Spatial-temporal Variation based Innovation History Visualization: A Case Study of the Liquid Crystal Institute at Kent State University

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Innovation began taking root as a term associated with science and industry in the nineteenth century, matching the forward march of the Industrial Revolution, although the language of that period focused more strongly on the invention, particularly technical invention (Green, 2013). Nowadays, innovation is defined simply as a "new idea, device, or method" (Wikipedia). In the Big Data era, innovation history research not only shows the raw data but also demonstrates and reveals the deep relationships of data and how the innovation was generated.

This poster mainly describes an innovation history analysis system, integrating and visualizing multi-source and isomerism data in a static and dynamic representation manner, considering spatial-temporal factors. A case study of the Liquid Crystal Institute (LCI) at Kent State University is presented. Liquid Crystal Institute (LCI) was founded in 1965 by Glenn H. Brown, a chemistry professor at Kent State University. The birthplace of liquid crystal displays (LCD), the LCI is the world's first research center focused on the basic and applied science of liquid crystals. The dramatic rise of the liquid crystal display (LCD) industry through the subsequent 40 years has fundamentally changed our modern life.

As shown in Figure 1, to research the innovation history of LCI, there are varieties of data sources in the forms of audio, video, digitalized images, text from the website, annual reports from 1965-2013, interviews with key researchers in LCI, booklets from LCI's 50 year anniversary that covers significant scientists and important events, as well as biennial International Liquid Crystal Conference (ILCC) materials about the largest academic meeting in the field of liquid crystals that was started by the LCI founding director Glenn H. Brown in 1965. At the data processing level, data searching rules related to the publications, grants, and patents are appointed. For text, text mining tools, such as Open CALAIS and Cogito Intelligence API, are used to extract people, locations, and event information from annual reports, booklets etc. After the initial processing of raw data, data are then imported into our system, including publications records, grants, patents, inventions, researchers (such as research staff, post-doctoral fellows, visiting scholars, etc.), special events, spin-offs, and conferences.

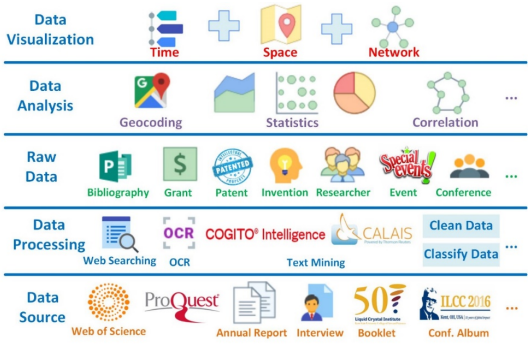

Figure 1. Structure of LCI innovation system

As argued by Robert E. Williams (Williams, 1987), location can be the critical link to integrating data from various sources and with various attributes of a place. Using locations as the key link, any location-related description, from the formal coordinates of places to the informal abstraction of places, can be understood by using GIS and various types of Big Data. Thus, the system geocoded the data which has location information. Besides traditional data statistics methods, with geo-located data, spatial statistics algorithms can also be

imported to our system to find the spatial correlation of data.

Data visualizations are used to demonstrate the worldwide impact of LCI related scientists, technologies, and events. Unlike other tools, such as the "Historical Data Exploration Tool" (Škvrňák and Mertel, 2016), this system will statically visualize time, space and network variables, whilst also considering the dynamic network changes in each period. Furthermore, spatial-temporal analysis algorithms will be imported to display the spatial and temporal pattern of LCI development. Figure 2 shows visualization results based on the gathered and processed data. It is developed by modern web technologies (html5 canvas, javascript, d3 – see Bostock et al, 2011; timeglider). In the center top, there's a timeline integrating important faculty members, inventions, personal prizes, spin-offs, and other great events since 1965.

Figure 2. Main interface of innovation history research system

Scientific collaboration is a complex social phenomenon in a search that has been systematically studied since the 1960s (Noldus and Van Mieghem, 2015). One of the goals of developing this system is to find out how the LCI can be so successful in liquid crystal field research and development. From the view of research collaborations, it may demonstrate the answers. Thus, the system processes the data related to papers, patents and grants, and visualize the collaboration networks shown in Fig. 3. On the left of the figure, it demonstrates the networks, in which each node indicates an author (inventor or grant recipient) and each link indicates the collaboration. On the right, it presents the detailed information of researcher when clicking on the node.

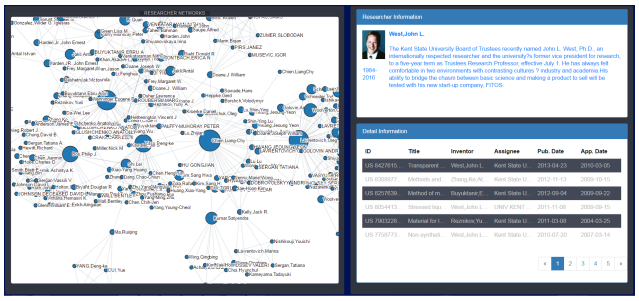

Figure 3. Collaboration visualization of patent awardees

This system can be used not only to further relevant historical research but also to serve as a prototype to demonstrate the potential for linking different visualization techniques to provide functions facilitating historical data exploration. Furthermore, it provides collaboration network analysis environment to dig out new findings in innovation history.

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