Artistic Visualisation of Trends in the VIS Arts Program

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Abstract

Data visualization techniques have become cornerstone for data mining, analysis, and communication, especially at the intersection of data, art, and design. In this context, the VIS Arts Program (VISAP) has provided a valuable platform for researchers in this field and has a history spanning a decade. To commemorate its 10th anniversary and gain a comprehensive understanding of its historical progress and trends, this project conducted in-depth data analysis and visualization, exploring VISAP's artworks, academic papers, conference venues, participants, and thematic trends, etc. I have designed a range of visualizations including hierarchical tree, contribution list, timeline, map and author network diagram, as well as the interactive connections within the view itself and between different views, to present the analysis results clearly and intuitively. The research not only provides us with a comprehensive view of the history of VISAP, but also aims to bring new insights and understandings to the fields of data visualization and interdisciplinary research.

Research Ethics Approval

This project obtained approval from the Informatics Research Ethics committee.
Ethics application number: 935851
Date when approval was obtained: 2023-07-12
The participants' information sheet and a consent form are included in the appendix.

Declaration

I declare that this thesis was composed by myself, that the work contained herein is my own except where explicitly stated otherwise in the text, and that this work has not been submitted for any other degree or professional qualification except as specified.

(*Qiuyun Zhang*)

Acknowledgements

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I would also like to thank my parents, whose unconditional support and encouragement are my indispensable source of strength and gave me the courage to persevere. I would like to thank my fellow students who helped me with my user research and their assistance helped me overcome many difficulties.

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Finally, I would like to thank the University of Edinburgh for providing me with an excellent learning environment. It has given me the opportunity to gain access to more knowledge, broadened my horizons, and laid a solid foundation for my future life.

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Chapter 1

Introduction

The introduction chapter introduces the motivation behind this project, followed by the problem statement and research questions. This chapter also details the methodology and highlights the contributions of the project. Additionally, an overview of the subsequent chapters of this dissertation is provided.

1.1 Motivation

Data visualization plays a crucial role in exploring, analyzing, and conveying data [35]. It facilitates the conversion of complex information into a comprehensible and straightforward format, enabling a wider audience to grasp the content. The convergence of data visualization, art, and design has spurred a fresh research field, where visualization strategies are deployed to construct data-driven artworks. These artworks compellingly communicate complex concepts [6, 23]. An excellent example of this domain is the VIS Arts Program (VISAP[1]), a mini-conference and exhibition that serves as a platform for visualization scholars, designers, and artists to present and discuss their work at the intersection of data visualization, art, and design [18].

The 2022 celebration of VISAP's 10th year provided a unique opportunity to look back on its progression over the past decade. Studying the submissions to VISAP, such as artworks, academic articles, locations held, participating individuals and thematic trends, can shed light on the maturation of this cross-disciplinary field and the pivotal role VISAP played in its evolution.

Furthermore, the cross-disciplinary aspect of VISAP and the artistic and design-oriented contributions demonstrated within the program making this project hold signif-

[1]VISAP: `https://visap.net/`

icance for both academic and industrial sectors. For academics and industry experts, assessing the themes and trends could aid in identifying potential gaps in this area, spotlighting emerging research fields, and shaping future research directions. Also, such analysis could offer valuable insights into novel methods for data visualization and design, along with a profound appreciation for the value of interdisciplinary collaboration.

1.2 Problem Statement

The task involves creating a collection of visualizations that effectively represent the temporal and thematic evolution in the VISAP across the last decade. Over this span, VISAP has served as a platform for presenting and discussing creations that blend data visualization, art, and design [18]. However, in spite of the numerous data artworks and papers featured at the conference, there lacks a comprehensive visualization that reveals the main themes and their trends throughout the program's history.

This project aims to fill this gap by performing an analysis of the VISAP data set uncovering time-based and thematic trends in the previous decade. By focusing on this unique issue, this project further aims to an in-depth insight into the contributions, authors, locations, and themes highlighted at the conference, as well as emphasizing the interdisciplinary nature of the program. To address this challenge, quantitative analyses are conducted on the contributions and the individuals associated with the conference. Consequently, a set of visualizations including hierarchical tree, timeline, map, contribution list and author network is designed that can effectively communicate the results of this analysis.

1.3 Research Questions

The main research questions of this project focus on the thematic and temporal development of the VIS Arts Program in the past ten years. The ultimate aim is to develop a suite of innovative, artistic and interactive visualizations to help researchers, designers and artists gain better insight into developments in the field.

For this project, the research questions are as follows:

1. How to perform a quantitative analysis of VISAP contributions to identify temporal and thematic trends in the past ten years, and how can these findings be

prepared for visualization?

2. What set of visualizations should be generated to effectively present the analysis results in an engaging manner?

3. How does VISAP's interdisciplinary nature and artistic design orientation manifest in the visualization?

1.4 Methodology

The core methodology of this project is the combination of visualization design process and qualitative evaluation. At the design phase, I aimed to artistically represent the trends in VISAP, enhancing our design through iterative revisions informed by user feedback. Additionally, I carried out user research using qualitative method to deeply understand user experience and feedback, which provide directions and basis for improving the visualization prototype. This integrative methodology helps us better grasp user needs, enhancing the effect of visualization, and ensuring that it aligns with the visualization goals of the project. The following subsections provide a more detailed look into our design process and user study methods.

1.4.1 Data Analysis & Design Process

In the initial stages of the project, brainstorming method was employed to define the design concept, which aimed to artistically present the trends of the VIS Arts Program. Brainstorming facilitated exploration a variety of feasible design ideas enabling the formation of a preliminary visual representation that provides a clear direction for the subsequent design process.

In the brainstorming stage, some quantitative data analysis was conducted using Python's Pandas library to identify temporal and thematic trends to see what data could be displayed in preparation for subsequent visualization.

During the sketch design iteration phase, the design concept was transformed into a preliminary digital sketch using the Figma tool, including basic user interaction elements such as bar chart and line chart. Based on user feedback, the design sketches were further iterated using paper to refine the digital sketch. The creation of paper sketch defined the design direction of the final prototype, incorporating various elements like

hierarchical tree, map, network and timeline, etc. to provide the best user experience in an engaging manner.

Once finalizing data analysis and the design direction for the final prototype, the project transitioned to the prototyping phase. After the prototype was created, user feedback on the prototype was collected and based on that feedback several iterations were made on UX-related factors such as layout, colors, images and functionalities.

1.4.2 User Study

A user study was conducted to assess the effectiveness of visualizations designed to represent contributions to the VIS Arts Program by gathering feedback from individuals less familiar with but interested in VISAP. I opted for a qualitative research format, interviewing users to understand experiences with these visualizations. I conducted interviews and collected data using online video conferencing tool MS Teams, all voice feedback was recorded, and screen capture was used to record interactions with visualizations.

This qualitative approach allows for an in-depth exploration of the perspectives and experiences of the participants, thus helping to evaluate and improve the visualisations to better communicate trends and insights about VISAP.

Ethical considerations are necessary when conducting research with humans. Therefore, I have applied for and obtained relevant ethics approval (reference number 935851, see Appendix A.1 for details).

1.5 Contributions

The screenshots of the final dashboard are shown in Figure 1.1 and Figure 1.2. The demonstration video[2] of the prototype and an interactive online version[3] of the prototype are also available. The project mainly consists of four linked visualizations and an independent network visualization:

1. **Tree Visualization of Themes & Contributions.** This project exhibits the annual theme and all the titles under the theme in a hierarchical tree. To improve user experience and visual effect, the project adopts an interactive design where all

[2]Video Demonstration: `https://uoe-my.sharepoint.com/:v:/r/personal/s2311488_ed_ac_uk/Documents/demo_video.MP4?csf=1&web=1&e=anwa0B`

[3]Interactive Prototype: `http://www.utahinrichs.de/msc_projects/2023/Qiuyun/`

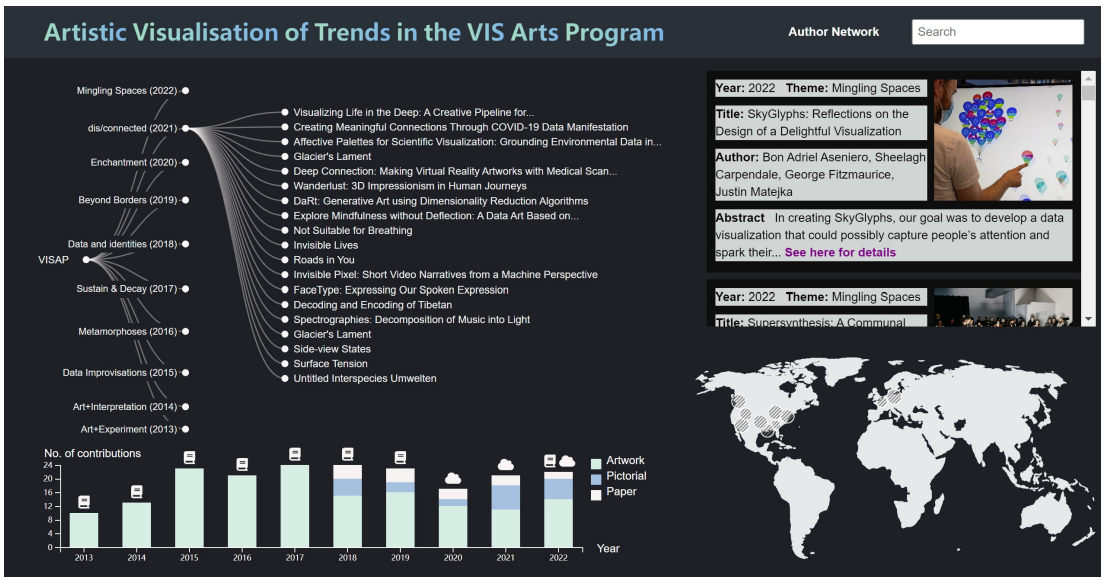


Figure 1.1: Screenshot of the main page of the final prototype.

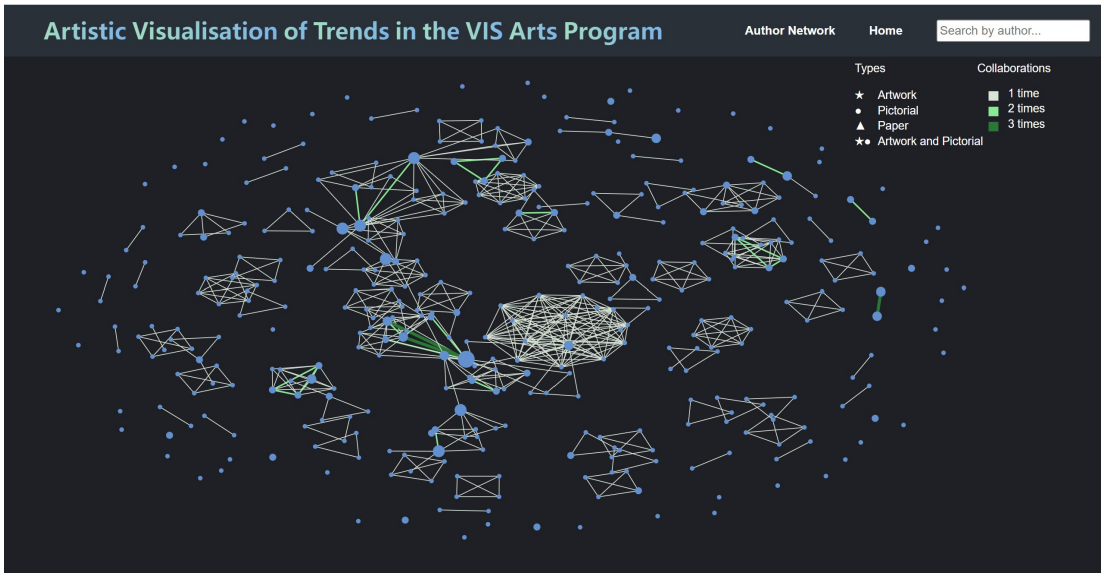


Figure 1.2: Screenshot of the 'Author Network' page of the final prototype.

titles under a specific theme are only displayed when users hover their cursors over it. Furthermore, the project also provides users with clear navigation through text highlighting.

2. **List of contributions (artworks, papers, pictorials).** In this view, each work block lists the year, title, theme, authors and the abstract. The image of the work is placed on the right side of the textual information to ensure its clear visibility. At the same time, users can access the full work information by clicking the work

link at the end of the abstract. Users can also view more works information by sliding the scroll bar and find desired works through the search box.

3. **Timeline Visualization.** Through the stacked bar chart, the project statistically represents and visually displays the number of works and types of various works by year. It uses different colors to represent different types of work and small icons to indicate the submission format for each year.

4. **Map Visualization.** This project uses a map to clearly show the locations of VISAP held in the past ten years and the type proportion and quantity of works presented in each location. To allow users to better understand and observe, the project uses a dynamic design where specific locations are enlarged and detailed information is displayed when users hover their cursors over them.

5. **Linked Views.** Among the four views of the tree visualization, list of contributions, timeline, and map, I have designed interactive logic to create organic links between them. For example, when the user clicks a rectangle for a certain year on the timeline, not only will the rectangle be highlighted, but also the corresponding location on the map, the theme in the hierarchical tree, and the work list will be simultaneously highlighted and updated. This allows users to immediately see comprehensive information related to the selected year. Similarly, when the user selects an element in the hierarchical tree or map, other views will also be highlighted and display information related to the selected element.

6. **Author Network.** In the author network visualization, the project shows the number of contributions and collaboration relationships of all authors who have participated in VISAP. Through the size of the circle, the color and thickness of the line, users can intuitively see the contribution degree and collaboration frequency of authors. At the same time, the project uses the shape identifiers to clearly mark the types of work that authors participated in, and the shape identifiers can be clicked to jump to the actual link of the work, making the information more readable. Users can also find a specific author by entering the author's name in the search box.

The set of visualisations generated in the dashboard presents the results of the analysis in a variety of forms of charts, with the rich interactive features of the charts themselves and the connections between the views engaging the user in a more compelling way.

In addition, the design of these charts, such as hierarchical tree and network diagram, emphasises the artistic aspects of the data visualisation, and the images of each artwork are shown in the list of contributions to better reflect the interdisciplinary nature of VISAP and the artistic design-orientation of the contributions.

1.6 Dissertation Overview

The remainder of this dissertation is structured as follows:

Literature Review: Chapter 2 delves into the intersection of data visualization and art, emphasizing the role of artistic elements in the visualization process. It evaluates past visualizations in the context of cultural collections and draws useful visualization techniques from them, as well as discusses the principles of our design using dashboards for data presentation.

Exploring the VIS Arts Program: Chapter 3 provides an overview of VISAP and details the data used in the project including the supplementary data collected from VISAP and the procedure of data processing.

Design Process and Prototyping: Chapter 4 details the design process, tracing the formation of the final design of the project — from initial brainstorming, visualisation preparation and creation of preliminary sketches, to identifying problems and improving them, to creating low-fidelity prototype and finalizing the ultimate high-fidelity prototype.

Implementation: Chapter 5 provides an in-depth discussion of the technical implementation of dashboard during web development.

Evaluation: Chapter 6 provides a detailed account of the user research conducted to measure the effectiveness and results of the final visualization prototype, which also includes reflections on the prototype's potential limitations and possibilities for improvements.

Discussion: Chapter 7 discusses interpretation of the overall results of the project, reflecting the initial research tasks and actual contributions. It also explores potential paths for future research and work.

Conclusion: Chapter 8 provides a summary of the thesis, summarizing the overall design, the design and development process of the prototype and areas for future improvements.

Chapter 2

Literature Review

This chapter will first discuss the concept of data visualization, emphasizing its significance and practical applications. This is followed by two examples of artistic data visualisations to understand how my project should reflect the artistic and design-oriented contributions presented in VISAP. Subsequently, I will review two visualization projects in the context of cultural collections, so as to draw on the visualization methods that are effective for this project to visualize the ten-year trends of VISAP. This project utilizes a dashboard for data visualization, which is a system that integrates and summarizes key decision-making data, presenting information via charts, tables, gauges and so on [7, 9]. Lastly, I will cover some fundamental principles for creating user-friendly dashboard design.

The following research questions guided the literature review:

- How have artistic elements been incorporated into data visualization?
- How have the cultural collection been visualized in past projects?
- How is the dashboard designed in the context of cultural collections?

When it comes to visualization, it has been defined and described by many people. According to Keim et al. [20], it is about presenting abstract data using an interactive visualisation interface. They see it as transforming complex data into interactive visuals. Similarly, Purchase et al. [28] emphasise the role of computer graphics in information visualisation aimed at helping humans to solve problems. These definitions and descriptions emphasise the value of visualisation in understanding data, discovering patterns and extracting insights.

In the field of data visualization, graphical methods are generally used to represent data. Depending on the purpose, a detailed view like a scatterplot or a summary view

like a histogram can be used [32]. Overall, the primary objective is to extract meaningful information by visualizing data and statistics, interpreting and presenting results [32].

Van Wijk et al. [34] noted that the generation of large data sets in today's society is made possible by advanced acquisition equipment such as MRI machines and supercomputers. Data visualisation allows a variety of professionals and members of the public to extract meaningful insights from these large data sets. This is largely due to the fact that the human visual system can quickly recognise patterns and features [34].

Nowadays, data visualization has a wide range of applications in various fields. Scientific papers often use diagrams and visual encoding techniques for illustration [4]. Meanwhile, news and government sources often employ bar charts, line charts, and maps [4]. These practices cater to specific needs in science, media, and government. In addition, Manovich [24] highlights that over the past 20 years, information visualisation has become commonplace in the sciences and has gained traction in the arts and culture. In this context, my dissertation focuses on artistic visualization of trends in the VISAP.

2.1 Artistic Data Visualization

In recent years, the rise of computer graphics and online data sources has had a significant impact on information visualisation. This has attracted artists and designers. Using the visual capabilities of the personal computer, these creatives actively broadened the conceptual landscape of information visualization as an artistic practice [35].

Artistic visualizations, as defined by Viégas and Wattenberg [35], refer to data visualizations created by artists to produce artistic works. Given the broad definition of art, it is difficult to define exactly what an art visualisation is, but they emphasise that it is based on real data. This means that the true essence of artistic visualisation is not just aesthetics, but also a true mapping between data and visuals with artistic intent.

In the sections that follow, I present two projects in artistic visualization that highlight some of the core qualities of artistic visualization.

2.1.1 Homes for Sale

Jason Salavon's digital work 'Homes for Sale' (Figure 2.1) shows a comprehensive photo collection of homes for sale in the United States, using a technique of averaging color values [35]. The final product paints a blurry but captivating visual, almost as if the city's weather patterns are mixed with the spectral impressions of the houses [23].

Figure 2.1: Homes for Sale. Source: Jason Salavon, 2023

Drawing on rich numerical data, Saravon's work exhibits a sublime aesthetic quality, a criterion that has historically been important in judging works of art. This demonstrates how objective quantitative digital data can be translated into subjectively interpreted works of art, demonstrating the marriage of art and technology [23].

Creating static data visualisations demonstrates the artistic potential of digital compression techniques. These techniques can compress complex data into compact, manageable forms, helping them to be transmitted and stored in today's digital age [15].

All in all, Saravan's "House for Sale" uses color averaging to transform large amounts of image data into an artistic vision. Similarly, my project also use this technology to process a large amount of theme and artwork title data, such as presenting data in the form of average or commonality through a hierarchical tree, with the annual theme as the master node and the corresponding title as a child node. As can be seen, Salavon's emphasis on the art of data visualisation provides insights into balancing data and art when designing prototype, thus reflecting the interdisciplinary nature of VISAP.

2.1.2 Last Clock

With the proliferation of city cameras, video has become a prevalent data source [35]. Artists like Jussi Ángeslevä and Ross Cooper are using this wealth of data to experiment with their artistic potential, including "Last Clock" [1]. Structured like an analogue clock, reinterpreting time using live feeds from city cameras (Figure 2.2).

Figure 2.2: Last Clock. Source: Ängeslevä and Cooper, 2023

In "Last Clock", each of the hands represented by concentric circles is a slice of real-time video, and each rotation leaves a visual echo that captures the moment. Over time, the clock became a distinctive marker of its environment, producing a powerful record

of time and space [35]. Strictly speaking, this artwork is not intended for surveillance or video viewing, but instead demonstrates the history and rhythm of a location, creating a visually pleasing abstraction that offers a unique perspective of its surroundings [1, 35].

In conclusion, ”Last Clock” creatively uses video in analogue clock format to represent time and space. In my project, the stacked histogram timeline is adopted to depict annual contribution changes. Inspired by ”Last Clock”, I combined visual effects such as color and transparency to represent yearly changes in type of work and time. Additionally, the interactive design of ”Last Clock” also provides the possibility to add interactive elements when designing the timeline, so that users can better understand and manipulate data. More design details will be presented in Chapter 4.

2.2 Visualization of Cultural Collections

With the rise of digitisation, vast cultural heritage collections are now accessible online in innovative formats that benefiting both researchers and general users [37]. However, effectively displaying these vast digital collections is a challenge. In response to this, Whitelaw [36] proposed the idea of ”generous interface”, which can provide rich, navigable content display and encourage in-depth user exploration and browsing.

The next two subsections will focus on two cultural collection visualization projects: ”Selfiexploratory” and ”Speculative W@nderverse”. These projects provide new insights to extensive collections of selfie data and science fiction collections through innovative visualizations. They transform complex data sets into interactive visual displays while maintaining the cultural and emotional nature of the collections.

2.2.1 Selfiexploratory

Manovich et al. developed an innovative web application called ”Selfexploratory” to examined 3,200 Instagram selfies from five cities around the world [31]. Visualisation designer Moritz Stefaner emphasises that each photo is not just data, but also carries emotions and patterns, underlining the project’s idea of ”media visualisation” [25].

The app (Figure 2.3) enables multifaceted inspection of photo data sets, and users can flexibly filter photos based on multiple factors, such as city, gender, age, etc, which are analyzed and extracted by this software [25, 27, 31]. Furthermore, the method of interpreting the images blends human judgment and software-based measurements. For example, gender and age charts are generated using human labels and estimates, while

other graphical representations rely on precise software analysis of facial metrics [25]. Windhager et al. point out that maps are often used to show the geographic origin of cultural objects and relics, because this is a frequently recorded metadata dimension. Additionally, they are also used to show the historical trajectory of cultural heritage in a geographical context [37].

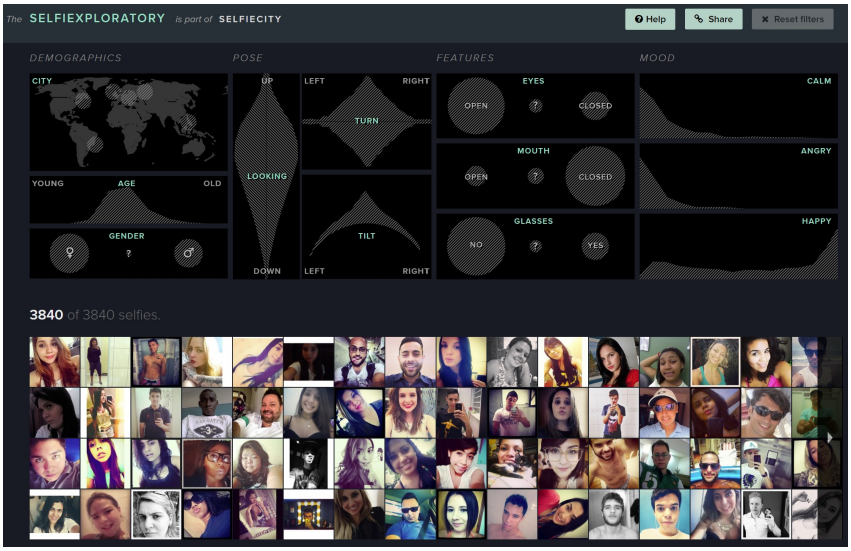


Figure 2.3: A screenshot from Selfiexploratory application.

These graphs update dynamically based on user selections, providing a flexible approach to identifying patterns and trends in large media data sets. As lead developer and UI designer Dominikus Baur explains, this interface holds great promise for applications such as digitizing museum collections or managing personal media [31].

2.2.2 Speculative W@nderverse

”Speculative W@nderverse” is an innovative visualization tool created by an interdisciplinary collaboration of literary scholars and information visualization experts [14]. It aims to facilitate the exploration and analysis of an extensive collection of science fiction short stories, catering to general readers and academic researchers [13, 14].

This platform (Figure 2.4) includes an interconnected visualization system with four main views: Item View, Keyword Cloud, Keyword Hierarchy, and Timeline [14, 30]. The item view displays detailed information for each science fiction item, such as title, author, year of publication, literary form, and links to abstract and editions [11, 14], which is applicable for my project to display the detail of each artwork. The background of each item shows the cover of the corresponding anthology, providing users with a visual cue to identify items belonging to the same anthology [14].

The timeline view displays items based on their publication or reprint year, offering scholars a tool for period-focused research and providing general readers with temporal context for the collection [14]. Also, timelines often complement other visualizations as ”linked views” for navigating time [14].

Keyword clouds and hierarchy views provide an overview of themes in the anthology that relate to established themes in early science fiction literature. Hierarchical diagrams, such as tree diagrams, effectively show the structure of collection metadata, given the different classifications of cultural objects [33, 38]. The platform also provides traditional search and filter options, allowing users to search by keyword, author, anthology or filter based on criteria like author gender and anthology title [11, 14].

The empirical studies and user feedback confirm that the W@nderverse successfully stimulates the curiosity of general readers and supports research by literary scholars. It embodies a new approach to incorporating visualization into literary research [14].

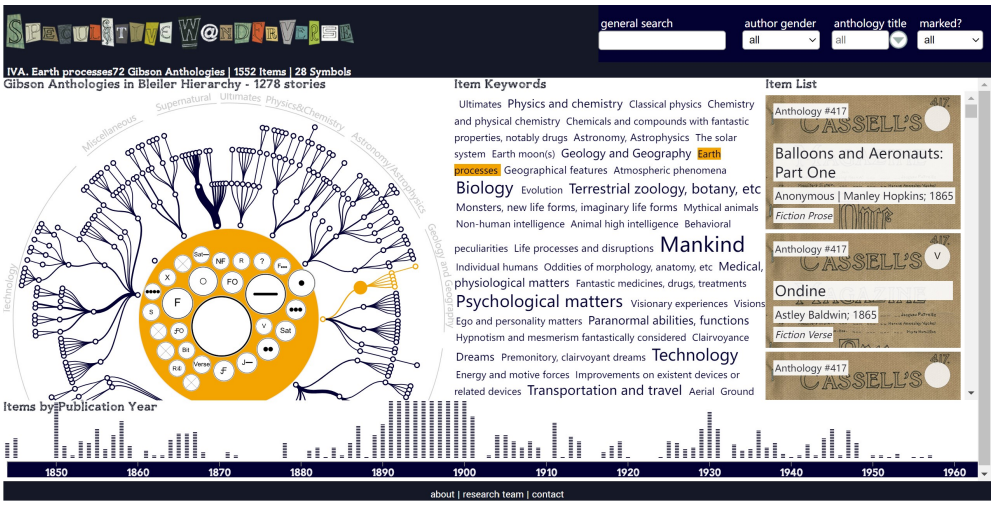


Figure 2.4: A screenshot from Speculative W@nderverse application.

In line with these two projects, my project is also a visual representation of a cultural collection. The VISAP data set is more than just a collection of artwork and papers, it contains annual themes and thematic trends. Inspired by ”Selfiexploratory”, the map functionality designed to filter by city can be adapted to the context of my project, enabling the filtering of locations by year. On the other hand, the timeline feature presented in the ”Speculative W@nderverse” could be integrated into my project to highlight changes in the number and type distribution of artworks over the decade. This can be interconnected with other visualizations. Additionally, my project could draw on the idea of hierarchical tree structure that can effectively represent the evolving themes over the past decade and the titles of yearly artworks.

2.3 Dashboard Design

As mentioned earlier, dashboard is a system that integrate key decision-making data, presenting information through charts, tables, and other visual elements [7, 9]. These designs combine techniques from multiple views to offset potential analytical limitations of a single approach [8]. Effective dashboard design is crucial for analyzing large and complex data sets [10, 21]. It has been widely used in business, public health, learning analytics, and energy, etc. [5, 12, 22, 26]. Dashboards are designed to simplify and abstract complex data points for a clearer understanding of the most critical data [2].

Building a user-friendly dashboard involves several key principles. It should not overwhelm users [39] and should avoid visual clutter [10]. The dashboard should align with existing workflows [2] and avoid displaying excessive data [19]. A careful balance between functionality and visual characteristics is critical to the success of a dashboard [39]. This is further complemented by organized diagrams, accessible interactive features, and skilled complexity management [29].

The layout pattern of a dashboard is essentially the arrangement of its widgets and information graphics have diverse layout classifications [3, 16, 40]. As shown in Figure 2.5, dashboards typically employ hierarchical grouping of data and their visual representation. This enhances the prominence of certain data types and enables efficient organization of potentially large content components [2].

The utilization of color is also an important visual variable in dashboard design. As shown in Figure 2.6, shared color schemes apply different colors to specific groups of data, improving dashboard familiarity and consistency. Alternatively, a data encoding color scheme (represented by topographic map in Figure 2.5) utilizes colors to represent categories or ranges of values in the data [2]. Essentially, a smart mix of layout, color, and functionality is critical to producing effective dashboards that simplify complex data sets for users.

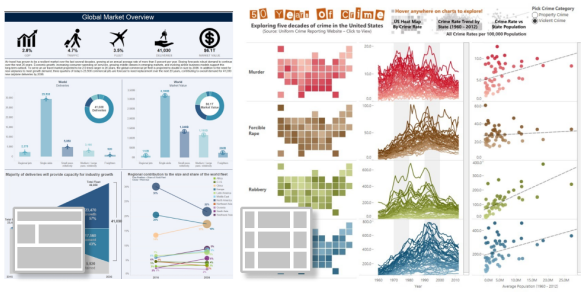


Figure 2.5: Examples of different dashboard page layouts. Source: Bach et al., 2023

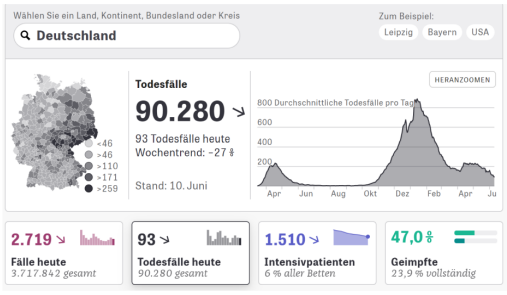


Figure 2.6: Example of shared color schemes. Source: Bach et al., 2023

Chapter 3

Exploring the VIS Arts Program

This chapter will explain the questions, ”What is VISAP?” and ”What data has been collected as part of the program?” as well as the data processing that was conducted.

3.1 Overview of the VISAP

The VIS Arts Program (VISAP[1]) is a special mini-conference within the IEEE VIS conference[2]. It provides a unique gathering place for visualization researchers, designers, and artists. At VISAP, they can display and discuss their work, which often merges data visualization, art, and design. As the largest event associated with the IEEE VIS conference, one of VISAP's main goals is to encourage new ideas, promote discussions, and support collaboration across different research fields and practical areas [17, 18].

Every year, VISAP runs around different themes that's relevant to art, design, and academic research communities. It welcomes a variety of contributions, ranging from interactive artworks to collaborations between art and science. These submissions can be part of either the paper track or the exhibition track [17, 18].

Over the past decade, each year's VISAP event has adapted various formats — online, physical, or hybrid. This flexible approach shows VISAP's commitment to remaining current in our rapidly changing world.

Accepted works will receive notable visibility, be published on the official VISAP website and in a dedicated exhibition catalogue, and will be indexed in the IEEE Xplore digital library [17]. Through this wide visibility and by promoting interaction between different disciplines, VISAP encourages innovation in data visualization.

[1]VISAP: `https://visap.net/`
[2]IEEE VIS conference: `https://ieeevis.org/`

3.2 Data Collected as Part of the VISAP

This project uses an existing structured CSV data set collected from the VISAP website, including all accepted works from the past ten years. Due to the project's needs and lack of fields such as abstract, link, and image of each work and the author field of some works, additional data was collected from VISAP using the Scrapy crawler[3].

The complete CSV data set from VISAP contains all contributions over the years, including artwork, papers, participant involved such as authors and organizers, as well as data about session specifics, themes, and thematic trends over the years, etc. However, this project only focuses on the data relevant to the current visualization.

This includes the following data:

- Information about all 197 contributions accepted by VISAP in the last decade.
- VISAP's yearly location, theme, and format (physical, online, or hybrid).
- Specific information for each contribution such as title, author, year and type (artwork, paper, pictorial).
- Additional collected data includes abstract, associated URL and image (if available) for each work, enhancing the overview and understanding of the data.

3.3 Data Processing

The purpose of data processing is to ensure the quality of the data in the CSV file and to make it suitable for further data analysis. This process is mainly performed with Python. I found inconsistency in work type representations, such as different capitalization and naming. While there are only three types of works: 'artwork', 'paper', and 'pictoral', some are labeled 'Artwork and Pictorial', 'special exhibit', or 'keynote'.

First, I unify all work types as lowercase. Then remove works of the type 'keynote', replaced 'special exhibit' with 'artwork', and classified works of the type 'Artwork and Pictorial' as both 'artwork' and 'pictorial', which means they will be counted in both types. In addition, I noticed that the 'Location' attribute includes both the full names and abbreviations of city names, so I just kept all full city names for readability.

Having explored the VIS Arts Program and the data collected from VISAP, the project moves to the heart of the project in the next chapter: the design process and prototyping, which begins the visualisation design of the collected data.

[3]Scrapy: `https://scrapy.org/`

Chapter 4

Design Process and Prototyping

My design process unfolded through these stages:

- Brainstorming: Generate multiple possible design ideas for the project.
- Sketching: Create design sketches based on a selected scheme.
- Prototyping: Construct low and high-fidelity prototypes from the drafted design.

4.1 Brainstorming

This section will introduce three different design ideas came up during the brainstorming stage, namely Scrolling Story, Multi-page Website, and Dashboard Visualization.

4.1.1 Scrolling Story

The initial idea is to present the data as a scrolling story (Figure 4.1). This is because the linear narrative method is suitable for telling the development process. This is similar to reading a book, guiding the reader through the content at the author's pace. This will highlight the evolution of VISAP in a timeline, including annual themes, key works and authors, etc. This approach has obvious advantages when presenting time series information, providing users with a fascinating view of the history of VISAP.

However, the scrolling story format lacks sufficient interactivity to allow users to easily switch and compare information. Moreover, as more content is added, users may spend a lot of time scrolling to find the information they need, which undoubtedly affects the user experience.

4.1.2 Multi-page Website

Another idea is to build a multi-page website, with each page dedicated to a part of VISAP's information (Figure 4.2). For instance, one page could showcase VISAP's annual works, another could exhibit author contributions, while another could emphasize themes and trends, and so forth. This idea allows the presentation of ample information without appearing crowded. Additionally, with the aid of menus and navigation buttons, users could quickly locate the information they are interested in. However, this design has an obvious disadvantage, that is, users cannot see all the information in the same view, but need to jump between different pages, which makes it difficult for users to obtain a comprehensive overview and see the connection between data.

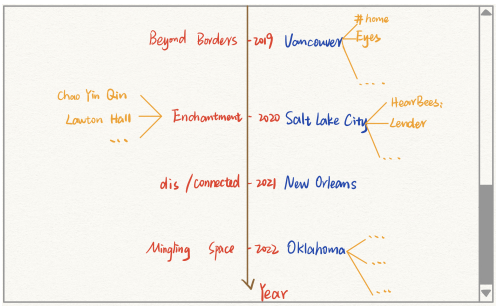


Figure 4.1: Idea 1: Scrolling Story.

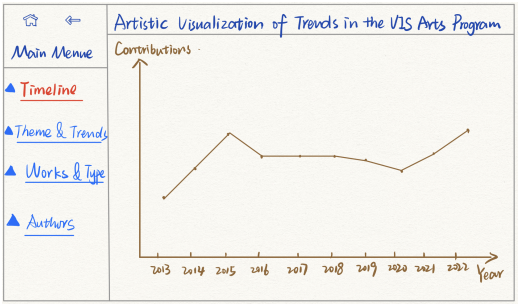


Figure 4.2: Idea 2: Multi-page Website.

4.1.3 Dashboard Visualization

The third idea considered is to present the data using a comprehensive dashboard. This approach would allow users to see all the important information in one view and allow for interactive exploration, which is the final selected design idea. The dashboard can display different types of VISAP information in one view through multiple charts, and the connection between data can be understood through interaction. However, I still need to pay attention to which data to visualize and how to do it effectively.

4.2 Visualisation Preparation

During brainstorming, quantitative data analysis was performed using Python's Pandas library. This involved examining the VISAP data set and conducting counting analysis to identify trends in time and themes, which laid the groundwork for future visualisations.

The VISAP data set includes 197 accepted works from 2013 to 2022. These works are distributed in the annual VISAP conference, with the number of works varying

from year to year, ranging from 10 to 24 of different types. Notably, 2013 has the least number of works, while 2017 and 2018 have the largest number of works. This indicates that the distribution of the number and type of works each year is an essential aspect to explore in the visualisation project.

In addition, VISAP has a unique theme every year, which is an important direction that can be visualized. At the same time, the location of the conference and the submission format are also different for each year, so depicting the distribution of locations and the changes in submission formats holds significant implications.

Digging further into the data set, it was observed that many works were collaborative efforts between multiple authors, and some authors have collaborated multiple times. This means that a network graph showing collaborative relationships between authors could also be a valuable component of the visualization project.

Furthermore, I generated a series of data closely related to visualization. For instance, I used the groupby method of the Pandas library to group the data by year and type, then used the sum method to calculate the number of works of each type per year. Similarly, I also used the groupby method to group by year to count the total number of works each year. Finally, I converted the CSV files after data analysis into an array format in JavaScript using Python, so that the data can be used directly in the subsequent visualization.

4.3 Sketching

This section will detail the two-round iterative process of the sketch design phase. In the first iteration, I adopted the design concept chosen during the brainstorming phase, which was to utilize a comprehensive dashboard for visualization. In this step, I used the Figma tool to transform the design concept into an initial digital sketch. Following this, the second iteration continued with the dashboard visualization concept, but this time I used paper sketch to improve on the first iteration.

4.3.1 Digital Sketch

The first iteration used the Figma tool to draw a dashboard containing eight basic visualizations (Figure 4.3). Each chart displays an independent part of VISAP information.

In this dashboard, the line chart shows the trend of the number of contributions to VISAP from 2013 to 2022, with tooltips to clarify the number of works each year. The

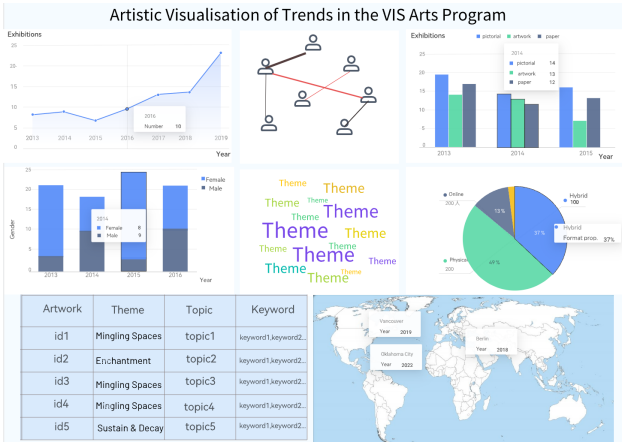


Figure 4.3: The first iteration of sketching.

grouped bar graph with tooltips displays the number of different types of work (such as artwork, paper, pictorial) each year.

The network graph shows the collaboration relationship and the number of contributions among authors, and the difference in the color of the connection line indicates the number of collaborations between authors. The stacked bar chart is used to show the change in author gender over time.

The word cloud graph displays specific themes each year, with the size of theme text determined by the number of contributions that year. Since the submission formats of works are different each year, such as physical, online, and hybrid, I chose a pie chart to visualize the proportion of submission types in the past ten years.

This design also has a table listing the themes each work belongs to and the specific topics and keywords extracted from the work through topic modeling method. Finally, there is a map to show the distribution of conference locations, and when hovering over a location on the map, a tooltip will appear to display more information related to that location, such as the number of works presented at that location.

However, there are some shortcomings in the dashboard of the first iteration. First, the eight charts each display the change of a single attribute. But I need to visualize multiple features of VISAP, and multiple attributes of VISAP may be correlated, so it would be a better choice to combine multiple attributes in the same chart. Secondly, there are too many basic visualization charts on the dashboard, such as bar chart, line chart, and pie chart, which may cause visual confusion for users, resulting in a complex and featureless dashboard. In addition, since the submission form of works in the past decade has mostly been physical, using a pie chart to present this information would make online and hybrid nearly invisible on the pie chart.

4.3.2 Paper Sketch

The second iteration (Figure 4.4) was based on the digital sketch of the first iteration and is improved by using a paper sketch. It was reduced to five charts by merging and simplifying, and new visualization elements were added. This allows users to capture more information in a dashboard with fewer but more engaging charts.

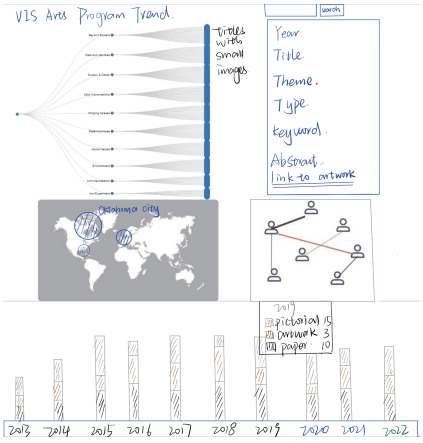


Figure 4.4: The second iteration of sketching.

The timeline at the bottom of Figure 4.4 combines the line and grouped bar chart from Figure 4.3. First of all, since the change in the number of contributions per year is not continuous but scattered, I changed the line chart to a bar chart in the timeline. At the same time, the distribution of the types of works in each year is combined on the timeline in the form of a stacked histogram, forming a stacked histogram timeline. This way, the overall trend in the number of contributions each year and the distribution of work types can be incorporated. In addition, the pie chart representing the submission types of each year in Figure 4.3 has been changed to differentiate the different submission types each year by the font color of the year on the timeline.

The presentation of the map and author network diagram is basically the same as in the first iteration. But since the map in Figure 4.3 is a very detailed political map, the map in the second iteration is designed to be simpler and uses circles to indicate locations, with the size of the circles representing the number of works presented at that location. This creates a connection between the map and the timeline.

The hierarchical tree in the upper left corner of Figure 4.4 replaces the table and word cloud in Figure 4.3 that presented the themes. The hierarchical tree presents data in the form of commonality, reflecting the combination of art and data. The first layer of the tree represents the theme of each year, and the second layer presents the titles of all the works under that theme. On the right side of the hierarchical tree is a detailed

information list of the works, including year, title, theme, type, author, actual link to the work, etc. There is a search box on the top of the list that can be used to perform precise searches on the title, theme, author, etc. of the works in the list.

4.4 Prototyping

Finally, I chose the second iteration of the sketch phase as the basis for the visualization, but I adjusted the dashboard layout of this sketch according to the actual conditions during the prototyping stage.

4.4.1 Main Dashboard

As shown in Figure 4.5, the low-fidelity prototype of the main part of the dashboard is as follows: the hierarchical tree is at the top left of the page, and the the work list is on the right of the hierarchical tree. The lower left corner of the dashboard is the timeline, and the lower right corner is the map showing the location distribution. The search box is located on the right side of the navigation bar.

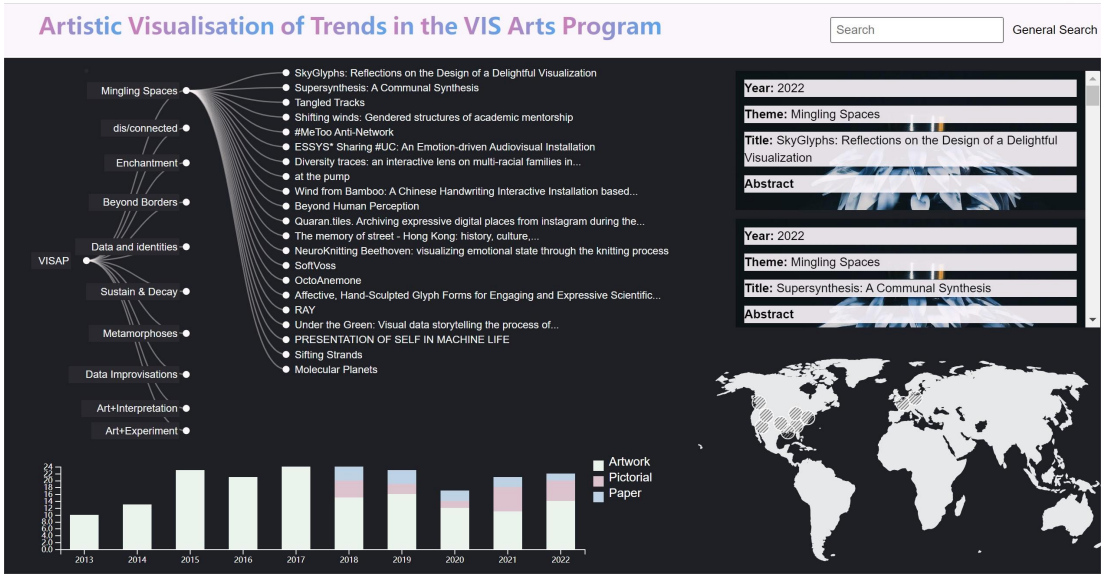


Figure 4.5: Low-Fidelity prototype of main dashboard.

However, since the background color of the dashboard is black, the colors of the navigation bar, title, and bar chart originally designed did not match. Therefore, I changed the color of the navigation bar and title to coordinate with the background color (Figure 4.6). Likewise, the color schemes of stacked bar chart and pie charts in the map tooltip were also adjusted accordingly.

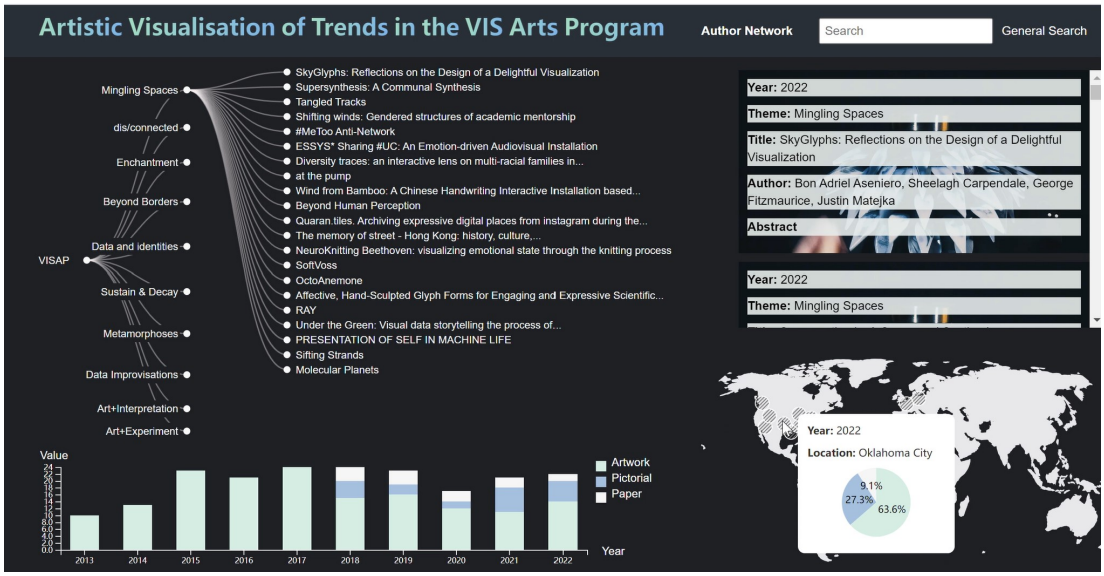
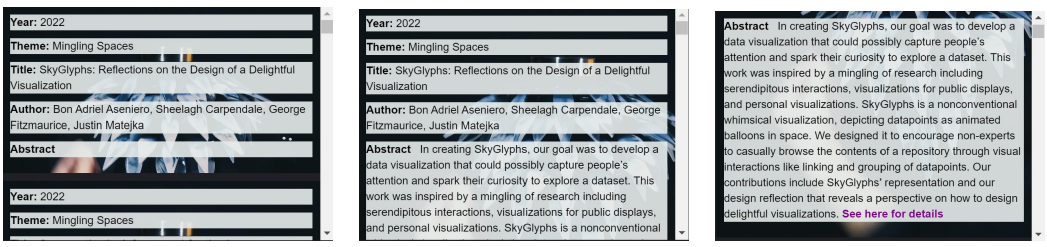


Figure 4.6: Dashboard design after changing the color scheme.

As shown in Figure 4.6, the first-level nodes of the hierarchical tree list the themes of each year, and the child nodes of each theme are all the titles under the theme. When the user hovers over different themes, the title under the theme will be displayed. This design is because if all titles under all themes are displayed simultaneously, it would occupy a large space. Because some titles are too long, in order not to cover the list of works on the right, only the first 9 words of the title are displayed, and the rest are replaced with ellipses. When hovering over a theme or title, the selected text will be highlighted to prompt the user.

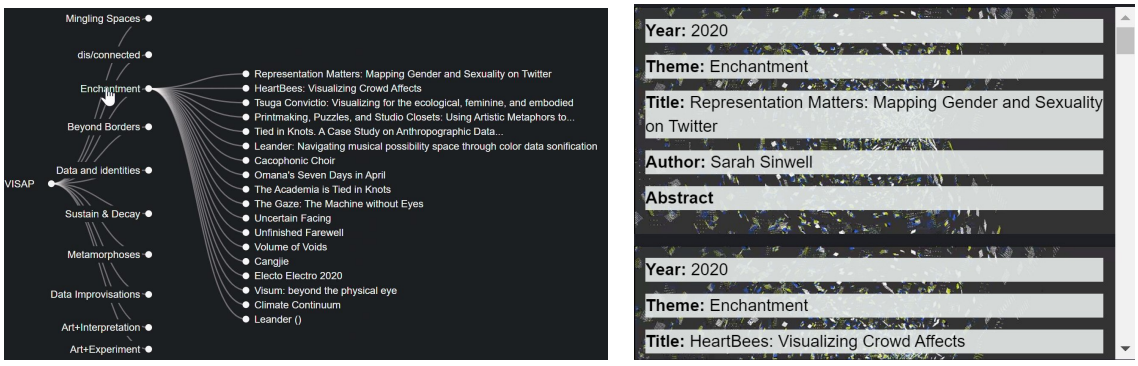
Each individual work block in the detailed work list uses the work image as the background. The text displays the Year, Title, Theme and Abstract of each work. Users can expand the Abstract by clicking on the Title or Abstract text (Figure 4.7). At the end of the expanded abstract, there is a link 'See here for details', which can be clicked to open the actual related link of the work in a new window. In addition, users can view more works information by sliding the scroll bar.



(a) Folded abstract. (b) Expanded abstract. (c) Link to the actual work.

Figure 4.7: Detailed work list.

There is a filtering relationship between the hierarchical tree and the work list. For example, when a user clicks on a theme in the hierarchical tree, the list on the right will filter out all the works under the selected theme (Figure 4.8). Similarly, clicking on a specific title in the tree will display only relevant information about that work.



(a) The theme selected in the hierarchical tree. (b) Work list after selecting the theme.

Figure 4.8: Theme filtering.

In addition, the author is quite important for each work, so the authors of the work were also added in the work list (Figure 4.9). However, I noticed that using the image in Figure 4.6 as a background blurred it, so I placed it next to the text for clarity. Moreover, I consider that users may not know that they need to click on the title or abstract to view the complete abstract, so I directly display the abstract to users, but only display the first 20 words of the abstract to save space (Figure 4.9). Only the theme and title are displayed in the hierarchical tree, and the year information does not correspond to the theme, so I added year to the theme node as shown in Figure 4.10.

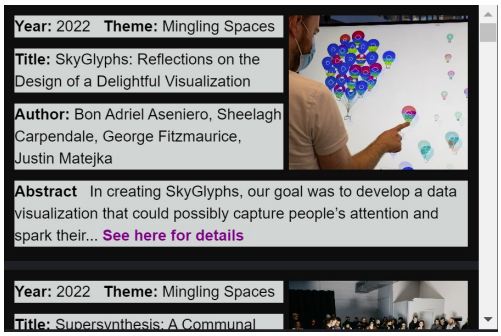


Figure 4.9: Work list after adjustment.

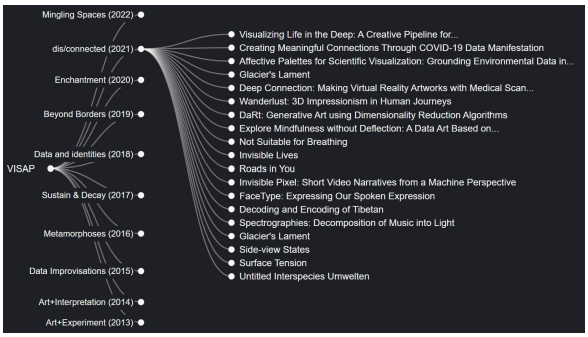


Figure 4.10: Hierarchical tree with year.

The search box above the list also has a filtering function. For example, when we enter the year '2019', the list will only display all works in 2019 (Figure 4.11). When entering a keyword such as 'track', the list will display works that contain 'track' in the title, theme or author (Figure 4.12).

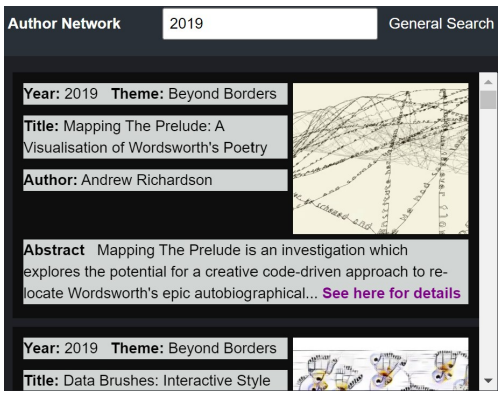


Figure 4.11: Year search.

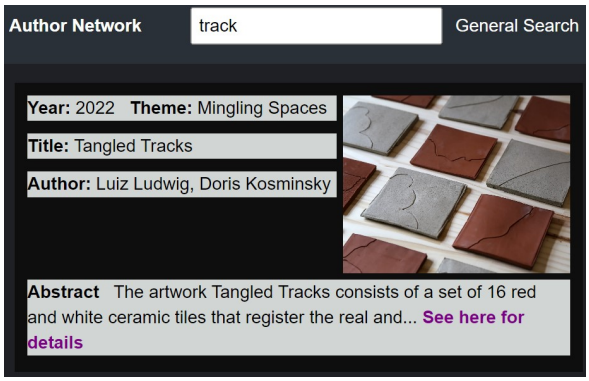


Figure 4.12: Keyword Search.

Figure 4.13 is the timeline of the stacked bar chart after changing the color scheme. In this color scheme, light green represents artwork, light blue represents pictorial, and light pink represents paper. Each year corresponds to a total number of works and the number of works of each type. When hovering over each rectangle, the tooltip displays detailed quantity information. However, it is worth noting that the scale of the y-axis is too compact, which is not easy for users to observe, and the label of the y-axis is not accurate enough. Therefore, I only showed part of the scale of the y-axis and changed the label to 'No. of contributions' to make it easier to understand (Figure 4.14). In addition, I added small icons above each bar to indicate the submission format of each year. A book represents in person, a cloud represents online, and a book plus a cloud represents hybrid. When the user hovers over an icon, the icon changes to text showing the submission format (Figure 4.14).

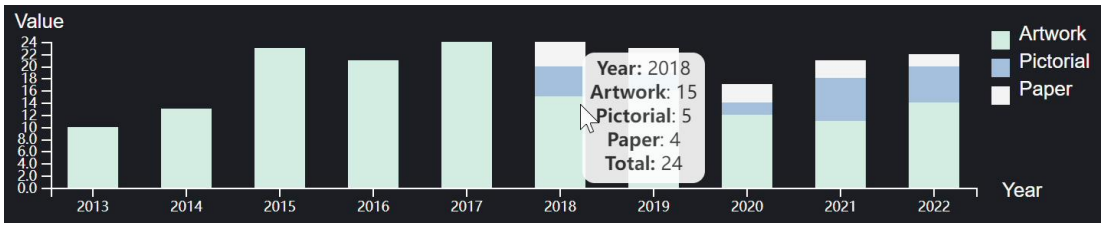


Figure 4.13: Timeline after changing color scheme.

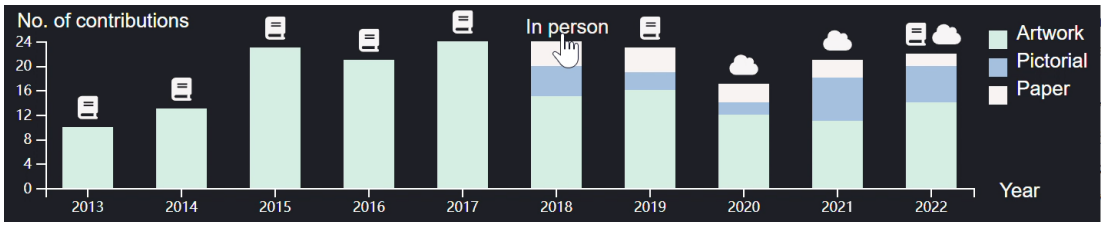


Figure 4.14: Timeline after improvements.

Initially I tried introducing a global map with ten circles representing locations over ten years (Figure 4.15). Each circle is the same size. When hovering over a circle, the tooltip will display the year of the location, the city name, and a pie chart to represent the proportion of the type of contributions that year. Its color scheme is consistent with that of the stacked bar chart and has a common legend. But all circles representing each location are the same size, which does not represent the difference in the number of contributions, so I changed to use different circle sizes to represent the difference in the amount of contributions (Figure 4.16). When hovering over a circle, the circle will be enlarged to make it easier for the user to notice the selected location. At the same time, I added the total number of contributions presented at that location to the tooltip and I changed the transparency of the tooltip so that the map where the tooltip covers was still visible (Figure 4.16). I also noticed that the hosting locations are mainly concentrated in Europe and North America. Displaying the entire map would cause circles to overlap and not be easily observed by users. Therefore, I re-centered the position of the map (Figure 4.16). This ensures that the circle is clearly visible.

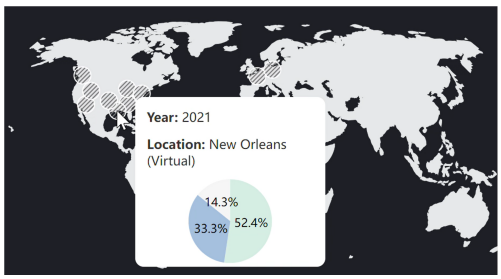


Figure 4.15: Global map.

Figure 4.16: Map adjustment.

When designing the high-fidelity main page of the dashboard (Figure 4.17), it is important to consider the links between different views. In previous designs, the hierarchical tree and the work list were connected but there was no relation with other views. Therefore, I added mutual connections between the four views. For example, when clicking on the rectangle corresponding to 2019 in the timeline, not only the rectangle will be highlighted, but also the circle corresponding to the location held in 2019 on the map will be highlighted. At the same time, the hierarchical tree will only display all titles under that theme and the work list will only display all works in 2019. Similarly, when clicking on the circle corresponding to 2019 on the map, the rectangle in the timeline will be highlighted, the hierarchical tree will only display the child nodes under the theme corresponding to the selected circle, and the work list will change accordingly. When clicking the theme node of the hierarchical tree, the other

three views will also change accordingly.

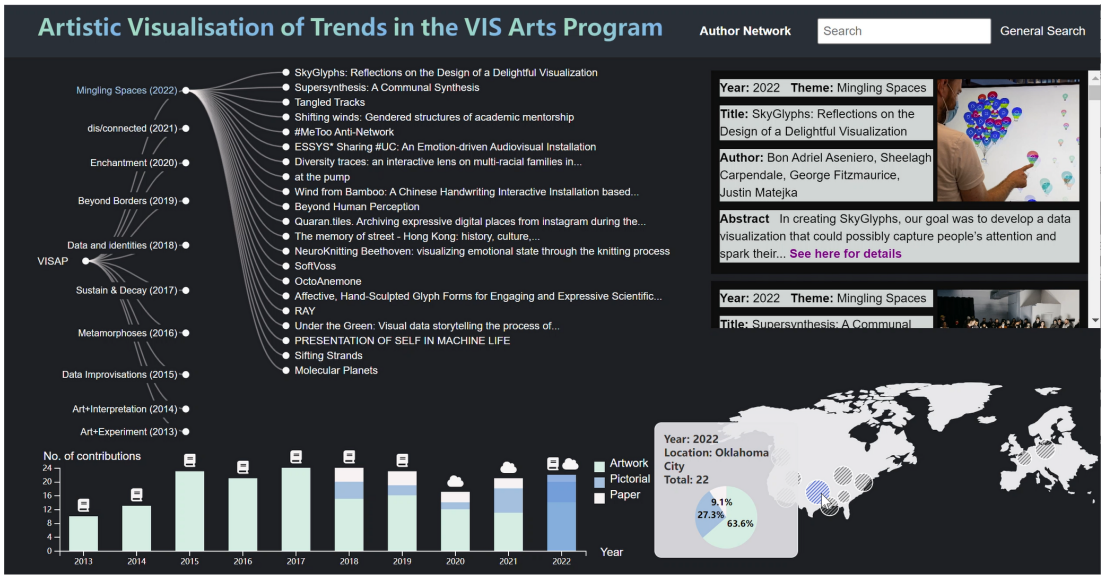


Figure 4.17: High-Fidelity prototype of main dashboard.

4.4.2 Author Network Page

In another page, I also added an author network graph (Figure 4.18) to display the contribution times and collaboration relationships of all authors who have participated in VISAP. Each circle represents an author, and the color of the circle represents the total number of contributions the author has made over the past decade, with red indicating the most collaborations. The lines between authors represent their collaborative relationships, and the depth of the line color indicates the number of collaborations between two authors. The tooltip that appears when hovering over each circle shows the detailed times of contributions and collaborations. However, using color depth to represent the degree of an author's contribution makes it difficult for users to distinguish. Therefore, I changed it to represent this using the size of the circle and the circle get bigger when hovering over it (Figure 4.19). In Figure 4.18, the line color is a categorical color scheme, which is not suitable for representing the feature of collaboration frequency. Therefore, in Figure 4.19, I changed it to a continuous color scheme and adjusted the line thickness to represent the number of collaborations. The deeper and thicker the line color, the more collaborations are indicated. When hovering over each circle, the tooltip will display the number of contributions and the number of collaborations with other authors, followed by a series of graphical representations of the types of works involved. The star represents 'Artwork', the circle represents 'Pictorial',

the triangle represents 'Paper', and star and circle together represent 'Artwork and Pictorial'. When hovering over these shapes, a highlight appears, and the actual link to the work will open in a new window if the user clicks on the shape. Since I only showed authors who collaborated with other authors in Figure 4.18, but in fact the author network should show all authors who have been involved in VISAP in the past decade, I re-added these authors who worked individually in Figure 4.19. Furthermore, I observed that from the 'Author Network' page, users could only return to the main dashboard interface using the back button, which might be inconvenient, so I added a 'Home' navigation option to the far right of the navigation bar (Figure 4.19).

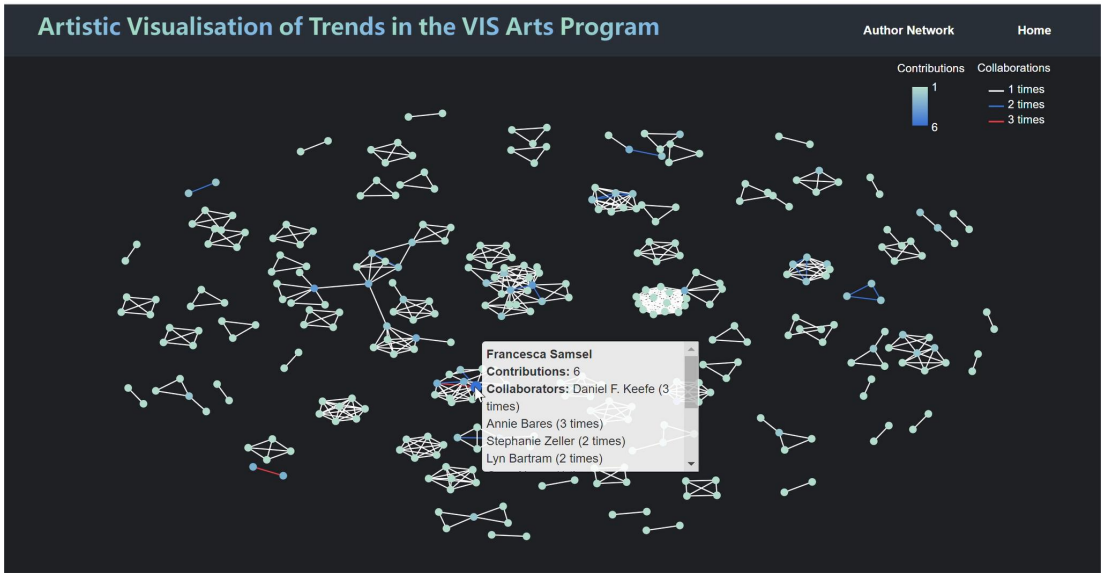


Figure 4.18: Low-Fidelity prototype of author network.

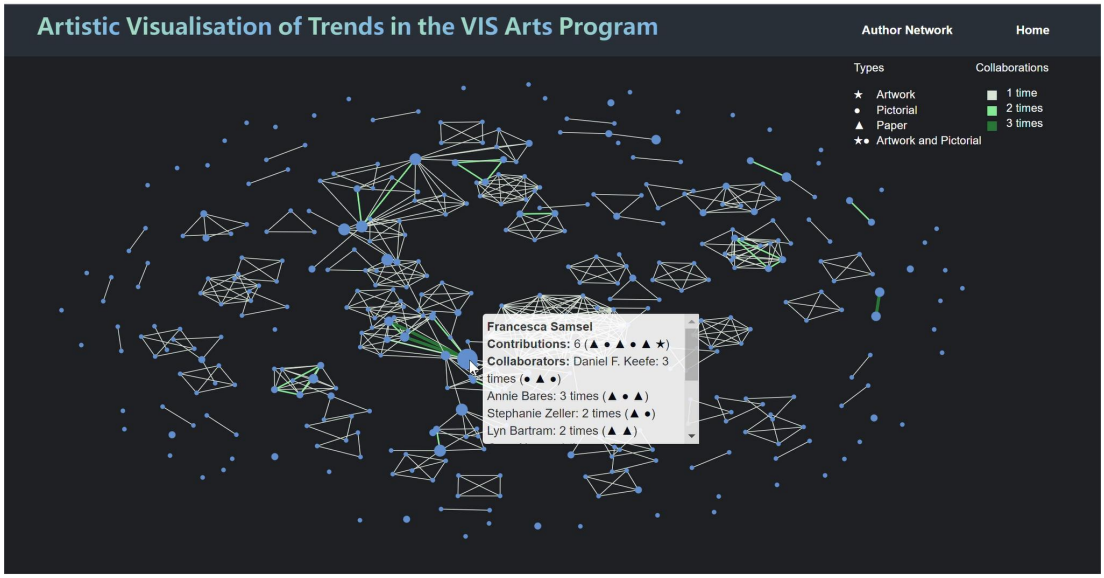


Figure 4.19: High-Fidelity prototype of author network.

Chapter 5

Implementation

After finalizing the design proposal, I started developing the website. This project provides an interactive dashboard for data visualization, showing elements such as timeline, map, hierarchical tree, scrolling list, and network diagram. This section details the technical aspects of website. Web development uses HTML, CSS and JavaScript front-end frameworks and D3.js[1] visualization library. These technologies help design and implement various complex and dynamic web content.

5.1 Hierarchical Tree

The hierarchical tree (Figure 4.17) first transforms data into a tree structure, and performs visual processing on the nodes, links and labels of the tree. The positions of nodes and labels are determined based on their depth in the tree structure, with font size and offset adjusted accordingly. Interactions like hovering or clicking change the display and color of related elements. For instance, hovering over a theme node shows only its associated nodes and links. On first load, the code simulates hovering over the second theme node, so initially only the titles under the second theme are displayed.

5.2 List of Contributions

The display of the work list and its search function (Figure 4.17) are created by traversing the JavaScript array of work data generated during the data analysis phase. An HTML element is created for each artwork, and relevant information such as the author, year, and theme are filled in. Lengthy author lists or abstracts are shortened and the actual

[1] D3: `https://d3js.org/`

link to the work is added at the end of the abstract. Secondly, the search box provides a functionality to search by title, year, theme, and author. As the user types, the list will update based on their input. On page load, the list is initialized using all the work data.

5.3 Timeline

The implementation of the stacked bar chart begins by creating SVG elements and defining a bar for each year's data, with its position and height determined by the total contributions of that year. Subsequently, the type of work and submission format information are bound to the bars, resulting in changes to their color and icons. Clicking on a bar updates the other three views and highlights it. Hovering displays more details, while clicking outside the bar will cancel the highlight. Finally, by rendering each element at the correct position, the complete stacked bar chart is drawn (Figure 4.17).

5.4 Map

The map (Figure 4.17) uses the geographic projection to convert geographic information into SVG elements for display. It first loads and parses world map data in GeoJSON format. Then project the coordinates of each city onto the map, draw a circle for each city to represent its data, and set the size of the circle based on the total number of works at each location. Finally, mouse hover and click events are added to each circle element to display corresponding tooltip information and update other charts.

5.5 Author Network

The implementation of the author network diagram (Figure 4.19) is based on the force-directed graph. Firstly, the raw author data is parsed to create nodes and links data structure representing each author and their relationships. The nodes contain the author's contribution times and collaborator information, while links represent the collaboration relationship between authors as well as the number of collaborations. After loading the nodes and links data, the simulation method is used to calculate the positions of each node and link. Meanwhile, the scale is used to map the data of contribution count to the size of nodes, and different collaboration counts and types of works are represented by different colors and shapes. Event listeners are implemented to enlarge nodes and display tooltips when the mouse hovers, as well as to interactively drag nodes.

Chapter 6

Evaluation

Following web development, I conducted a user study to gather feedback on the visualisation prototype and the website. This feedback will guide further optimization of my project. In this chapter, I outline the design of the study, the participants, the procedure, the data collection and analysis methods, and the key findings from the study.

6.1 Study Design

The main goal of the user study was to capture potential users' perceptions of the website and visualisations, particularly with regards to usability and information comprehension. I created a series of tasks (see Appendix A.4 for detailed task questions) and conducted semi-structured interviews (see Appendix A.5 for detailed interview questions) to understand users' interactions and impressions of the visualisations.

First, I observed how users interacted with the visualisations through pre-designed tasks (Appendix A.4) and then discussed their experience and insights. Through interviews, I learnt about their initial impressions of the design and layout, as well as their interaction preferences. Finally, I delved into users' challenges in understanding the information in the visualisations and collected their suggestions for improvement.

6.2 Participants

This project artistically visualises trends in VISAP over the last decade, targeting VISAP experts and a broader interested audience. I employed a variety of artistic visualisations to depict the evolution of VISAP in terms of time and themes. Therefore, the participants were chosen from these target groups.

I recruited a total of eight participants, with evenly splitting between male and female to ensure the impartiality of the study. These participants are all students, they are not very familiar with VISAP, but they all have a strong interest in its trends.

In addition, the participants had diverse academic backgrounds: five were from computer science and they had experience with data visualisation so they were able to provide professional feedback. Two participants from architecture brought insights from art and design. A chemistry student represents a broader audience and his feedback will help to better understand the needs and feelings of a non-specialist audience.

6.3 Study Procedure

1. Invite users to visit the visualization prototype (online and offline).
2. Observe and record how users interact with the prototype.
3. Provide users with some specific tasks on the visualization prototype, for example, asking them to explore how the number of contributions to the VIS Arts Program has changed over years (see Appendix A.4 for detailed task questions).
4. Observe and record how users complete these tasks through browsing and interacting with visualizations.
5. After users complete browsing and tasks, invite them to conduct a brief interview to understand their experience and feelings. The interview questions include:
   (a) Their perceptions on the prototype.
   (b) Their interactions with the visualizations.
   (c) Their understanding of the information in the visualizations.
   (d) Their suggestions for improvement.

6.4 Data Collection & Analysis

During the data collection phase, I used both online and offline methods as some participants were unable to attend the face-to-face interviews. Online participants interacted with the prototype by controlling my computer through MS Teams, while I could directly observe their interaction with the prototype.

As users interacted with the prototype and were interviewed, I carried out audio and screen recordings to capture their behaviour and feedback. I also recorded key observations using notes. All data was securely stored, anatomized and restricted to authorised researchers on the university's OneDrive.

During the data analysis phase, I revisited the screen recordings to analyse how users interacted with the prototype and how they performed tasks to reveal any difficulties they may have encountered. I then reviewed the recorded interviews, focusing on users' perceptions, their understanding of the visualised information and suggestions for improvement. I collated this feedback in order to get a clearer grasp of the user experience and requirements. Finally, I conducted an exhaustive reflection to identify common themes and patterns for improvement in future designs.

6.5 Results

The next sections explore insights gained from visualizations, feedback on functionality and usability issues, and overall design results for the visualization prototype.

6.5.1 Insights Gained from Visualizations

When asked to answer the questions in Appendix A.4, most of the participants were able to answer them, indicating that they could extract the required information from the visualisations. For example, they were able to identify annual contribution trends from the bar chart and identify contribution types based on color. However, the color used to highlight a clicked bar is the same as the pictorial color (Figure 4.17), which may lead participants to misunderstand that the types of all contributions are pictorial.

6.5.2 Interaction Functionality and Usability Issues

In general, participants interacted smoothly with the prototype without problems such as lag. Overall, they gave positive feedback on its interaction design. They felt that the design of the dashboard was clear and intuitive, making interactions between different views visible and straightforward.

From my observation, most users successfully located the contributions using the hierarchical tree. By clicking on the themes and titles, they could access related works and their detailed information. While browsing the work list, they could easily scroll to get more works. However, only a few would actively click on "See here for details"

to see the original link to the work. However, with my introduction, they were able to access this link for more information.

Participants could easily access tooltip information on bar chart, map, and author network by hovering the mouse. However, a usability issue was that participants were unaware that they could click on the bar chart or map circle to update other views. In addition, some elements did not provide the expected feedback when clicked on, such as images in the work list that did not lead to the actual link, or attempted to return to the main interface by clicking on the website title on the 'Author Network' page.

Additionally, participants could get the location of VISAP each year through the map. However, one participant noted that showing only Europe and North America could hinder understanding and divert attention from the information (Figure 4.16).

For the author network (Figure 4.19), most participants could recognized circles as authors, lines as collaborations, and circle size as the number of contributions. They were also able to recognise shapes indicating the type of contribution. However, some struggled to quickly find the number of author contributions from the tooltip.

6.5.3 Overall Design on the Visualization Prototype

Through interviews, I gathered participants' feedback on the design of the visualization prototype (see Appendix B for full suggestion list). They appreciated the design of presenting different parts of the visualization in a dashboard style, and they found that the website with a dark background was visually appealing. *"Using clear and various charts can directly convey information."* [Participant 3]. *"I think the black background and white text looked more professional and attractive."* [Participant 5].

Regarding visualisation methods, many were impressed by the design of the hierarchical tree and the author network. They found these designs to be aesthetically pleasing and responsive. Participants also appreciated the linking effect, where selecting an element updates related content in other views. Several participants said that they preferred the hierarchical tree design. *"It's very flexible, when clicked it reacts immediately and provides more details about the selected item."* [Participant 6] .

They also made some suggestions for improvement, such as using connecting lines between the timeline and the map to represent associations, instead of using pie chart in the map to show work type that have already been displayed in the timeline. Some participants also suggested adding a search box to the 'Author Network' page to help users search for a specific author and gain insight into his contributions.

Chapter 7

Discussion

I will discuss the improvements made to the design level after user feedback, the overall strengths and limitations of the project, and reflections on future work.

7.1 Design Improvements after User Research

The problems in the project need to be continuously improved through user research and future research of the project. Therefore, I will discuss the improvement strategies from two aspects of user experience and function implementation (see Appendix B for full suggestion and improvements list).

Some participants suggested adding a title before each chart to clarify its meaning, but I do not think this is necessary because I want the charts themselves to be as large as possible within the limited space. Therefore, I chose to leave out the title to make more space for the chart. In addition, some intuitive charts in the dashboard, such as stacked bar chart and map, users can easily understand their purpose and information.

In terms of user experience, the most important thing is that the presentation of some information in the dashboard can easily cause difficulties for users to understand and cause confusion, so I have made improvements from the following two points:

1. Change the highlight color after clicking on the histogram

   In the stacked bat chart, after selecting a bar, the highlight color of the bar is the same as the 'Pictorial' type represented by light blue, which may cause users to misunderstand that all contributions are of pictorial type. Therefore, as shown in the bar chart in Figure 7.1, I have changed the highlight color after clicking to light red to distinguish it from the three colors representing the type of work.

2. Replace the map with a complete world map

   Since the current map only shows Europe and North America, it may confuse users' understanding of the map. Therefore, I changed back to the previous full map version as shown in Figure 7.1, which can show people a clear and complete world map without confusing users.

The final main interface of the modified dashboard is shown in Figure 7.1.

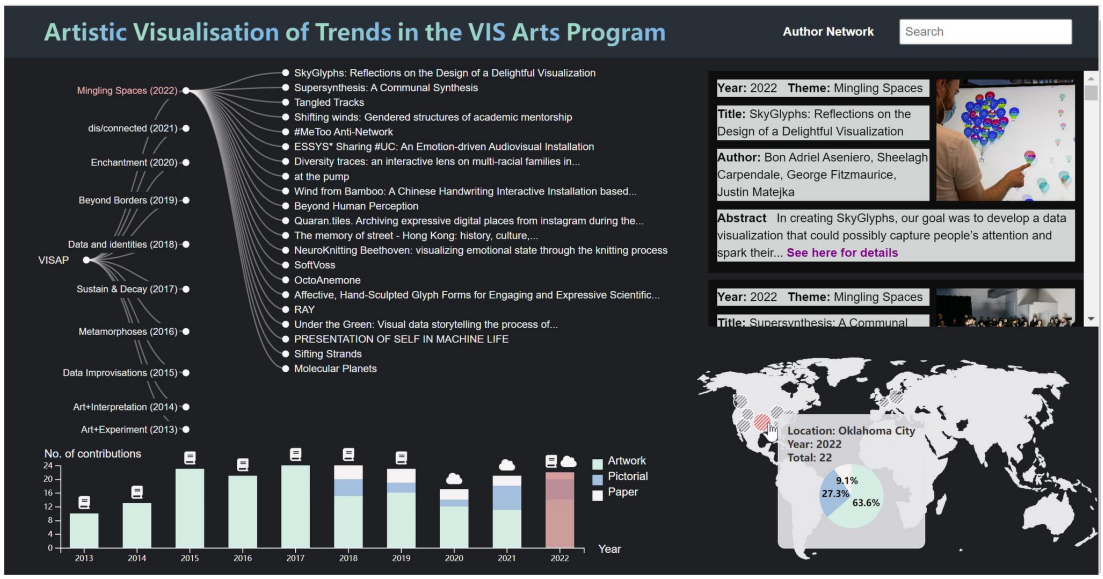


Figure 7.1: Main page of dashboard after improvement.

In addition, although the tooltip of the map shows the year and contribution type proportion of the VISAP for a specific location, which reflects the timeline. However, users may not recognise this connection. Therefore, I plan to use connecting lines in future enhancements to show the connections between them, as shown in the sketch in Figure 7.2. It will help the user to easily connect the year, location and contribution type proportion without repeating the information. However, there are some issues with this solution as the introduction of connecting lines may cause visual clutter.

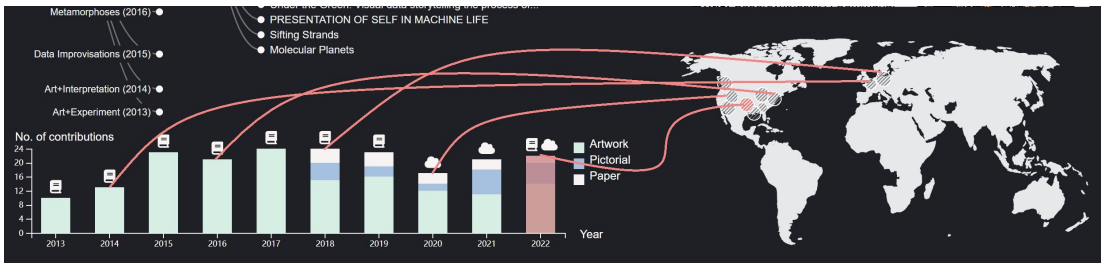


Figure 7.2: The sketch of adding connecting lines.

In terms of function implementation, when users are on the 'Author Network' page, if they want to find a specific author, they need to find the nodes in the graph one by one. Therefore, I added a search box to the 'Author Network' page so that users can directly search for specific authors. For example, as shown Figure 7.3, when the user enters 'jiabao li' (case-insensitive), the author's tooltip will pop up automatically, and the author's node will be enlarged to highlight. This improvement help users search for a specific author and learn about that author's contributions and collaborations.

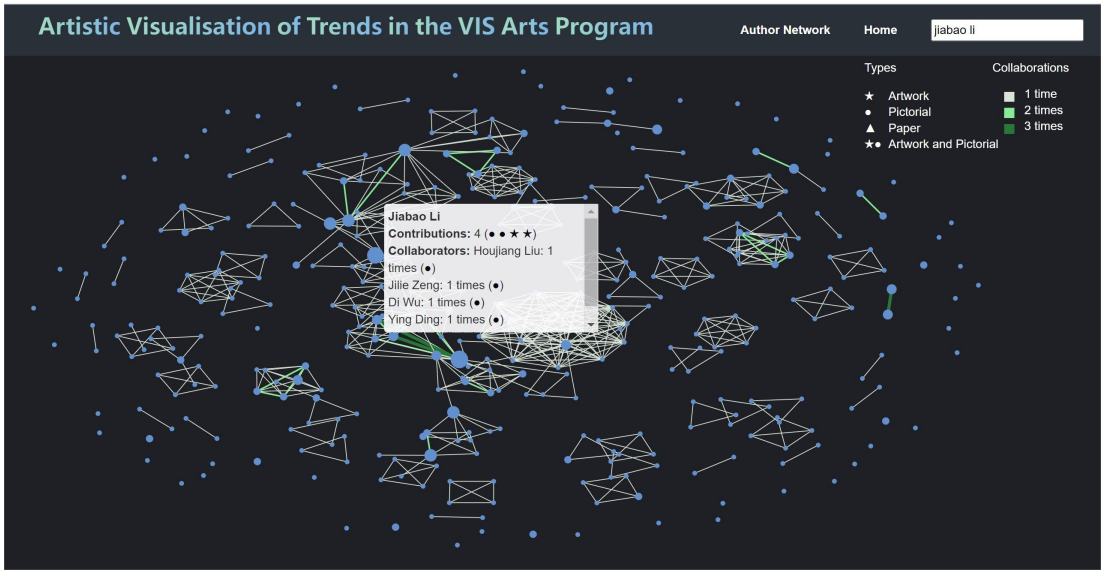


Figure 7.3: Adding a search box on the 'Author Network' page.

The demonstration video[1] an interactive online version[2] of the final prototype are available.

7.2 Overall Reflection on the Project

This project quantitatively analysed the VISAP contributions and a dashboard format was used to effectively present its findings, thus visually showing users the temporal and thematic trends of VISAP. The dashboard integrates multiple visualisation views and enhances the interaction between the views in the dashboard. It not only includes basic visualisations such as scrolling list, timeline, map, but also employs more innovative and attractive forms such as hierarchical tree and network diagram. This rich interactive functionality provides an engaging experience for the user.

[1]Video Demonstration:https://uoe-my.sharepoint.com/:v:/r/personal/s2311488_ed_ac_uk/Documents/demo_video.MP4?csf=1&web=1&e=anwa0B

[2]Interactive Prototype: http://www.utahinrichs.de/msc_projects/2023/Qiuyun/

The design of these diagrams such as hierarchical tree and network diagram emphasises the artistic aspect of data visualisation. In addition, the artistic and design-orientated contributions are demonstrated through images of each work in the contribution list. Through the artistic visualisations of VISAP trends, the project reflects the interdisciplinary nature of VISAP, showcasing works at the intersection of data visualisation, art and design.

7.3 Limitations and Open Questions

Although the project presents the trends of the VIS Arts Program over the past ten years, it may lost its direct connection to the original artwork to some extent due to the abstraction of the data. For example, artworks are mainly presented in the form of small images, which might prevent the audience from fully appreciating and understanding their implications. Additionally, the user research for this project only gathered feedback from a small subset of people, which may prevent us from fully understanding the needs and views of all target users.

For the limitation of abstract data representation, I am considering creating a special display area in the future. This will allow users to browse and magnify artworks, enabling to experience the details of artworks more directly. Additionally, users could compare the different images of artworks by sliding the image. I am also exploring alternative representation methods such as physicalization and sonification to compensate for the loss of intuitive feeling in the original artwork.

Furthermore, even though the current author network can provide users with various interactions, I am also considering that when clicking the node corresponding to the author's work, a window will pop up to display the basic information of the author's work, such as title, abstract, etc. In this way, users can have a preliminary understanding of the work before deciding whether to view the work link. Moreover, although the current visualization could present the trend of VISAP in the past ten years, I hope to implement a function that allows administrators to add data based on existing data, so that the visualization can still maintain its practicality as VISAP develops in the future.

In order to get more comprehensive user feedback, broader user research can be considered in the future, including groups that were not previously involved in the initial research.

Chapter 8

Conclusion

At the intersection of data visualization and art, the in-depth presentation of the temporal and thematic trends of the VIS Arts Program through artistic data visualization could establish a strong connection between the two fields. This project employed the VISAP data set to design a comprehensive dashboard showing temporal and thematic trends in VIS Art Program over the past decade. It helps fill gaps in previous research and may provide an intuitive tool for data scientists, researchers, and art enthusiasts to gain a better understanding of developments in this field.

This project focuses on the analysis and visualization of VISAP data set. In the data collection phase, I used web scraping techniques to refine the data set, especially supplementing abstracts, links and images of all the works. Then, data processing and quantitative analysis were carried out to lay the foundation for visualization. In the visualization part, I used a map to display the exhibition locations of VISAP over the years, a timeline to reflect changes in the number and types of contributions, and a scrolling list to display detailed information about the contributions. The hierarchical tree and the author network diagram respectively show the annual themes and collaborations between authors. More importantly, all views are interconnected, providing an interactive platform that allows users to fully explore the data and content of VISAP.

Although the VISAP data set has a wealth of data artwork and papers, there has long been a lack of a comprehensive tool to reveal the overall historical themes and their trends. However, this project has filled this gap by designing an interactive dashboard. It not only integrates a variety of innovative views, but also incorporates rich interactive functions between the views themselves and between views, allowing users to freely explore various dimensions of VISAP. This project emphasises the interdisciplinary nature of VISAP, providing a platform for researchers from different fields to explore

together and gain a deeper understanding.

However, there are still some areas for improvement in this project. For example, even though the dashboard design realizes the interactive connection between the various views, I will continue to refine the dashboard's interactivity, further strengthen the connection between the various views, and make the information flow more smoothly. Considering the limitations of abstract data representation, I plan to add specific areas that allow users to explore artwork details in greater depth such as zoomed-in images or alternative presentations such as physicalization and sonification. Additionally, based on user feedback, I could add a popup displaying a summary of each author's work in the author network. Moreover, considering that the VISAP data set will continue to be updated over time, further research can also be on how to add a real-time update function to the dashboard to ensure that the data provided is always up-to-date.

Bibliography

[1] Jussi Angesleva and Ross Cooper. Last clock. *IEEE Computer Graphics and Applications*, 25(1):20–23, 2005.

[2] Benjamin Bach, Euan Freeman, Alfie Abdul-Rahman, Cagatay Turkay, Saiful Khan, Yulei Fan, and Min Chen. Dashboard design patterns. *IEEE Transactions on Visualization and Computer Graphics*, 29(1):342–352, 2022.

[3] Benjamin Bach, Zezhong Wang, Matteo Farinella, Dave Murray-Rust, and Nathalie Henry Riche. Design patterns for data comics. In *Proceedings of the 2018 chi conference on human factors in computing systems*, pages 1–12, 2018.

[4] Michelle A Borkin, Azalea A Vo, Zoya Bylinskii, Phillip Isola, Shashank Sunkavalli, Aude Oliva, and Hanspeter Pfister. What makes a visualization memorable? *IEEE transactions on visualization and computer graphics*, 19(12):2306–2315, 2013.

[5] Sven Charleer, Joris Klerkx, Erik Duval, Tinne De Laet, and Katrien Verbert. Creating effective learning analytics dashboards: Lessons learnt. In *Adaptive and Adaptable Learning: 11th European Conference on Technology Enhanced Learning, EC-TEL 2016, Lyon, France, September 13-16, 2016, Proceedings 11*, pages 42–56. Springer, 2016.

[6] Tom Corby. Landscapes of feeling, arenas of action: Information visualization as art practice. *Leonardo*, 41(5):460–467, 2008.

[7] WHO Covid. Dashboard. *Geneva: World Health Organization*, 2020, 2020.

[8] Marian Dörk, Christopher Pietsch, and Gabriel Credico. One view is not enough: High-level visualizations of a large cultural collection. *Information Design Journal*, 23(1):39–47, 2017.

[9] Stephen Few. Information dashboard design. *S. Few*, 2003.

[10] Stephen Few. *Information dashboard design: The effective visual communication of data*. O'Reilly Media, Inc., 2006.

[11] Stefania Forlini, Uta Hinrichs, and Bridget Moynihan. The stuff of science fiction: an experiment in literary history. *Digital Humanities Quarterly (DHQ)*, 2016.

[12] Sarah Goodwin, Yasmina Dkhissi, Qiuhong Wu, Brendan Moyle, Karen Freidin, and Ariel Liebman. Informed dashboard designs for microgrid electricity market operators. In *Proceedings of the Twelfth ACM International Conference on Future Energy Systems*, pages 406–411, 2021.

[13] Uta Hinrichs and Stefania Forlini. In defence of sandcastles: research thinking through visualization in dh. *Digital Humanities 2017*, 2017.

[14] Uta Hinrichs, Stefania Forlini, and Bridget Moynihan. Speculative practices: Utilizing infovis to explore untapped literary collections. *IEEE transactions on visualization and computer graphics*, 22(1):429–438, 2015.

[15] Cat Hope and John Charles Ryan. *Digital arts: An introduction to new media*. Bloomsbury Publishing USA, 2014.

[16] Jessica Hullman and Benjamin Bach. Picturing science: Design patterns in graphical abstracts. In *Diagrammatic Representation and Inference: 10th International Conference, Diagrams 2018, Edinburgh, UK, June 18-22, 2018, Proceedings 10*, pages 183–200. Springer, 2018.

[17] IEEE VIS Arts Program. VIS Arts Program 2020. `https://visap.net/2020/`. Accessed: 2023-07-16.

[18] IEEE VIS Arts Program. VIS Arts Program 2022. `https://visap.net/2022/`. Accessed: 2023-07-15.

[19] Andrea Janes, Alberto Sillitti, and Giancarlo Succi. Effective dashboard design. *Cutter IT Journal*, 26(1):17–24, 2013.

[20] Daniel A Keim, Florian Mansmann, Jörn Schneidewind, and Hartmut Ziegler. Challenges in visual data analysis. In *Tenth International Conference on Information Visualisation (IV'06)*, pages 9–16. IEEE, 2006.

[21] Rob Kitchin, Tracey P Lauriault, and Gavin McArdle. Knowing and governing cities through urban indicators, city benchmarking and real-time dashboards. *Regional Studies, Regional Science*, 2(1):6–28, 2015.

[22] Bettina Lechner and Ann Fruhling. Towards public health dashboard design guidelines. In *HCI in Business: First International Conference, HCIB 2014, Held as Part of HCI International 2014, Heraklion, Crete, Greece, June 22-27, 2014. Proceedings 1*, pages 49–59. Springer, 2014.

[23] Qi Li. Data visualization as creative art practice. *Visual Communication*, 17(3):299–312, 2018.

[24] Lev Manovich. What is visualization? *paj: The Journal of the Initiative for Digital Humanities, Media, and Culture*, 2(1), 2010.

[25] Lev Manovich. Exploring urban social media: Selfiecity and on broadway. *Code and the City. London: Routledge*, pages 26–290, 2015.

[26] Wasinee Noonpakdee, Thitiporn Khunkornsiri, Acharaphun Phothichai, and Kriangsak Danaisawat. A framework for analyzing and developing dashboard templates for small and medium enterprises. In *2018 5th International Conference on Industrial Engineering and Applications (ICIEA)*, pages 479–483. IEEE, 2018.

[27] OFFC. Selfiexploratory. `https://selfiecity.net/selfiexploratory/`. Accessed: 2023-07-01.

[28] Helen C Purchase, Natalia Andrienko, Thomas J Jankun-Kelly, and Matthew Ward. Theoretical foundations of information visualization. *Information visualization: Human-centered issues and perspectives*, pages 46–64, 2008.

[29] Alper Sarikaya, Michael Correll, Lyn Bartram, Melanie Tory, and Danyel Fisher. What do we talk about when we talk about dashboards? *IEEE transactions on visualization and computer graphics*, 25(1):682–692, 2018.

[30] The Stuff of Science Fiction. Speculative W@nderverse. `http://stuffofsciencefiction.ca/vis/Wonderverse/`. Accessed: 2023-07-01.

[31] Alise Tifentale and Lev Manovich. Selfiecity: Exploring photography and self-fashioning in social media. In *Postdigital aesthetics: Art, computation and design*, pages 109–122. Springer, 2015.

[32] Antony Unwin. Why is data visualization important? what is important in data visualization? *Harvard Data Science Review*, 2(1):1, 2020.

[33] Richard J Urban, Michael B Twidale, and Piotr Adamczyk. Designing and developing a collections dashboard. In *Museums and the Web*, 2010.

[34] Jarke J Van Wijk. The value of visualization. In *VIS 05. IEEE Visualization, 2005.*, pages 79–86. IEEE, 2005.

[35] Fernanda B Viégas and Martin Wattenberg. Artistic data visualization: Beyond visual analytics. In *Online Communities and Social Computing: Second International Conference, OCSC 2007, Held as Part of HCI International 2007, Beijing, China, July 22-27, 2007. Proceedings 2*, pages 182–191. Springer, 2007.

[36] Mitchell Whitelaw et al. Generous interfaces for digital cultural collections. *Digital Humanities Quarterly*, 9(1), 2015.

[37] Florian Windhager, Paolo Federico, Günther Schreder, Katrin Glinka, Marian Dörk, Silvia Miksch, and Eva Mayr. Visualization of cultural heritage collection data: State of the art and future challenges. *IEEE transactions on visualization and computer graphics*, 25(6):2311–2330, 2018.

[38] Weijia Xu, Maria Esteva, Suyog D Jain, and Varun Jain. Interactive visualization for curatorial analysis of large digital collection. *Information Visualization*, 13(2):159–183, 2014.

[39] Ogan M Yigitbasioglu and Oana Velcu. A review of dashboards in performance management: Implications for design and research. *International Journal of Accounting Information Systems*, 13(1):41–59, 2012.

[40] Rebecca Zheng, Marina Fernández Camporro, Hugo Romat, Nathalie Henry Riche, Benjamin Bach, Fanny Chevalier, Ken Hinckley, and Nicolai Marquardt. Sketchnote components, design space dimensions, and strategies for effective visual note taking. In *Proceedings of the 2021 CHI Conference on Human Factors in Computing Systems*, pages 1–15, 2021.

Appendix A

Study Material

A.1 Ethics Approval

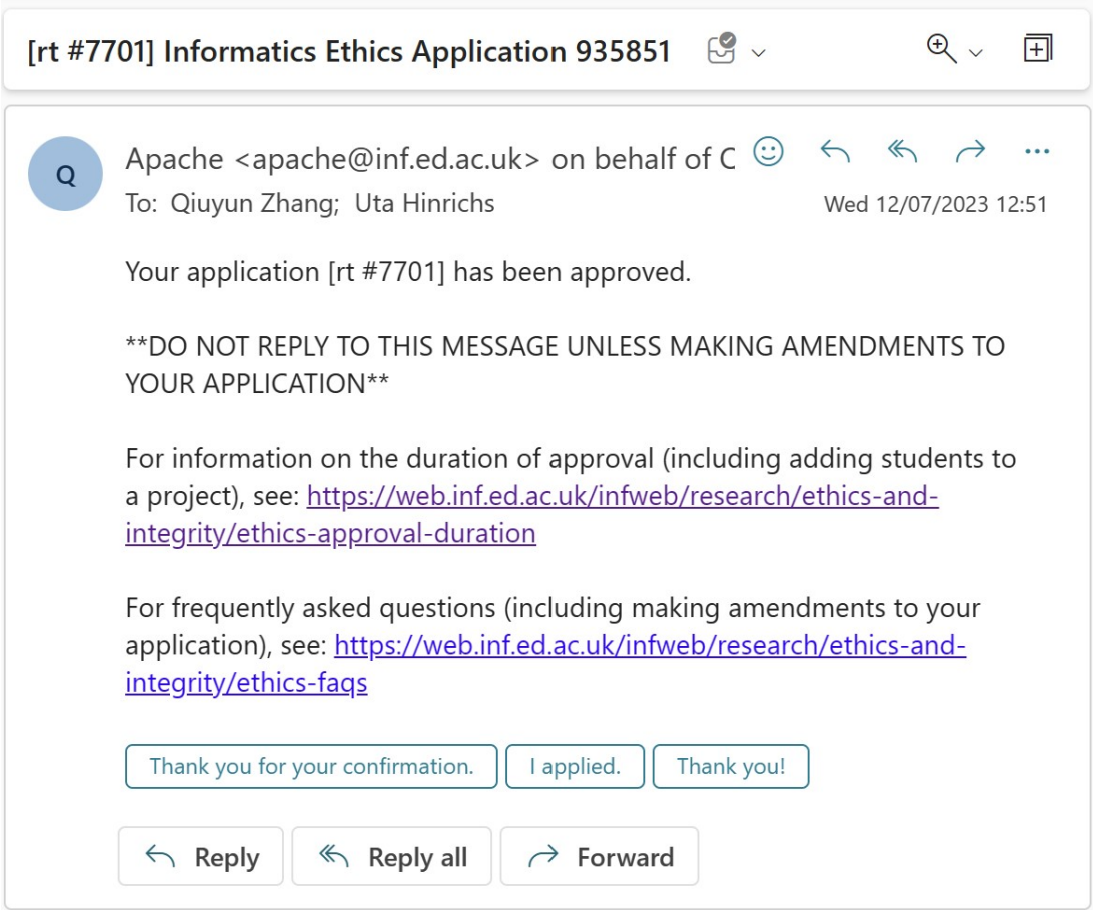


Figure A.1: Ethics Approval Email.

A.2 Participants' information sheet

Participant Information Sheet

Project title:	Artistic Visualisation of Trends in the VIS Arts Program
Principal investigator:	Dr. Uta Hinrichs
Researcher collecting data:	Dr. Uta Hinrichs and Qiuyun Zhang

This study was certified according to the Informatics Research Ethics Process, reference number 935851. Please take time to read the following information carefully. You should keep this page for your records.

Who are the researchers?

The researchers involved in this study include myself, Qiuyun Zhang (MSc student in Design Informatics), and my supervisor Dr. Uta Hinrichs (School of Informatics). Both of us will have access to the data collected during this study. We will be responsible for ensuring the confidentiality and proper handling of data in accordance with ethical guidelines and regulatory requirements.

What is the purpose of the study?

The purpose of the study is to evaluate the effectiveness of visualizations developed to represent contributions to the VIS Arts Program (VISAP). The VIS Arts Program is a mini-conference and exhibition where visualisation researchers, designers, and artists come together to showcase and discuss works at the intersection of data visualisation, art and design(https://visap.net/2022/). As part of my MSc project, I have developed a number of visualizations, that aim at conveying trends and insights of this unique event over the past decade. This study aims to collect feedback on these visualizations from specialist domain experts and individuals less familiar with VISAP. For example, we are interested in comments about the clarity of the visualization and their visual aesthetics. Feedback gathered will be used to further refine the visualizations, ensuring they effectively communicate trends and insights from the VISAP project. This study will help to advance understanding and awareness of the interdisciplinary nature of VISAP and the contributions of the art and design orientations presented at the conference.

Why have I been asked to take part?

You have been invited to participate in this research because of your interest in data visualization and arts. You may have contributed to the VIS Arts Program (VISAP) yourself in the past. As a participant, your perspective and feedback are critical to evaluating the effectiveness of the visualizations developed as part of this MSc project. We would like to gather your thoughts and comments on these visualizations in order to further improve them and ensure that they accurately convey the trends and insights of the VISAP project. Your participation will help increase awareness and understanding of VISAP, while also contributing to further developments in the fields of art, design, and data visualization.

Do I have to take part?

No – participation in this study is entirely up to you. You can withdraw from the study at any time, up until August 11th without giving a reason. After this point, personal data will be deleted and anonymised data will be combined such that it is impossible to remove individual information from the analysis. Your rights will not be affected. If you wish to withdraw, contact the PI. We will keep copies of your original consent, and of your withdrawal request.

What will happen if I decide to take part?

If you decide to take part in this study, you will be asked to participate in a semi-structured interview during which we will ask you a series of questions about your experience with a number of provided data visualizations. All questions will focus on the design of the visualizations. No person questions will be asked. The interview is expected to last approximately 30 minutes and may extend to an hour depending on the amount of details you provide.

Interviews will be conducted using a standard online video conferencing tool (i.e., MS Teams) for data collection. We will record your verbal statements in the form of audio and conduct a screen capture to record your interactions with the visualizations. Recorded audio and video will be kept strictly confidential and used for research purposes only. Your comments and feedback on the visualizations will help us evaluate and improve these to better communicate trends and insights about

the VISAP. All audio data will be transcribed and video data that contains identifying information will be blurred prior to any publication.

Are there any risks associated with taking part?

There are no significant risks associated with participating in this research.

Are there any benefits associated with taking part?

There is no direct financial compensation or benefit for participating in this study. However, by participating, you will have the opportunity to gain insight into trends and developments in the VIS Arts Program and expand your knowledge and insights in the fields of art, design and data visualization. Your participation is very important for us to improve and further develop the VISA. Your views will help us optimize our visualizations and refine our research directions, thereby affecting the future development of the project.

What will happen to the results of this study?

The results of this study may be summarised in published articles, reports and presentations. Quotes or key findings will be anonymized: We will remove any information that could, in our assessment, allow anyone to identify you. With your consent, information can also be used for future research. Your data may be archived for a maximum of 4 years. All potentially identifiable data will be deleted within this timeframe if it has not already been deleted as part of anonymization.

Data protection and confidentiality.

Your data will be processed in accordance with Data Protection Law. All information collected about you will be kept strictly confidential. Your data will be referred to by a unique participant number rather than by name [amend as appropriate]. Your data will only be viewed by the researcher/research team Dr. Uta Hinrichs and Qiuyun Zhang.

All electronic data will be stored on a password-protected encrypted computer, on the School of Informatics' secure file servers, or on the University's secure encrypted cloud storage services (DataShare, ownCloud, or Sharepoint) and all paper records will be stored in a locked filing cabinet in the PI's office. Your consent information will be kept separately from your responses in order to minimise risk.

What are my data protection rights?

The University of Edinburgh is a Data Controller for the information you provide. You have the right to access information held about you. Your right of access can be exercised in accordance Data Protection Law. You also have other rights including rights of correction, erasure and objection. For more details, including the right to lodge a complaint with the Information Commissioner's Office, please visit www.ico.org.uk. Questions, comments and requests about your personal data can also be sent to the University Data Protection Officer at dpo@ed.ac.uk.

Who can I contact?

If you have any further questions about the study, please contact the lead researcher, Qiuyun Zhang, s2311488@ed.ac.uk.

If you wish to make a complaint about the study, please contact inf-ethics@inf.ed.ac.uk. When you contact us, please provide the study title and detail the nature of your complaint.

Updated information.

If the research project changes in any way, an updated Participant Information Sheet will be made available on http://web.inf.ed.ac.uk/infweb/research/study-updates.

Alternative formats.

To request this document in an alternative format, such as large print or on coloured paper, please contact Qiuyun Zhang, s2311488@ed.ac.uk.

General information.

For general information about how we use your data, go to: edin.ac/privacy-research

A.3 Participants' consent form

Participant number:_____

Participant Consent Form

Project title:	Artistic Visualisation of Trends in the VIS Arts Program
Principal investigator (PI):	Dr. Uta Hinrichs
Researcher:	Dr. Uta Hinrichs and Qiuyun Zhang
PI contact details:	uhinrich@ed.ac.uk

By participating in the study you agree that:

- I have read and understood the Participant Information Sheet for the above study, that I have had the opportunity to ask questions, and that any questions I had were answered to my satisfaction.
- My participation is voluntary, and that I can withdraw at any time without giving a reason. Withdrawing will not affect any of my rights.
- I consent to my anonymised data being used in academic publications and presentations.
- I understand that my anonymised data will be stored for the duration outlined in the Participant Information Sheet.

Please tick yes or no for each of these statements.

1.	I allow my data to be used in future ethically approved research.	**Yes** ☐	**No** ☐
2.	I agree to take part in this study.	**Yes** ☐	**No** ☐
3.	I agree to being audio recorded as part of this study.	**Yes** ☐	**No** ☐
4.	I agree to being video recorded as part of this study.	**Yes** ☐	**No** ☐

Name of person giving consent	Date	Signature
	30/07/2023	

Name of person taking consent	Date	Signature
Qiuyun Zhang	30/07/2023	

A.4 Task Questions

1. How has the number of contributions to the VIS Arts Program developed over the years?
2. How have the types of contributions (artworks, pictorials, papers) changed over the years?
3. Browsing through the different contributions to the VIS Arts Program, try to find 3 contributions that you find interesting.
4. Find a person that has contributed multiple works to the VIS Arts Program.

A.5 Interview Questions

1. What insights were you able to gain from this visualization about the VIS Arts Program?
2. What are your initial impressions of the visual design and layout of the prototype?
3. Is there anything that you particularly liked about interacting with the visualizations?
    a. [follow-up questions, if this does not come up already] Were you able to easily understand and interpret the information presented in the visualization? Were there any elements that were confusing or unclear?
4. Is there anything that you found difficult to do or difficult to understand?
    a. [follow-up questions, if this does not come up already] Were you able to easily understand and interpret the information presented in the visualization? Were there any elements that were confusing or unclear?
5. Do you have any suggestions for improving the user experience?
6. Do you have any design suggestions for conveying trends and insights about the VIS Arts Program in a more engaging way?

Appendix B

Suggestions and Improvements List

No.	Usability Issue/Suggestion	Improvement
1	Users do not understand that bars in histogram and circles in map are clickable.	Make the cursor turn into a pointer when hovering over a bar or circle. Also, highlight the bar when the mouse hovers over it.
2	Change the highlight color of the bars in the bar chart.	Change the highlight color of the bars to a light red, to distinguish it from the colors indicating types.
3	Display the entire world map.	Revert to the earlier version of the map that displayed the entire world.
4	Users mistakenly think that they need to click on 'General Search' to search.	Remove 'General Search' and only keep the search box.
5	Click website title to return to the dashboard main page.	Add the website title to the index.html link so that clicking the title can return to the home page.
6	Add a title before each chart.	Maintain the current version without any changes.
7	Move the 'Location' information in the map's tooltip to before 'Year'.	Swap the order of 'Location' and 'Year'.

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Table B.1 – *Continued from previous page*

No.	**Usability Issue / Suggestion**	**Improvement**
8	Add a feature for searching authors on the 'Author Network' page	Add a search box on the 'Author Network' page, where the tooltip for the searched author will automatically appear.
9	Clicking on the title and picture of the work in the work list can also jump to the real link of the work.	Add links to both the title and image of each work.
10	Clicking on the image of the artwork can magnify the image.	Future work: Add a feature to zoom in on an image by clicking on it to see the details of the artwork, or to compare images of different artworks by sliding them around.

Table B.1: Full list of suggestions and improvements.