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Visualizing the Scholarly Impact of Medical Education Researchers

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Abstract: The Carle Illinois College of Medicine is a new professional school with an engineering-focused approach to the medical education of Physician Innovators. Over 200 faculty representing diverse disciplines from across the Illinois campus were identified to provide instruction, curricular support, and mentorship for student-driven research. Representing academic departments in STEM, medicine, health and life sciences, this trans-disciplinary approach to medical education creates unique opportunities for innovation. While processes to review the academic performance of students are continually being iterated upon, another aspect of assessing the research efficacy of a college is to track the scholarly impact of affiliated faculty. Librarian information professionals embedded in academic libraries have developed expertise in the understanding, use and application of research metrics. This information has typically been provided in narrative form, non-interactive graphs, or has required a significant understanding of specialized visualization tools (such as Tableau), which may also incur licensing fees.

The Grainger Engineering Library Information Center at the University of Illinois at Urbana-Champaign has developed a new visualization web tool to display and disseminate data on scholarly impact of faculty in the new medical school. This tool requires no additional software for use or access, displays information in interactive form, and provides meaningful connections between data points. By harvesting bibliographic metadata through the Scopus API, the NIH and NSF websites, and the USPTO office, college administrators are able to visualize the publications, collaborations, citation metrics, and funded projects of their faculty. Harvested metadata is stored in a Microsoft Access relational database in separate tables. Bibliographic data and metrics including author name, list of publications within a specific date range, h-index, cited by count, number of co-authors and list of funded grants, and patents is then transcribed into a combined table. Utilizing HTML5 and Scalable Vector Graphics (SVG), a web-based program displays each data element of the combined table with a clickable link to expanded results for each author. With a focus on engineering, technology, and innovation in the new medical school, granted patents of affiliated faculty and students are tracked to assess the entrepreneurial impact of the curricula. By tracking scholarly impact, universities are provided with metrics to help set the direction

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of curricular development, recruit high performing faculty and students, and make strategic budgeting decisions.
Keyboards: Visualization Tool, Research Impact, Metrics, Bibliographic Analysis, Citations, Patents, Grants

1. Literature Review:

Visualization as a tool for assessing scholarly impact is not a new concept. As Behrisch et al (2018) found "effective and efficient visualizations" can "show the most information in the simplest possible form." To understand scholarly impact, visualizations can provide an interactive display that brings together many different data points to understand the multiple facets of scholarship. As Martin (1996) stated, "no single indicator of research output or performance will ever reveal more than a small part of the multidimensional picture." Ravenscroft, Liakata, Clare, and Duma (2017) tell us "academic impact is traditionally measured through the use of author metrics, such as per-author and per-journal citation counts." While bibliometric data on citations and number of publications is plentiful, there is limited connectivity between research articles, corresponding authors, and information available for other scholarly information, such as data on grants and patents. Svider et al (2012) and Li et al (2017) remind us that information on grants is often used to measure research productivity. However, there is a significant lack of connectivity between grants and corresponding published articles for the funded research (Boyack & Jordan, 2011). Bibliometric data on patents can also provide a method for evaluating the impact of a researcher on technology and innovation (Narin, 1994). Moed and Halevi (2015) go further and tell us that "patents are almost the only form of public communication that can be used as indicators of technological innovation and thus it is used as a part of the evaluation of institutions and individuals." As these data end points are often siloed in different databases and websites, it can be difficult to develop a holistic approach to assessing the scholarly impact of individuals and institutions. Data on scholarship is also increasingly being included in the assessment of the level of efficacy of research efforts in a college (Hendrix, 2008; Li et al, 2017; Svider et al, 2012; Waltman, 2016). However, faculty and administrators seeking a broader perspective of the impact of scholarship in their college or department find they must navigate different systems to gather this data. For students seeking guidance on research projects, there are often no resources available that brings these many different data points together in a single display that is both interactive and informative. Multiple studies found in the literature have shown that mentorship can be an effective method for improving student performance and success, particularly at the graduate and doctoral level (Ahsan, Zheng, DeNoble, & Musteen, 2018; Roberts, Tinari, & Bandlow, 2019; Schexnayder et al., 2018).

2. Overview:

As Physician Innovators, medical students in the Carle Illinois College of Medicine work with a group of 35 faculty mentors from across campus. As these students progress through the engineering-focused curriculum, they have

access to interdisciplinary researchers for mentorship on developing innovative interdisciplinary solutions to health's greatest challenges. To provide faculty, administrators, and students with data on the scholarly impact of these research mentors, the Grainger Engineering Library developed a web-based visualization tool to display bibliographic data on research publications, grants, and patents. From 2009 to 2019, this group of research mentors published 3,690 unique scholarly articles with a combined 102,479 times cited. In addition, this group has a combined total of 456 National Science Foundation (NSF) and National Institutes of Health (NIH) funded grants and 1,656 patents granted by the United States Patent and Trademark Office (USPTO).

3. Methodology:

Utilizing server-side scripting, the Elsevier Scopus API (Application Programming Interface) is called to harvest research articles by bringing back publications of authors based on their unique Scopus ID. Metadata from these articles is stored in a table in a relational Microsoft Access database. With the table of publications de-duplicated, further scripts and SQL (Structured Query Language) queries are utilized to generate tables and counts of co-authors and number of times publications in the articles table have been cited.

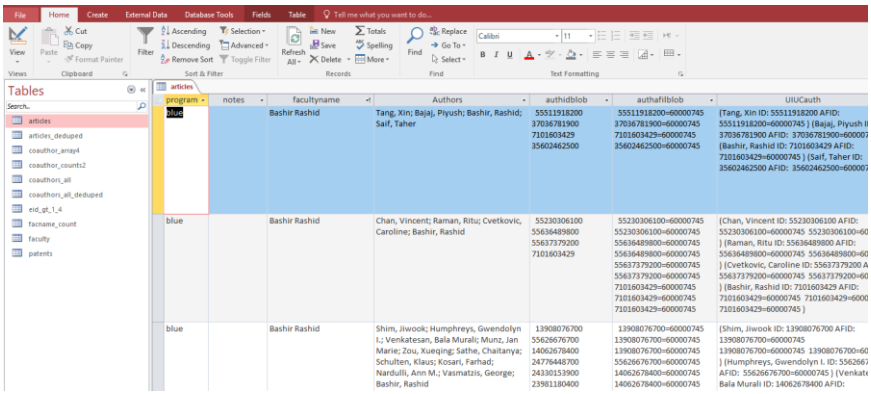


Figure 1: A datasheet view of the articles table in Microsoft Access

By querying a separate Access database of NSF and NIH grants funded at the University of Illinois at Urbana-Champaign, scripts are run to search by author name. All corresponding metadata for grants is then harvested for this group of research mentors. By calling on the USPTO PatentsView API, an Access database table of all patents assigned to the Board of Trustees of the University as an organization is generated. From here a table is created including all of the metadata for patents where these 35 researchers are listed as inventors or co-inventors.

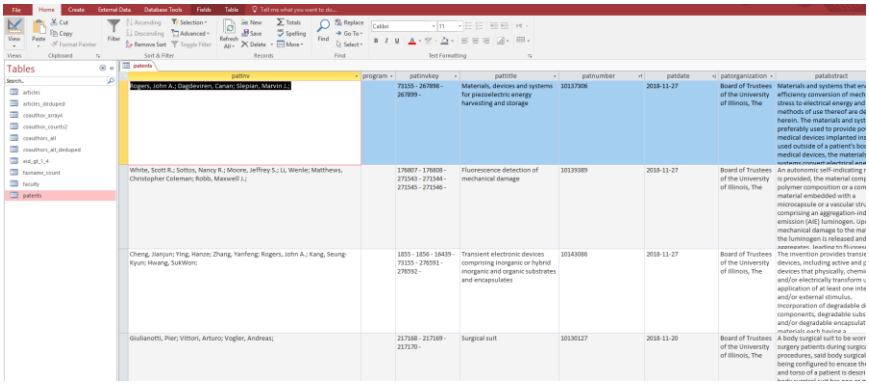


Figure 2: A datasheet view of the patents table

4. Visualization Tool:

With all of the necessary data harvested, a web-tool utilizing server-side scripting in Active Server Pages (ASP) was created to bring these many different data points into one single display for all 35 research mentors.

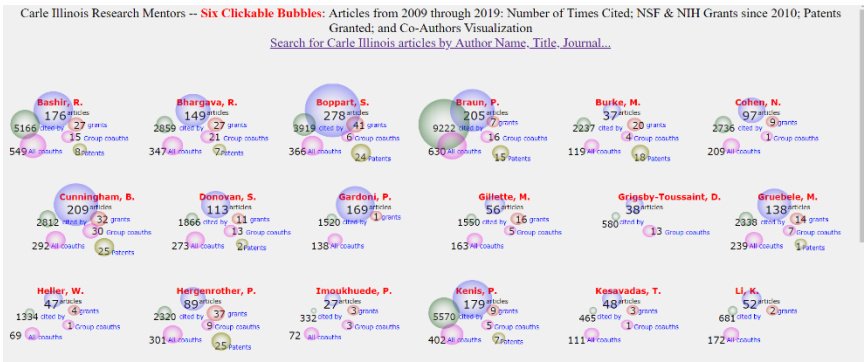


Figure 3: An ASP website displaying clickable links for each author

Six clickable bubbles are generated using Scalable Vector Graphics (SVG) and HTML5. Each bubble represents one of 6 data points for each research mentor: articles published in the date range specified, a Scopus index of citations for each author's publications, a list of all co-authors and their affiliations, funded NSF and NIH grants, list of articles co-authored within the group of authors, and patents granted by the USPTO. By bringing this data together in a single display, users are provided with an easy, quick, interactive, and combined profile of research impact for a group of authors. Each clickable bubble is generated with SVG programming and is scaled in size proportionate to the value of the corresponding data point. This visualization provides a simple way of displaying research metrics that provides more information to users than text values alone.

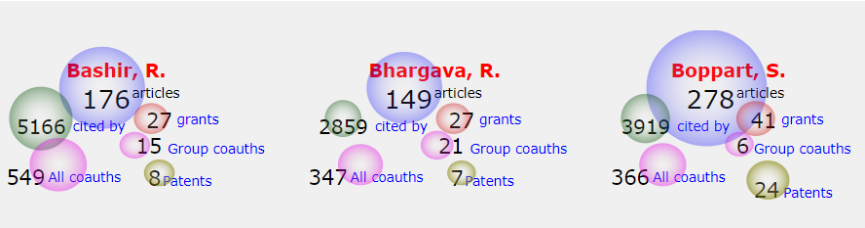


Figure 4: Each research mentor has their own group of clickable data points.

The center bubble provides a link to a list of articles indexed in Scopus for each research mentor (see **Figure 4**). Bibliographic information is included for each publication, including title, authors, source title (publication), and abstract text (see **Figure 5**).

Search Results

Your search for: Boppart Stephen retrieved 278 results

Sort Results by Times Cited

1

Title: Local wavefront mapping in tissue using computational adaptive optics OCT

Authors: South, Fredrick A.; Liu, Yuan Zhi; Huang, Pin Chieh; Kohlfarber, Tabea; Boppart, Stephen A.

Source Title: Optics Letters, v. 44(5) p. 1186-1189 1 March 2019

Abstract: © 2019 Optical Society of America The identification and correction of wavefront aberrations is often necessary to achieve high-resolution optical images of biological tissues, as imperfections in the optical system and the tissue itself distort the imaging beam. Measuring the localized wavefront aberration provides information on where the beam is distorted and how severely. We have recently developed a method to estimate the single-pass wavefront aberrations from complex optical coherence tomography (OCT) data. Using this method, localized wavefront measurement and correction using computational OCT was performed in ex vivo tissues. The computationally measured wavefront varied throughout the imaged OCT volumes and, therefore, a local wavefront correction outperformed a global wavefront correction. The local wavefront measurement was also used to generate tissue aberration maps. Such aberration maps could potentially be used as a new form of tissue contrast.

Links: Full-Text of Article 0 Citing References Scopus Record with References

2

Title: Intra-operative imaging of surgical margins of canine soft tissue sarcoma using optical coherence tomography

Authors: Selmic, Laura E.; Samuelson, Jonathan; Reagan, Jennifer K.; Mesa, Kelly J.; Driskell, Elizabeth; Li, Joanne; Marjanovic, Marina; Boppart, Stephen A.

Source Title: Veterinary and Comparative Oncology, v. 17(1) p. 80-88 March 2019

Figure 5: An index of articles is provided for each author.

Three links are provided for each publication, including a link utilizing the Digital Object Identifier (DOI) for each publication to take you to the full text version of the article (see **Figure 5**). The remaining two links point to Scopus for each publication, including the cited references and the article record with references. The records are by default sorted by date but can be resorted by number of times each publication is cited.

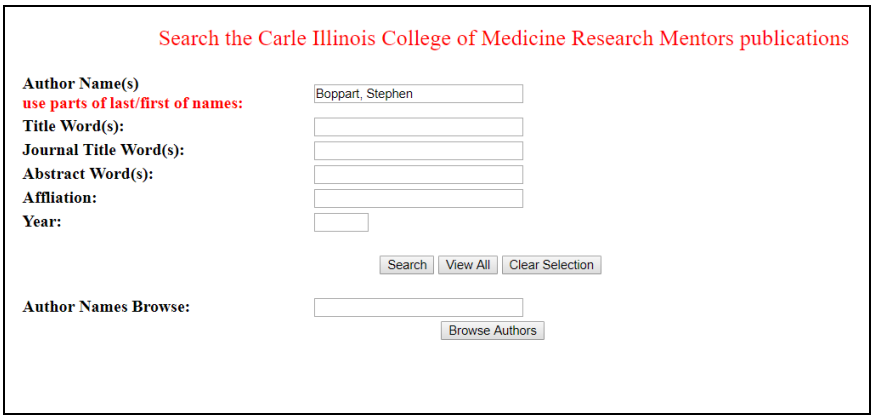


Figure 6: A page with different options for searching by author or title information.

For visualizations that include larger group of authors, a search tool is included and is linked from the main page (see **Figure 6**). This page allows a user to search by author or by bibliographic article information. This is particularly helpful if a user is searching for information on specific subjects or areas of research within a group of authors.

Two of the clickable bubble data points are included for each author that provide information on co-authors for the publications in this harvested dataset.

Figure 7: Users can see a list of all co-authors for each research mentor.

Each co-author is listed along with their affiliation (see **Figure 7**). This information provides a quick glance view of the number of collaborations for each research mentor, including data on where these institutions/organizations are geographically located. This information is particularly vital for colleges and departments that emphasize or require collaborations. A second data point groups co-author information and limits it to collaborations within the group of research mentors. This information is displayed with further interactivity by allowing a user to see the number of publications co-authored with other research mentors.

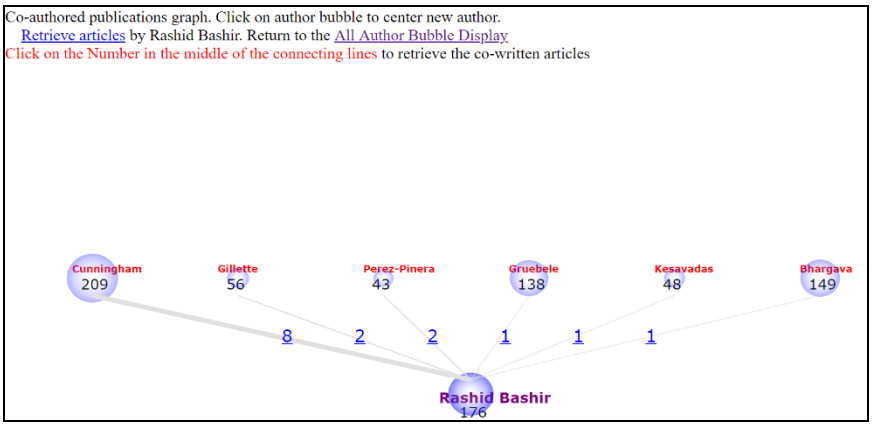


Figure 8: Users can see the number of co-authored publications between mentors.

A link is provided for each collaborative relationship between research mentors that includes a list of co-authored publications.

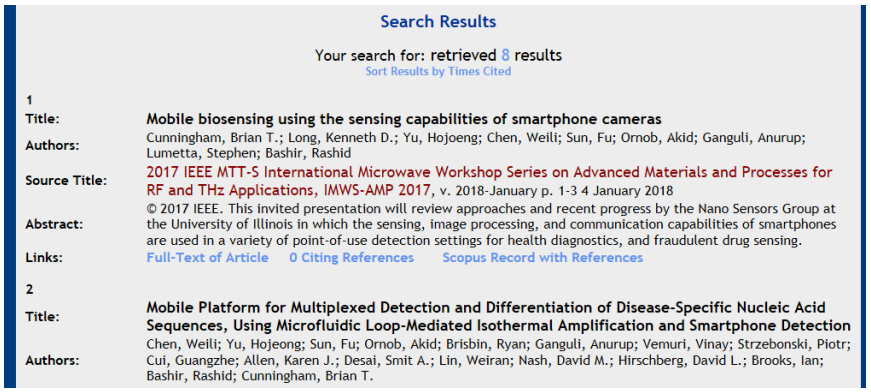


Figure 9: Bibliographic information is given for co-authored publications.

While articles are considered a reflection of research impact, there is other data available that can help provide a broader understanding of the impact of a mentor on scholarship in general. Grant information is increasingly being made available in major abstract and indexing services such as Scopus. This data is still largely not provided in bibliographic records and when included, does not connect to related grant records on the funding agency's website.

Grants (NSF and NIH) Search Results

You searched for: Donovan Sharon and retrieved 1 NSF Grants and 10 NIH Grants

NSF Grant #1

PIs: Stephen Boppart, Lawrence Schook, Sharon Donovan, Scott White, Charles Werth

Title: MRI: Acquisition of a Molecular Imaging Instrument for Dynamic Material and Biological Systems

Dates, Amount: 09/01/2009 - 08/31/2013 $1,770,910.00 ENG
0922539
Boppart

Abstract: "This award is funded under the American Recovery and Reinvestment Act of 2009 (Public Law 111-5)."
The acquisition and use of this molecular imaging instrument will enable new research directions and educational opportunities and programs that will significantly contribute to the intellectual base of knowledge in these disparate but unified areas, and do so on national and international levels. The five research areas include (1) monitoring dynamic chemical reactions within advanced self-healing materials, (2) tracking nanoparticle biodistribution and visualizing their incorporation into the physiological processes of living organisms over time, (3) following the homing pathways of stem cells and their functional significance, (4) investigating metabolomics to understand the biological and physiological basis of nutrition, and (5) monitoring the dynamic three-dimensional distributions of materials, chemicals, and microbes in environmental samples. The acquisition of this molecular imaging instrument will not only enable the rapid expansion of existing research programs, but also provide the opportunity for new directions of investigation.

NIH Grant #1

PIs: DONOVAN, SHARON MARIE; CHAPKIN, ROBERT STEPHEN

Title: Dietary and microbial predictors of childhood obesity risk

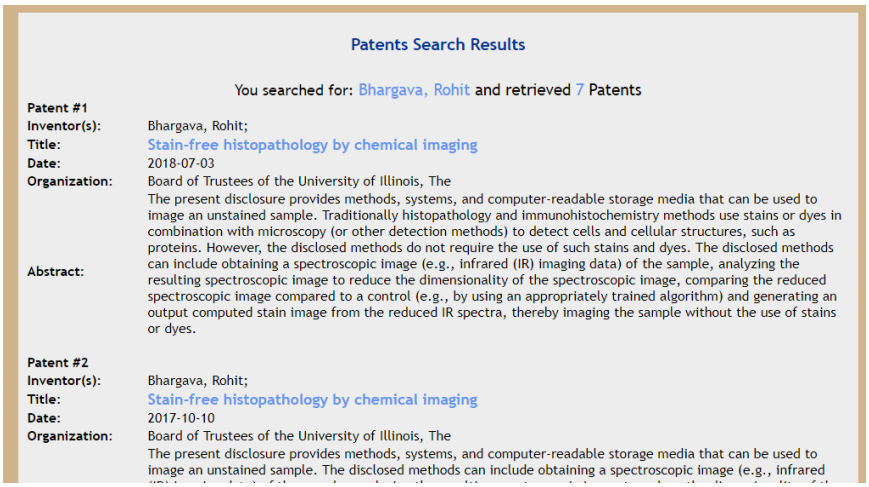
Dates, Amount: 2017 $689038 NIDDK

Project Summary/Abstract: The first three years-of-life are critically important for establishing growthtrajectories and gut microbiota composition, both of which are influenced by diet and other environmentalfactors. Obesity

Figure 10: Search results include funded NSF and NIH grants for each mentor.

Grant information can give a user another data point to assess research areas of interest for each mentor. As the NSF and NIH are the largest funders of natural and applied science research, grants funded from these two agencies are included for each research mentor. Each result includes base information on each grant, including a link to a more comprehensive record on the corresponding funding agency's website.

As the Carle Illinois College of Medicine emphasizes an engineering and innovation-focused curriculum, patents can give a simple but effective way of measuring the entrepreneurial impact of a research mentor. This data is limited to patents granted by the USPTO to each research mentor while they were affiliated with the University of Illinois at Urbana-Champaign. Each result includes the list of inventor(s), date the patent was filed, affiliation (organization), and abstract text. Each result includes a link to the full text version of the patent in Google Patents, including figures. These links were generated by a server-side script that automatically appended the patent number to the end of the standard Google Patent's URL.



Patents Search Results

You searched for: Bhargava, Rohit and retrieved 7 Patents

Patent #1
Inventor(s): Bhargava, Rohit;
Title: Stain-free histopathology by chemical imaging
Date: 2018-07-03
Organization: Board of Trustees of the University of Illinois, The
Abstract: The present disclosure provides methods, systems, and computer-readable storage media that can be used to image an unstained sample. Traditionally histopathology and immunohistochemistry methods use stains or dyes in combination with microscopy (or other detection methods) to detect cells and cellular structures, such as proteins. However, the disclosed methods do not require the use of such stains and dyes. The disclosed methods can include obtaining a spectroscopic image (e.g., infrared (IR) imaging data) of the sample, analyzing the resulting spectroscopic image to reduce the dimensionality of the spectroscopic image, comparing the reduced spectroscopic image compared to a control (e.g., by using an appropriately trained algorithm) and generating an output computed stain image from the reduced IR spectra, thereby imaging the sample without the use of stains or dyes.

Patent #2
Inventor(s): Bhargava, Rohit;
Title: Stain-free histopathology by chemical imaging
Date: 2017-10-10
Organization: Board of Trustees of the University of Illinois, The
The present disclosure provides methods, systems, and computer-readable storage media that can be used to image an unstained sample. The disclosed methods can include obtaining a spectroscopic image (e.g., infrared

Figure 11: Search results page includes information on patents where a mentor is listed as inventor or co-inventor.

5. Conclusions:

While scholarship is multifaceted, there is a lack of tools that bring together heterogeneous data points to help you understand the scholarly impact of a researcher. Those tools that do exist provide only limited connectivity between these different facets of scholarship. As the corpus of scholarship increases each year, it is critical that tools are developed and iterated upon to build meaningful connectivity between the siloed bibliometric data points. By bringing bibliometric data together on number of publications, citation counts, co-authors, grants and patents, the Grainger Engineering Library developed a simple, effective, and interactive visualization web-tool that brings together a holistic view of scholarship. With this information available, faculty, administrators, and students in the Carle Illinois College of Medicine can review, assess and understand the scholarly impact of their research mentors.

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