Interweaving Data and Stories: A Case Study on Unveiling the Human Dimension of U.S. Refugee Movements through Narrative Visualisation

E. G. Ogbonda[†][1] , J. C. Roberts [‡][1] and P. W. S. Butcher [§][1]

[1]Bangor University, UK

Abstract

In response to the escalating global refugee crisis, we present a case-study of developing an advanced tool for interpreting high-dimensional refugee data. Developed using Mapbox and D3.js, our interactive visualisation harmonises geographical and temporal dimensions of U.S. refugee data from the State Department's Refugee Processing Center. Our modular approach and robust data preprocessing enable seamless interactions among diverse visual components. The result is a narrative-driven visualisation that reveals broad immigration trends and individual refugee movements, fostering a nuanced and empathetic understanding of refugee dynamics. This work highlights the power of narrative visualisations in shaping policy decisions and promoting global discourse on the refugee crisis, marking a significant leap in data visualisation for refugee and immigration challenges.

CCS Concepts
• **Human-centered computing** → **Visualization design and evaluation methods;** *Visualization toolkits; Visual analytics;*

1. Introduction

Amidst the intensifying global refugee crisis, an urgent need for nuanced analytical strategies emerges. The UNHCR's alarming report indicates that by the end of 2022, a staggering 82.4 million people had been forcibly displaced, with 26.4 million designated as refugees. Alarmingly, over half of these refugees are children under 18. The sheer magnitude of this predicament underscores the urgency of well-informed and timely interventions. Traditional data representation struggles to convey the intricate dynamics of this crisis, defined by its temporal shifts, demographic nuances, and diverse socioeconomic elements. Our study melds data visualisation with narrative, through which we aim not merely to enumerate the refugee statistics but to contextualise them offering a holistic understanding of refugee movements, particularly focusing on U.S. immigration.

We contribute a blend of interactivity, temporal granularity, and narratology. Our approach reiterates the crucial role of advanced data visualisation in shaping informed discussions and policies regarding the escalating refugee crisis.

2. Related Work

Data visualisation researchers have persistently grappled with interpreting immigration patterns, given the intricate web of human movement dynamics. Several studies (e.g., [SH10; HD11; WaCP*15]) highlight the pivotal role that visual narratives have in creating engaging storytelling systems. Modern breakthroughs celebrate the power of interactive data mapping [HB03; BOH11] by empowering users to seamlessly decipher temporal and geographic intricacies. Much previous research (e.g.,[Cen17; Ins20]), however, focus on static visuals and demographic tables while inadvertently sidelining the narrative element. Meanwhile, efforts such as the Atlas [Fiv18] depict the potential of sophisticated visualisation in scrutinising multifaceted issues, although they veer away from immigration. While, narrative and explanatory visualisations can help people understand intricacies of laws and policies [RBSN22]. Some initiatives, e.g., from the United Nations [fRef21], have endeavoured to bridge visual storytelling with dynamic immigration data exploration. Yet, they occasionally miss out on offering a holistic narrative or a temporal analysis. Our project adeptly fills this gap, synergising state-of-the-art visualisation tools, like Mapbox and D3.js, with a structured narrative. We aim to provide an intricate yet lucid panorama of refugee trends, spotlighting the temporal influences of pivotal geopolitical events on migration trajectories. In this paper we focus on our methodology, which encompassed a diverse data landscape, specialised tools, technical design, implementation and evaluation [Mun14].

---

† glory.ogbonda@bangor.ac.uk
‡ j.c.roberts@bangor.ac.uk
§ p.butcher@bangor.ac.uk

3. Developing the narrative framework

We develop our narrative by several detailed processes: data-analysis, design, implementation and evaluation.

Data Collection: Our foremost task involved collecting a robust dataset from the U.S. Department of State's Refugee Processing Center [US 22]. This dataset, spanning the late 20th century to the present, offers insights into refugee demographics and migration patterns within the U.S. To enhance utility, data preprocessing such as cleaning was essential, ensuring accuracy and relevance whilst also safeguarding privacy standards [CY22].

Technical Design: Following the Five Design-Sheets (FdS) methodology [RHR16], our technical design phase was iterative, commencing with a treemap representation of migration patterns (Figure 1). Feedback, from using the questions from the Critical Design Survey (CDS) [RAOR23], indicated that these visualisations did not comprehensively explain the narrative. Thus, we amalgamated earlier brainstormed concepts: a geographic map and a circle plot (Figure 2). This meshed approach, applying the Gestalt principle of similarity, improved user comprehension [EF12]. We also refined interactions, ensuring users could access detailed data effortlessly, enhancing overall engagement.
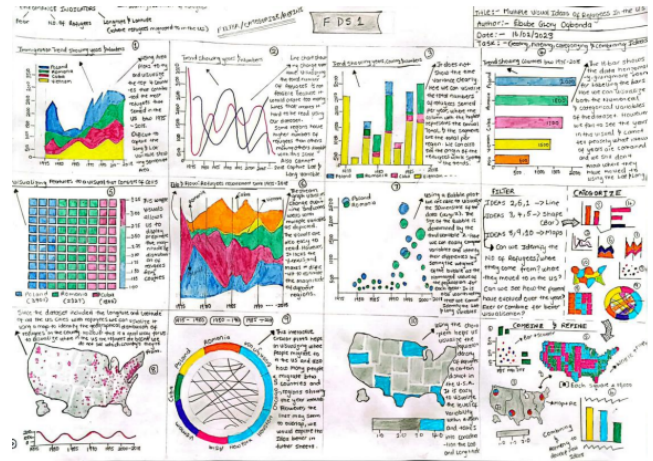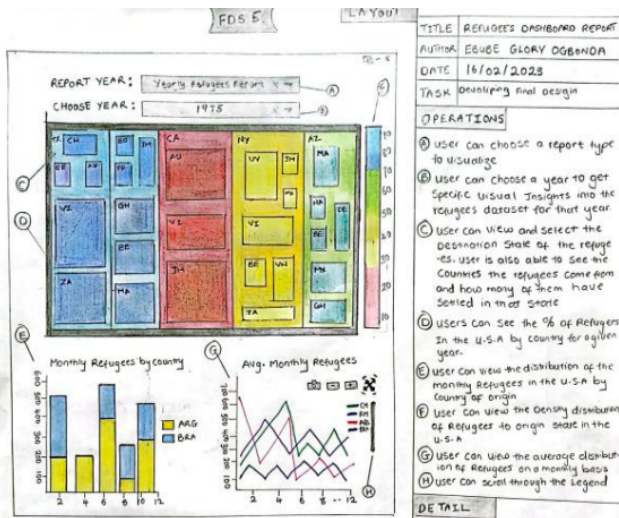

Figure 1: *Initial treemap proposal; sketch from our design study.*

Implementation: Using a modular approach was adopted for coding, ensuring component-level independence yet preserving synergy [LWW*14], and usable interactive visualisations [TKI00]. We deployed Mapbox for our dynamic maps, see Figure 3, supported by the powerful D3.js for crafting our visualisation's interactivity [Map23; BOH11; Bos15]. These tools, mainly D3.js's json function, proved instrumental in our visual narrative's creation [FM11].

Evaluation: A continuous evaluation was vital. We employed reflective design using the Critical Design Sheet (CDS) questionnaire [RAOR23] and the Five Design Sheet (FdS) [RHR16] design-methodology ensuring design efficiency, narrative coherence, and fostering a storytelling ethos [SH10].
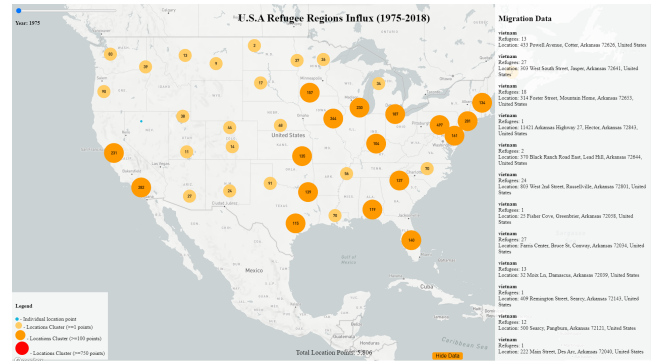

Figure 2: *Idea sketches from our design study; with bubble plot.*

Figure 3: *One of the narrative visualisations, using Mapbox.*

4. Implications, Future Directions, and Conclusion

Our project [Ogb23] married narrative storytelling with immigration patterns, presenting a transformative platform for comprehending intricate sociopolitical data. Such narrative-driven presentations breathe life into impersonal datasets, fostering user empathy [LWW*14]. This innovative approach holds promise for a more comprehensive application, especially in domains like social sciences and public health. Transforming datasets into engaging narratives can encourage more profound and empathetic user interactions [TKI00]. Future advancements include leveraging user feedback for interface enhancement and integrating diverse datasets for broader global narratives. Exploring advanced visualisation tools might refine our story-telling prowess.

Our journey underscored, first, the necessity of meticulous data understanding, particularly during the collection and preprocessing phases. Second, it was crucial to discern the inherent story. Our emphasis rested on portraying the humanistic and complex essence of U.S. refugee movements [HHE07]. The design choices encompassing our core visualisation required balancing the density of displayed information, interaction, to develop an engaging narrative visualisation.

References

[BOH11] BOSTOCK, MICHAEL, OGIEVETSKY, VADIM, and HEER, JEFFREY. "D³ Data-Driven Documents". *IEEE Transactions on Visualization and Computer Graphics* 17.12 (2011), 2301–2309. DOI: 10.1109/TVCG.2011.185.

[Bos15] BOSTOCK, M. *Data-Driven Documents*. 2015. URL: https://d3js.org/.

[Cen17] CENTER, PEW RESEARCH. *U.S. foreign-born population trends*. 2017. URL: https://www.pewresearch.org/publications/?formats=fact-sheet&research-teams=social-trends.

[CY22] CHENG, H.-Y. and YU, C.-C. "Scene classification, data cleaning, and comment summarization for large-scale location databases". *Electronics* 11.13 (2022), 1947. DOI: 10.3390/electronics11131947.

[EF12] ESBITT, K.V. and FRIEDRICH, C. "Applying gestalt principles to animated visualisations of Network Data". *Proceedings Sixth International Conference on Information Visualisation*. 2012. DOI: 10.1109/iv.2002.1028859.

[Fiv18] FIVETHIRTYEIGHT. *The Atlas of Redistricting*. 2018. URL: https://projects.fivethirtyeight.com/redistricting-maps/.

[FM11] FULLER, R. and MILLETT, L. I., eds. *Privacy, data security, and the growing complexity of heterogeneous computing environments*. National Academies Press, 2011.

[fRef21] For REFUGEES, UNITED NATIONS HIGH COMMISSIONER. *Refugee data visualisation*. 2021. URL: https://www.unhcr.org/refugee-statistics/.

[HB03] HARROWER, M. and BREWER, C.A. "ColorBrewer.org: An internet tool for the selection of color schemes for maps". *Cartography and Geographic Information Science* 30.2 (2003), 146–158. DOI: 10.1179/000870403235002042.

[HD11] HULLMAN, JESSICA and DIAKOPOULOS, NICK. "Visualization Rhetoric: Framing Effects in Narrative Visualization". *IEEE Transactions on Visualization and Computer Graphics* 17.12 (2011), 2231–2240. DOI: 10.1109/TVCG.2011.255.

[HHE07] HUANG, W., HONG, S.-H., and EADES, P. "Effects of sociogram drawing conventions and edge crossings in social network visualization". *Journal of Graph Algorithms and Applications* 11.2 (2007), 397–429. DOI: 10.7155/jgaa.00152.

[Ins20] INSTITUTE, MIGRATION POLICY. *The U.S. immigrant population by state and county*. 2020. URL: https://www.migrationpolicy.org/programs/data-hub/charts/us-immigrant-population-state-and-county.

[LWW*14] LIU, S., WU, Y., WEI, E., et al. "StoryFlow: Tracking the evolution of stories". *IEEE Transactions on Visualization and Computer Graphics* 20.12 (2014), 1743–1752.

[Map23] MAPBOX. *Mapbox*. 2023. URL: https://www.mapbox.com/.

[Mun14] MUNZNER, T. *Visualization analysis and design*. CRC Press, 2014.

[Ogb23] OGBONDA, GLORY. *Unveiling the Human Dimension of U.S. Refugee Movements through Narrative Visualisation. GitHub source code*. Released under MIT license. 2023. URL: https://github.com/OgbondaGlory/Visualising_USA_Refugee_Regions_Influx_data.

[RAOR23] ROBERTS, JONATHAN C., ALNJAR, HANAN, OWEN, ARON E., and RITSOS, PANAGIOTIS D. "A method for Critical and Creative Visualisation Design-Thinking". *Accepted for publication at IEEE Visualisation 2023, poster*. 2023.

[RBSN22] ROBERTS, JONATHAN C., BUTCHER, PETER, SHERLOCK, ANN, and NASON, SARAH. "Explanatory Journeys: Visualising to Understand and Explain Administrative Justice Paths of Redress". *IEEE Transactions on Visualization and Computer Graphics* 28.1 (2022), 518–528. DOI: 10.1109/TVCG.2021.3114818.

[RHR16] ROBERTS, JONATHAN C., HEADLEAND, CHRIS, and RITSOS, PANAGIOTIS D. "Sketching Designs Using the Five Design-Sheet Methodology". *IEEE Transactions on Visualization and Computer Graphics* 22.1 (2016), 419–428. DOI: 10.1109/TVCG.2015.2467271.

[SH10] SEGEL, EDWARD and HEER, JEFFREY. "Narrative Visualization: Telling Stories with Data". *IEEE Transactions on Visualization and Computer Graphics* 16.6 (2010), 1139–1148. DOI: 10.1109/TVCG.2010.179.

[TKI00] TRACTINSKY, N., KATZ, A. S., and IKAR, D. "What is beautiful is usable". *Interacting with Computers* 13.2 (2000), 127–145. DOI: 10.1016/S0953-5438(00)00031-X.

[US 22] U.S. DEPARTMENT OF STATE'S REFUGEE PROCESSING CENTER. *Refugee Admissions Report*. 2022. URL: https://www.refugeeresettlementdata.com/.

[WaCP*15] WALKER, RICK, ap CENYDD, LLYR, POP, SERBAN, et al. "Storyboarding for visual analytics". *Information Visualization* 14.1 (2015), 27–50. DOI: 10.1177/1473871613487089.