A Framework for Authoring Logically Ordered Visual Data Stories

Humphrey O. Obie
Swinburne University of Technology
Melbourne, Australia
hobie@swin.edu.au

Caslon Chua
Swinburne University of Technology
Melbourne, Australia
cchua@swin.edu.au

Iman Avazpour
Deakin University
Geelong, Australia
iman.avazpour@deakin.edu.au

Mohamed Abdelrazek
Deakin University
Geelong, Australia
mohamed.abdelrazek@deakin.edu.au

John Grundy
Monash University
Melbourne, Australia
john.grundy@monash.edu

Tomasz Bednarz
CSIRO Data61
Sydney, Australia
tomasz.bednarz@data61.csiro.au

Abstract—Visual data storytelling has gained widespread adoption as a means of communicating information visualisation. This is partly due to the increased interest in data journalism. Besides being engaging, it has been shown to foster better comprehension and memorability of information to target audiences. The visual data story authoring process involves several stages. However, current tools neither consolidate the visual data story creation process nor integrate the essential features, such as the recommendation of logically sequenced story pieces, for producing coherent narratives. This paper briefly demonstrates our approach and framework for supporting the creation of logically sequenced visual data stories.

I. Introduction

The challenges in constructing and interpreting visualisations have been the target of several works in the information visualisation domain. For example, Lee et al. [1] and Grammel, Tory and Storey [2] have modelled cognitive sensemaking activities in visualisation construction, and outlined the major barriers encountered by users and how they construct, understand and interpret visualisations. Consequently, new approaches are emerging to better incorporate user interactions, visualisation similarity and sequencing, visualisation recommendation and domain knowledge with visualisations to accomplish tasks that were previously delegated to visualisation experts.

We have previously demonstrated how the adoption of visual data stories, i.e., combining interactive visualisations with storytelling, increases visualisation understanding and memorability [3]. Following this previous work, in this paper, we are presenting our approach and framework for data stories authoring. Most current visualisation tools mainly focus on the exploratory aspect of information visualisation and provide little support for information visualisation presentation goals [4]. Hence, we believe our approach can fill the gap in supporting visualisation authoring and comprehension.

Visual data stories often consist of multiple visualisations that serve as story pieces [5]. Also, effectively communicating the visual data story requires specifying an order in which the visualisation story pieces should be presented. Furthermore, recent researches [6], [7] in narrative visualisation have shown that the order in which visualisation story pieces are presented affects the target audience comprehension and memorability of the information: ineffective sequences increase the cognitive burden on the visual data story audience while optimal sequences facilitate better sensemaking of the visual data story. In creating visual data stories, users can no longer afford to arbitrarily sequence their visualisation story pieces. Hence, it is crucial for visual data story authoring tools to incorporate effective sequence recommendation features in tool design to assist users in creating logically sequenced visual data stories.

We present our approach for recommending and presenting effective visualisation sequences by introducing a framework for the consolidation of the visual data story authoring process. Moreover, we motivate the design of our framework by identifying visual data story authoring tasks.

II. Visual Data Story Authoring Tasks

To support the creation of meaningfully sequenced visual data stories, we identified 6 tasks that our framework should satisfy. These are summarised below:

(T1) Support the creation of visualisations as story pieces from raw data;

(T2) Support the construction and visualisation of meaningfully ordered sequence of story pieces;

(T3) Support the creation of notes or annotations associated with findings;

(T4) Support insight discovery and modification of prior work sessions;

(T5) Enable look-up and inspection of fully interactive visualisations for more details;

(T6) Support the presentation and recording of logically sequenced visual data story for a target audience.

III. Visualisation Sequence Recommender

We adapt the Graphscape [8] model in recommending the most optimal visualisation sequences to users. Graphscape is a directed graph model for reasoning about visualisation similarity and sequences. Users need to be able to create, modify and interact with visualisation sequences in an easy to understand manner. To support this necessity, we assume a meta-visualisation approach [9], [10] in visualising the sequences recommended by the model or manually created by the user. We encode visualisation sequences as nodes and directed edges in a graph canvas. The nodes are visualisation specifications and the edges between nodes show a logical connection between the nodes. Figure 1b shows an example of our meta-visualisation of visualisation sequences approach. Our approach also facilitates the creation of manual sequences within the graph canvas. We assumed this approach for 2 reasons; firstly, we aimed to concretise the abstract graph model to help users intuitively understand and interact with the (recommended) visualisation sequences in addition to the model recommendation results; and secondly, meta-visualisation displays have been shown to be effective in supporting visual understanding when there are numerous visualisations to be analysed together, in our case, multiple visualisation story pieces in a single sequence view [9].

## IV. Consolidating the Visual Data Story Authoring Process

We present a framework for authoring logically sequenced visual data stories. Our framework extends prior works [4], [5] on the visual data story authoring process and consists of three primary loosely coupled components, namely, visualisation, sequence, and presentation components.

A. Visualisation Component

Visual data stories often consist of multiple visualisations. Thus individual visualisations are story pieces which, when combined meaningfully, forms a unified theme and supports a coherent narrative. The visualisation component, shown in Figure 1a, supports the creation (**T1**), inspection (**T5**), naming and export of individual visualisations either as complete visualisation artefacts or as input to the sequence component, and is loosely coupled to the other components.
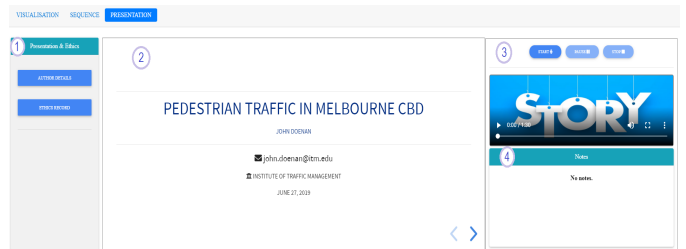
B. Sequence Component

A collection of story pieces i.e., individual visualisations need to be meaningfully ordered to support the creation of a coherent visual data story. The sequence component, shown in Figure 1b, supports the manual creation of visualisation sequences or automatic optimal sequence recommendation (**T2**). It also supports the creation of reference notes (**T3**) that are dynamically bound to a target visualisation and its corresponding presentation slide, analogous to author notes in presentation software like Powerpoint. The sequence component is loosely coupled to the other components: it supports the input of visualisations from the visualisation component and direct import of independent, externally created visualisation
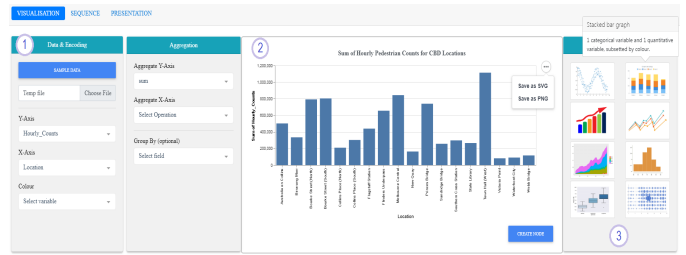
(a) 1. Data input and visualisation encoding, 2. Visualisation area, 3. Visualisation templates.
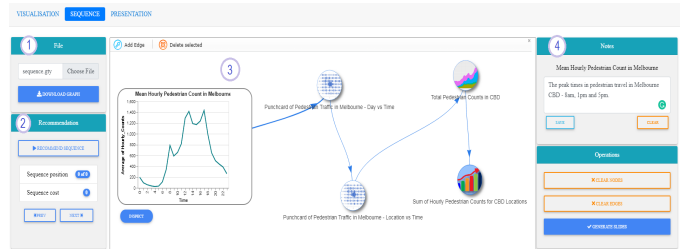
(b) 1. Sequence file input and download, 2. Sequence recommendation panel, 3. Graph canvas for sequence visualisation, 4. Reference notes.

(c) 1. Author and ethics record information, 2. Presentation slides, 3. Video recording of presentationa and preview, 4. Presentation reference notes.

Fig. 1. Screenshots of the three components interfaces.

specifications. The state of created sequences can be saved via import and export of sequence files in a custom file format (**T4**).

C. Presentation Component

The presentation of logically sequenced story pieces to support a narrative is the final phase of the visual data story authoring process. The presentation component, shown in Figure 1c, supports the creation of basic presentation slide decks with author reference notes and interactive visualisations. It also provides support for ethical considerations in the presentation of visual data stories via ethical records and author details form. Presentation slides can be generated from complete logical visualisation sequences or multiple disconnected visualisations. Video recordings can be created, previewed and exported in the presentation component (**T6**).

V. Conclusion

This paper presented our approach for authoring logically sequenced visual data stories. Our approach loosely decouples the core components of our framework as linked interfaces, so users can have the flexibility to create different elements of

their visual data stories in an independent manner. Our future work will assess the effect of our approach with the aim of understanding how our framework supports users in the visual data story authoring process.

ACKNOWLEDGMENT

REFERENCES

[1] S. Lee, S. H. Kim, Y. H. Hung, H. Lam, Y. A. Kang, and J. S. Yi, "How do people make sense of unfamiliar visualizations?: A grounded model of novice's information visualization sensemaking," *Visualization and Computer Graphics, IEEE Transactions on*, vol. 22, no. 1, pp. 499–508, 2016.

[2] L. Grammel, M. Tory, and M.-A. Storey, "How information visualization novices construct visualizations," *IEEE Transactions on Visualization and Computer Graphics*, vol. 16, no. 6, pp. 943–952, Nov. 2010.

[3] H. O. Obie, C. Chua, I. Avazpour, M. Abdelrazek, J. Grundy, and T. Bednarz, "A study of the effects of narration on comprehension and memorability of visualisations," *Journal of Computer Languages*, vol. 52, pp. 113 – 124, 2019. [Online]. Available: http://www.sciencedirect.com/science/article/pii/S1045926X19300059

[4] R. Kosara and J. Mackinlay, "Storytelling: The next step for visualization," *Computer*, vol. 46, no. 5, pp. 44–50, May 2013.

[5] B. Lee, N. H. Riche, P. Isenberg, and S. Carpendale, "More than telling a story: Transforming data into visually shared stories," *Computer Graphics and Applications, IEEE*, vol. 35, no. 5, pp. 84–90, 2015.

[6] J. Hullman, S. Drucker, N. Henry Riche, B. Lee, D. Fisher, and E. Adar, "A deeper understanding of sequence in narrative visualization," *IEEE Transactions on Visualization and Computer Graphics*, vol. 19, no. 12, pp. 2406–2415, Dec. 2013. [Online]. Available: http://dx.doi.org/10.1109/TVCG.2013.119

[7] J. Hullman, R. Kosara, and H. Lam, "Finding a clear path: Structuring strategies for visualization sequences," *Comput. Graph. Forum*, vol. 36, pp. 365–375, 2017.

[8] Y. Kim, K. Wongsuphasawat, J. Hullman, and J. Heer, "Graphscape: A model for automated reasoning about visualization similarity and sequencing," in *Proceedings of the 2017 CHI Conference on Human Factors in Computing Systems*, ser. CHI '17. New York, NY, USA: ACM, 2017, pp. 2628–2638. [Online]. Available: http://doi.acm.org/10.1145/3025453.3025866

[9] J. Peltonen and Z. Lin, "Information retrieval approach to meta-visualization," *Machine Learning*, vol. 99, no. 2, pp. 189–229, May 2015. [Online]. Available: https://doi.org/10.1007/s10994-014-5464-x

[10] S. Xu, C. Bryan, K. Li, J. Zhao, and K.-L. Ma, "Chart constellations: Effective chart summarization for collaborative and multi-user analyses," *Computer Graphics Forum*, vol. 37, pp. 75–86, 06 2018.