Summary Document for the Bulletin Video Entitled:

RAMPVIS: Answering the Challenges of Building Visualization Capabilities for Large-scale Emergency Responses

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Abstract

In this bulletin video, we summarize the volunteering activities of a group of visualization researchers who provided support to epidemiological modeling during the COVID-19 pandemic. Epidemiological modeling during a pandemic is a complex and continuous process. The intraoperative workflow entails different visualization tasks at four different levels, i.e., disseminative, observational, analytical, and model-developmental visualization. The visualization volunteers were organized into seven teams, including a generic support team, an analytical support team, a disseminative visualization team, and four modeling support teams. During the volunteering activities, we encountered a few major challenges. We made an effort to address these challenges and gained useful experience.

Keywords: Visualization, visual analytics, COVID-19 responses, epidemiological modeling, volunteering operation.

Introduction

In this bulletin video, we summarize the volunteering activities of a group of visualization researchers who provided support to epidemiological modeling during the COVID-19 pandemic. The summary is based primarily on the first report of the activities available at arXiv (2012.04757) in December 2020, which was later published in Elsevier Epidemics [1]. The summary also touches upon briefly some technical contributions reported in several other publications [2-10], which include some contributions made after December 2020.

Since the emergence of COVID-19, data visualization has been widely visible in traditional and online media for disseminating information related to COVID-19. Meanwhile what has not been obvious to the public is the fact that techniques of visualization and visual analytics (VIS) can and should be used to help healthcare scientists and experts in combating COVID-19. However, there have been some challenges for many epidemiologists and modeling scientists to receive adequate VIS support. These challenges include:

- Epidemiologists and epidemiological modeling scientists are not accustomed to receiving VIS support systematically,
- Visualization is widely mistaken only for information or knowledge dissemination.
- There are not enough visualization researchers around to support epidemiologists and modeling scientists.
- There is a lack of a VIS infrastructure that can quickly be adapted to support epidemiologists and modeling scientists.

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RAMPVIS: A Volunteering Group of VIS Researchers

RAMPVIS was formed by a group of 22 VIS volunteers, who answered a call in May 2020 to support the modeling scientists and epidemiologists in the Scottish COVID-19 Response Consortium (SCRC), which was part of the rapid responses organized by the Royal Society (UK) [93]. A few more volunteers joined the RAMPVIS group in the summer and autumn of 2020. The volunteers encountered the aforementioned challenges as well as other difficulties due to the pandemic, such as the limited time for developing usable VIS tools, the travel restriction, and hampered communication with domain experts for in-depth requirements analysis, delayed availability of epidemiological data and models, and so on. In addition, there was a shortage of skilled developers for designing and engineering a VIS system, and a fair amount of uncertainty in organizing and scheduling volunteering resources.

The initial request from the SCRC was focused on the last stage of the modeling workflow for disseminating modeling results to decision makers. In the first meeting on May 14, 2020, the VIS colleague in the meeting indicated the visualization needs in many other parts of the workflow. The SCRC coordinator, who is an open-minded scientist, immediately welcomed the idea of providing visualization capabilities throughout the modeling workflow. We also realized that this would need many visualization specialists. A call for visualization volunteers went out on May 15, 2020. Within two weeks, 22 visualization researchers in the UK answered the call. The RAMPVIS operation was established (https://sites.google.com/view/rampvis/). The first version of VIS infrastructure was alive in August. Later the main UK research funding body provided RAMPVIS with a one-year grant. This bulletin videos described mainly the earlier volunteering activities before the funded period.

RAMPVIS: Seven Teams

The SCRC modeling workflow was complex and continuous. It entailed different visualization tasks at four different levels [11], namely:

- disseminative visualization,
- observational visualization,
- analytical visualization, and
- model-developmental visualization.

We quickly organized ourselves into seven teams. For example, the *generic support team* focused on building a VIS infrastructure to host different visualization software, starting with simple plots

and dashboards for routine observational visualization. The VIS infrastructure has several advanced features, such as ontology, agents, and automated propagation [1, 2, 3]. The team also studied the design space of dashboards [6].

The *analytical support team* was to enable data mining and visual analytics in the modeling workflow. They immediately focused on analytical techniques for time-series data and worked with the generic support team to develop analytical agents for processing data automatically [1]. Later the team developed a web-based tool for data-driven prediction [10].

In the SCRC, there were several teams of modeling scientists working on different models. As we anticipated that task analysis would be model-specific and might take some time, we organized four *modeling support teams* to work with modeling teams individually. One team generated hierarchical glyph-based visualization within the first three months for visualizing the results of a multi-resolution epidemiological model [1, 9]. Another team developed several visualization solutions for a model taking human movement into account [1]. The third modeling support team focused on visualization of contact-tracing data [1, 4], while the fourth team worked on visualization tools and techniques for uncertainty and sensitive analysis [1, 7, 8].

The *disseminative visualization team* focused on storytelling visualization [1]. Later they developed a novel technique for meta-authoring storyboards.

The volunteering effort led to several technical advancements. Some have been reported in the ten publications at the end of this summary [1-10], while others are under review or being prepared for submission. In addition to a noticeable amount of open-source code (https://github.com/ScottishCovidResponse), the VIS researchers also documented and reflected on their activities in a structured manner, resulting in 29 digital notebooks [5].

RAMPVIS: Addressing the Challenges

As mentioned in Section 1, we encountered four major challenges. We made an effort to address these challenges and gained useful experience. In particular, we made the following observations [1]:

- Expert users often see visualization as "for informing others" rather than "for helping myself". This can be a big stumbling block during requirement analysis.
- From the perspective of epidemiological modeling, the RAMPVIS effort allowed us to appreciate how VIS may be used in many aspects of modeling workflows, in addition to disseminating modeling results.
- During the pandemic, domain experts were extremely busy. Different teams did not follow the same formula for requirement analysis. The diverse approaches indicated that standard practice might not always be applicable. VIS development in emergency responses can benefit tremendously from broad VIS knowledge, in the form of theories, methodologies, literature, and personal experience.
- Having a VIS team working with each modeling team was necessary for gaining adequate understanding of the model concerned and identifying model-related VIS requirements. Meanwhile, the generic support team progressed to the development stage quickly because of not only the necessity but also the less complex requirement analysis.
- Using volunteer effort is not an ideal solution for emergency responses. It would be more efficient if we could utilize an existing technical and knowledge infrastructure for such an emergency response, if such an infrastructure had existed for other operations and had an advanced VIS server and a team of VIS developers who were knowledgeable about different levels of visualization tasks. Nevertheless, the outcomes delivered by the VIS volunteers between June and December 2020 without any funding are unprecedented. This demonstrates the importance of VIS as well as volunteering effort in emergency responses.

The RAMPVIS effort showed that collective VIS support is necessary and feasible, and such capabilities should be available to epidemiological modelers from the very beginning in future emergency responses. Our approaches to the aforementioned challenges are valuable contributions to the first step towards a methodology for developing and providing VIS capacity to support emergency responses. Our more detailed reflections and recommendations can be found in two papers on RAMPVIS activities in general [1, 5].

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References

[1] M. Chen, A. Abdul-Rahman, D. Archambault, J. Dykes, A. Slingsby, P. D. Ritsos, T. Torsney-Weir, C. Turkay, B. Bach, A. Brett, H. Fang, R. Jianu, S. Khan, R. S. Laramee, L. Matthews, P. H. Nguyen, R. Reeve, J. C. Roberts, F. Vidal, Q. Wang, J. Wood, and K. Xu. RAMPVIS: answering the challenges of building visualisation capabilities for large-scale emergency responses. *Epidemics*, 39:100569, 2022.

[2] S. Khan, P. H. Nguyen, A. Abdul-Rahman, B. Bach, M. Chen, E. Freeman, and C. Turkay. Propagating visual designs to numerous plots and dashboards. *IEEE Transactions on Visualization and Computer Graphics*, 28(1): 86-95, 2022.

[3] S. Khan, P. Nguyen, A. Abdul-Rahman, E. Freeman, C. Turkay, and M. Chen. Rapid development of a data visualization service in an emergency response. *IEEE Transactions on Services Computing*, 15(2):1251 - 1264, 2022.

[4] M. Sondag, C. Turkay, K. Xu, L. Matthews, S. Mohr, and D. Archambault. Visual analytics of contact tracing policy simulations during an emergency response. *Computer Graphics Forum*, 41(3):29-41, 2022.

[5] J. Dykes, A. Abdul-Rahman, D. Archambault, B. Bach, R. Borgo, M. Chen, J. Enright, H. Fang, E. E. Firat, E. Freeman, T Gönen, C. Harris, R. Jianu, N. W. John, S. Khan, A. Lahiff, R. S. Laramee, L. Matthews, S. Mohr, P. H. Nguyen, A. A. M. Rahat, R. Reeve, P. D. Ritsos, J. C. Roberts, A. Slingsby, B. Swallow, T. Torsney-Weir, C. Turkay, R. Turner, F. P. Vidal, Q. Wang, J. Wood, K. Xu. Visualization for epidemiological modelling: Challenges, solutions, reflections & recommendations. *Philosophical Transactions of the Royal Society A*, 380(2233), 2022.

[6] B. Bach, E. Freeman, A. Abdul-Rahman, C. Turkay, S. Khan, Y. Fan, and M. Chen. Dashboard design patterns. *IEEE Transactions on Visualization and Computer Graphics*, 29(1):342-352, 2023.

[7] E. Rydow, R. Borgo, H. Fang, T. Torsney-Weir, B. Swallow, T. Porphyre, C. Turkay, and M. Chen. Development and evaluation of two approaches of visual sensitivity analysis to support epidemiological modelling. *IEEE Transactions on Visualization and Computer Graphics*, 29(1):1255-1265, 2023.

[8] E. E. Firat, B. Swallow, and R. S. Laramee. PCP-Ed: Parallel coordinates plots for ensemble data. To appear in *Visual Informatics*, accepted in 2022.

[9] A. Slingsby, R. Reeve, and C. Harris. Gridded glyphmaps for supporting spatial COVID-19 modelling. *Proc. IEEE VIS Short Papers*, Melbourne, Australia, 2023.

[10] T. Gonen, Y. Xing, C. Turkay, A. Abdul-Rahman, R. Jian, H. Fang, E. Freeman, F. P. Vidal, and M. Chen. Visual analytics based search-analyze-forecast framework for epidemiological time-series data. To appear in *Proc. VIS Workshop on Visualization for Pandemic and Emergency Responses*, Melbourne, Australia, 2023.

[11] M. Chen and A. Golan, What may visualization processes optimize? *IEEE Transactions on Visualization and Computer Graphics*, 22(12):2619-2632, 2016.