Related work

Many studies have been reported to investigate specific design features to support collaborative information analysis. For example, Goyal and Fussell [4] studied the effect of hypotheses sharing on sensemaking. Mahyar and Tory [7] designed a visualization to connect collaborators' common findings and evaluated its support for team performance. Hajizadeh et al. [5] explored how sharing teammate's interactions affects awareness. These studies report interesting results of controlled lab studies to validate hypotheses of specific design features. However, they do not provide insight on how teams would collaborate with a complete tool as nexus of features in the real world over extended period of time.

Field studies were conducted aimed to understand design requirements of collaborative information analysis in more realistic settings. Chin et al. [2] observed and analyzed the analytic strategies, work practices, tools ad collaboration norms of professional intelligence analysts. Kang and Stasko [6] studied how student analysts, as in our study, completed in-class intelligence projects. Carroll et al. [1] attempted to model a complex analytic task scenario in a lab setting, and examined the development of team awareness in a four-hour-long task. These studies helped improve understanding of current work practice with state-of-the-art tools or no tools at all. We built our tool based upon their study findings, and pursue to further explore design implications by investigating tool usage in a similar naturalist environment.

Our study took place during the 10th week of the course. Before that students learned several analytic techniques, including IEW (a technique to extract and assess values of evidence), ACH (a technique to evaluate multiple hypotheses against evidence), timeline analysis and network analysis, as well as state-of-the-art tools to facilitate these techniques. Two weeks before our study, students practiced applying these techniques in a hands-on project. A typical workflow started with IEW to extract and model data from documents. Students then replicated key facts into analytic artifacts such as an ACH Matrix in PARC ACH, a timeline and a network graph in Analyst's Notebook. They had to repeat the process for each different tool because the data cannot be shared and carried over directly. Most tools they used lacked serious collaboration support (except that some teams used Google Doc to construct an IEW table). Analysts were unable to contribute simultaneously (known as production blocking [3]). The analysis work was often divided by tools: each individual created and analyzed an artifact with a tool on their own. This had the consequence that findings and hypotheses be made without integrating collective efforts and diverse knowledge. Analysts must coordinate work by manually sharing notebooks or graphs, resulting in a scattered placement of results, requiring repeated manual resynchronizing to identify redundant or missing pieces of information, analysis of information, and analytic hypotheses. The instructor and students in our study were aware of the shortcomings of available tools with respect to support of collaboration.

References

[1] John M. Carroll, Marcela Borge, and SI Shih. "Cognitive artifacts as a window on design". In: *Journal of Visual Languages & Computing* 24.4 (2013), pp. 248–261. URL: http://www.sciencedirect.com/science/article/pii/S1045926X13000207.

[2] George Chin Jr, Olga A. Kuchar, and Katherine E. Wolf. "Exploring the analytical processes of intelligence analysts". In: *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems*. 2009, pp. 11–20. ISBN: 9781605582467. URL: http://dl.acm.org/citation.cfm?id=1518704.

[3] Michael Diehl and Wolfgang Strpebe. "Productivity Loss In Brainstorming Groups : Toward the Solution of a Riddle". In: *Journal of personality and social psychology* 53.3 (1987), pp. 497–509. DOI: 10.1037/0022-3514.53.3.497.

[4] Nitesh Goyal and Susan R Fussell. "Effects of Sensemaking Translucence on Distributed Collaborative Analysis". In: *CSCW '16 Proceedings of the 18th ACM Conference on Computer Supported Cooperative Work & Social Computing*. 2016.

[5] Amir Hossein Hajizadeh, Melanie Tory, and Rock Leung. "Supporting awareness through collaborative brushing and linking of tabular data." In: *IEEE transactions on visualization and computer graphics* 19.12 (Dec. 2013), pp. 2189–97. ISSN: 1941-0506. DOI: 10.1109/TVCG.2013.197. URL: http://www.ncbi.nlm.nih.gov/pubmed/24051785.

[6] Youn-ah Kang and John Stasko. "Characterizing the intelligence analysis process: Informing visual analytics design through a longitudinal field study". In: *2011 IEEE Conference on Visual Analytics Science and Technology (VAST)*. Ieee, Oct. 2011, pp. 21–30. ISBN: 978-1-4673-0014-8. DOI: 10.1109/VAST.2011.6102438. URL: http://ieeexplore.ieee.org/lpdocs/epic03/wrapper.htm?arnumber=6102438.

[7] Narges Mahyar and Melanie Tory. "Supporting Communication and Coordination in Collaborative Sensemaking". In: *Visualization and Computer Graphics, IEEE Transactions on* 20.12 (2013), pp. 1633–1642.