FabGalaxy: Search and Visualization Tool for Emerging Research in Personal Fabrication

Liang He
Paul G. Allen School of Computer Science & Engineering
University of Washington, Seattle, US
lianghe@cs.washington.edu

Kate Jung
Department of Electrical Engineering
University of Washington, Seattle, US
sjung94@uw.edu

ABSTRACT
While personal fabrication attracts an increasing number of researchers within the community of human-computer interaction (HCI) and graphics, junior researchers feel less comfortable to search for particular topic and related work and get aware of the development of the filed of personal fabrication. In this paper, we present FabGalaxy, an interactive search and visualization tool that quickly familiarizes scholars with the young research field. It consists of two main parts: *text-based search engine* and *graphic exploration visualization*. Authors and keywords are used to assist for the research search and exploration. We hope that our tool can provide an instant, accurate, and comprehensive access to growing research field such as personal fabrication. In the future, we envision a reusable framework that could be customized for other academic areas, thereby lowering the barriers for young researchers.

Author Keywords
Data visualization; fabrication; author; keyword; d3.

INTRODUCTION
Personal fabrication, as an emerging research field in , has been growing fast in the past decade in human-computer interaction (HCI) and graphics. According to the survey on personal fabrication [2], there are over 200 archived paper published on fabrication in the top tier conferences in the field of HCI and graphics (e.g., CHI, SIGGRAPH, *etc.*). While junior researchers join the force of doing fabrication research, there are still high barriers for young scholars to step into this field. The main challenges include: (i) What are the common research areas are there in the field of fabrication? (ii) Who are most active in this field? (iii) How easy to find related work on a particular topic? Unlike other HCI research fields, tangible artifacts and applications are usually created in such kind of research projects, so that it is inspiring and beneficial for ideation if scholars can access both the publication and the outcome artifact as well easily.

While existing academic search engines such as Google Scholar [9] already provide powerful academic search and the searched results are informative, the extracted content are non-domain specific and the text-based results prevents the researcher from quickly locating the related work, in particular, in the searching for fabrication research. To help people quickly explore and search academic works in fabrication, Muller et al. created an online repository to record all publications on personal fabrication research in HCI and graphics [4]. We build our interactive visualization interface based on the data scraped from the repository and answer the mentioned questions by contributing in three aspects: (i) providing an interactive node-link graph for people with less knowledge to explore the main subareas, the active scholars, and published work; (ii) providing a quick search based on author and keyword and synchronizing the search and the graphic visualization for user's awareness; and (iii) providing a list of search results that show the key information of each publication for inspiration. We envision the framework of combining exploration and search for academic field learning could be reused beyond the field of fabrication.

RELATED WORK
Our work is largely inspired by the existing academic visualization tools [1, 10]. Aminer aims to create a semantic-based profile for each researcher by extracting information from the distributed Web and provide accurate searching and analysis of interesting discovered patterns [1]. However, like other popular search tools, Aminer is not particularly helpful for domain-specific search such as fabrication. Prior researches have provided novel visualizations that present the analysis of the research network and research trends [7, 12, 11]. PivotPaths is an interactive visualization that explores multiple facets of the information resources [3]. Similarly, we expose multiple aspects of the research publication including the author information, keywords, publishing conference, and year, for the purpose of exploring the published work on fabrication.

The main visualization form in our system is inspired by applications that utilize ring-like graphs [5, 8]. NYC FoodDiverse [5] uses clouds of points to represent the restaurants in New York City and bright lines to highlight the selected food types. The Pudding [8] uses a series of orbital rings and the animations of dots switching between rings to showcase a digital publication that explains ideas debated in culture with visual essays. Both visualizations are aesthetically appealing and the choice of calmed colors and proper animations results in our decision on making the node-link graph. In our graph, we use dots/nodes to represent the authors, the keywords, and the publications.

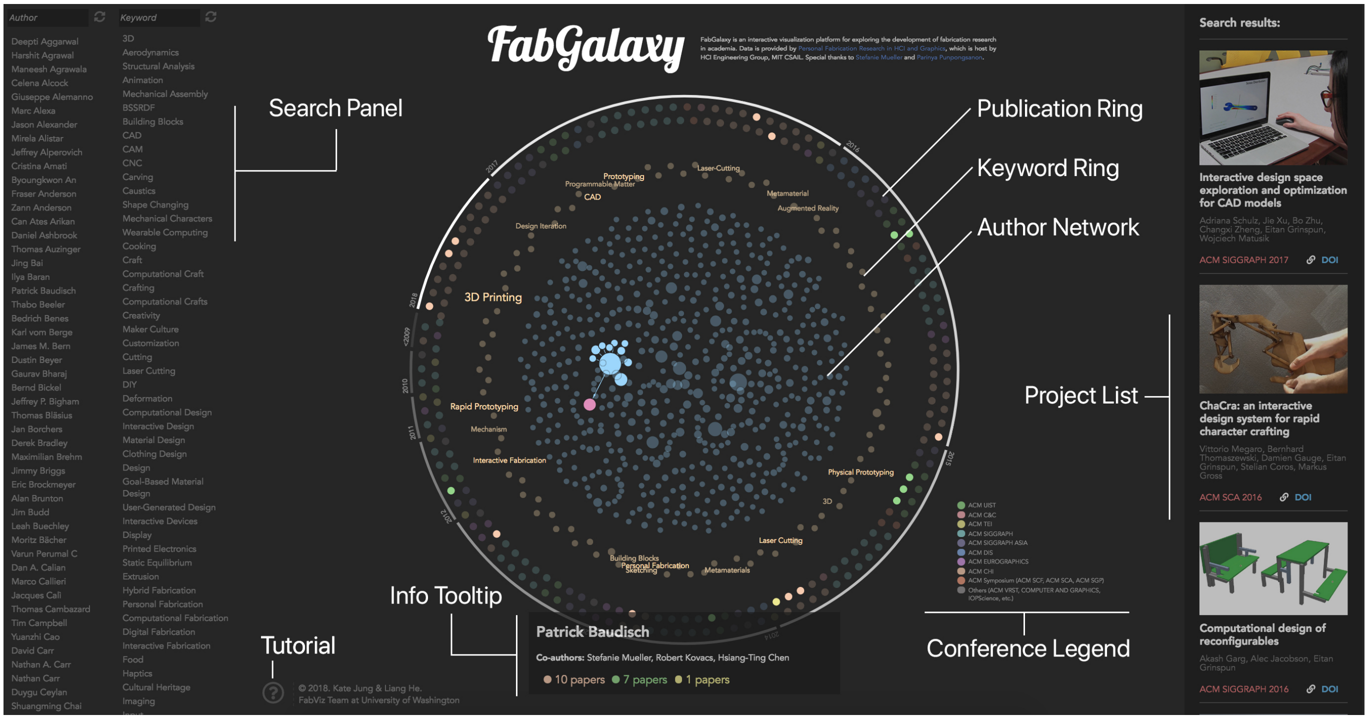

Figure 1. Full view of FabGalaxy

FABGALAXY

In our system, we have two major parts: the graph exploration panel and the search panel (Figure 1). The graph exploration panel presents the author network in the form of point cloud and the keywords and the publications in two separate concentric rings, which are surrounding the author network.

There are four types of nodes in the author network graph (Figure 2). First, there is the author node selected by the user, in light blue. Other nodes that are in light blue have a link with the selected node. The node colored in green is the selected node's top collaborator. When it is pink, however, it means that they are both top collaborators to each other. By differentiating the collaborators with the top collaborators, the users are able to have a more guided walk on the graph.

The search panel enables the scholar to quickly select and search publications by authors and keywords. In addition, a list of publications related to the author and keyword of interest is shown as well for future visit and reference.

METHODS

In order to allow users to easily search for authors and keywords while letting them actively explore the field, we use strictly different types of layouts for the different panels in our system. Specifically, we use scroll-down lists for the search and result side panels, sorted in a alphabetical and chronological order, respectively. This starts and ends the delivery of information in a way that is straightforward to users, and leaves a room for exploration in the middle graph panel. The visual encodings and algorithms used for each panel are as follow:

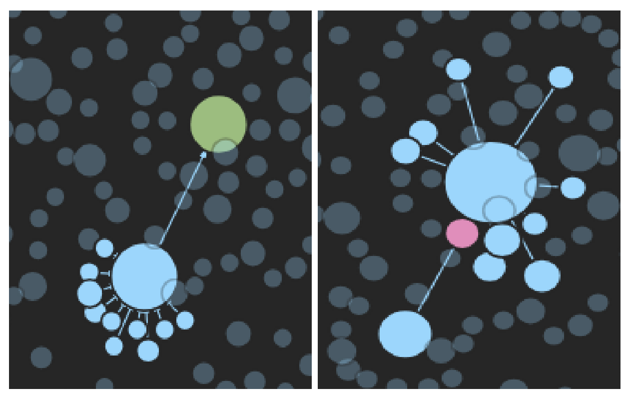

Figure 2. Author Node Connections

Graph Exploration Panel

The graph panel has three layers: an inner author node-link graph, a middle keyword ring, and an outer publication ring. By placing all authors and publication nodes in layers of rings, the users can distill the information in one full view when they hover over certain nodes.

One important feature that publication search engines fail to show is the network of authors, and the node-link graph is the most intuitive way to represent it. We use d3-force to model the network, which is the library that implements a velocity Verlet numerical integrator for simulating physical forces on particle [6]. And we use different radial force parameters to make three-ring structure.

select top k collaborators		
k	# of total links	# of unique links
all	3984	1922
5	2458	1627
3	1684	1211
1	597	501

Table 1. Author Links: selecting different number of top collaborators result in vastly different numbers of total inputs. However, most unique links are captured by only top 5 collaborators

As d3-force library requires a tuple of source and target for each link, there must be a total of 3984 link inputs for 597 researcher nodes in the field of fabrication to represent the complete network. However, of those links, only 1922 links are unique. This indicates that the network can be reduced by sorting and selecting the top k collaborators for each author (Table 1).

To minimize unnecessary memory uptake and computations, selecting the top (k=1) collaborator is ideal, but it only captures one-fourth of the entire network connections. However, we also found that two walks on such graph cover 88% (1694/1922) of the desired links, more than what is captured by selecting top 5 collaborators. Therefore, we choose the top (k=1) collaborator in the node-link author graph to resolve the scalability issues.

Search Panel

Author and keyword search is available through the search panel, where it uses a simple regex to match the words and names. Besides the dynamic inquiry by typing in the author name or the keyword in the search boxes at the top, it also supports the user to select individual author and keyword from the list. The selected authors and keywords are highlighted by bright colors, which are corresponded to the colors used in the graph panel (i.e., blue for authors and yellow for keywords). When the user hovers either the author and the keyword, the corresponding author and keyword in the graph panel are highlighted, and vice versa. Both the search panel and the graph panel are synchronized through all user interactions.

DISCUSSION

The goal of FabGalaxy is helping users find the publications they are interested in. Therefore, the order of panels and the rings in the graph panel are chosen so that it can lead to a patterned and effective search. First, the users locate specific authors by searching them on the leftmost search panel, or by hovering on the author node. Then, they can look for collaborators and associated keywords. Finally, they obtain the result of the publication list specific to authors and keywords.

The most important function of FabGalaxy is the interactive features in the graph panel. By making side panels static and the rings rotate in the graph panel, the design focus the users' attention and interactions to the middle graph panel. The users can gain insights about other researchers by walking on the author node-link graph and from the highlighted keywords. These together give immediate insights about the recent works of each researcher and keyword throughout the years.

From the audience, we find that people find the author network most useful. While the ultimate goal of FabGalaxy is to effectively filter the publications in the fabrication field, the users tend to spend more time exploring the author networks. As a result, the result list panel on the right serve more as a wish list for users, which may be useful for the future.

FUTURE WORK

Our next steps for improving the tool include: (i) refining the graph panel by redesigning the connecting lines between the author nodes. For example, the thickness of the lines could reflect how frequently two authors collaborates; (ii) highlighting authors when the user hovers keywords in both the search panel and the graph panel; (iii) introducing more facets of the author information and the publications, for instance, the citations of a particular paper; (iv) implanting our framework to other research fields; and (v) fixing implementation bugs.

CONCLUSION

In this paper, we introduced FabGalaxy, an interactive visualization tool for the exploration and search in the field of personal fabrication research. The system is composed of two main interactive panels: node-link based graph and dynamic search. We described the key methods to implement the author network, keyword ring, and the publication ring in the graph panel and how the search panel work together with the graph panel for the purpose of both exploration and search. We also showed the list of publications based on the user's interest, which lead to future readings. Further, we discussed the limitations of our current prototype and concluded with steps for future investigations on our tool.

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