

# Interactive Visualizations (IVI) Report

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Repository: <https://github.com/schwitzkasten/FHNW-IVI.git>

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# 1. LO1: Performance

Performance in interactive visualizations is vital in the big data era to ensure a positive user experience, provide real-time data analysis, handle complex data effectively, ensure accessibility and scalability, facilitate quick insight discovery, and maintain a competitive edge. In this LO it will be looked at how the performance of Visualizations behaves.

## WebGL

In the context of performance visualizations, WebGL's functionality as a rasterization engine is crucial. It allows for efficient rendering of complex visuals like points, lines, and triangles, essential for detailed and dynamic graphical representations. The use of GPU for processing and the requirement for specific code through vertex and fragment shaders, written in GLSL, enable high-performance visualizations. These shaders play a key role: the vertex shader computes vertex positions for rendering primitives, and the fragment shader assigns colors to each pixel, directly influencing the visual output's quality and performance. Since WebGL's API primarily focuses on setting up states for these shaders, it's integral in optimizing the performance of visualizations. Efficient use of WebGL in performance visualizations hinges on how well one can manage and execute these shader functions and state setups, ensuring that the necessary data is accessible and processed effectively by the GPU (*WebGL Fundamentals*, o. J.).

The benefit of the GPU over the CPU is that is specifically made for Visual tasks. It contains thousands of kernels, processes are running parallel to each other, more efficiently in in processing lots of small tasks(*CPU vs. GPU*, 2022).

To investigate the performance differences, I created a visualization that shows 500000 random points in a 2D coordinate system. Points in a 2D coordinate system. Once the visualization was rendered with the SVG mode and once with WebGL.

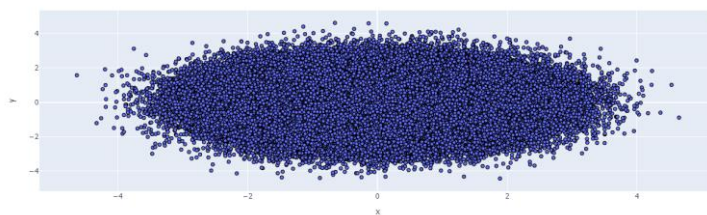


Figure 1: Plot WebGL

The plot created with WebGL was shown much faster than the one created with SVG. The runtime difference was not that huge. For the WebGL [1.31s] and for SVG [1.54s]. The plot created with WebGL was much smother to handle than the SVG. Handling the SVG plot let VScode to crash or stop working. This shows that the WebGL plot is much more resource efficient than SVG.

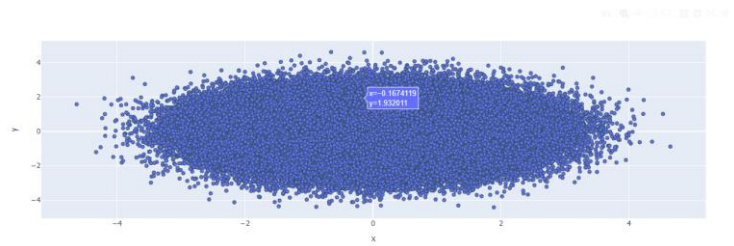


Figure 2: Plot SVG

In addition the look of the SVG plot is different from the WebGL. The SVG points are much more detailed and have very clear borderlines.

## Tiling

Tiling can improve the performance of interactive visualization of large amounts of data by dividing the data into smaller dividing the data into smaller tiles and loading and displaying only the required parts. This allows the computing power to be more effectively and reduces the load on the computer. The interactive nature of Tiling allows users to navigate quickly and easily between different sections of the data, enabling a faster and more and more responsive experience (Forrest, 2023).

Datashader is a graphical pipeline system for the fast and flexible creation of meaningful visualizations. creation of meaningful visualizations of large datasets. Datashader divides the creation of images into a series of explicit steps that allow calculations to be performed on intermediate representations.(Yang, 2022)

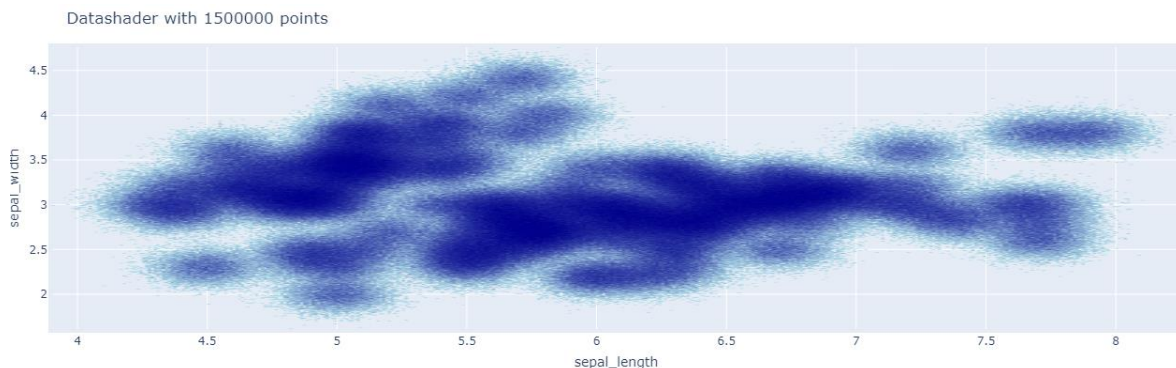


Figure 3: Datashader plot

In this example, the plot contains 1.5 million datapoints. The handling of the plot runs very smoothly and without any delays.

A slightly different approach is taken from the framework Deck.gl. JavaScript, typically constrained by its single-threaded event loop model, struggles with tasks that require heavy computation, such as managing large datasets and rendering 3D graphics. To address this limitation, deck.gl employs the WebGL library, which enables asynchronous access to the user's computer GPU. This approach shifts the computationally intensive tasks away from the browser to the GPU, which is more capable of handling such demands. Consequently, deck.gl is able to produce impressive visualizations, efficiently

managing and rendering millions of data points with enhanced speed and performance (Muramoto, 2019).

## 2. LO2: Dashboard design principles

Dashboards, as visual tools, use charts, graphs, and various elements to present data effectively. A well-designed dashboard focuses on maximizing visual representation while efficiently managing textual content. This design strategy is crucial because humans can process visual information much faster than text, up to sixty thousand times quicker. Consequently, the layout and design of a dashboard are vital in user experience design, significantly influencing the success of applications and websites.

Good dashboard design is not just about aesthetics; it plays a key role in optimizing the customer journey. By adhering to key design principles, it ensures that users spend more time engaging with the website and effectively extract insights from the data presented. These principles, which primarily focus on the strategic placement and design of dashboard elements, function more as guidelines rather than strict rules. They are not fixed but are crucial in creating an intuitive and informative dashboard that enhances user interaction and data understanding (Mokkup.ai, 2023).

### Schneiderman's mantra

"Schneiderman's Mantra is an extremely influential organizing principle for the creation of visualization systems. It goes as follows" (HAMPDATAVISUALIZATION, 2016):

**Overview first:** The initial stage involves presenting the complete dataset using a scatterplot or the most suitable display technique for your data. This phase is designed to offer a comprehensive perspective, enabling your audience to gain a basic understanding of the data and setting the stage for subsequent steps in the visualization process (HAMPDATAVISUALIZATION, 2016).

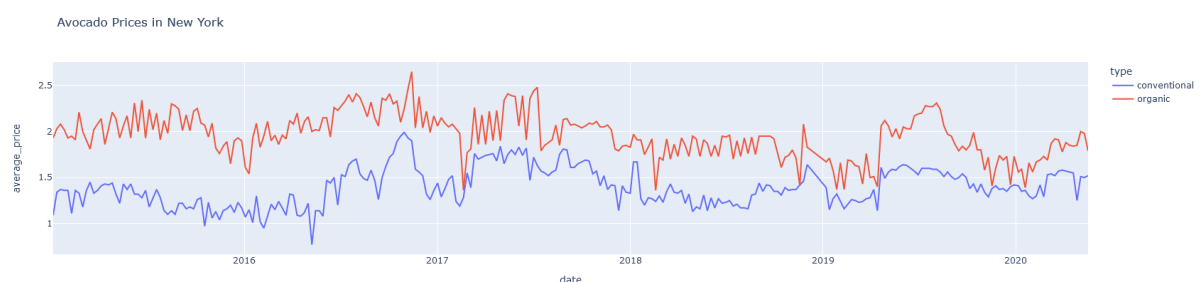


Figure 4: Overview

**Zoom and Filter:** Zooming in on a specific part of a dataset eliminates irrelevant data by focusing on particular coordinates, thereby providing more resolution and detail to the data of interest. Filtering complements this by removing unnecessary data based on selected attributes, simplifying the data display and making more space for detailed information. The method of filtering varies depending on the data type: checkboxes are

recommended for ordinal or nominal data, while range sliders are better suited for filtering quantitative values (HAMPDATAVISUALIZATION, 2016).

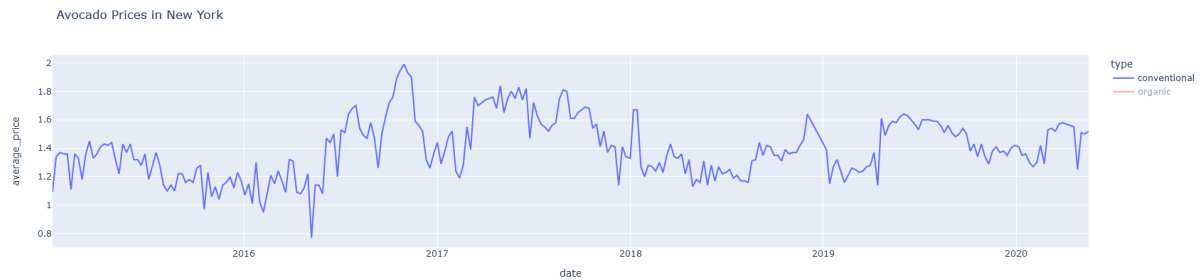


Figure 5: Filter

**Details on Demand:** Providing details on demand empowers users to control and further explore data without overcrowding the display. The most prevalent form of this feature is the tooltip, which reveals specific details about a data point when hovered over with a mouse. This interactive approach enables users to casually browse and extract insights from the data. Additionally, another method includes enabling users to select a particular field, which then highlights the corresponding data, further facilitating targeted exploration and analysis (HAMPDATAVISUALIZATION, 2016).

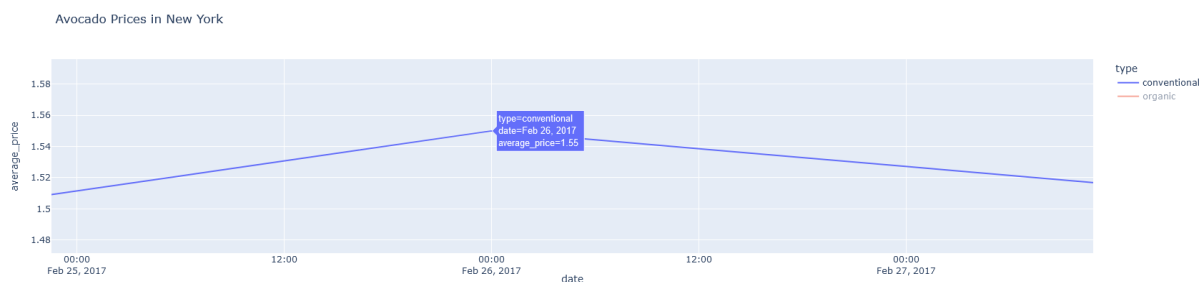


Figure 6: Details on Demand

## Brushing

“Brushing is a powerful technique that allows you to interact with your data and explore relationships between different visualizations. Selecting a portion of data in one chart can highlight corresponding data points in other visualizations. This is an excellent feature for creating insightful, interactive dashboards” (Chip, 2023)

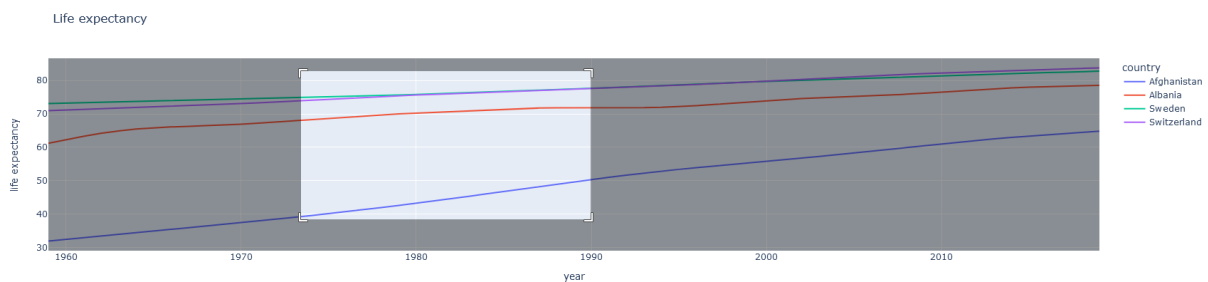


Figure 7: Brushing

## Linking

The linked view paradigm is a method that uses multiple simple views of data. When you interact with a view, the representation of the data changes in all linked views. An example simple example would be that selecting a date in one view also changes the dates in all other views. This date changes. In short: If one view changes, all other views also change (Wills, 2008).

## 3. LO3: HCI Basics

Human-Computer Interaction (HCI) is an interdisciplinary field dedicated to the design and evaluation of computer systems and technologies with which humans interact. Its primary goal is to enhance the interface between humans and computers, making technology more user-friendly, efficient, and enjoyable. HCI specialists concentrate on developing and deploying computer systems that meet the needs and preferences of human users. A significant portion of HCI research is directed towards improving how people use and understand interfaces, aiming to optimize the overall experience of interacting with technology (*What Is Human Computer Interaction?*, 2022).

### Fitts's Law

“Fitts’ law states that the amount of time required for a person to move a pointer (e.g., mouse cursor) to a target area is a function of the distance to the target divided by the size of the target. Thus, the longer the distance and the smaller the target’s size, the longer it takes” (*What Is Fitts’ Law?*, o. J.).

$$ID = \log_2 \left( \frac{2D}{W} \right)$$

$ID$  = Index of Difficulty,  $D$  = Distance to target,  $W$  = Width of target

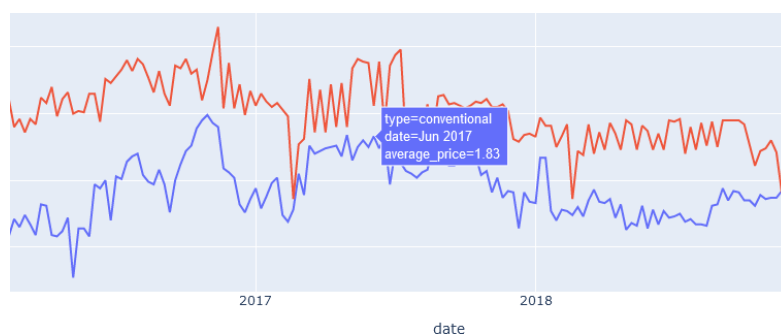


Figure 8: Fitts's Law

In our case Fitts’s Law can be addressed with the hovering information as shown in the Figure above. This we can achieve with the setting “hovermode”.

## Weber's Law

Weber's Law, introduced by German physicist Ernst Heinrich Weber in 1834, is a fundamental principle in the field of psychophysics. It postulates that the just noticeable difference (JND) between two stimuli is a constant proportion of the intensity of the original stimulus. Essentially, this means the perception of change in a stimulus's intensity is relative, not absolute. Weber's Law also explains why detecting small differences in high-intensity stimuli is more challenging than in low-intensity stimuli. Our sensitivity to changes is greater when the original intensity is low, making it easier to discern differences between two dim light bulbs than between two very bright ones. This relative perception underscores the importance of Weber's Law in understanding how humans interact with and interpret the world around them (Mahr, 2023).

$$\frac{\Delta I}{I} = K$$

*$\Delta I$  = Delta to initial Stimulus Value,  $I$  = Initial Stimulus Value,  $K$  = Weber Fraction*

## Miller's Law

Miller's Law, a key principle in UX design, is derived from psychologist George A. Miller's theory that the average person can hold about seven (plus or minus two) items in their working memory. This concept is crucial in UX design for creating user interfaces that are easy to navigate and understand. It suggests that interfaces should be designed with the limitation of human memory in mind, avoiding overloading users with too much information at once (Greenman, 2022).

In practical terms, this means simplifying interfaces by grouping information into chunks of seven or fewer items, whether it's menu options, form fields, or buttons. By doing so, the design becomes more intuitive and user-friendly, as users can process and remember the information more efficiently. Miller's Law essentially guides designers to create more cognitively accessible products, ensuring that users are not overwhelmed and can interact with digital products more effectively and comfortably. This law is a cornerstone in creating designs that cater to the natural limits of human cognitive processing, enhancing overall user experience (Greenman, 2022).

Plain Values	Miller's Law
0796842976	079 684 29 76
1326841352CHF	1'326'841'352CHF
4408675309	(440) 867-5309

## 5 Dimensions of Interaction Design

"Products and services are how designers communicate with their users. The better the design, the easier it is to understand what the designer is trying to tell the user" (Instructor, 2015).

**1D Words:** In design, words play a crucial role in communicating significant information to users. For instance, labeling a CTA button with "Book Demo" clearly indicates to users what action will occur upon clicking the button.

**2D Visual representations:** Graphic elements like images, symbols, or icons can effectively communicate key information to users. For instance, rather than using text to detail a product's main benefits, a designer could use custom icons to visually represent each benefit clearly.

**3D Physical objects:** Various tools facilitate user interaction with a graphical user interface. For instance, a stylus can be employed for tablet navigation, while a mouse is typically used with a computer. Additionally, touch screens are designed for direct interaction with one's hands. It's crucial for designers to take into account the specific medium through which users will interact with the interface, ensuring that the design elements are tailored for efficient use with that medium.

**4D Time:** Designers need to carefully consider how media elements such as animations, videos, and sounds evolve over time to enhance user experience. It's important to determine the ideal duration for a video or sound clip to ensure it contributes to an optimal user experience.

**5D Behavior:** This encompasses the physical and emotional reactions of users, along with how the product responds to the user's actions and inputs (*What Is Interaction Design?*, o. J.).

## 4. LO4: Evaluation

### Usability Test

"In a usability-testing session, a researcher (called a "facilitator" or a "moderator") asks a participant to perform tasks, usually using one or more specific user interfaces. While the participant completes each task, the researcher observes the participant's behavior and listens for feedback (Moran, 2019)."

There are two types of evaluation testing. One is Qualitative and the other is Quantitative.

**Qualitative** usability testing focuses on gathering insights, findings and anecdotes about how people use the product or service. Qualitative usability testing is best used to uncover problems in the user experience. This type of usability testing is more common than quantitative usability testing.

**Quantitative** usability testing focuses on collecting metrics that describe the user experience. Two of the most common metrics collected in quantitative usability testing are task success and time on task. Quantitative usability testing is best suited for benchmarking.

All usability testing involves participants performing some assignments on the provided designs (Moran, 2019).



## **User Experience**

Data visualization involves the creative presentation of complex data through visual means, simplifying comprehension, analysis, and decision-making based on gathered insights. Within UI/UX design, this process is crucial for converting raw data into impactful, user-focused imagery, significantly improving the user's interaction experience (Design, 2023).

## **Usability testing**

For my Usability test the Avocado Dashboard will be used. We'll take five people because with the first person you get new information and feedback. With the second person there will be overlaps, but still new insights can be gained. This decreases steadily with the size of the test persons. In my case a combination of Qualitative and Qualitative usability testing was used. I observed the participants how they interacted with my plot and I saw their results from the questions I gave them. The participants are used to the computer platform and are in the age range of 23-32 years. They have some decent knowledge of dashboards and their features.

Questions:

1. Show me the price of organic avocados Houston on October 8<sup>th</sup> 2018.
2. Compare the exact prices of organic avocados on July 28<sup>th</sup> 2019 in Denver and Albany.
3. True or False: Is the price of conventional avocados in the town of Charlotte ever below the price of the organic avocados?
4. Price for conventional avocados and organic avocados from June 7<sup>th</sup> 2018 from the whole US.
5. Which Location have had the overall highest price for conventional avocados?

I knew beforehand the execution of the test that question 5 would not be possible to answer with the current Dashboard design. Because it is not possible to compare multiple locations at once. The participants would have had to click through the whole stack of locations.

## **Results**

Q1: Here all the participants were able to quickly find the right location and filter after the exact date. Some participants first tried to hover over the line of the plot to find the right date. But in the overall view the exact date cannot be seen. Then they panned into the right spot.

Q2: For this question more interactions with the Dashboard were needed to be able to compare the values from the different locations. Here the time it took was well over the one from Q1. The question could be answered from all participants correctly.

Q3: The response time on this Question was very low. The participants were very quickly with finding the one time the condition were reached. Some of the participants I saw zooming in before giving me the final answer. Because the datapoints are somewhat close to each other.

Q4: Here 2 of the participants said very quickly that they cannot figure out the average US price for the avocados because they thought there is only a location wise split for the prices. The other 3 participants scrolled through the list and found the Total US prices.

Q5: Here the reaction from all the participants was the same. They said if they wanted to find the maximum price they would have had to go through every location and note the highest price from each and then compare them to give a good answer.

## **Improvements**

### **Qualitative**

From observing them answering the questions I realised my dashboard needs to be improved in the following things:

- When working with dates add an date input field
- Add other plots for a better overview and being able to understand the data quicker for example a map of the US, histogram and more
- Being able to compare different values easier without changing the data every time
- Pin Values that differ from all the others to the top in my case it would have been Total US

### **Quantitative**

From the answers I got from the participants I should improve my dashboard in the following things:

- Being able to compare the different locations and the according values
- Make basic interactions like zooming out of the plot more visible
- Pin Values that differ from all the others to the top in my case it would have been Total US

## 5. Bibliography

- Chip. (2023, April 11). *Implementing Brushing for Enhanced Data Exploration*. <https://www.quanthub.com/how-do-you-implement-brushing-in-your-dashboard/>
- CPU vs. GPU: What's the Difference? (2022, Dezember 14). CDW.Com. <https://www.cdw.com/content/cdw/en/articles/hardware/cpu-vs-gpu.html>
- Design, D. (2023, August 10). Data Visualization in UI/UX: Communicating Insights Effectively. *Medium*. <https://devoq.medium.com/data-visualization-in-ui-ux-communicating-insights-effectively-7ddc5bc7b3d>
- Forrest, M. (2023, Januar 23). *Map Tiles: Everything You Need To Know*. CART. <https://carto.com/blog/map-tiles-guide>
- Greenman, R. (2022, Juli 21). *What is Miller's Law in UX Design? [2023 Guide + Examples]*. <https://careerfoundry.com/en/blog/ux-design/what-is-millers-law/>
- HAMPDATAVISUALIZATION. (2016, Februar 26). Schneiderman's Mantra. *Data Visualization*. <https://hampdatavisualization.wordpress.com/2016/02/26/schneidermans-mantra/>
- Instructor, I. C. (2015, September 7). *The Five Languages or Dimensions of Interaction Design*. The Interaction Design Foundation. <https://www.interaction-design.org/literature/article/the-five-languages-or-dimensions-of-interaction-design>
- Mahr, N. (2023, November 21). *Weber's Law | Overview, Application & Examples*. Study.Com. <https://study.com/WEB-INF/views/jsp/redesign/academy/lesson/seoLessonPage.jsp>
- Mokkup.ai. (2023, September 14). 8 Essential Dashboard Design Principles for Effective Data Visualization. *Medium*. <https://medium.com/@mokkup/8-essential-dashboard-design-principles-for-effective-data-visualization-40653c5fd135>
- Moran, K. (2019, Dezember 1). *Usability Testing 101*. Nielsen Norman Group. <https://www.nngroup.com/articles/usability-testing-101/>
- Muramoto, A. (2019, November 13). *High-performance data visualizations with Google Maps Platform and deck.gl*. Google Cloud Blog. <https://cloud.google.com/blog/products/maps-platform/high-performance-data-visualizations-google-maps-platform-and-deckgl>
- WebGL Fundamentals*. (o. J.). Abgerufen 22. Dezember 2023, von <https://webglfundamentals.org/webgl/lessons/webgl-fundamentals.html>
- What is Fitts' Law? — Updated 2023*. (o. J.). The Interaction Design Foundation. Abgerufen 22. Dezember 2023, von <https://www.interaction-design.org/literature/topics/fitts-law>
- What is Human Computer Interaction? A Complete Guide to HCI | Simplilearn*. (2022, Dezember 1). Simplilearn.Com. <https://www.simplilearn.com/what-is-human-computer-interaction-article>
- What is Interaction Design? | Tiller Digital*. (o. J.). Tiller. Abgerufen 22. Dezember 2023, von <https://tillerdigital.com/glossary/interaction-design/>
- Wills, G. (2008). Linked Data Views. In C. Chen, W. Härdle, & A. Unwin (Hrsg.), *Handbook of Data Visualization* (S. 217–241). Springer. [https://doi.org/10.1007/978-3-540-33037-0\\_10](https://doi.org/10.1007/978-3-540-33037-0_10)

Yang, S. (2022, April 24). *Big Data Visualization Using Datashader in Python*. Medium.  
<https://towardsdatascience.com/big-data-visualization-using-datashader-in-python-c3fd00b9b6fc>

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