia National Laboratories has been creating annual maps of science and technology for planning and evaluation purposes. Bibliographic data from journals and conference proceedings are used in a multi-stage process that produces maps at the discipline level (for structure) and research community level (for detail), and combines them for visualization. Structural maps are validated by comparing them to known journal categorizations schemes. Detailed maps are validated using multi-document summarization techniques. Maps from subsequent years can be linked to allow study of the dynamics of science at local levels. Details of process, accuracy, and linking will be presented.

Visualizing Critical Trails of Scientific Knowledge
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Scientific frontiers represent the most vibrant and volatile form of scientific knowledge. The desire to identify, understand, and track the development of scientific frontiers is deeply rooted in philosophy of science, sociology of science, information science, and a wide variety of scientific disciplines. While landmarks and groundbreaking works in science are relatively easy to tell, identifying and understanding emerging trends and pivotal points in large-scale intellectual transformations, such as paradigm shift, the evolution of competing paradigms, and the movement of a research front, has been so painstakingly time consuming and intellectually demanding that the majority of scientists and scholars do not have effective tools to access and study such phenomena in a holistic approach, i.e. to see a forest as well as trees. I will present a few examples of how paradigm shifts, scientific revolutions, scientific debates, and the impact of external events can be depicted through the use of the CiteSpace system for progressive knowledge domain visualization of scientific literature.

Citation structure of an Emerging Research Area

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The distribution of citation links over scientific papers is highly non-uniform, and distinct regions or clusters of papers are evident using various analytical methods. Studies have shown these locally dense clusters of citation activity to have a fairly homogeneous subject matter and social structure, that is, the participants share common interests and form a social network. Information visualization or mapping techniques allow us to create a spatial view of this network, showing both its internal link structure at the paper or author level, and its external structure in the context of other research areas. For each area we distinguish between the cited literature, including its leading concepts and authors, and the citing literature which, by virtue of its pattern of citation links, actively creates the structure. The latter constitutes what is sometime called the research front. Here we take a critical look at the nature of these linkages: to what degree are they the result or artifact of self-citations, or what have been called “citation circles”? What is the role of review papers versus regular research articles? Also, what can be learned by examining the texts in which the citations originate – the so-called citing contexts? Is there a shared “research agenda” or collective narrative being told by the participants? How do these findings then fit with a normative or constructivist perspective? Data is presented from a case study of a single emerging research area in plastic electronics.

Studying and Supporting the Emerging Global Brain

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Today, humanity's knowledge is stored in an exponentially increasing number of papers, books, emails and in other formats. No man and no machine can process this enormous amount of data and hence most of the knowledge gets reinvented, is duplicated across

sciences, or is simply lost forever after a short period of time. However, to survive as a species, we will need to preserve our planet or find means to sustain life as we know it by other means. Besides achieving survival, we should aim to enable all human beings to live a healthy, productive and fulfilling life. Meeting these challenges requires the design of cyberinfrastructures that provide access to humanity's collective knowledge, data and tools and support the 'global brain' that is emerging on this planet. This talk will present results of our studies of the emerging global brain and the beginnings of a cyberinfrastructure that aims to support the growth of a global scholarly brain.