Cartography M.Sc.

Evaluating techniques and design gaps between static and animated flow maps

Zhiheng Jiao

Outline

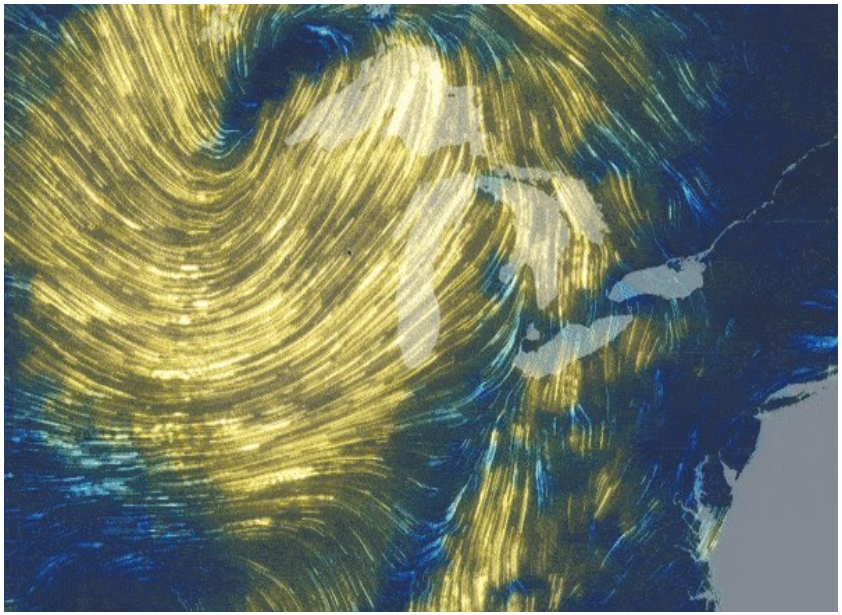
- Introduction and Motivation
- Methodology
- Results
- Discussion
- Conclusion

Introduction and Motivation

Background

- Animated visualizations might improve the efficiency or quality of readers' understanding of changing spatial patterns (Tversky et al., 2002 & Griffin et al., 2006).

- There are not too many studies available on animated maps, and there is a research gap worth exploring.

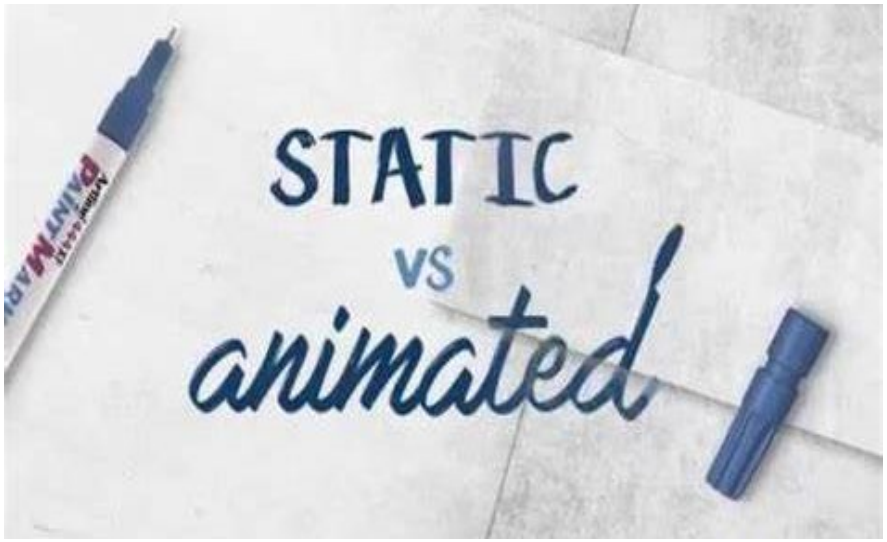


Introduction and Motivation

Motivation

- Static map design rules may not be perfectly applied to animated flow maps

- Explore design gap between animated and static flow maps based on static and dynamic visual variables



Introduction and Motivation

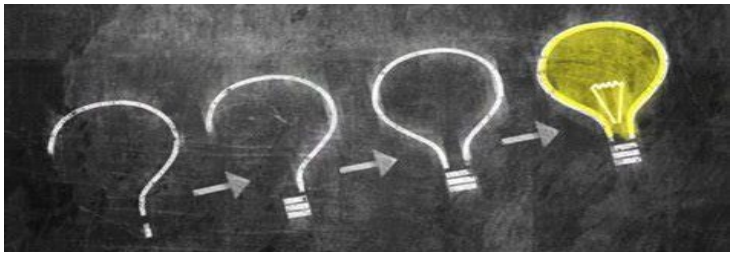
Research Objectives

- General research objective (RO) is to evaluate techniques for creating animated flow maps and explore differences in design principles between animated and static flow maps.
- Four research questions (RQs) based on techniques, design guidelines and visual variables will be answered.

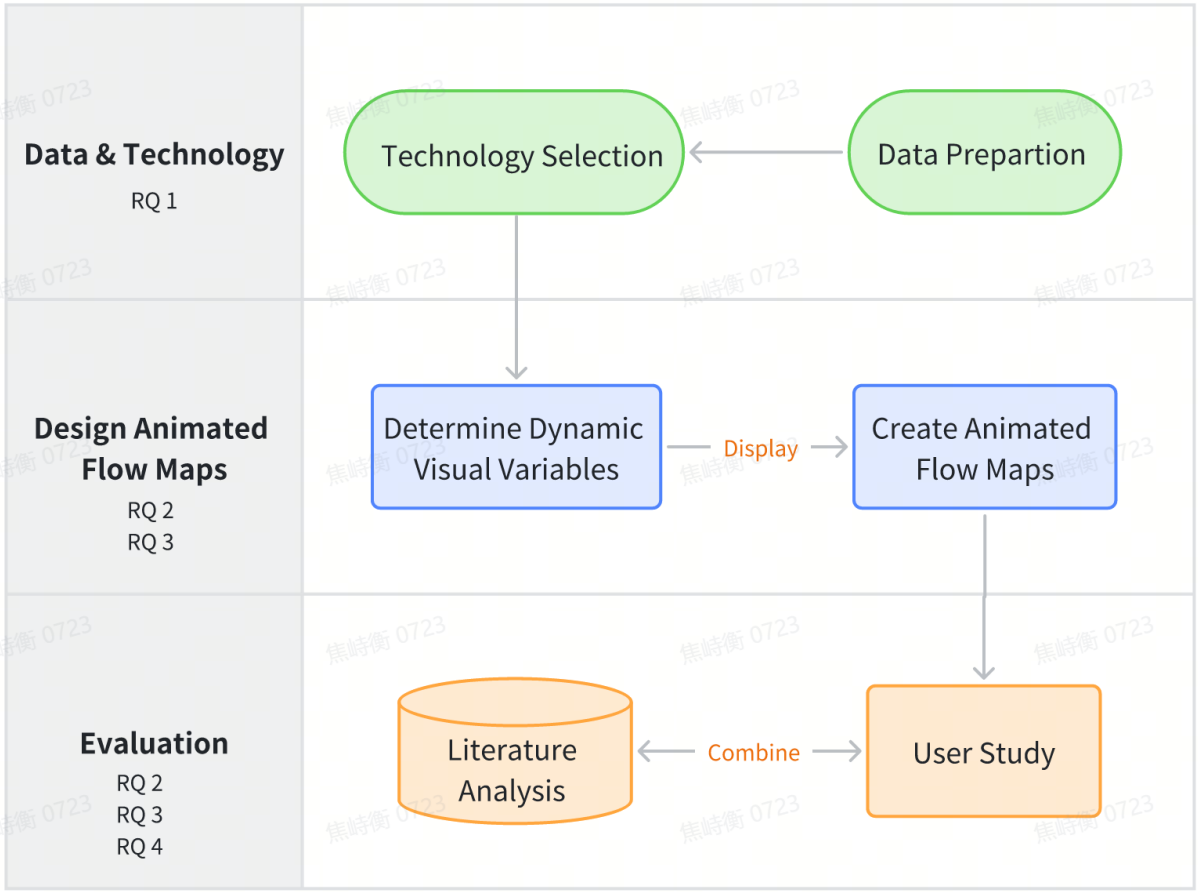
Introduction and Motivation

Research Questions

- RQ-1. Which techniques can be used for making online animated flow maps and how they can be used?
- RQ-2. Which design rules from static flow maps may not be suitable for animated flow maps?
- RQ-3. Which design guidelines from static flow maps can be adapted, and what new design suggestions can be incorporated to create animated flow maps?
- RQ-4. Which variables are the most efficient for showing the volume of flows on animated flow maps?



Methodology



Methodology

Data & Technology – RQ1

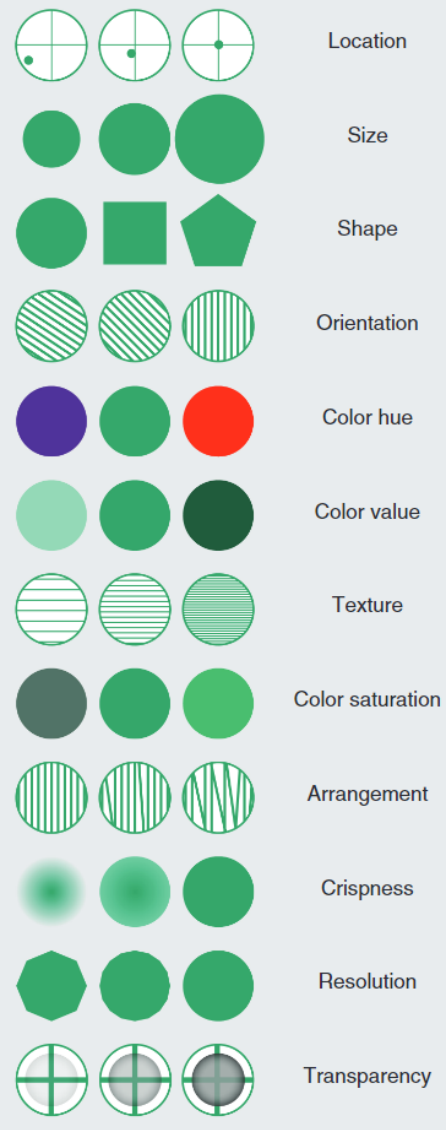
- Data:
  1)Flights data from the General Administration of Civil Aviation of China (CAAC).
  2) Exports data was obtained from the Trading Economics website
- Type: Animated Origin-Destination Flow Maps.
- Code: Echarts.js

```
JSON
var data = {
  cities: [
    {
      name: "A",
      value: [116.27030, 41.03916],
    },
    {
      name: "B",
      value: [121.473701, 31.310416],
    },
  ],
  moveLines: [
    {
      fromName: 'A',
      toName: 'B',
      coords: [
        [116.27030, 41.03916],
        [121.473701, 31.310416],
      ],
    },
    {
      fromName: 'B',
      toName: 'C',
      coords: [
        [121.473701, 31.310416],
        [90.76628, 41.6502],
      ],
```

Methodology

Define Visual Variables – RQ2-3

- Bertin's (1967), along with the contributions of Morrison and MacEachren (1977 & 1995) defined 12 static visual variables.
- Both flight and export data possess quantitative attributes.
- 'Size' has been the most frequently used static visual variable for representing quantitative information and has also been identified as 'good' by most researchers.



(Roth, 2017)

Methodology

Define Visual Variables – RQ2-3

- DiBiase et al., (1992) and MacEachren (1995) summarized six dynamic visual variables:
  1. Moment (moment of display)
  2. Duration
  3. Frequency (rate of occurrence)
  4. Order
  5. Rate of change
  6. Synchronization (phase correspondence)

- Köbben & Yaman (1995) examined 'Rate of Change' and 'Duration' that are relatively effective in displaying quantitative information

	perceptual property			
dynamic visual variable	association	order	quantity	selection
moment	○			
duration		●	✪	
frequency	✪	✪		○
order	✪	✪		○
rate of change		●	○	
synchronisation	*not tested*			

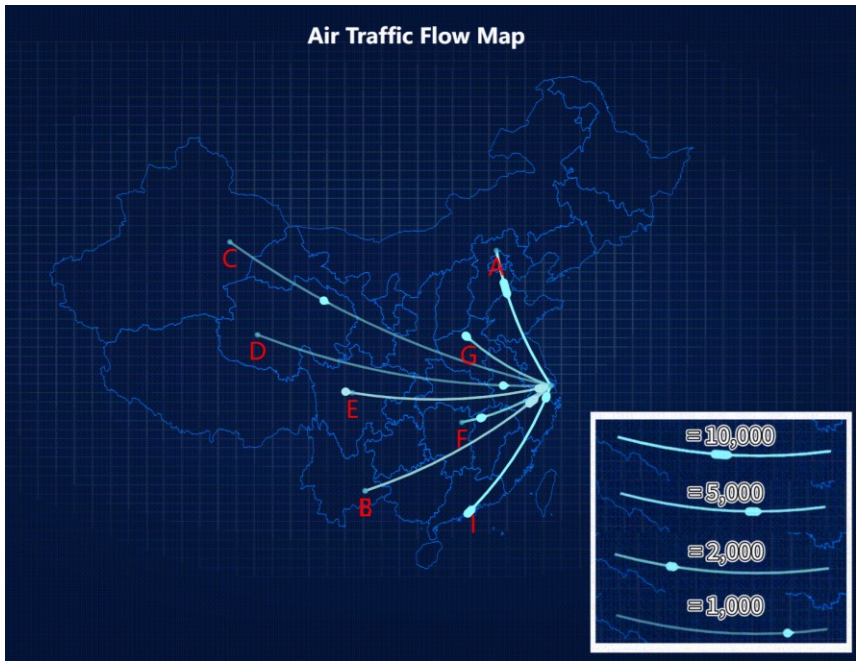
● – strong ✪ – fair ○ – weak

(Köbben & Yaman, 1995)

Methodology

Design Animated Flow Maps

- **Rate of Change** represents how dynamic the movement is on an animated flow map (expressed in frames per minute) (Köbben & Yaman, 1995).
- Therefore, **“Speed”** was used (Rate of how dynamic the object is)"
- **Duration** refers to the real-time period during which an element remains in the user's view in an animation (Köbben & Yaman, 1995).
- Thus, **“Tail/spot length”** was used here as the length of "moving visual attributes"



Methodology

User Study – RQ2, 3, 4

Questionnaire

- **Aims**

  1) whether animated flow maps can effectively convey information to users using dynamic visual variables?

  2) which dynamic visual variable is more efficient in representing volume of information?

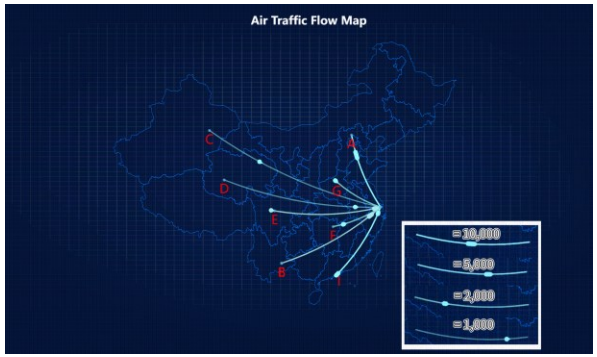
- **Procedure**

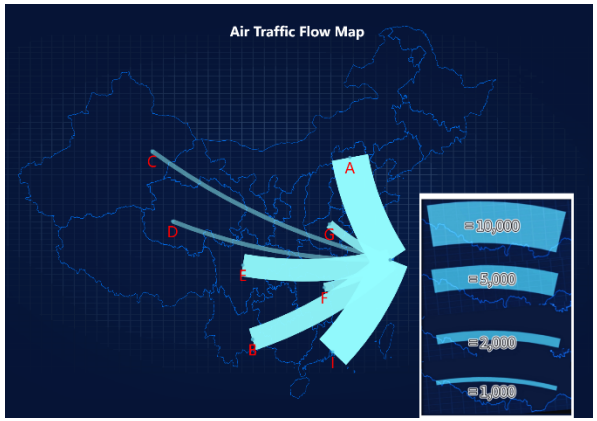
  200 participants, 22 questions in terms of ‘ease of learning/efficiency’, ‘error management’, and ‘subjective satisfaction’ will be assessed

Methodology

User Study – RQ2, 3, 4

Sample Question:





Look at the **map**, can you see different volumes of air traffic flows?

- ○ Strongly Agree: "Yes, I can clearly and easily perceive the varying volume of air traffic flows on this map."
- ◉ Agree: "Yes, I can notice that the volume of air traffic flows differs on this map, although it may require some attention."
- ○ Neutral: "I'm not sure if the volume of air traffic flows is different on this map. It's not immediately apparent to me."
- ○ Disagree: "No, I cannot distinguish any noticeable difference in the volume of air traffic flows on this map."
- ○ Strongly Disagree: "No, I cannot perceive any difference in the volume of air traffic flows on this map at all."

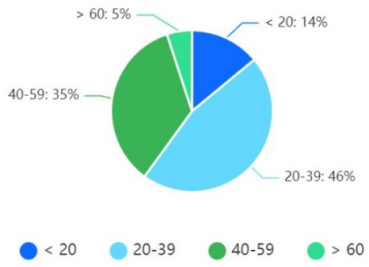
Clear selection

Please estimate the volume ratio between **Flight-A and Flight-D**
e.g., if Flight-A has 5,000 passengers and Flight-D has 1,000, then the ratio will be 5:1

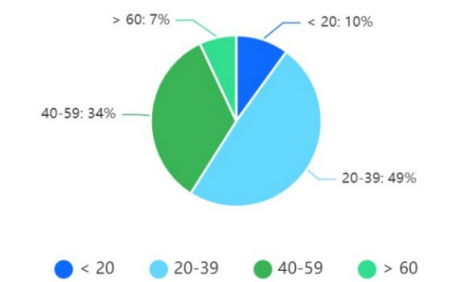
- ○ 5:1
- ○ 2:1
- ○ 1:1
- ○ I cannot estimate them

Results - General Information

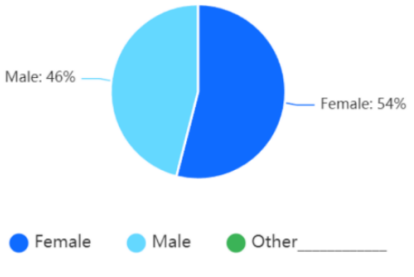
- 200 participants were divided into two user groups, consisting of 99 males and 101 females.
- The age group was widely varied, spanning from under 20 to above 60 years old, with the largest percentage falling within the 20-39 years old range.
- Most of them chose moderate to little experience with maps in both groups, which was also the case for animated flow maps.



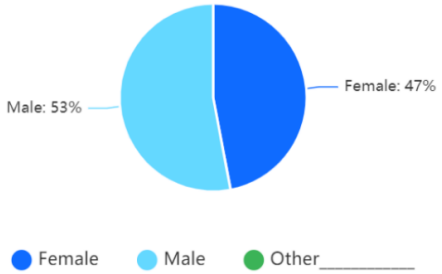
Group-A



Group-B

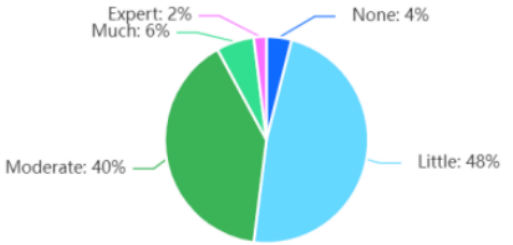


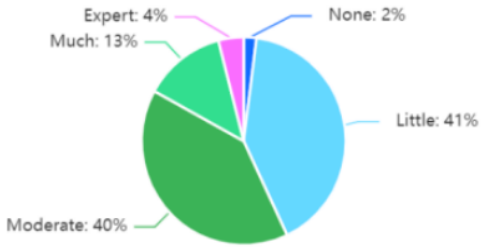
Group-A

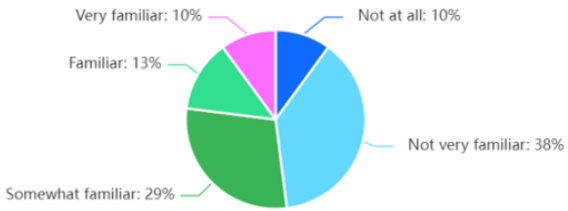


Group-B

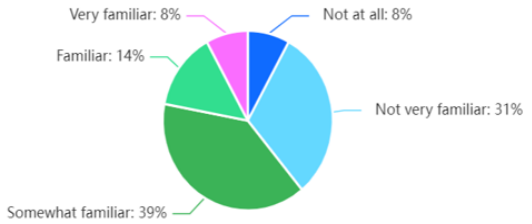
Results

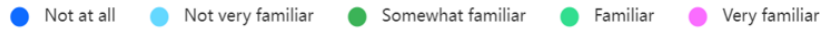






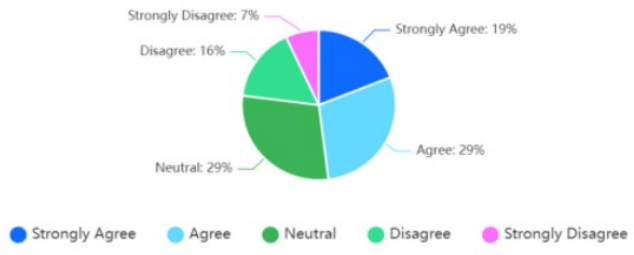
Group-A

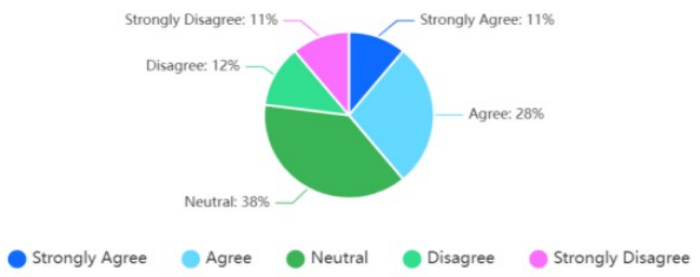




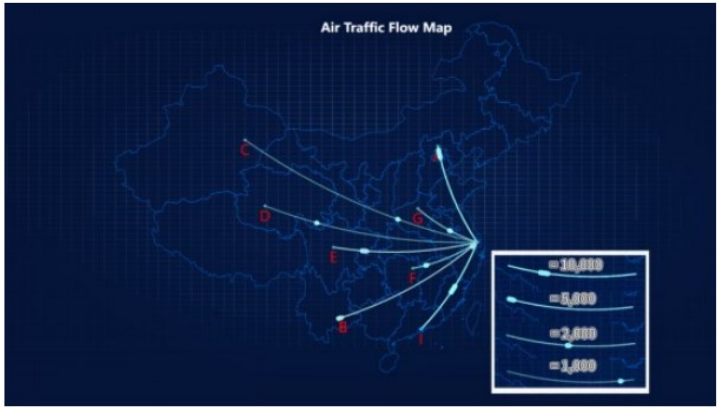
Group-B

Results - Volume visual estimation





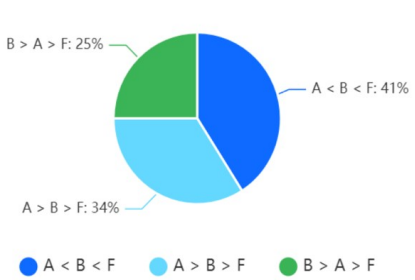
Group-A

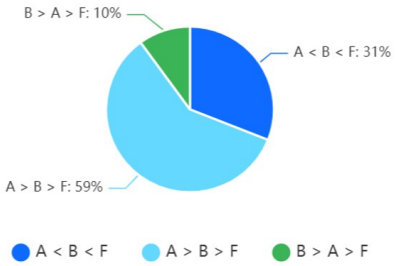


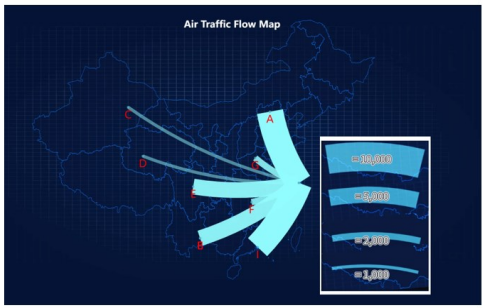
Group-B

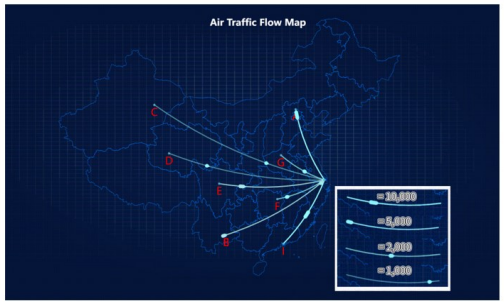
*For **"Q5 perception of different volumes"**,* the result shows that static flight maps utilizing the 'width' feature to represent volume information might offer a more intuitive demonstration to map users and make it easier for them to perceive differences. (***Similar result in exports map Q11)***

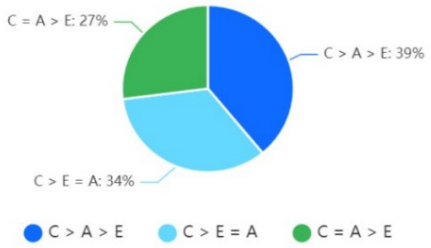
Results - Volume visual estimation

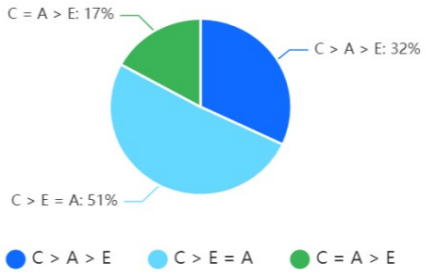


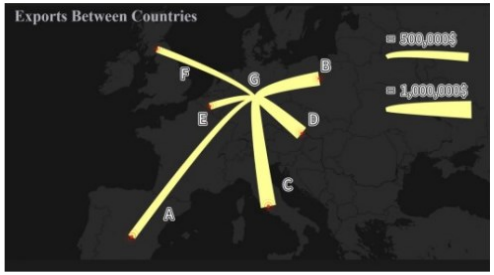




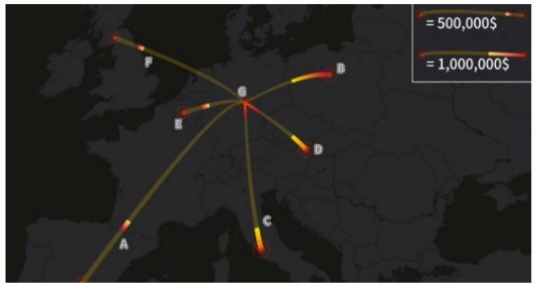








Group-A



Group-B

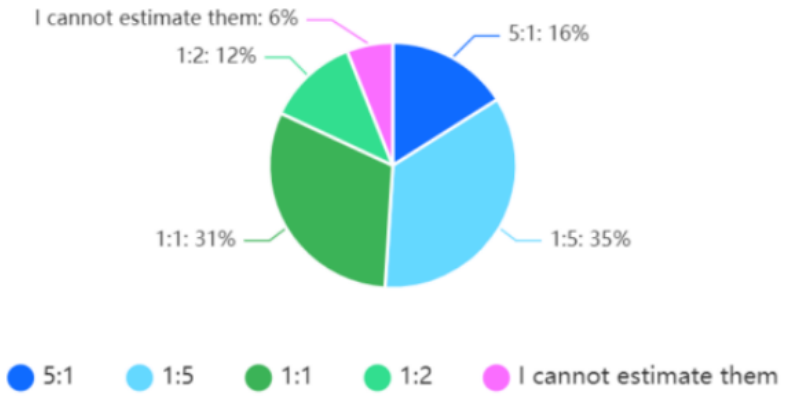
*For **"Q6 ranking flow lines volumes"***

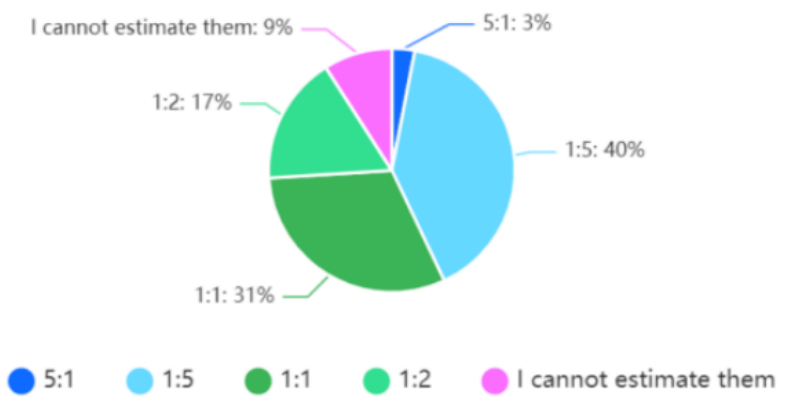
The result shows that the accuracy in Group-B is higher than Group-A. (animated 59% > static 34%)

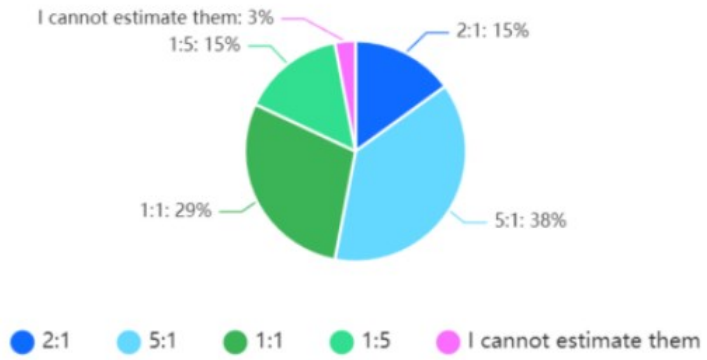
Q12 has similar result with rates of 51% and 34%, respectively

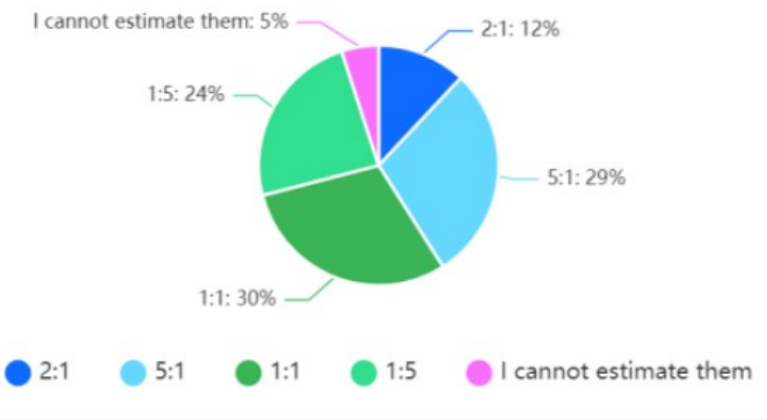
Results - Volume visual estimation

*For **"Q7-Q8 & Q13-Q14 ratio of flow lines",** Group-B and Group-A demonstrated similar accuracy.*



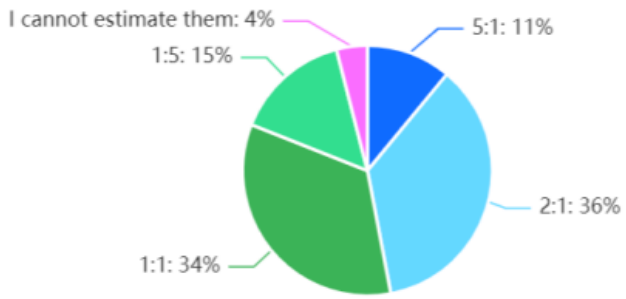


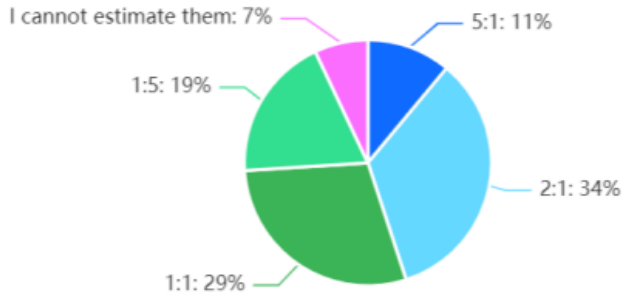


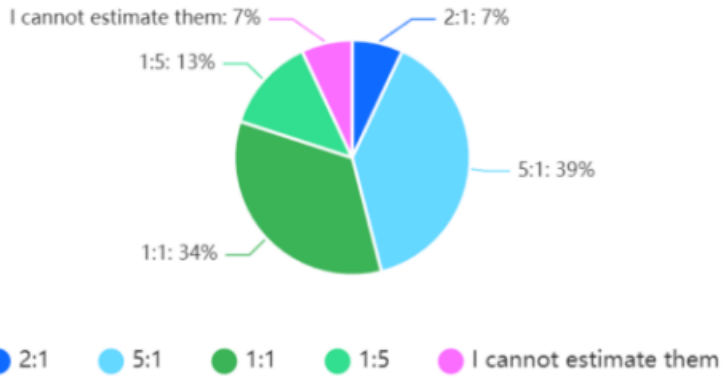


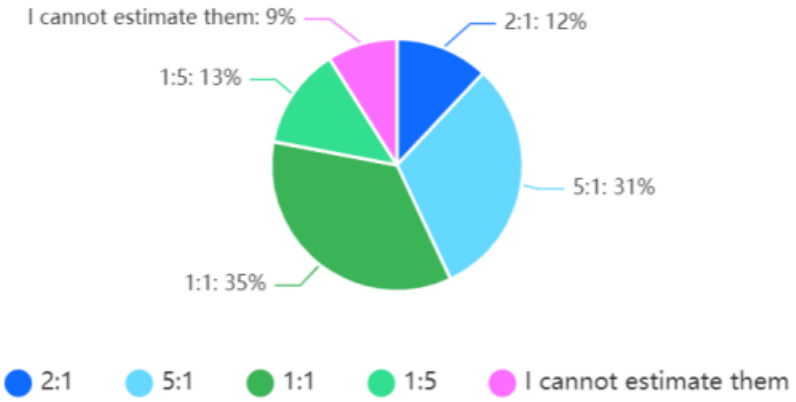
Results - Volume visual estimation

However, more people in group-b selected *I cannot estimate them* in all cases



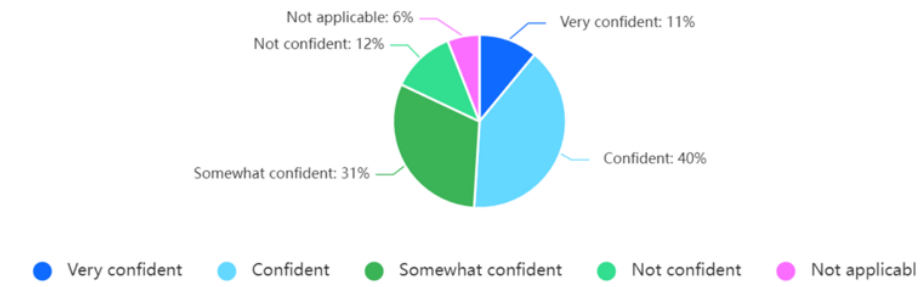


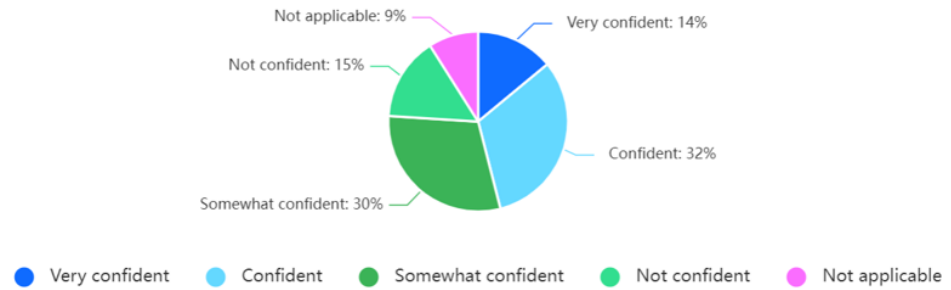


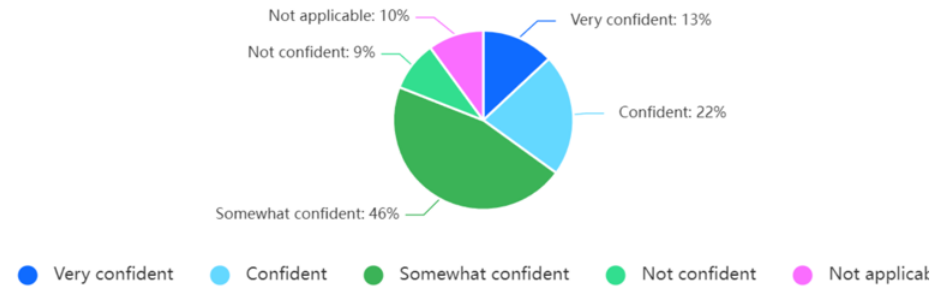


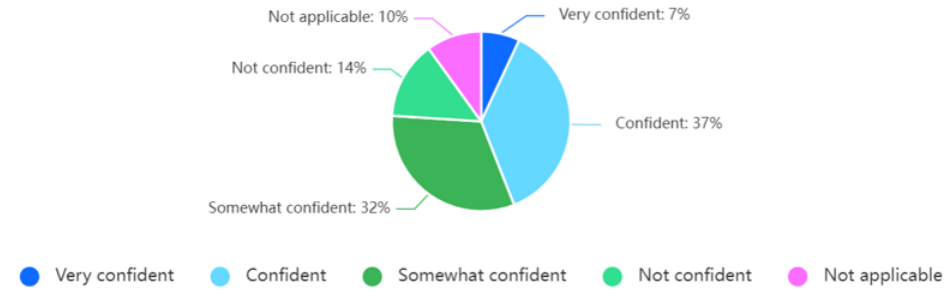
Results - Efficiency estimation

*For **"Q9-Q10 & Q15-Q16 confidence and time cost estimation lines"**,* Group-B was more polarized because it had higher confidence levels in their estimations, but also showed a greater tendency to feel "not confident" or "not applicable."



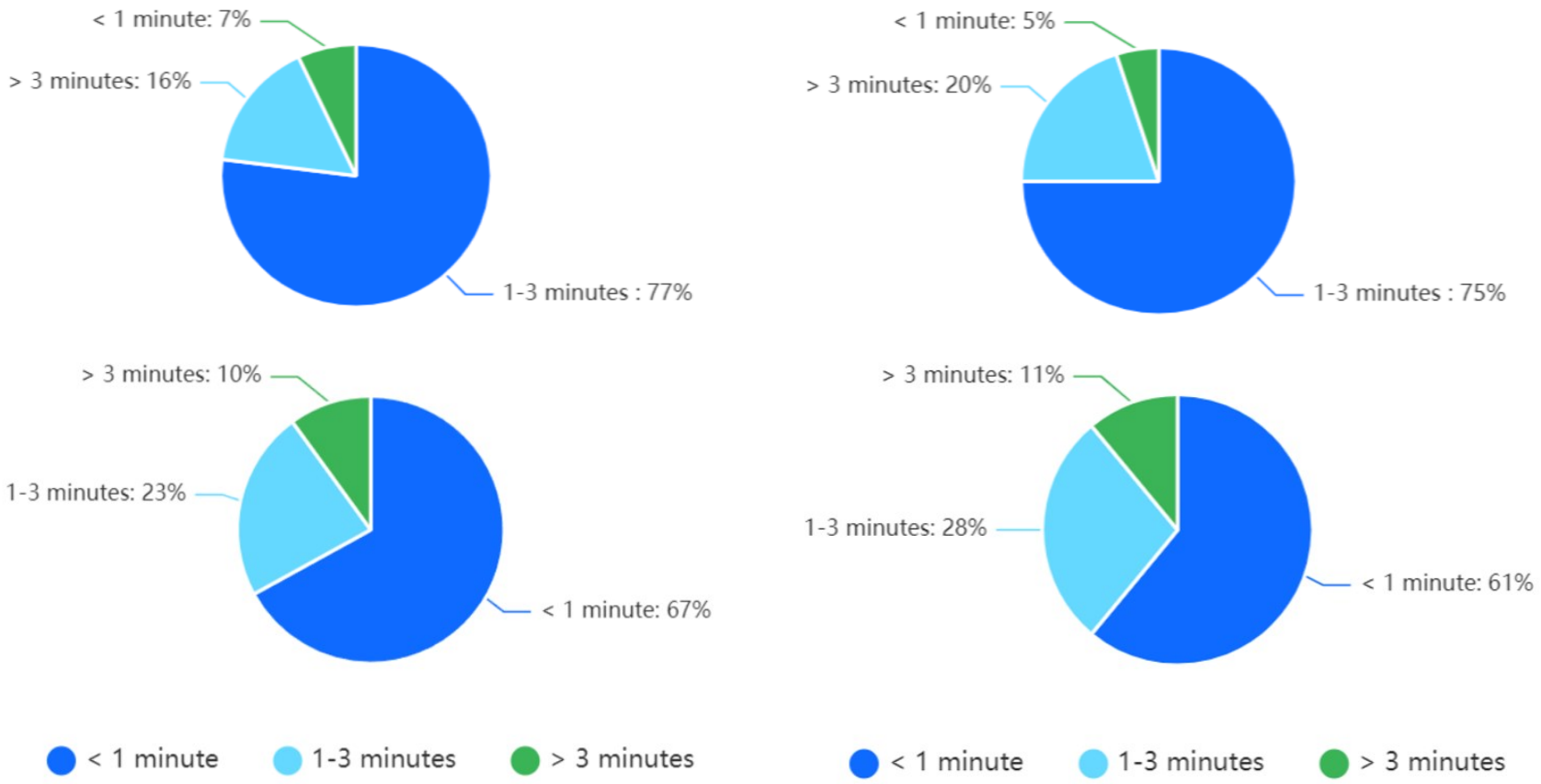






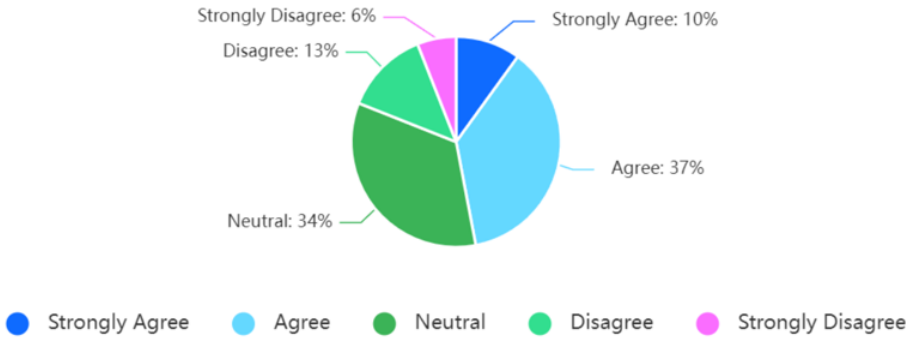
Results - Efficiency estimation

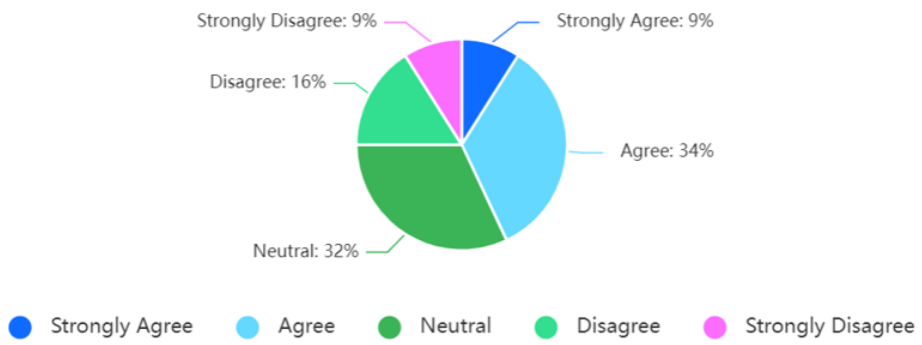
*For **"Q9-Q10 & Q15-Q16 confidence and time cost estimation lines"**,* Efficiency estimation analyses indicated that participants in Group-B spent more time on average making estimations

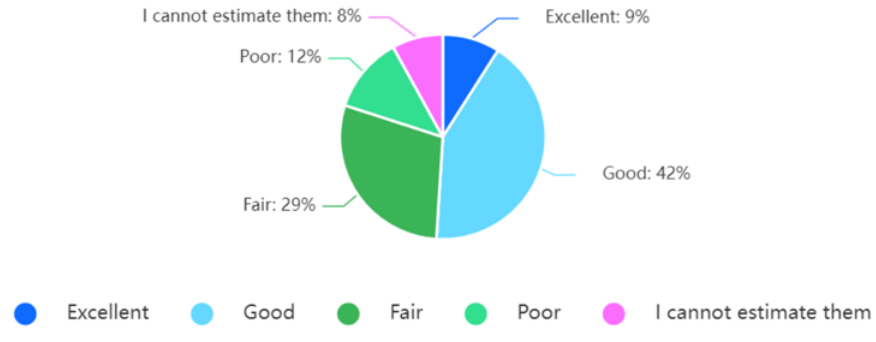


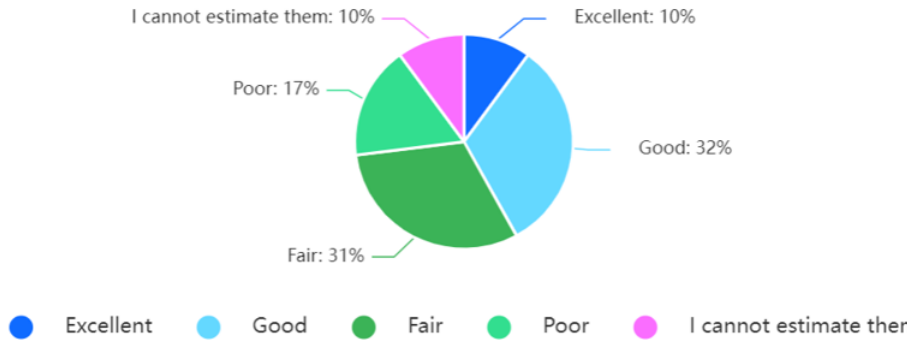
Results - User Experience

*For **"Q17-Q21 visually crowded test, ease of learning & subjective satisfaction".** In Group-A, a combined 47% of participants chose 'strongly agree' or 'agree.' Conversely, in Group-B, the corresponding percentage was slightly lower at 43%.*



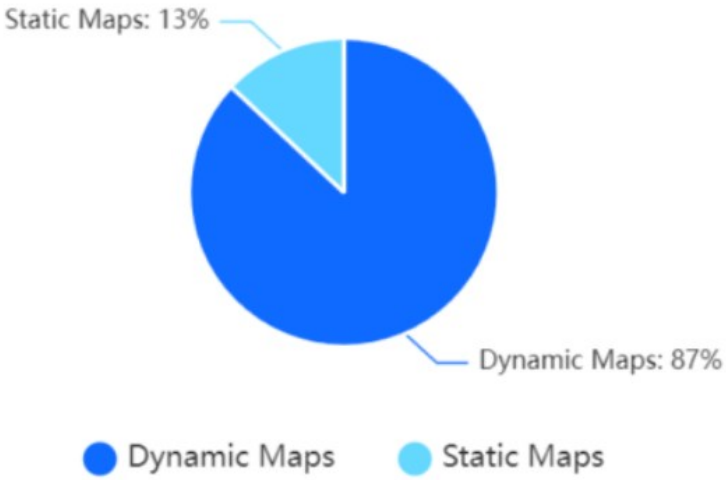




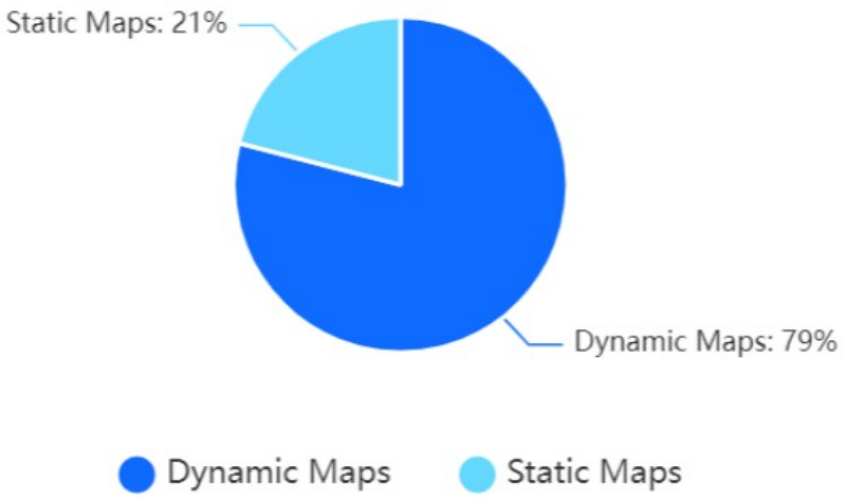


Results - User Experience

*For **"Q17-Q21 visually crowded test, ease of learning & subjective satisfaction ".*** Interesting findings showed that in Group-A, 87% of participants favored animated maps, while in Group-B, 79% persisted in selecting animated maps for a better visual experience.



Group-A



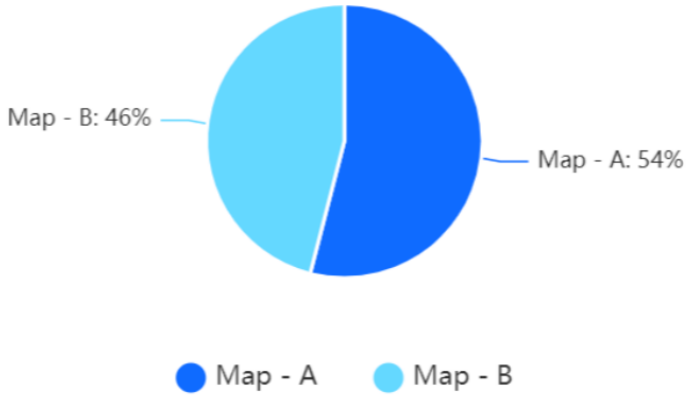
Group-B

Results – Visual variables (only group-b)

*For **"Answers for Q22, compare different dynamic visual attributes".*** Among Group-B participants, 54% opted for 'tail/spot length' as the preferred method, which employs duration as a dynamic visual variable, while 46% favored 'speed,' which uses the rate of change as a dynamic visual variable.

Map-A

Map-B



Discussion – Findings for RQ1

2.4 Techniques for making animated flow maps

- 2.4.1 Techniques for Origin-destination Maps
  - Method 1: Leaflet.Canvas-Flowmap-Layer
  - Method 2: FlowmapBlue - Flow map visualization tool.
- 2.4.2 Techniques for Trajectory-based Maps
  - Method 1: Using GEOlayers 3 plugin for Adobe After Effects
  - Method 2: Using Adobe Illustrator and After Effects
- 2.4.3 Techniques for Continuous Maps
  - Method 1: Using ArcGIS API for JavaScript
  - Method 2: Echarts.js
- 2.4.4 Database for Making Animated Flow Maps

Discussion – Findings for RQ1

- Techniques for making various types of animated flow maps were summarized.

- Notably, while these methods can be used individually, **combining** them synergistically often yields the most powerful results. For example, one study merged After Effects, ArcGIS, and the D3 library, resulting in a sophisticated and insightful animated flow map (Jacobs, 2018).

Discussion – Findings for RQ2-3

13 essential design strategies from Borden Dent & colleagues (2009)

- 1. Managing Line Overlaps: While the guideline to position smaller intersecting flow lines on top of larger ones might be relevant, animated maps usually do not have overlaps because the 'width' visual variable is not commonly used in animated maps.
- 2. Directional Arrows & Arrowhead Scaling: Arrows are crucial for indicating flow direction in static maps, but their role might not be essential in animated maps. Flow lines in animated maps usually have starting and ending points.
- 3. Line Placement and Balance: Achieving a balanced composition might not be the top concern in animated flow maps. However, the flow lines on animated flow maps are usually created automatically and do not overlap with each other.
- 4. Distributive Flow Lines: The concept of distributive flow lines, maintaining proportional widths, may not be well suited for animated maps. The reason is similar to 'overlaps'; animated maps often don't use widths to represent flow quantity.

Discussion – Findings for RQ2-3

13 essential design strategies from Borden Dent & colleagues (2009)

- 1. Simplicity and Information Presentation: The principle of simplicity remains essential in animated maps, but the challenge lies in presenting changing information coherently. The user test in Group B shows that many participants might need more time to understand the animated map information or cannot estimate differences in some flow lines. Therefore, simplicity and information presentation should be one of the highest design focuses in animated maps.

- 2. Flow Line Priority: The principle of assigning the highest visual importance to flow lines remains pertinent in animated maps. In the context of animated maps, due to the dynamic nature of animated maps, considerations must be given to how flow lines evolve over time and how their hierarchy may change during animation transitions. The user test showed that most participants cannot precisely understand some important information from the maps. In other words, there is a gap between the design of flow lines and what can still be enhanced based on flow line priority or other design rules.

- 3. Visual Balance: Balancing the placement of new lines is essential, especially as animations involve the introduction of new elements over time. Visual equilibrium must be maintained throughout the animation sequence.

Conclusion

Outcomes:

- the examination of these principles revealed that certain guidelines related to line overlaps, directional arrows, and line placement might not be entirely suitable for animated maps.

- The user study indicated that 'duration,' represented by 'tail length,' emerged as the most efficient dynamic visual variable for conveying volume information.

Limitations:

- In participant distribution across age groups. The focus on younger participants may overlook older individuals' cognitive processes.
- There was no examination on integration of static and dynamic visual variables.

Future study:

- The innovative integration of static and dynamic visual variables to enhance map design was also mentioned and might be a focus of future studies (Hannah, 2021).

Reference

Griffin, A. L., MacEachren, A. M., Hardisty, F., Steiner, E., & Li, B. (2006). A Comparison of Animated Maps with Static Small-Multiple Maps for Visually Identifying Space-Time Clusters. Annals of the Association of American Geographers, 96(4), 740–753.

Hannah, C. (2021). The Migration of Plant Species in The Bridge of Beyond. Retrieved June 20, 2023

Jacobs, B. R. (2018). Visualizing Bird Migration with Animated Maps. Cartographic Perspectives, 91.

Köbben, B. J., & Yaman, M. (1995). Evaluating dynamic visual variables. International Cartographic Association, 45–53.

Lobben, A. (2008). Influence of Data Properties on Animated Maps. Annals of the Association of American Geographers, 98(3), 583–603.

Narayanan, N., & Hegarty, M. (2002). Multimedia design for communication of dynamic information. International Journal of Human-Computer Studies, 57(4), 279–315.

Tversky, B., Morrison, J. Q., & Bétrancourt, M. (2002). Animation: can it facilitate? International Journal of Human-computer Studies, 57(4), 247–262. https://doi.org/10.1006/ijhc.2002.1017


ITC
UNIVERSITY OF TWENTE.
TECHNISCHE
UNIVERSITÄT
DRESDEN
Thanks for
Watching
Technical
University
of Munich
TU
WIEN
TECHNISCHE
UNIVERSITÄT
WIEN
Vienna University of Technology