Visual Matters: Experiments in the Public Visualization of Text

CSDH-SCHN 2020: Presentation Paper

U of Alberta: Geoffrey Rockwell, Jingwei Wang, Bennett Tchoh, Chaolan Wu, Ali Azarpanah
McGill: Stéfan Sinclair

1.0 Introduction

Visualization is the new knowing. From big data to complex processes, visualization tools and data walls are deployed for discovering knowledge and representing it back to others. The tools, however, are not accessible to most scholars, especially humanists who are trained to work with text. The Visual Matters project takes a speculative design approach to prototyping alternative visualization environments that challenge ideas about the surveillance of data. We do this by adapting an existing text analysis environment, Voyant Tools (voyant-tools.org), so that it can be used in new ways by textual scholars to learn through the graphical. In this paper we will discuss:

- **Significance and Methodology**: We will outline the speculative design approach of prototyping that we have taken and why we think it is important.
- **Auditing Voyant**: We will discuss how we audited how Voyant works (or not) on data walls and touch tables.
- **Book Map**: We will demonstrate a first working speculative design called the Book Map.
- **Prototypes:** We will discuss two sketches for future research and development.
- **Conclusion:** We will end with a few thoughts on visualization, ubiquitous screens and knowledge.

2.0 Significance and Methodology

Interacting is believing. Visualizations work rhetorically when users feel they are exploring data and drawing their own conclusions rather than being told what to think. To understand the potential of visualization we therefore need to experiment with designing interactions. For this reason Visual Matters takes a speculative design approach of prototyping alternative visions. We do this through **scenarios** that use two future **contexts** for experiments in text visualization,

1. **Data Walls** - How can data walls be used by groups for research and instruction with Voyant?
2. **Touch Tables** - How can touch tables be used by small groups with Voyant?

Significance: Why do these prototypes matter? The "CSEC Presentation" that Edward Snowden and Glenn Greenwald leaked to *The Globe and Mail* in 2012 shows the Olympia system developed by the Communications Security Establishment of Canada. From the PowerPoint slides we can see how Olympia allows intelligence analysts to combine and visualize both data from different surveillance databases, but also processes of querying across databases. It is both a data visualization tool and a visual programming environment. For those studying big data and surveillance who don't have access to Olympia, the slides are a trace or fiction of what intelligence officers imagine they could do (Rockwell & Sinclair 2017). They provide those of us without access with the equivalent to a design fiction with which we can speculate about the practices of surveillance in the age of big data.

Olympia is just one example of a big data visualization tool developed to manage information about people and communications. Companies like Palantir and IBM have developed other suites of tools that they can customize for organizations (Palantir and Watson Analytics respectively). The rest of us can only imagine how our information is being managed without access to these industrial tools. Promotional materials available online or through the Spy Files released by Wikileaks (https://wikileaks.org/the-spyfiles.html) help us understand what is being developed and used, but they are difficult to find and digest. By contrast a speculative design approach can imagine how we are being managed. For example, Christian Laesser's They Know web site tells a story of how surveillance we have heard about from Snowden could affect a fictional architecture student in Berlin. The story is told through a short video which draws on speculative designs of what the systems look like. The web site includes a poster and documentation showing the sources of the speculations. Similarly in this project we are prototyping how textual scholars might know using Voyant together on data walls or touch tables. To do that we needed to audit how Voyant works in these new contexts, and then design speculative prototypes.

Speculative Design Research: Most design research practices are aimed at producing functional designs, but as Dunne and Raby point out in the "Critical Design FAQ" there is a tradition of design as critique that goes back to Italian Radical Design of the 1970s. Dunne's book *Hertzian Tales* (2005), first published in 1999, introduced Critical Design as an alternative to commercial product design. In the FAQ they define Critical Design as an approach that "uses speculative design proposals to challenge assumptions, preconceptions and givens about the role products play in everyday life." The idea is not to produce design ideas that are more efficient or that meet some need, but to create speculative designs that provoke critical thought about everyday life and its products. It is about the implications of things like visualizations rather than the applications. This approach isn't really a method, but a supplement to design practices that use design for critical purposes. Dunne & Raby further developed the approach in *Speculative Everything* where they provide examples of how speculative designs can present possible futures as scenarios. As such Speculative Design is related to science/speculative fiction in that science or speculative fiction writers use fiction to imagine the implications of technology in a way that can provoke reflection on the present. Speculative design is likewise aimed at provoking reflection, but with fictional products rather than words. The fictional designs

encourage us to imagine potential scenarios of use or alternative futures that change how we think.

Visual Matters borrows this approach to critically explore how visualization is emerging as a way of knowing and specifically a way of knowing large collections of texts. Visualization has traditionally been seen as a way of objectively representing data so that people can "carry out tasks more effectively." (Munzer 2014 , 1) The idea is that visualization can show patterns in otherwise indigestible data making it easier for users to draw conclusions about the phenomena visualized. The challenge for people like Tufte (1983, 1990) was in how to best present data visually with the least distractions.

The history of text analysis tools in the humanities is a history of developing forms of interactive reading (Sinclair 2003). Tools like TACT (released in 1989) demonstrated a new way of using computers to interpret texts (Lancashire 1996). Instead of running batch processes on a mainframe that produced results that would be printed for study, the new interactive tools on personal computers could be used to query texts immediately on the screen. TACT brought a primitive version of a graphical user interface and visualization to the humanist and their personal computer. This history of reading tools like TACT and before it ARRAS (Smith 1984) is being lost as the tools are now difficult, if not impossible to run.

While digital humanists have been developing visualization tools to study texts since the work of John B. Smith (1973, 1978), visualization got little attention in the humanities generally until Franco Moretti argued in *Graphs, Maps, Trees* (2007) that computer visualizations enabled the "distant reading" of texts. Distant reading was presented as an alternative to interpretative "close reading." Distant reading would help explain historical trends the way scientific visualization lets users explore a phenomenon.

Johanna Drucker (2014) rightly critiques the naïve scientific view that visualization shows the phenomena itself, pointing out that data should be called "capta" as it is not given (data) so much as captured and represented through a surrogate (capta). She shows how the whole pipeline of visualization from the choices of what data to capture to the visual form chosen involves interpretation which should be critically interrogated. She imagines visualization tools that rather than hiding the agency of the person making the choices would be capable of showing interpretation in all its subjectivity. She imagines visualization tools that can show the ambiguity of evidence and point of view rather than presenting the illusion of a god's-eye view. In short she proposes generative visualization for humanists where we make new knowledge through interpreting with visualization rather than just representing knowledge. In this she is aligned with Speculative Design as imagined by Dunne and Raby. Speculative design is about trying to create designs that provoke new thinking and knowledge rather than just illustrating what is known or what is given.

Visual Matters draws on these ideas about design and visualization practice to think through how text visualization might be different than scientific visualization. The project creates a

context where alternative tools can be prototyped and shared. The questions we will speculate about through design include those that Drucker raises:

- How can visualization tools aid in exploring and representing to others a multiplicity of interpretations?
- How can visualization communicate where information is missing or ambiguous in ways that open room for speculation?
- How can visualization be a site for negotiating ideas about texts in a group rather than simply presenting them?
- How can a tool make clear the positionality of the interpreter? How can it present a story of different views on data?

References:

n. a. (2012). "CSEC Presentation." Uploaded to SCRIBD by C. Freeze of The Globe and Mail. PDF of CSEC PowerPoint slides from 2012 presentation at Five Eyes conference. <https://www.scribd.com/document/188094600/CSEC-Presentation>

Drucker, J. (2014). *Graphesis: Visual Forms of Knowledge Production*. Cambridge, Massachusetts, Harvard University Press.

Dunne, A. and F. Raby (n.d.) "Critical Design FAQ". <http://www.dunneandraby.co.uk/content/bydandr/13/0>

Dunne, A. (2005). *Hertzian Tales: Electronic Products, Aesthetic Experience, and Critical Design*. Cambridge, Massachusetts, MIT Press.

Dunne, A. and F. Raby (2013). *Speculative Everything: Design, Fiction, and Social Dreaming*. Cambridge, Massachusetts, MIT Press.

Laesser, C. (2014). They Know. Web site at <https://they-know.org/en>. Accessed Jan. 13, 2019.

Lancashire, I., Ed. (1996). *Using TACT with Electronic Texts*. New York, Modern Languages Association of America.

Moretti, F. (2007). *Graphs, Maps, Trees: Abstract Models for Literary History*. London, Verso.

Munzer, T. (2014). *Visualization Analysis and Design*. New York, CRC Press.

Rockwell, G. and S. Sinclair (2016). *Hermeneutica: Computer-Assisted Interpretation in the Humanities*. Cambridge, Massachusetts, MIT Press.

Rockwell, G. and S. Sinclair (2017). "Watching out for the Olympians! Reading the CSEC Slides." *Information Ethics and Global Citizenship: Essays on Ideas to Praxis*. Eds. T. Samek and L. Shultz. Jefferson, North Carolina: McFarland, p. 46-61.

Sinclair, S. (2003). "Computer-Assisted Reading: Reconceiving Text Analysis." *Literary and Linguistic Computing*. 18(2): 175-184.

Smith, J. B. (1973). "Image and Imagery in Joyce's Portrait: A Computer-Assisted Analysis." *Directions in Literary Criticism: Contemporary Approaches to Literature*. Eds. S. Weintraub and P. Young. University Park, PA, The Pennsylvania State University Press: 220-227.

Smith, J. B. (1978). "Computer Criticism." *STYLE*. XII(4): 326-356.

Smith, J. B. (1984). "A New Environment For Literary Analysis." *Perspectives in Computing*. 4(2/3): 20-31.

Tufte, E. (1983). *The Visual Display of Quantitative Information*. Cheshire, CT, Graphics Press.
Tufte, E. (1990). *Envisioning Information*. Cheshire, CT, Graphics Press.

3.0 Auditing Voyant

Introduction

Voyant-Tools (VT) is one of the most used free text analysis and visualization suites, available to the general public at voyant-tools.org. It was developed by Stéfan Sinclair & Geoffrey Rockwell with an initial release in 2003. In the month of October 2016, VT was accessed 81,686 times from 156 different countries (Rockwell & Sinclair, 2016). VT has a variety of text analysis and visualisation tools which have options for customisation. Although VT's interface was designed for use on a personal computer by a single user, its many visualisations makes VT a good candidate to be tested on a huge data wall and a data table. Our goal was to test how a group of scholars working on analysing a text could work interactively on VT displayed on a data wall and on a large data table. Large displays are more common these days and can be found in many areas of the campus. They are owned by businesses and universities and are used to display commercial ads and to provide information to students and shoppers (among other applications). For our testing, we needed displays which are touch sensitive and accessible to students. We were able to find them in the Digital Scholarship Centre (DSC) at the University of Alberta.

The DSC has study spaces, multimedia equipment, broadcasting spaces, modern computers, a 3D printer, virtual reality equipment and of special interest to us, a 7.3m x 1.4m touch capable data wall with a resolution of 12K and a 55inch data table. Both displays are run by a Windows operating system and are available for booking from the DSC website. The data wall and the data table were booked 4 times during which the interactive use of VT for text analysis was tested but unfortunately we could not do further testing of our proposed solutions because the DSC was closed due to the COVID-19 pandemic.

Voyant Tools on the data wall and touch table

The data wall is run by a desktop computer to which a mouse and keyboard are attached. We decided to only use the touch sensitive datawall as our input terminal i.e. starting from the launching of the browser to the loading and analysis of text., it became quickly apparent that working directly on the data wall was not very practical. With a very large space to work with it was impractical to use the whole data wall without running back and forth. We realised that we needed just about a third of the data wall (2.4m x 1.4m)--and that was still a very large space to work with. Hence the dimensions of the data wall made it possible for three groups of people to use the data wall simultaneously. But this usage has many challenges because the data wall is run by one operating system, the three groups have to share the start menu and keyboard for example. To launch a new program from the start menu, a user who is working on the right side of the data wall has to walk to the left side and to access the start menu. The program window

might open in full screen mode above the other windows being used by the other users. The newly opened program window has to be reduced and dragged to the right usually across the windows of other users. A similar difficulty was faced with the keyboard which has to be shared among the group of users. It has to be dragged from one area of the screen to another.

VT's default interface is made up of 5 panels and the user can set which text analysis tool or visualisation is displayed in each panel. On a desktop the pointer changes to a resize pointer when placed over the edges of the panels. Mousing over is not possible on a touch screen and it was impossible to resize individual panels. VT also has a skin builder—discussed in more detail below—in which the number, size, and other parameters of each panel can be preset and placed into a new VT window but it also requires the ability to mouse over which is not possible on the data dall. The browser window could be resized but the larger the window, the more the users has to step back to have the whole window in view. Also, many options of VT panels use sliders for the visualization options. Although clicking and dragging different VT elements worked, the slider didn't work on the data wall. Different levels could be selected by clicking along the slider's length.

Similar problems were faced on the data table, i.e. it was difficult to resize the panels and the slider didn't work. It is not uncommon for such problems to be faced when an interface designed to be used on one platform is used on another.

These issues faced could be addressed by Microsoft implementing changes in the operating system to make common use instances like mousing over available to touch screens, but bringing these issues to the attention of such a big corporation like Microsoft and having them address is not obvious. A more realistic solution will be website designers implementing some design changes on their interface. Solutions to the problems faced are the following:

- Instead of a slider, a clickable dropdown menu could be used. (Windows surface tablets now permit mouse overs with the use of the stylus).
- To make resizing easier, resize icons could be added to the corner of each panel.
- To address the problem of the shared keyboard, a mini virtual keyboard could be added such that it appears below a text input area each time it is selected. Studies have shown a preference for smaller keyboards (Gu, Shim, Kim, & Lee, 2018) and highly customisable keyboards have been created to meet this need (for example Virtual Keyboard by Mottie (2020)).

These proposed solutions improve the use experience for both the data wall and the data table but they seems more useful for the data table since it was designed for direct use. The data wall's large size and other common issues like poor touch calibration, possible harm to eyes due to the screen that has to remain bright to be visible to people standing at a distance from the screen and physical strain from using such a large display makes simultaneous remote access by multiple users through personal portable mobile devices like smartphones, tablets and laptops a better solution for the interactive use of the data wall (Rittenbruch, 2013).

References

Gu, J., Shim, Y. A., Kim, S., & Lee, G. (2018, November). "A Small Virtual Keyboard is Better for
        Intermittent Text Entry on a Pen-Equipped Tablet." In Proceedings of the 2018 ACM
        International Conference on Interactive Surfaces and Spaces. pp. 167-175.
Mottie. (2020). Virtual Keyboard (1.30.1) [Mobile application software]. Retrieved from
        https://mottie.github.io/Keyboard/
Rittenbruch, M. (2013, October). "Supporting collaboration in large-scale multi-user
        workspaces." In Proc. of the Workshop: Collaboration meets Interactive Surfaces: Walls,
        Tables, Tablets and Phones. pp. 1-8.
Rockwell, G., & Sinclair, S. (2016). *Hermeneutica: Computer-Assisted Interpretation in the
        Humanities*. Cambridge, MA: MIT Press.

4.0 Design 1: Book Map

To explore the potential of visualization on data walls in public spaces, our team developed a
prototype called the Book Map, which is an interactive visualization designed for the data wall of a
public library. The Book Map shows the trajectories that a text (book) takes around the world. It
presents an animation of the movement of the text on a map of the world. Imagine this on a large
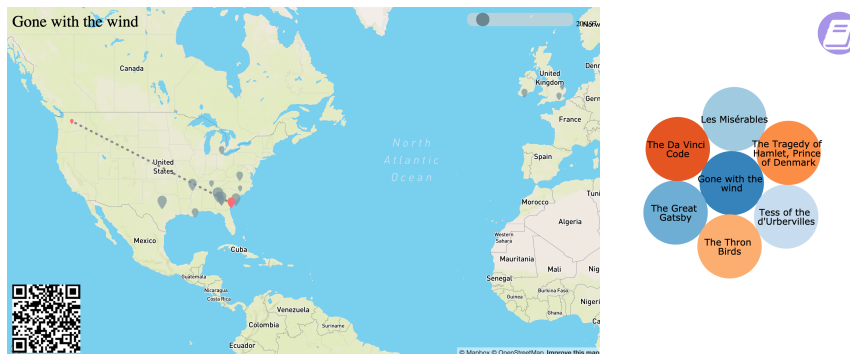data wall at the entrance of a public library.

Figure 4.1: Screenshots of the Shared Visual Space and Personal Controls of the Book Map

The design challenge we set ourselves with this prototype was to imagine a visualization that lots of
people could interact with in a public space. To this end, users can scan the QR code in the lower
left which will call up an interface on their smartphone where they can choose a book to map.
Multiple people can choose books at the same time and these books will then ping-pong around the
world.

The Book Map uses Natural Language Processing, Named-entity Recognition, and Geo-Spatial
Data to visualize geo-locations in books on a public data wall. It was inspired by the Voyant
DreamScape tool (https://voyant-tools.org/?corpus=frank&view=dreamscape). There are special
administrative interfaces for adding books and editing the list of locations recognized. Technically,
Book Map is a website built with Python Django framework, which involves multiple sections for
different functionalities.

Challenges
- Although NER performs efficiently in extracting locations from a book, there will be inevitably some error data that have to be revised manually.
- The geo-location system cannot handle the fictional locations from a book, which leads to another discussion about how to visualize a fictional location on a real map.
- It is still a challenge to display multiple books on the single Book Map. When a viewer chooses a book, the currently displayed book will be replaced by the new one.
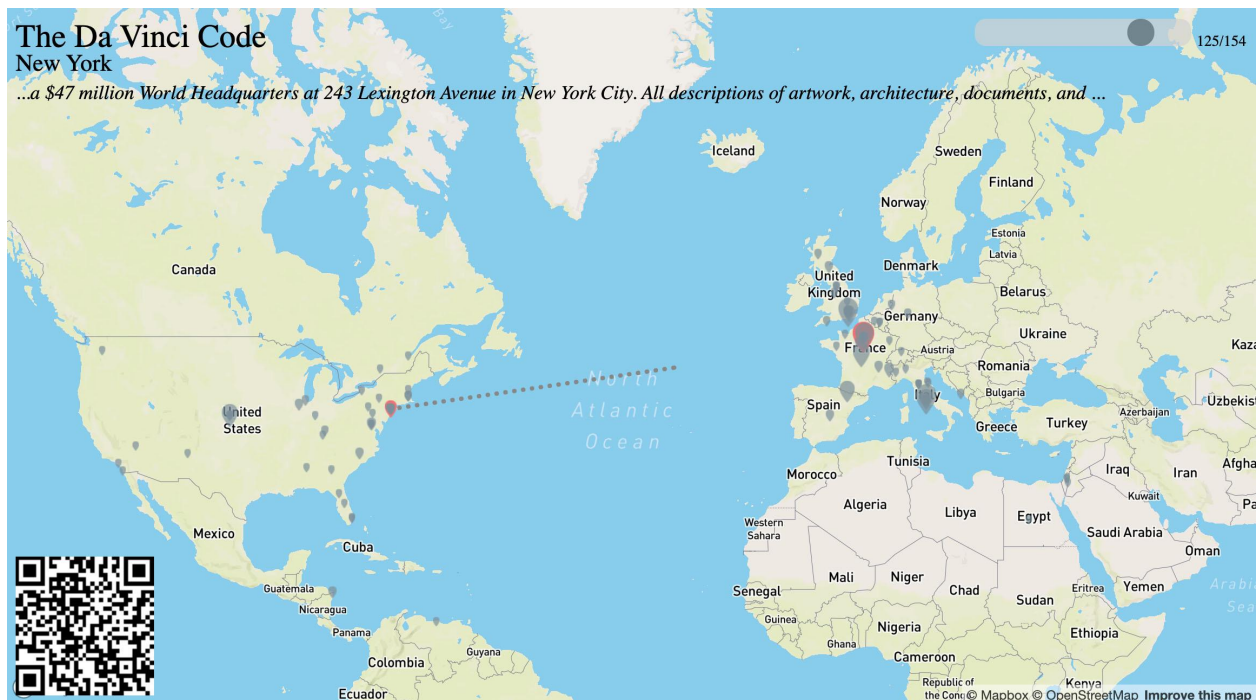

Figure 4.2: Main Map Screen

Figure 4.2 is the main visualization screen of the Book Map, which is supposed to be projected to a big screen or data wall in the library. Imagine it in the foyer of a public library. It displays the information of a chosen book (which will be explained in Book Bubbles Screen), which includes:
- The title of the book
- The geo-locations of the book
- All locations extracted from the text of the book will be displayed as pins on a world map
- The name of the current geo-location
- Display the name of the current location, such as Paris, Venice, London, etc.
- The geo-path of the book
- An animated path shows the trace of the geo-locations in the book, in accordance to the sequence of the text of the book
- The context around the current geo-location
- Display the context corresponding to the current location in the book. A single location may show different contexts as it may appear multiple times in the book.
- The total occurrence of the geo-location
- If the Map Screen is rendered on a PC or a touchscreen, the readers are allowed to tap the location pin to check its total occurrence in the book.

- QR code to Book Bubbles Screen
- Display the QR code linking to the Book Bubbles Screen.

Figure 4.3: Book Bubbles Screen

When viewers scan the QR code with their mobile phones from the Map Screen, they will be redirected to the Book Bubbles Screen where they can choose a book using mobile phones.
All the books are displayed in touchable bubbles. When a user wants to see the locations of a given book, he/she can drag the book bubble to the Book Icon at the top-right corner, and this book will be projected to the Map Screen in real-time. Imagine different books being launched using different colours by visitors to the library. The books could be books about the local city or specific to celebrations that week. Visitors could see where they could go with books in the library.

Book Management Toolkits
Book Map provides a series of toolkits for the librarians/administrators to add/manage books.

Extract locations from a book

| Choose a txt file… | Browse | | Extract |

Current book files:

File Name	Last Modified Date
hamlet.json	04/03/2020, 03:15:34
little maid marian.json	04/17/2020, 15:18:56
winterdreams.json	04/03/2020, 03:39:58
les_mise◆◆rables.json	04/02/2020, 23:13:48
tess_of_the_durbervilles.json	04/03/2020, 03:29:53
frankenstein.json	04/03/2020, 03:44:59

Figure 4.4: Extractor

This Extractor allows librarians to extract geo-locations from a given book. Librarians first upload the text file of a book, and the program will apply the following processes to it:

1. Use Stanford NER to recognize named entities in the book;
3. Extract the location entities and store the context around them;
4. Use Mapbox API to convert the location entities to geo-location data;
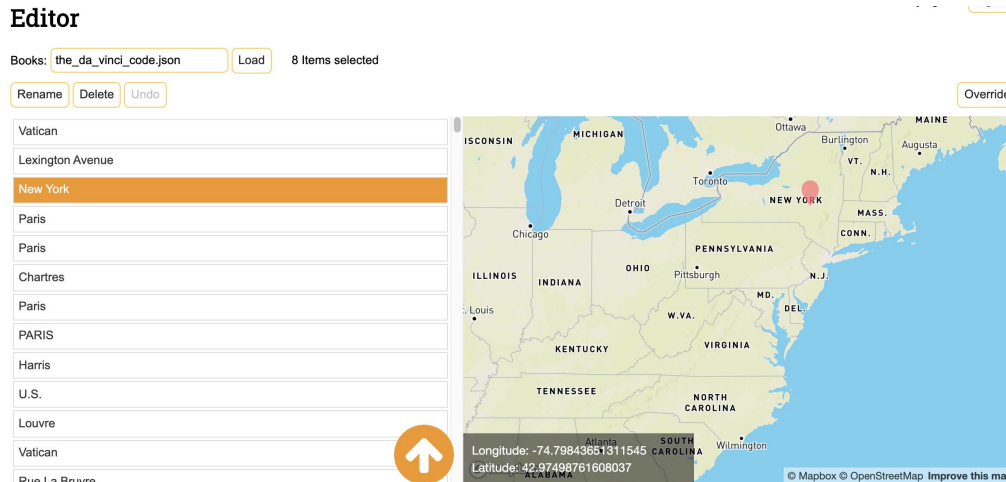5. Store the data as a JSON file on the server.

Figure 4.5: Editor

Once a book has been extracted as a location JSON file, librarians can edit it manually to correct any potential errors caused by automation. The following features are provided by the Editor,

- Rename a location. If the librarians find there is something wrong with the name of the location, they can modify it.
- Delete a location. A location can be removed from the data. However, it needs to be noticed that once a single piece of a location is removed, all the locations sharing the same name will be deleted from the data.
- Modify the geo-data of a location. Librarians can modify the latitude & longitude of a selected location by dragging/dropping the pin on the world map.
- Save the JSON file. Once the modification is done, librarians can override the JSON file on the server to bring the modification into effect.

Configure bubbles

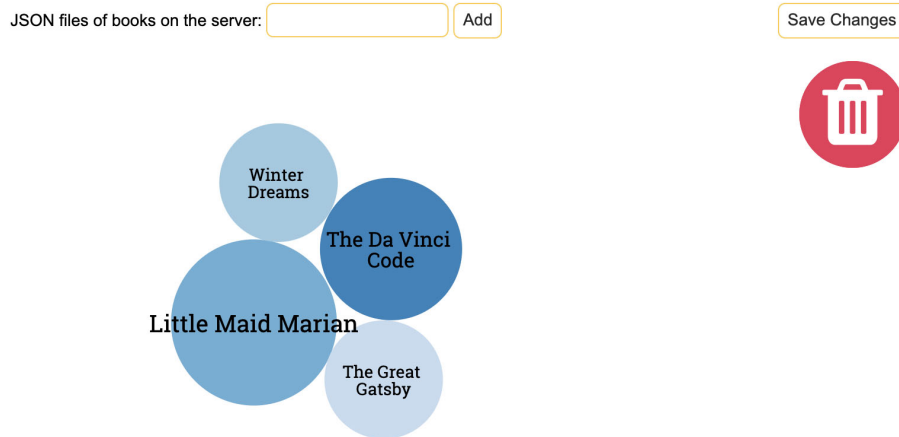JSON files of books on the server: [ ] [Add]   [Save Changes]

Figure 4.6: Bubble Configurator

Using Bubble Configurator, librarians can edit bubbles of the books which are to be displayed on the Book Bubbles Screen. They can,

- Add a new bubble. Librarians firstly choose a book's JSON file on the server (which was generated by Extractor), then they can configure the title and the size of the bubble and add it to the preview section;
- Remove a bubble. Librarians can drag/drop a bubble to the Delete icon at the top-right corner to delete the bubble;
- Save the configuration. Once finished, Librarians can save the configuration so that the change will be applied to the actual Book Bubbles Screen.

The Book Map is a working prototype that we hope to test in the Digital Scholarship Centre of the U of Alberta when people are allowed to gather again.

5.1 Design 2: Teamwork Scenario

The touch table has become more and more popular among the workspace and study area. People took advantage of its features and turned it into a powerful tool of collaboration or presentation. For example, Samsung has developed the Flip 2 display for collaboration (Example 2: https://www.youtube.com/watch?v=vuJd42bYFi4) and Kodisoft company has transformed the touch table into a foodservice table where customers can have their own menu and play games together while they are waiting for lunch. Our team also came up with several scenarios of using touch tables for collaboration and presentation.

As the group project and teamwork prevail in universities and workplaces, we first thought about how we can use the touch table to enhance the productivity of the collaboration in the group project. Hence, our team proposes a scenario of using a touch table to conduct visualization teamwork in Voyant. Imagine a group of students wants to use Voyant to study their texts, using the touch table in the library. They hope that each student can have a chance to explore the visualization on their own but also study the project together in the shared table where each team member can interact

and explore. In our proposal, Voyant creates sections for each student to play with visualization, but also has a shared table for team collaboration. Students can click save to Spyral as a way to take notes for their own and they can add the screenshot or note to the shared collaboration platform such as Google Docs or others.

In the design, the touch table can be separated into two parts. The major one is the Voyant interface, accompanied by a small section of the collaboration platform. Here is how it looks:
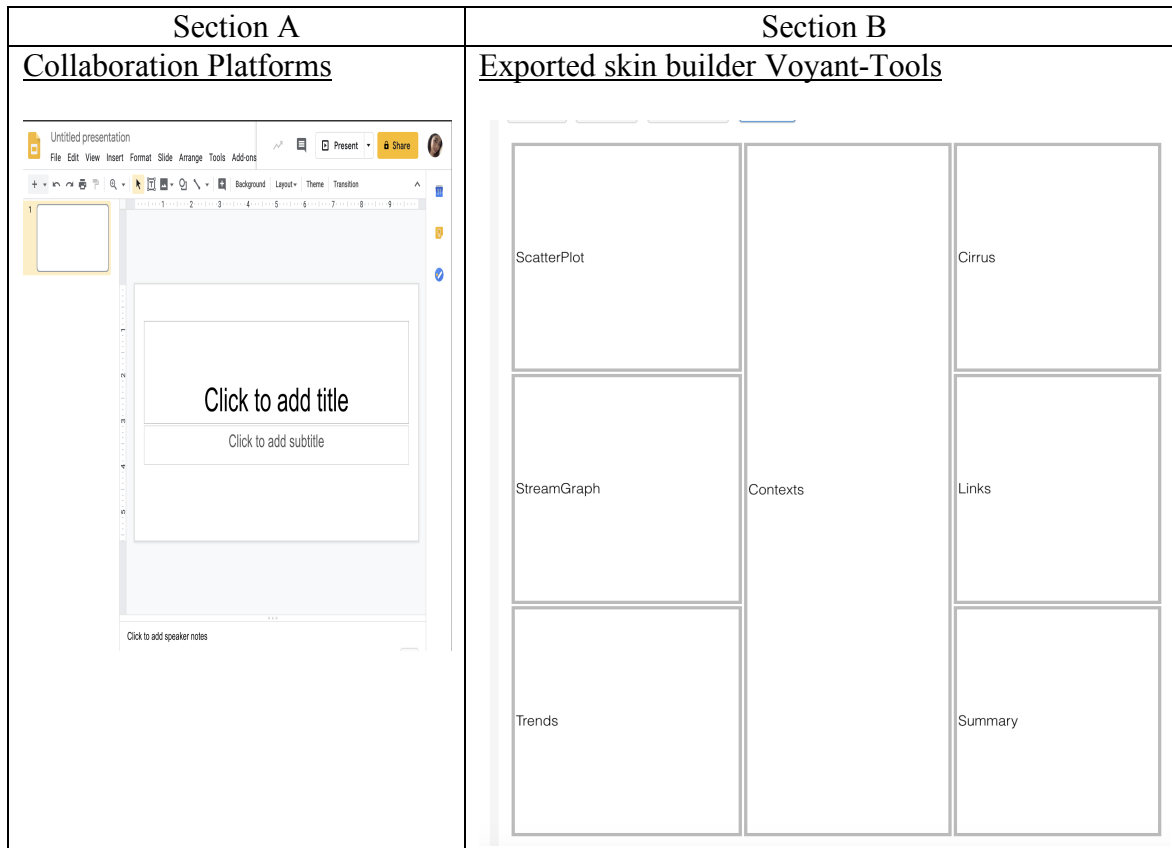

Figure 5.1.1: Wireframe of Scenario

Voyant can be separated into two parts. In the middle of the interface are the shared sections and the sections in the two sides are individual sections where each member can play with the visualizations themselves and the individual can swap their section to the shared section. Here is how it works:

- If each student wants to play around the visualizations themselves, each student can use the visualization on the two sides. They can analyze the text individually, choosing different types of visualization. The numbers of sections in the two sides can be added based on the number of students in the project. The sections in the two sides can be rotated in a comfortable direction for students to read.
- If students want to discuss their project together, they can use the shared space in the middle. In the shared space, students can open the new window to do the visualization or a student can switch one of their own visualizations to the middle section, sharing his/her work with the rest of the group members.

- If students are preparing for the presentation, they can open the PowerPoint or Word document beside the Voyant website, adding a screenshot and note immediately.

5.2 Design 3: Teaching or Lecture Scenario

Large scale visualization walls are increasingly becoming an important tool in teaching and research presentations. This experiment tries to utilize the potential capabilities of visualization walls when a group of participants investigates texts using Voyant. Specifically, the experiment aims to show the data wall's abilities to provide a platform to present the process of digital humanities research. A professor who wrote a book rich with analysis and data visualizations is invited to give a lecture about the book at the UofA. He/She wants to use the walls to show how he/she used Voyant in his/her research. His/Her plan is to reconstruct the process of writing the book.

He/She decides to divide the data walls into four sections:

Figure 5.2.1: Wireframe of Scenario

1. In the left section, a short video shows how the professor gathered and cleaned his/her data.
2. In the second section, participants can try tools and code the professor used in the process of building the corpus through a file-sharing platform.
3. In the third section, participants will pass works to Voyant. They will try to enter different formats of resources (plain text, MS Word, MS Excel, PDF files, XML files, webpages, etc.) gathered in the professor's Voyant corpus. They will learn, for instance, to enter XML documents into the tool by using XPath expressions.
4. In the leftmost section, the results of the analysis and visualization produced by the voyant tool will be presented. Participants will work with the voyant tool to generate different visualizations and will learn about different options of Voyant like the "Stopwords" option. There could be different configurations of tools.
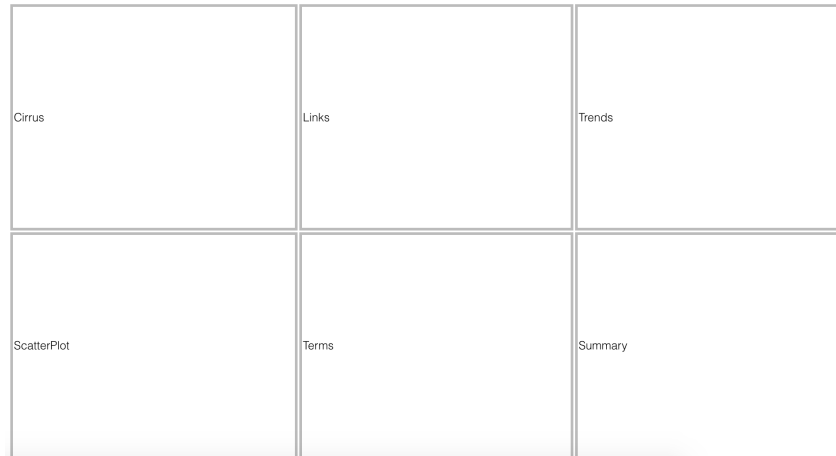
Figure 5.2.2: Wireframe of Voyant Skin

6.0 Conclusion

For thousands of years we have been strived to know ourselves but only recently has visualization become a truly ubiquitous form of mediation for that knowledge. We are beyond the titillating examples of science fiction interfaces offered to us through films like Minority Report and the Matrix, we are inundated with challenging new visualizations in news media, video games, and even so-called smart devices that control our homes. One thing is sure: these systems will only grow in importance for consumers, but also corporations, governments and other organizations.

We are just beginning to get a handle on what's possible in research labs at universities, where large data walls and large touch tables are increasingly accessible. This research was doubly motivated: first, to better understand the technologies and how they may be used by groups, and second, to better understand our existing tools and how well they work (or not) through these new interfaces.

We started with a conceptual examination of visualizations, why they matter, who is currently using them and to what ends, as well as introducing speculative design as a way of understanding visualizations in a less functional way. We proceeded with an audit of Voyant as used on a large touch table, which allowed us to perceive some greater potential while identifying important shortcomings in both the tools and the systems meant to support them. Engaging with our own exercise in speculative design, we presented the Book Map project which was designed from the outset to support scaled interfaces, from phones to large data walls. Finally, we outlined an exercise in collaborative design that leverages some of the customizability of Voyant to allow a group to articulate how different tools might work together for different purposes, especially when supported by large scale displays.

We don't wish to exaggerate the significance of this work, but we strongly believe that humanists must be involved in designing, prototyping and implementing new visualizations tools intended to help generate knowledge. We are just at the beginning and much work remains to be done.

7.0 Resources

Examples
- https://www.youtube.com/watch?reload=9&v=5OXGZYHfcxE
- https://www.youtube.com/watch?v=vuJd42bYFi4
- https://www.youtube.com/watch?v=oImHUVOylfw

Useful resources:
- https://www.researchgate.net/publication/334371382_Multimedia_Exhibition_Design_Exploring_Intersections_Among_Storytelling_Usability_and_User_Experience_on_an_Interactive_Large_Wall_Screen
- https://link.springer.com/content/pdf/10.1186/s40537-018-0150-7.pdf
- https://arxiv.org/pdf/1908.00056.pdf
- https://www.researchgate.net/publication/303401193_Use_of_Large_Multi_Touch_Interfaces_A_Research_on_Usability_and_Design_Aspects