Visualizing Forensic Publication Impacts and Collaborations: Presenting at a Scientific Venue Leads to Increased Collaborations between Researchers and Information Professionals

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ABSTRACT: The Information Services Office (ISO) of the National Institute of Standards and Technology (NIST) proactively sought out an opportunity to present the findings of a study that showed the impact of NIST's forensic research output to its internal customers and outside researchers. ISO analyzed the impact of NIST's contributions to the peer-reviewed forensic journal literature through citation analysis and network visualizations. The findings of this study were compiled into a poster that was presented during the Forensics@NIST Symposium in December 2014. ISO's study informed the forensic research community where NIST has had some of the greatest scholarly impact. This paper describes the methodology used to assess the impact of NIST's forensic publications and shares the results, outcomes, and impacts of ISO's study and poster presentation. This methodology is adaptable and applicable to other research fields and to other libraries. It has improved the recognition of ISO's capabilities within NIST and resulted in application of the methodology to additional scientific disciplines.

INTRODUCTION

The National Institute of Standards and Technology (NIST) is a non-regulatory agency within the United States Department of Commerce (DOC). NIST's mission is to promote U.S. innovation and industrial competitiveness by advancing measurement science, standards, and technology in ways that enhance economic security and improve the quality of life.

The Information Services Office (ISO) is responsible for creating, maintaining, organizing, and disseminating information to support the research and programmatic needs required to fulfill the scientific and technical mission of NIST. ISO supports the work of NIST through its assessment activities and works closely with NIST program staff to help NIST senior management determine the impact of NIST's research.

The Information Services Office proactively sought out an opportunity to present the findings of a study that showed the impact of NIST's forensic research output to its internal customers and outside researchers at a Forensics@NIST Symposium. ISO analyzed the impact of NIST's contributions to the peer-reviewed forensic journal literature through citation analysis and network visualizations. The findings of this study were compiled into a poster that was presented during the Forensics@NIST Symposium in December 2014 (Bruss, 2014). ISO's study informed the forensic science research community about where NIST's published research in forensic science has had some of its greatest scholarly impact.

The poster session, held at a venue outside of the library and information fields but familiar to and well attended by its customer base, led to a series of positive developments for ISO. First, new relationships were forged with the forensics community at NIST. Second, these new relationships led to a co-presentation with a NIST forensics researcher at an American Association for Forensic Sciences workshop. Finally, the poster presentation generated additional requests for similar analyses in other fields of study.

BACKGROUND ON FORENSICS@NIST SYMPOSIUM

In December 2014, NIST hosted a two-day symposium, Forensics@NIST, showcasing the forensic science research performed in its world-class laboratories across many disciplines, including computer forensics, biometrics, genetics, firearms and toolmarks, and statistical measurements. (More information about the Forensics@NIST Symposium is available at http://www.nist.gov/forensics/forensics-at-nist-2014.cfm.)

The NIST Special Programs Office (SPO) Forensic Science Research Program invited NIST researchers with projects related to forensic science to present posters at the Forensics@NIST 2014 Symposium. The poster session highlighted relevant research beyond the symposium's oral presentations.

Thirty posters were displayed on the second day of the symposium. Authors were on hand during the allotted poster sessions to answer questions and share contact information with interested attendees.

INTRODUCTION TO FORENSIC SCIENCE

According to the American Academy of Forensic Sciences, any science used for the purposes of the law is a forensic science. The forensic sciences are used to resolve civil disputes, to enforce criminal laws and government regulations, and to protect public health. Based on images enhanced by television, movies, and books, forensic science became identified with law enforcement and the prosecution of criminal cases. However, this is misleading because forensic science is objective, unbiased, and applies equally to either side of any legal matter.

The forensics sciences span many areas of interest including anthropology, odontology, pathology, and toxicology to name a few. Regardless of the area of expertise, a forensic scientist must be unbiased, accurate, methodical, and detailed since the work of a forensic scientist is intended to be used in court.

LITERATURE REVIEW

Studying the scope, depth, range, and complexity of forensic sciences literature is not new. A review article, "Forensic Science," published in *Analytical Chemistry* in 2011, offers an in-depth look at the field of forensic science, and aids in understanding the work that has been accomplished in recent years to demonstrate the validity of specific forensic methods (Brettell, 2011). Overcoming the challenges of searching the forensic sciences literature is the topic of a recent *Forensic Sciences Review* article (Teitelbaum, 2015).

Bibliometric study of the forensic sciences literature is a frequently published topic. A 1993 article in *Forensic Science International* was one of the first papers to look at the impact of forensic science journals (Jones, 1993). A 1998 paper examined citation trends and practices in the *Journal of Forensic Sciences* (Jones, 1998). Impact factors of forensic science and toxicology journals continued to be a topic of study in later years (Jones, 2003; Jones, 2007). Also, at that time, the most highly cited articles and authors in forensic sciences became a subject of interest (Jones, 2005a; Jones, 2005b).

Bibliometric studies of journals publishing bio-medicolegal research in Europe were the topics of two papers in the *International Journal of Legal Medicine* (Boscolo-Berto, 2012; Ferrara, 2011). Those papers examined the publication metrics of a number of bio-medicolegal sub-disciplines, including forensic pathology, forensic toxicology, forensic genetics, and forensic anthropology.

A more recent study analyzed citation patterns for articles published in *Forensic Science International: Genetics* since its launch in 2007 (Phillips, 2014). That paper identified the most highly cited articles published by the journal since it was first published, and amongst those, the articles having the greatest impact— i.e., the articles with the highest citation rates per year since their publication.

While the forensic sciences literature has been studied in depth, the tools to analyze it have been limited to tables and simple graphics, such as pie charts and bar graphs found in the aforementioned papers. Recently, data visualization tools have become available and enable complex visual representations of information, such as world maps and network diagrams. For example, the studies of the National Oceanographic and Atmospheric Administration (NOAA) climate literature include geographic maps that analyze climate articles by citing country and network diagrams that show co-author collaborations. (Belter, 2012; Belter, 2013).

METHODOLOGY

The *Web of Science* database was used to identify NIST-authored forensic publications (note that identification of commercial products is not intended to imply recommendation or endorsement by the National Institute of Standards and Technology, nor is it intended to imply that the products identified are necessarily the best available for the purpose). *Web of Science* was selected for several reasons. Most relevant to this study, the *Web of Science* output is compatible with the software used for the visualizations. In addition, the Organization-Enhanced feature in *Web of Science* simplifies the task of identifying papers by NIST authors (by including organizational name variations in a single search). Organizations are only associated with author names in *Web of Science* for papers published since 1978, so the search results were limited to 1978-2014.

The *Web of Science* subject category "Medicine Legal" is assigned to journals that publish forensic sciences research, so all NIST publications in Medicine Legal were included in the study. Forensics is a multi-disciplinary research field and authors publish in many journals that do not fall under the Medicine Legal subject category. To capture these, ISO developed a complex *Web of Science* search using a variety of forensics-related keywords, and then reviewed the abstracts and keywords of all of the papers for relevance. The combined search strategy yielded the 198 documents included in this study (Figure 1).
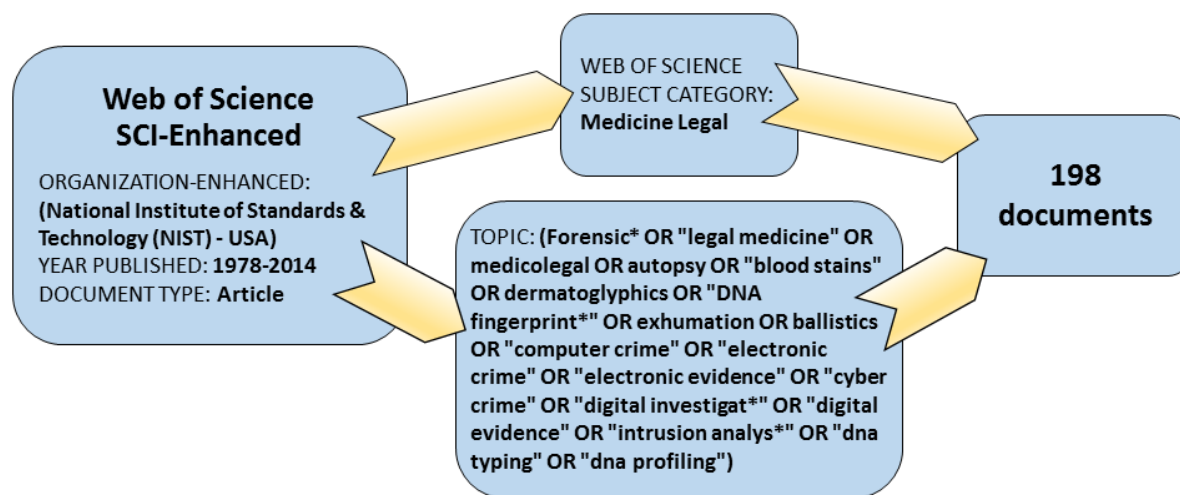

Figure 1: Combined Search Using *Web of Science*

The full list of *Web of Science* records and the citations to those *Web of Science* records were then extracted and analyzed using multiple visualization tools to create a co-author network structure and a citation map. These visualizations were selected to show not only the structure of forensic research collaborations at NIST but also the breadth of NIST's impact internationally.

A network structure was created using the Science of Science (Sci^2) Tool to extract a co-author network from the *Web of Science* search results. Sci^2 is a modular toolset specifically designed to analyze and visualize scholarly datasets – it supports temporal, geospatial, topical, and network analyses. The co-author network was then visualized using Gephi, an open source tool for analyzing and visualizing large network graphs.

Sci^2 was used because ISO staff were familiar with using the software and it could easily analyze data from *Web of Science*. Sci^2 takes the *Web of Science* data and converts it to an edge and node table which is necessary for creation of a network. Authors (represented by circles in the visualization) were connected to collaborators (via lines) and arranged using Gephi algorithms. Gephi functions allowed for resizing the nodes (circles) and lines based on the number of citations and collaborations, respectively. Subdisciplines for the network were assigned manually by studying the underlying papers for each author and identifying their predominant research field. Gephi was used because it's proficiency for network analysis manipulation.

A citation map was created using Tableau to map the citing country data. The number of citations is represented by the intensity of the color fill – the darker the color, the higher the number of citations to NIST forensic research.

FINDINGS

NIST forensic research is interdisciplinary and collaborative, as reflected in the body of publications produced. Publication types include journal articles, conference papers, books, book chapters, and technical reports. The focus of this paper is on NIST collaborations as studied in the peer-reviewed journal literature. This analysis, based on the *Web of Science* search, yielded 198 NIST forensic publications in 24 different research areas and 51 journals since 1978. Most of the articles (151) have been published since 2003, with more than 15 articles published in each of the years 2011, 2013, and 2014 (Figure 2). Of the 198 NIST forensic publications, only seven were published with a single author.
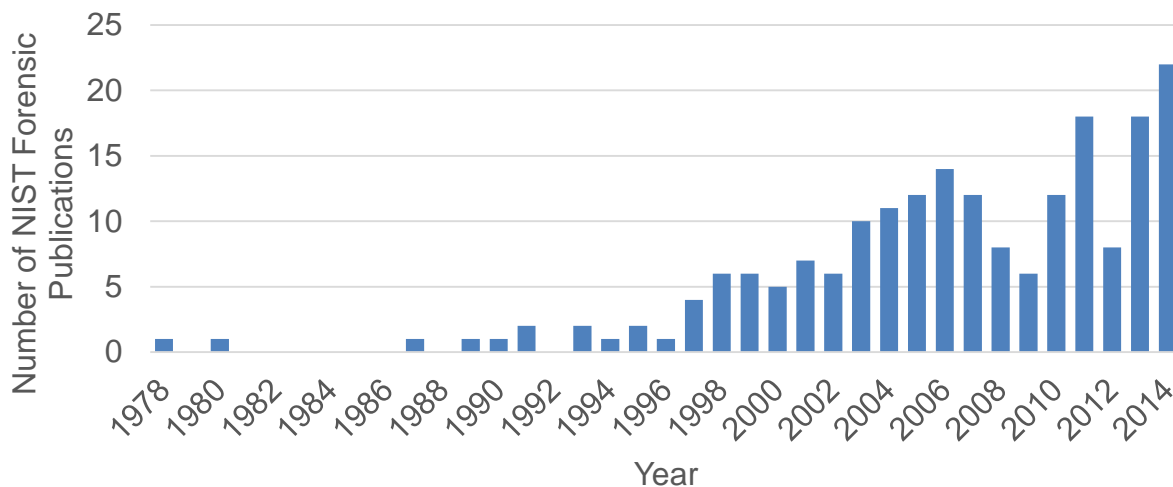
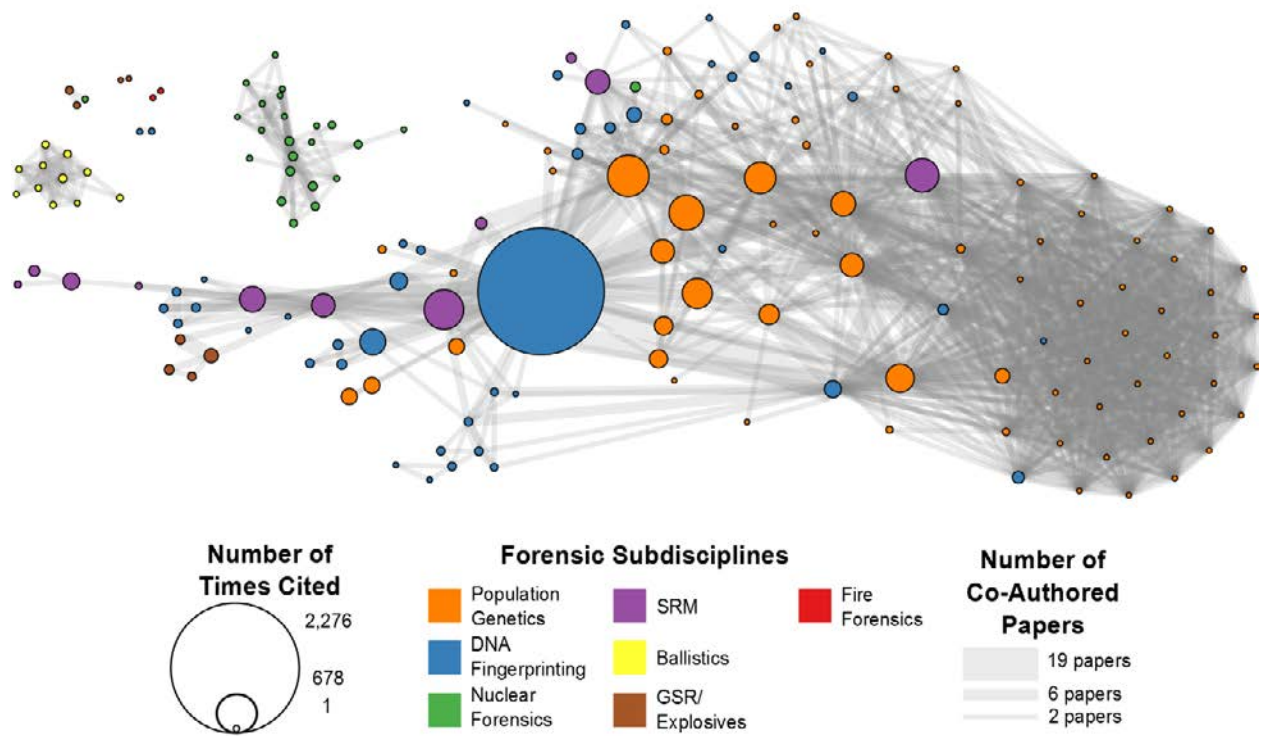**Figure 2:** Number of NIST Forensic Publications, 1978-2014

The co-author network shows the collaboration between authors who have published two or more papers together, along with their research fields (Figure 3). Each node represents an author—NIST or non-NIST—who has co-authored with a NIST scientist; each node size represents the number of citations the author has received. The largest node represents Dr. John M. Butler, with 60 authored works and 2,276 citations. Dr. Butler is a NIST Fellow and NIST's leading forensic researcher.

The colors in the network diagram represent different forensic subdisciplines. The most prevalent are population genetics (43%) and DNA fingerprinting (26%). Figure 3 shows the close relationship and frequent collaborations of authors in the fields of population genetics, DNA fingerprinting, and Standard Reference Materials (SRMs). Authors in ballistics, nuclear forensics, and gunshot residue (GSR)/explosives tend to co-author within their own field.

NIST forensic publications have been cited 3,751 times since 1978. The most highly cited paper is "The development of reduced sized STR amplicons as tools for analysis of degraded DNA" by John M. Butler, Yin Shen, and Bruce R. McCord in 2003.

NIST forensic publications are cited by authors from 2,496 institutions and in 632 unique journals. They are cited most often by articles in *Forensic Science International: Genetics,* with 408 citations, and in *Journal of Forensic Sciences*, with 170 citations.

NIST forensic publications have been cited by foreign authors from 113 different countries. They are cited most frequently by authors in China (224 papers), Germany (218 papers), and the United Kingdom (215 papers) (Figure 4).

Figure 3: Co-author Network Showing Collaborations between Forensic Authors
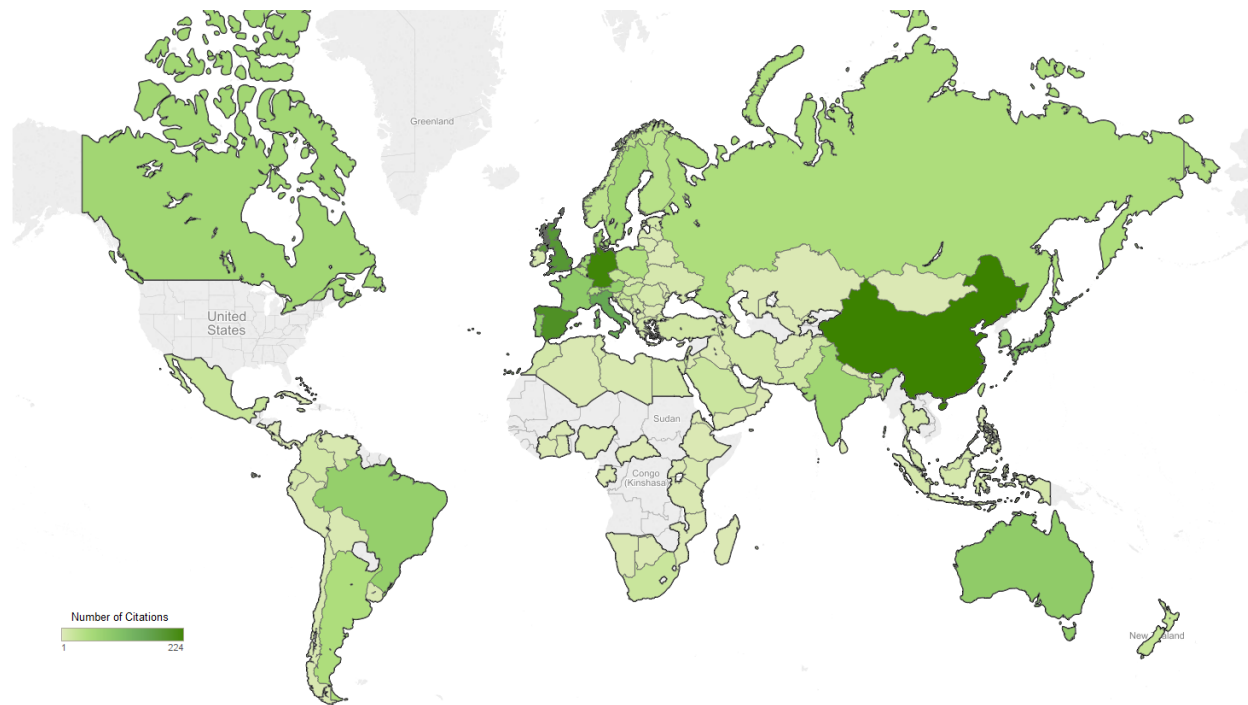
Figure 4: Citation Map Showing Location of Foreign Authors Citing NIST Forensic Publications

RESPONSE TO THE POSTER

Researchers expressed a keen interest in the results of ISO's study during the poster session at the Forensics@NIST 2014 Symposium. Substantial and interesting conversations at the poster session enabled ISO staff to demonstrate their capabilities, which included:

Methodology: The co-author network visualization (Figure 3), in particular, captured the attention of conference attendees and provided an opportunity to discuss and market ISO's data visualization capabilities. It also spurred a number of conversations about the visualization tools used to create the image. This, in turn, provided the opportunity to promote ISO's visualization computer—a dedicated computer that provides NIST researchers with 24/7 free access to an array of specialized software, including the programs used to generate the poster images.

Limitations of citation analysis: The poster session enabled ISO staff to learn more about the differences between forensic subdisciplines, and the possible limitations of using citation analysis for research areas where practitioners tend not to publish in peer-reviewed journals. The discussions included the possibility (but also difficulty) of using altmetrics, such as download statistics.

Forensic publication analysis: The poster provided an opportunity to discuss expansion of the analysis beyond the journal literature. That particular conversation at the poster session strengthened the relationship between ISO and NIST's leading authors of forensic research.

Applications of the methodology to other disciplines: Staff from other research areas at NIST attended the poster session and saw potential applications of ISO's study to their various disciplines. In addition, analysts from another government agency (the National Institute of Justice) asked ISO's advice on how to conduct similar impact analyses.

Additional ISO studies: To date, ISO's poster at Forensics@NIST has led to requests from NIST researchers for additional studies, including:
- expanding the analysis beyond NIST publications to overall trends in the forensic literature
- applying the methodologies to publications and data in other scientific disciplines
- interpreting the visualizations to identify research gaps

DISCUSSION

Forensic research at NIST crosses many disciplines from legal medicine and chemistry to computer science and food science technology. This research and the resulting publications by NIST scientists have proven impact on the international forensic research community as demonstrated through ISO's study and findings.

While this study captured the majority of NIST's forensics-related journal articles, it was not possible to identify every NIST paper due to the interdisciplinary nature of forensics. In future studies, ISO will further develop and refine its search strategy for identifying NIST forensic publications to broaden the scope of the search while improving its accuracy. ISO also intends to study the forensic field as a whole to uncover trends that will help NIST scientists identify potential areas of future research.

Presenting this poster at the forensic conference alongside forensic researchers positioned ISO staff as peers and provided multiple opportunities to interact with NIST researchers in ways that would not otherwise have materialized. ISO made key contacts with a number of NIST researchers at this conference that have led to ongoing collaborations.

CONCLUSION

Sharing ISO analysis, results and methodologies in a scientific venue outside of the library and information science fields has opened new doors. NIST scientists are now seeing ISO staff as collaborators and not just support staff helping with literature reviews, book and journal requests, and ready reference questions.

To meet customer expectations, ISO will continue to develop its data analysis and visualization skills beyond the tools used in this study. As researchers ask for similar studies, ISO will develop the data visualization skills of additional staff to accommodate the growing number of customer requests. This methodology developed for

this poster has applications well beyond forensic research. This methodology can be used as a roadmap by other libraries for any science/technology research area. ISO shared the methodology, highlighting its adaptability, through a poster at the 2015 Special Libraries Association conference (Bruss, 2015) and will continue to share developments and expanded applications as they progress.

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