Information Visualization: Typologies and Functions Aligned with Distinct Purposes*

Abstract

This article conceptualizes information visualization as an epistemic and mediating device within Library and Information Science (LIS), emphasizing its role in contemporary data-intensive and AI-supported information environments. Rather than treating visualization as a neutral graphical artifact, the study frames visual representations as functional instruments, systematizing 60 typologies into 16 categories that shape interpretation, decision-making, and knowledge organization. Based on the Data Visualization Catalogue by Severino Ribecca, the article systematizes 60 visualization typologies and reorganizes them into 16 functional categories aligned with distinct communicative purposes. Furthermore, the study discusses how this functional framework can support artificial intelligence–assisted visualization processes, including automated selection of visualization types, semantic mediation of metadata, and adaptive visual interfaces in digital libraries, bibliometric systems, and open science infrastructures. The proposed functional mapping model offers both a theoretical reference and an applied orientation for researchers, librarians, designers, and information professionals.

Keywords: Information visualization; functional visualization typologies; artificial intelligence–assisted visualization; library and information science (lis); knowledge organization systems; digital libraries; bibliometric analysis.

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Visualización de la información: tipologías y funciones alineadas con distintos propósitos

Resumen

Este artículo presenta la visualización de la información como un dispositivo epistémico y de mediación dentro de la Bibliotecología y Ciencia de la Información (BCI), destacando su papel en los entornos informacionales actuales, caracterizados por un uso intensivo de datos y el apoyo de sistemas de inteligencia artificial. En cambio de tratar la visualización como un artefacto gráfico neutral, el estudio propone las representaciones visuales como instrumentos funcionales, al modelizar 60 tipologías en 16 categorías que influyen en la interpretación, la toma de decisiones y la organización del conocimiento. Con base en el Data Visualization Catalogue de Severino Ribecca, el artículo sistematiza 60 modelos de visualización y las reorganiza en 16 categorías funcionales, alineadas con propósitos comunicativos diferenciados. Además, el estudio analiza cómo este marco funcional puede respaldar procesos de visualización asistidos por inteligencia artificial, incluyendo la selección automatizada de tipos de visualización, la mediación semántica de metadatos y el desarrollo de interfaces visuales adaptativas en bibliotecas digitales, sistemas bibliométricos e infraestructuras de ciencia abierta. El modelo de mapeo funcional propuesto ofrece tanto una referencia teórica como una orientación aplicada para investigadores, bibliotecarios, diseñadores y profesionales de la información.

Palabras clave: visualización de la información; tipologías funcionales de visualización; visualización asistida por inteligencia artificial; bibliotecología y ciencia de la información (BCI); sistemas de organización del conocimiento; bibliotecas digitales; análisis bibliométrico.

1. Introduction

Since the cave paintings of prehistoric times, humanity has sought ways to communicate and express itself. Over time, paintings replaced these early forms of expression, becoming artistic objects that resonated emotionally with society. Later came written documents—in various forms such as clay tablets, papyrus, parchment, paper, and digital formats—which also engaged the public. Today, in the contemporary era, audiovisual media has become the dominant form of entertainment, marked by interactive systems and on-demand visual experiences. All these historical stages share a fundamental element: information visualization.

In contemporary knowledge environments, information visualization operates as a cognitive and communicative infrastructure rather than a mere representational technique. In Library and Information Science, visualizations increasingly mediate access to large-scale bibliographic collections, scientometric indicators, and digital cultural heritage.

Its representation is carried out thropromoting more interactive decision-making processes rather than relying on lengthy reports (Zhu & Chen, 2008); and employing symmetric or asymmetric relations to support understanding, for example, through the use of different types of maps (Holmquist et al., 1998).

These scenarios demonstrate that information visualization has always been present in society, whether in simple or complex forms, aiming to convey meaning through visual representation. As the saying goes, "A picture is worth a thousand words," and this is widely accepted, as images can capture the beauty of landscapes and the impact of visual and auditory content, conveying both natural realities and surreal creations.

Research in visualization and human–computer interaction has shown that visual representations reduce cognitive load, accelerate pattern recognition, and support exploratory analysis (Card et al., 1999; Börner, 2010). Despite the proliferation of visualization tools, the field still lacks a consolidated functional framework capable of guiding the selection of appropriate visualization types according to specific informational purposes—particularly in LIS contexts, where visualization is often adopted pragmatically without explicit theoretical grounding.

Multimedia elements—such as images, sounds, and data sets—may offer a meaningful foundation for establishing standards in information visualization, especially in the context of the digital era (Uzwyshyn, 2007). This applies even to areas not traditionally associated with such practices, such as libraries, educational systems, commerce, public safety, and publishing platforms. Based on this context, the central hypothesis of this study is that information visualization integrates multimedia and semantic data to enable new approaches in digital analysis and communication.

Information visualization can serve a variety of functions in contemporary society—for example, in mobility control and population-level big data, including Twitter messages, bike rental monitoring, and surveillance cameras (Kotoulas et al., 2014). It can also support semantic structuring of streaming services based on static datasets, using frameworks like Dublin Core for academic applications. Furthermore, it can be integrated into interactive academic and media formats, as in the case of the model "Phylogeny determined by protein domain content," which combined textual and video components for the first time in a scientific publication (Yang et al., 2005).

Another application involves everyday phenomena, such as meteorology and online thematic mapping (Dörk et al., 2011), where it becomes possible to trace the evolution of content domains—such as (i) philosophy worldwide, (ii) music bands, and (iii) prominent fine artists—through graphic scales and temporal visualizations, aiming to reveal the influence of certain elements over others. To guide this discussion, the present study focuses on the versatility of information visualization and its representation across key societal contexts, based on typologies and functions. Specifically, it introduces 60 visualization types and 16 associated functions. This type of approach can be applied across various fields of knowledge, including the social, economic (Affonso et al., 2020), political, and digital domains (Rozsa et al., 2017).

This article addresses this gap by proposing a functional typology of information visualization aligned with communicative purposes relevant to bibliotecology, information science, and knowledge mediation.

By linking visualization forms to functions, the study aims to support informed design choices in areas such as bibliometrics, digital libraries, scientific communication, and information literacy.

1.1 Background and Rationale

Given the broader contextual scenario in which visual media continues to gain prominence in society, this study is justified from the perspective that information visualization emerges as a response to the demands of tacit knowledge—particularly due to its capacity for rapid appropriation of elements and its ability to synthesize information into explanation (An et al., 2008). Its effectiveness often requires only a minimal level of prior knowledge for the representation to be meaningfully absorbed.

Another critical point is that we currently live in a society shaped by information visualization through human-computer interaction. This is supported by fields such as geographic information systems, operations research, data mining, machine learning, decision science, and cognitive science (Andrienko et al., 2007). Together, these domains bring information visualization to the forefront of society's attention as it faces the pressing informational challenges of the future—challenges that are already at our doorstep.

The entire process of visualization can be understood in three stages: (i) the past focuses on the analysis of patterns based on time, location, people, queries, interests, opportunities, schedules, choices, alerts, social networks, and shared priorities—these form the basic data for inference-making; (ii) the present evaluates the context of prioritized information by combining past data with current circumstances, relying on reliable data feeds, personalized filters, contextual adaptation on-demand, and analytical sensors for data/information flow according to specific priorities; (iii) the future engages predictive analysis by anticipating applicable scenarios, supporting decision-making, proposing new applications or tasks, and conducting information surveillance (Schilit & Theimer, 1994).

2. Theoretical Background

Following a defined order of presentation, this section aims to reference the context of the proposed objectives, focusing on the possibilities of visualization.

This proposal is structured around two contexts: the first concerns the intersections enabled by information visualization; the second focuses on its use in everyday reality.

2.1. Intersection of Information Visualization

Information visualization refers to the representation of information through graphical or visual means. Its primary purpose is to facilitate assimilation and understanding. It arises from the need to process large volumes of information (see Figure 1), assigning to the communicator the task of transforming abstract data into visible messages. The most common tools for the practical application of this representational technique include concept maps and network diagrams (Pinto et al., 2009).

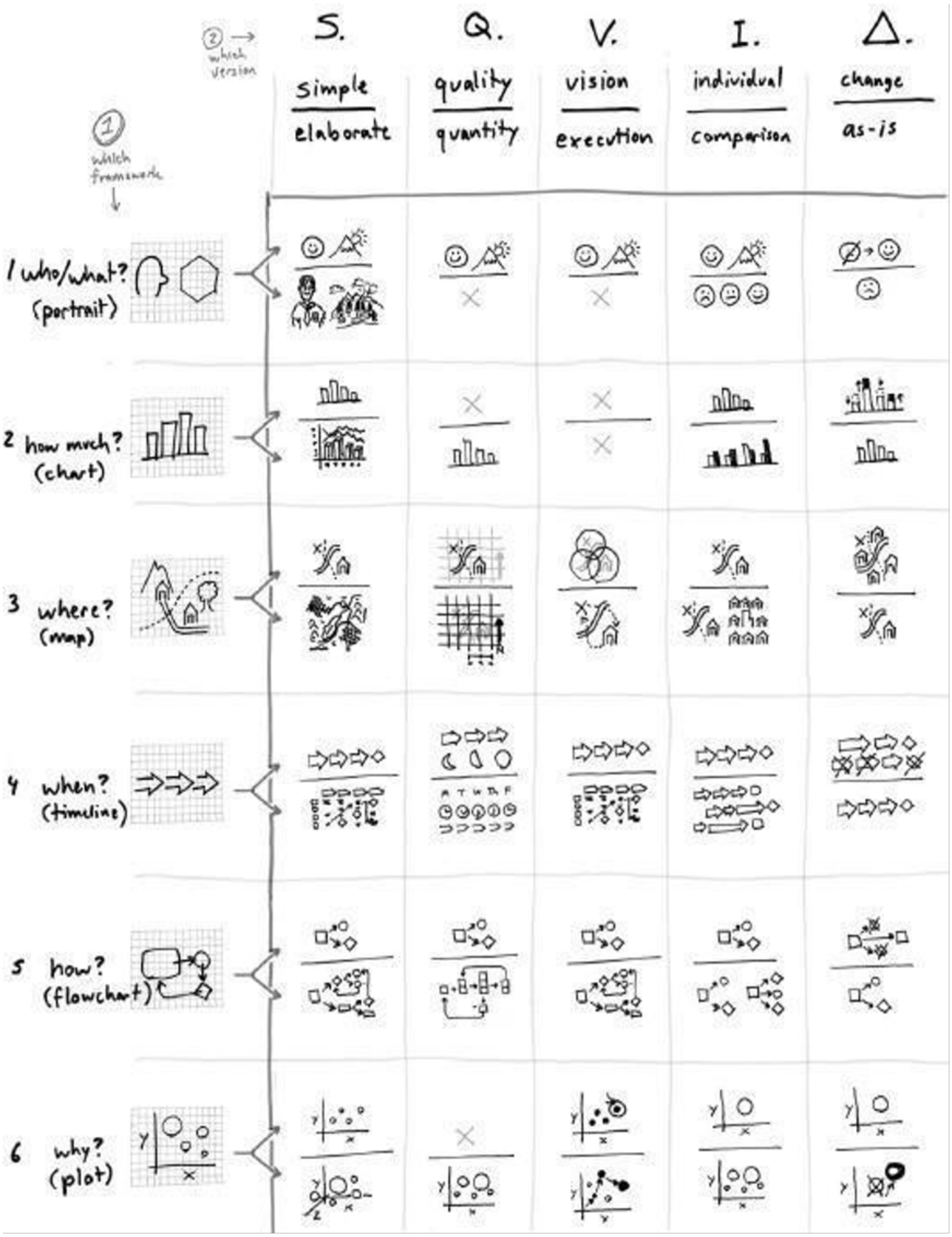

Figure 1. Illustration of information visualization options.
Source: Roam (2011).

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Information visualization is inherently interdisciplinary, encompassing areas such as computer graphics, geography, and information science. It holds considerable potential to enhance how large volumes of information are accessed, processed, and managed.

Accordingly, its role is to consolidate data into a unified environment, simplifying its analysis. Among the tools employed in this type of representation are science maps (Börner & Chen, 2002), concept maps, geographic maps, and digitized information.

According to Börner (2010), "[...] science maps have guided our quest for knowledge by enabling us to visualize scientific results, assisting in the navigation, understanding, and communication of changes in science and technology" (p. 8) (translated). Visual representations of the results of scientometric analyses constitute the field of scientography.

Aiming to support the development and interpretation of science maps, scientography serves as a tool for visualizing relationships and multiple perspectives within a scientific community. A scientogram can be developed through six stages: data collection, definition of the unit of analysis (authors, institutions, or keywords), selection of analytical measures, calculation of similarity between units (data correlation), reordering of analytical units, and graphical visualization for interpretation (Pinto et al., 2009).

Mapping the relationships within a scientific research field can be conducted through quantitative analysis of the occurrence of textual data or bibliographic records related to a given body of scientific production. Semantic mapping is typically based on co-occurrence matrices of terms.

This study also addresses key conceptual elements such as Open Access publishing, metadata, metric and visual information analysis, with emphasis on co-word analysis combined with information visualization methods applied to metadata in scientific publications (Pinto et al., 2010a). A science map is thus understood as a spatial representation of the relationships among disciplines, fields, specialties, articles, and/or authors, offering a depiction of the intellectual structure of a research area and facilitating information retrieval in large datasets (De Bellis, 2009).

The initial development of science maps was driven by information resource agencies that generated rich data and census-type collections, later adopted by research and educational institutions to support the consolidation of strategic information in scientific domains.

The representation of knowledge through concept maps is grounded in administrative tools, evolving from traditional organizational charts. These models offer greater specificity in their structure and are defined by labeled elements that function as simplified representations of generated knowledge (Novak, 1990).

Traditionally, concept maps have been used primarily as tools for individuals to demonstrate their understanding of a given topic. Early software-based implementations focused on mapping concepts by simulating the creation of synthetic maps, allowing for their reproduction from a model. This method became more appealing with the incorporation of features such as color, shape, and hyperlinks to indicate the origin of mapped concepts. However, it only became essential for knowledge representation when computational resources were integrated into its application (Cañas et al., 1994), particularly through web-based development tools adopted by scientific institutions. This process established a new role for concept maps—as tools for knowledge visualization—enabling their integration into the broader domain of information visualization.

This may be one of the most widely explored systems in the technical domain, particularly due to its ability to simplify everyday societal activities—ranging from GPS (Global Positioning System) and location maps to bus and subway route systems, as well as remote tracking of population behaviors (such as mobile phone usage by telecom providers, social media engagement, credit card transaction systems, or device activation integrated into government monitoring platforms—e.g., tourism control systems).

For appropriate representation, Geographic Information Systems (GIS) are used. These are programmed through software platforms that integrate data, hardware, and trained professionals to collect, store, retrieve, and manipulate spatial data, with the aim of enabling interactive visualizations (Maliene et al., 2011).

Academia has adopted this technique in response to applications that, according to Aronoff (1989), represent the basic functions of Geographic Information Systems. These include: classification and measurement, based on sets of graphical and alphanumeric information, enabling attribute-based operations; map overlay, a spatial analysis that combines data tables to identify shared characteristics; neighborhood analysis, which focuses on features within a specific area; and connectivity analysis, which integrates the previous functions to generate relational patterns based on similarity.

Printed information visualization has long been possible, at least since the emergence of portable written formats such as papyrus, parchment, and paper. However, the fragility of these media led to the adoption of more flexible supports, evolving into electronic, digital, and virtual models.

In this context, administrative and informational centers began to shift the format of their documents, digitizing sources and generating new data directly in digital form. This process received strong support from academic institutions, which served as the testing ground for many major digital infrastructure companies. Among these early adopters, Thomson Reuters stands out for its strategy of storing and consolidating information in proprietary repositories and acquiring datasets globally—contributing to the consolidation of a monopoly on scientific, journalistic, and innovation-related information.

Still, no initiative surpassed the scope of the Google Print project, launched in 2002, which was authorized to digitize books from prestigious American universities (Harvard, Stanford, University of Michigan, Oxford) and the New York Public Library. However, as Darnton (2011) points out, universities eventually intervened and began developing their own digital repositories, fearing that Google would appropriate and commercialize this knowledge.

Google's next step was to map the planet to expand its geospatial information resources, digitizing streets, cities, and even remote environments such as islands.

2.2. Use of Information Visualization Resources

As with usability, information visualization has emerged as a supporting resource across multiple fields of knowledge, without disciplinary restrictions.

When examining the evolution of information practices in the biological and biomedical sciences, it becomes evident that image- and graph-assisted experiences have become foundational pillars for clinical diagnostics (Oishi et al., 2009), particularly in the analysis of embryos, computed tomography, and emerging applications of computer-assisted X-ray imaging.

In computer science, the evolution of information visualization has extended beyond binary code representations, advancing into areas such as virtual reality, artificial intelligence, and the development of interactive resources—all aimed at producing more engaging, realistic, and cloud-based visualizations.

Another relevant dimension is the administrative application of visualization, particularly its capacity to represent uncertainty. Zuk and Carpendale (2006) propose a set of principles related to graphical system properties for dealing with this issue. These include: (i) graphical representations that reflect business priorities and highlight what should be perceived; (ii) the inclusion of clear and detailed information when necessary; (iii) the display of data variation; (iv) the use of time series for financial analysis and adjustment; (v) the appropriate scaling of dimensions for accurate data interpretation; and (vi) consistent contextualization of data within the core narrative. Only through adherence to such principles can graphical visualization in administration foster reliability.

Information visualization is also extensively explored in the field of geography, where this area fully leverages its potential—particularly for meteorological applications. Its usefulness includes the evaluation of variables such as temperature, geopotential height, wind vectors, magnitude lines, and streamlines, all of which are analyzed using planar structures (Dee, 2011). These scientific visualization techniques have been widely adopted by meteorological agencies around the world and are even applied to areas that previously received little attention,

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such as outdoor sports competitions—for instance, surfing, sailing, and regattas.

Numerous examples can be cited to demonstrate how information visualization has become both lasting and transformative, reshaping domains that were previously less visible. One of the fields that has most notably appropriated these resources is Information Science. The emphasis on visually rich, image-based representations has led to a shift away from static studies and attracted new scholars to the field—especially those who rely on computing technologies for research development.

In this context, metric studies of information have increasingly adopted graph-based approaches to represent scientific collections. In Information Science, this approach is known as mapping (White et al., 2004), encompassing analyses such as co-occurrence networks (Zhao & Chen, 2014) and citation networks (Pinto & González, 2014).

Another key application involves the analysis of social networks, which allows for the identification of relationships and knowledge flows among individuals and groups. A general methodology can be used to understand complex patterns of interaction, based on: (i) identifying actors who serve as network connectors—those with the highest number of direct relationships; (ii) identifying actors who act as structural bridges within the network, arbitrating the flow of information between nodes; and (iii) defining the intensity and nature of relationships established among actors (Gonzales et al., 2012; Pinto et al., 2023).

Information visualization can also be considered a set of methods, techniques, and tools that support the analysis of visual structures and relational aspects of images. Pinto et al. (2010b) developed an application for generating ontologies based on the representation of information through interactive imagery, structuring a hierarchical tree of terminologies and their associated power relations.

More recently, the use of graphical and image-based representations to enhance semantic web navigation has also gained traction in Information Science. Kbouchi et al., (2012) describe this type of resource as offering three modes for identifying interactive research pathways: through precision, connotation, and thematic representation. This approach, combined with the use of search systems based on new interaction paradigms, supports the semantic dimension of information spaces—whether via controlled vocabularies or folksonomies.

In concept map representation, it is also possible to visualize information through mental maps, conceptual diagrams, and visual metaphors. These frameworks can support logical reasoning, simplify complex ideas, and offer alternative perspectives that improve motivation, attention, and understanding. Such methods have already been tested in classroom settings and business meetings (Eppler, 2006).

Finally, scientific fields more broadly have made intensive use of tag clouds to customize content and search behaviors. These resources are routinely used to track engagement with blogs, websites, and user visits (bookmarking), as well as social media platforms—where frequency of use and interaction patterns are now linked to real-world practices (Ames & Naaman, 2007). Notable examples include their adoption in emergency response systems (e.g., fire departments) (Fausto et al., 2013) and in the scientific health domain (Burg & Pinto, 2014).

3. Methods

This study is based on the graphical representation of content commonly encountered in websites and systems. The study adopts a qualitative and theoretical-descriptive methodology grounded in Library and Information Science. The corpus consists of 60 visualization typologies (see Figure 2) drawn from the Data Visualization Catalogue by Severino Ribecca (n. d.). Each typology was analyzed in terms of structural properties, communicative affordances, limitations, and relevance for information environments such as digital libraries, bibliometric platforms, and scientific information systems.

Rather than pursuing empirical validation, the methodological focus lies on conceptual systematization. The typologies were reorganized into 16 functional categories corresponding to recurrent informational purposes (e.g., comparison, hierarchy, distribution, flow, and temporal analysis), consistent with LIS traditions of classification and mediation.

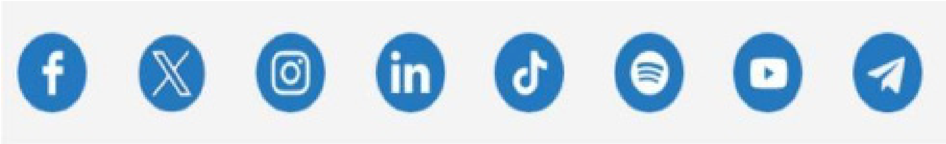

Figure 2. Model of social media icons according to the Data Visualization Catalog.
Source: Created by the author.

The focus of this study is to explore the forms of representation offered by the Data Visualization Catalog, making it possible to examine both the types and functions of these visual representations.

This serves as the foundation of the research and aims to identify how different forms—such as charts, plots, diagrams, tables, packaging, and maps—can be incorporated. Accordingly, the primary objective is to identify existing models, their applications and limitations, as well as their functions and groupings.

This is a theoretical study concerned with elucidating typologies ranging from the simplest to the most complex, along with their visual structures and associated functions.

4. Application of Information Visualization Typologies

As part of the results, this study presents 60 information visualization typologies, each accompanied by a definition, scope, and, in some cases, noted limitations. In addition, 16 functions are included, with the typologies explained in relation to their respective roles.

As a delimitation criterion for the 60 typologies, the model developed by Severino Ribecca (n. d.) was adopted.

4.1. Typologies of Representation

The typology of information visualization—or data visualization—is a technique that uses visual elements to represent complex, numerical, or large-scale data. Its purpose is to facilitate data comprehension, enabling decision-makers to identify patterns and complex concepts through visual representations.

This study aims to identify 60 forms of visualization, which are detailed in the following sections (see Figure 3).

1. Arc Diagram, an arc diagram is a method used to represent two-dimensional network diagrams. In this type of visualization, nodes are arranged along a single line (a one-dimensional axis), and arcs are used to illustrate the connections between those nodes. The thickness of each arc can represent the frequency of interaction between the source and target nodes. Arc diagrams are particularly useful for identifying co-occurrence within data. However, a known limitation is that they do not display network structure and node connectivity as effectively as traditional 2D graphs. Additionally, a high number of links can create visual clutter, making the diagram more difficult to interpret.

2. Area Chart, an area chart is a type of line-based visualization where the space below the line is filled with a specific color or texture. These charts are constructed by plotting data points on a Cartesian coordinate grid, connecting them with a line, and then filling the area beneath the completed line. Similar to line graphs, area charts are used to display the progression of quantitative values over time. They are most commonly applied to show trends rather than to convey exact values. Two popular variations include: stacked area charts and grouped (or overlapping) area charts. In the grouped version, all data series start from the same zero baseline. In the stacked version, each data series begins where the previous one ends, creating a cumulative visual effect.

3. Bar Chart, a bar chart uses horizontal or vertical bars (often called column charts when vertical) to display discrete numerical comparisons across categories. One axis of the chart shows the specific categories being compared, while the other represents a scale of discrete values. This type of visualization differs from histograms in that it does not represent continuous developments

Figure 3. Data and Information Visualization by Severino Ribecca (n. d.): Infographics

Source: The Data Visualisation Catalogue ([202-])

over an interval. Instead, the data in this model is categorical and typically answers the question "how many?" in each category.

4. Box-and-Whisker Plot, a box-and-whisker plot is a convenient way to visually display the distribution of data through its quartiles. The lines extending from the boxes—called "whiskers"—are used to indicate variability outside the upper and lower quartiles. Outliers are sometimes plotted as individual points aligned with the whiskers. This type of chart can be drawn either vertically or horizontally. Although box plots may seem more basic compared to histograms or density plots, they have the advantage of occupying less space, which is particularly useful when comparing distributions across multiple groups or datasets.

5. Brainstorming Diagram, a brainstorming diagram is used to map ideas, words, images, and associated concepts. It is also a tool and method for idea generation, finding associations, classifying ideas, organizing information, visualizing structures, and supporting study or planning processes. These diagrams are often employed in the early stages of a project and serve as a visual form of note-taking. They can also be helpful in collaborative work and team-building activities. The structure typically consists of major categories extending from a central node, with smaller categories branching off as subcategories—each of which may develop further into related subtopics.

6. Bubble Chart, a bubble chart is a multivariable representation that combines elements of a scatter plot with a proportional area chart. Like a scatter plot, it uses a Cartesian coordinate system to plot points along a grid, where the X and Y axes represent two distinct variables. However, unlike standard scatter plots, each point is assigned a label or category (displayed alongside or within a legend). Each plotted point also includes a third variable, represented by the area of its circle. Color may be used to differentiate categories or represent a fourth variable. Time can be depicted either by assigning it to one axis or by animating changes over time. Bubble charts are typically used to compare and show relationships between categorized circles using spatial position and proportional size. The overall layout supports the identification of patterns and correlations.

7. Bubble Map, a bubble map uses circles placed over a designated geographic region, with each circle's area proportional to its corresponding value in the dataset. This method is effective for comparing proportions across geographic areas without the distortion caused by differences in regional size, as is often the case with choropleth maps. However, a key limitation of this visualization type is that large bubbles can overlap with other bubbles or regions, which must be considered during interpretation.

8. Bullet Chart is commonly used to display performance data. It functions similarly to a bar chart but includes additional visual elements to provide contextual information. This type of chart was originally developed as an alternative to dashboard gauges and meters, which often lacked sufficient information, were inefficient in space usage, and cluttered with "chartjunk." In this chart, the primary data value is represented by the length of the central bar, known as the feature measure. A perpendicular line marker, called the comparative measure, indicates a target or benchmark to compare against the feature measure. If the main bar surpasses the comparative measure, it signals that the target has been met. Segmented background bars are used to display qualitative performance ranges. Each shade represents a category such as poor, average, or excellent performance. Ideally, no more than five performance ranges should be used to maintain clarity.

9. Calendar, a calendar is a visual tool used to display time periods and organize events. Time periods are typically divided into units such as days, weeks, months, and years. A date refers to a specific day within such a system. The most common calendar format is the Gregorian calendar, typically shown in monthly grids with seven columns (one for each day of the week) and five to six rows. However, the layout of a calendar is not fixed and may vary, as long as it visually represents the chronological sequence of dates or time units.

10. Candlestick Chart, also known as a Japanese candlestick chart, this chart is used in trading to visualize and analyze price movements over time for securities, derivatives, currencies, stocks, bonds, and commodities. Although candlestick symbols may resemble box plots, their function is distinct. Each candlestick displays multiple price indicators—opening price, closing

price, highest price, and lowest price—within a single visual symbol. Each candlestick represents trading activity for a specific time period (e.g., one minute, hour, day, month). The main rectangle is called the real body, indicating the range between the opening and closing prices. The lines extending from the top and bottom are known as the upper and lower shadows (or wicks), showing the highest and lowest traded prices during that period. When the closing price is higher than the opening (bullish), the real body is typically colored white or green. When the closing price is lower than the opening (bearish), it is usually black or red. Candlestick charts are effective for identifying and forecasting market trends and for interpreting market sentiment based on the color and shape of the candlesticks. For example, a long real body signals strong buying or selling pressure, while a short body suggests limited price movement and market consolidation.

11. Chord Diagram, a Chord Diagram is used to visualize interrelationships between entities. The connections between entities are used to show that they share something in common. This makes it ideal for comparing similarities within a dataset or between different groups of data. Nodes are arranged around a circle, with relationships between points connected using arcs or Bézier curves. Values are assigned to each connection and represented proportionally by the thickness of each arc. Color can be used to group data into categories, helping users compare and distinguish between groups. Excessive clutter can become a problem when too many connections are displayed.

12. Choropleth Map, a Choropleth Map is used to display geographic areas or divided regions that are colored, shaded, or patterned in relation to a data variable. This provides a way to visualize values across a geographic area, revealing variation or patterns throughout the displayed location. The data variable is represented using color progression for each region. Typically, this may involve a gradient from one color to another, a single hue scale, transparency levels, light to dark shades, or a full color spectrum. One disadvantage of using color is the inability to read or compare values precisely from the map. Another issue is that larger regions may appear more emphasized than smaller ones, which can distort the viewer's perception of the shaded values. A common error when producing choropleth maps is encoding raw data values (such as total population) instead of normalized values (e.g., population per square kilometer), which are essential for generating an accurate density map.

13. Circle Packing is a variation of the Treemap that uses circles instead of rectangles. The containment of each circle represents a level in the hierarchy: each tree branch is shown as a circle, and its sub-branches are represented as nested circles within it. The area of each circle can also be used to encode an additional arbitrary value, such as quantity or file size. Color may be used to assign categories or represent another variable through varying shades. Although visually appealing, this type of visualization is not as space-efficient as a Treemap, due to the empty areas between circles. Nevertheless, it often reveals the hierarchical structure more clearly than a Treemap.

14. Connection Map are drawn by linking geographic points using lines or curves. They are useful for showing spatial connections and relationships but can also be used to display travel or transportation routes through a sequence of links. These maps can reveal spatial patterns by illustrating the distribution and intensity of connections across a given area.

15. Density Plot, visualizes the distribution of data over a continuous interval or time period. It is a variation of the Histogram that uses kernel smoothing to plot values, creating a smoother distribution by reducing noise. The peaks of a Density Plot help to identify where values are concentrated. One advantage over Histograms is the improved ability to determine the overall distribution shape, as it is not affected by the number of bins used. For instance, a Histogram with only four bins may obscure the true distribution compared to one with twenty bins, while a Density Plot provides a clearer representation regardless of such constraints.

16. Donut Chart is essentially a Pie Chart with a central cutout. However, it offers a slight advantage over traditional Pie Charts, which are often criticized for emphasizing the relative sizes of segments rather than showing overall change. Donut Charts partially address this issue by de-emphasizing area, prompting the viewer to focus more on changes in total values. This makes

them a helpful alternative when comparing multiple charts over time or among categories.

17. Dot Map, this method involves detecting spatial patterns or the distribution of data across a geographic region by placing equally sized dots on a designated map area. There are two types of Dot Maps: (1) one-to-one (one dot represents a single count or object), and (2) one-to-many (one dot represents a specific unit, e.g., 1 dot = 10 trees). This visualization is ideal for identifying how items are distributed geographically and for revealing clusters. They are easy to understand and useful for general overviews, though not precise for retrieving exact values.

18. Dot Matrix Chart: Displays discrete data through a series of organized dots, each colored to represent a specific category and grouped into a matrix. They are used for quick overviews of distribution and category proportions in a dataset. Dot matrix charts also compare category distribution and proportions across multiple datasets to uncover patterns. When using a single category where all dots are the same color, the chart mainly highlights proportions.

19. Error Bars: While not a standalone chart, error bars function as a graphical enhancement to visualize data variability in Cartesian plots. They can be applied to scatter plots, dot plots, bar charts, or line graphs, adding an extra layer of detail. Error bars indicate estimated error or uncertainty to convey measurement precision. Typically, they represent standard deviation, standard error, confidence intervals, or minimum/maximum values, using markers overlaid on the original chart.

20 Flowchart: Also known as a Process Flow Diagram, Workflow Diagram, or Process Map, this visual tool represents the sequential steps in a process. Flowcharts map out processes using a series of connected symbols, simplifying understanding and communication. Useful for explaining procedures, systems, abstract concepts, or complex algorithms, they assist in planning, developing, or improving processes. Flowcharts can be laid out horizontally or vertically.

21. Flow Map: Geographically displays the movement of information or objects from one location to another and their quantity. Commonly used to show migration data (people, animals, products), the flow's magnitude is represented by line thickness. These maps depict migration distribution geographically and are drawn from an origin point with branching "flow lines." Arrows can indicate direction or inflow/outflow, and unidirectional lines can show trade exchanges. Merging or grouping flow lines and avoiding overlaps helps minimize visual clutter.

22. Gantt Chart is commonly used as an organizational tool for project management; it displays a list of activities (or tasks) along with their durations over time, indicating when each task starts and ends. This makes Gantt Charts useful for planning and estimating the overall timeline of a project. It also allows identification of which tasks run in parallel. The chart is structured as a table: rows represent activities, and columns serve as the time scale. The duration of each activity is shown as a bar drawn along the timeline. The bar's starting point marks the activity's start, while the end point indicates its expected completion. Color coding can be used to group activities into categories. To indicate task completion status, a bar can be partially filled, shaded differently, or colored separately to distinguish between completed and remaining work. Connecting arrows can be used to show dependencies between tasks. Critical paths—key activities required for project completion—may also be highlighted with a sequence of emphasized arrows.

23. Heatmaps, they visualize data through variations in color. When applied to a tabular format, they are useful for examining multivariate data by placing variables in rows and columns and coloring the cells within the table. They are effective for showing variance across multiple variables, revealing patterns, identifying similarities among variables, and detecting potential correlations. Typically, all rows represent one category (with labels displayed on the left or right), and all columns represent another (with labels on the top or bottom). Individual rows and columns are divided into subcategories that correspond to one another in a matrix. Cells represent the intersections between rows and columns and may contain categorical or numerical data. As this visualization relies on color to convey values, it is better suited for providing a generalized overview of numerical data, since it can be difficult to distinguish color tones precisely or extract specific data points. However, this

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limitation can be mitigated by displaying data values directly inside the cells.

24. Histogram, a histogram visualizes the distribution of data across a continuous range. Each bar in a histogram represents the tabulated frequency within a given interval. Histograms help estimate where values are concentrated, identify extremes, and highlight any gaps or outliers. They are also useful for providing a rough overview of a probability distribution.

25. Illustration Diagram: is a type of graphic that displays an image—or multiple images—accompanied by notes, labels, or a legend to explain concepts or methods; describe objects or locations; show how things work, move, or change; and provide additional information about the displayed subject. Images may be symbolic, pictorial, or realistic. Enlargements and cross-sections are sometimes used for more in-depth analysis or to show additional details.

26. Kagi Chart, this chart is used to display the overall levels of supply and demand for a specific asset by visualizing price movements through a series of line patterns. These charts are time-independent and help filter out the noise that may occur in other financial charts (such as candlestick charts), allowing key price movements to be displayed more clearly. Recognizing recurring patterns in Kagi Charts is essential for interpreting them. Although Kagi Charts display dates or times on the X-axis, these are actually markers for key price actions and not part of a continuous time scale. The Y-axis is used as the value scale. The line initially moves vertically in the direction of the price movement and continues to extend as long as the price, however slightly, maintains its direction. Once the price reaches a predefined "reversal" value, the line curves in a U-shape and moves in the opposite direction. Each small horizontal line on the chart indicates where a price reversal occurred. When a horizontal line connects an upward line to a downward one, it is known as a "shoulder," whereas a line connecting a downward to an upward line is referred to as a "waist."

27. Line Chart, used to display quantitative values over a continuous range or time period. It is commonly used to show trends and analyze how data has changed over time. The chart is drawn by first plotting data points on a Cartesian grid and then connecting them with a continuous line. Typically, the Y-axis represents a quantitative value, while the X-axis represents a time scale or sequence of intervals. Negative values can be shown below the X-axis. The direction of the line indicates change: an upward slope shows increasing values, while a downward slope shows decreasing values. The path of the line across the chart may create patterns that reveal trends within a dataset.

28. Marimekko Chart this one is used to visualize categorical data across a pair of variables. In this chart, both axes represent variables on a percentage scale, which determines the width and height of each segment. As such, Marimekko Charts function like a type of bidirectional 100% stacked bar chart. This makes it possible to detect relationships between categories and their subcategories along both axes. The main limitations of Marimekko Charts are that they can be hard to read—especially when there are many segments—and that it is difficult to make accurate comparisons between segments, since they are not aligned along a common baseline.

29. Grouped Bar Chart a variation of a bar chart that is used when two or more data series need to be plotted along the same axis and grouped into category matrices. As with standard bar charts, the length of each bar in a grouped bar chart is used to show discrete numerical comparisons between categories. Each data series is assigned a distinct color. Bars belonging to the same group are placed next to one another, with spacing between groups. This format is ideal for comparing categories that contain the same subcategory variables. Each bar represents a subcategory grouped under a larger matrix category. Grouped bar charts can also be used to compare mini-histograms, with each bar representing meaningful intervals of a variable, or to display time-series data variations across categories.

30. Network Graph, a type of visualization that shows how things are interconnected using nodes and connecting lines (edges) to represent relationships and clarify the type of connection between a group of entities. Typically, nodes are drawn as small points or circles, though icons may also be used. The links are usually displayed as straight lines between nodes. However, not all nodes and links are equal: additional variables can be visualized—for example, by scaling node size or link thickness

proportionally to an assigned value. When mapping connected systems, this model helps interpret the structure of a network by revealing clustering of nodes, connection density, or how the overall layout is arranged. There are two main types: undirected (showing only connections between entities) and directed (indicating unidirectional or bidirectional links using small arrows).

31. Nightingale Rose Chart, these Charts are drawn on a polar coordinate grid. Each category or interval in the data is divided into equal segments around the radial chart. The distance that each segment extends from the center of the polar axis corresponds to the value it represents. Thus, each ring radiating from the chart's center acts as a scale for plotting segment size and indicating larger values. A key limitation of Nightingale Rose Charts is that outer segments are visually emphasized due to their larger surface area, which can disproportionately represent value increases.

32. Chord Diagram without Ribbons a Chord Diagram without Ribbons is a simplified version of a traditional Chord Diagram, displaying only the nodes and connecting lines. This model shifts the emphasis toward the connections within the data rather than the proportional representation of flows.

33. Open-High-Low-Close Chart, or "OHLC" is a financial trading tool used to visualize and analyze price changes over time for securities, currencies, stocks, commodities, and more. These charts are useful for interpreting daily market sentiment and forecasting potential price shifts based on emerging patterns. The Y-axis represents the price scale, while the X-axis displays time. For each time interval, the chart plots a symbol that captures two ranges: the high and low prices traded, and the opening and closing prices for that period. The vertical line represents the high–low price range. Tick marks on the left indicate the opening price, while those on the right indicate the closing price.

34. Parallel Coordinates Chart, used to plot multivariate numerical data. Parallel coordinates charts are ideal for comparing many variables together and observing relationships among them. They are useful for comparing a matrix of products sharing the same attributes (e.g., computer or car specifications across different models). In this model, each variable is assigned an axis, and all axes are placed parallel to each other. Each axis can have a different scale (depending on the variable's unit of measurement), or all axes can be normalized to keep scales uniform. Data values are plotted as a series of lines connected across all axes. This means each line is a collection of points on each axis, all joined together. The drawback of this type of chart is that it can become very cluttered and therefore unreadable when too much data is included. The best way to address this issue is through interactivity and a technique known as brushing, which highlights a selected line or collection of lines while fading all others. This allows users to isolate and explore sections of interest while filtering out noise.

35. Parallel Sets, similar to Sankey Diagrams in how they display flow and proportions. However, Parallel Sets do not use arrows and instead divide the flow path at each set of displayed lines. Each set of lines corresponds to a dimension, and its values and categories are represented within the segments along that set. The width of each line and the flow path derived from it are determined by the proportional share of the total in that category. Each flow path can be color-coded to visualize and compare distribution across different categories.

36. Pictogram Chart, uses icons to provide a more engaging overview of small discrete datasets. Icons typically represent the subject or category of the data—e.g., population data would use human figures. Each icon can represent a single unit or a specific number of units (e.g., one icon equals ten items). Datasets are displayed side by side in columns or rows of icons, allowing for visual comparisons between categories. The use of icons can sometimes help overcome language, cultural, and educational differences, and also offers a more representative, memorable view of the data.

37. Pie Chart Widely, used in presentations and office settings to show proportions and percentages among categories by dividing a circle into proportional slices. Each arc length represents a share of the category, while the full circle represents the total sum of the data. Pie charts are ideal for giving a quick idea of the proportional distribution of values. However, their main disadvantages include: (1) they cannot display more than a few values effectively, as each segment becomes too small and harder to distinguish; (2) they are space-inefficient, often requiring additional legends; and (3) they are poor

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at supporting accurate comparisons across multiple pie charts, as judging by area is harder than by length.

38. Point and Figure Chart, used to display the relationship between supply and demand of a specific asset through a series of X and O columns. Point and figure charts are time-independent and focus on filtered price actions. They do not plot trading volume and are primarily used to identify "breakouts" in the supply-demand relationship. These charts also help identify support and resistance levels, and potential trendlines. While they may display time markers on the X-axis, these simply indicate the date of key price movements and are not part of a time scale. The Y-axis is used as the value scale. Xs represent rising prices (demand exceeds supply), and Os represent falling prices (supply exceeds demand). Before drawing a point and figure chart, box size and reversal value must be defined. You must also decide whether to track daily close, highs, or lows, depending on the direction of the previous column. The box size determines the minimum price change required to draw a new X or O, and the reversal value dictates how sensitive the chart is—lower reversal values produce more detailed charts, while higher values filter out insignificant fluctuations.

39. Population Pyramid, a pair of back-to-back histograms (for each sex) that display the distribution of a population by age group and gender. The X-axis represents population size, while the Y-axis lists all age brackets. This visualization type is ideal for identifying demographic patterns and changes. Multiple population pyramids can be used to compare trends between nations or selected population groups. The shape of a population pyramid can help interpret current population dynamics and project future demographic developments.

40. Proportional Area Chart, ideal for comparing values and showing proportions (in size or quantity) to provide a quick overview of relative data sizes without using explicit scales. Typically uses squares or circles, though any shape can be used as long as its area represents the data. A common mistake is sizing the shape based on height or width rather than area, which can cause exponential distortions. Instead, the area must be calculated to accurately reflect data magnitude. Because estimating values precisely is difficult with area-based visuals, they are more suitable for presentations than for analytical tasks.

41. Radar Chart, a type of chart used to compare multiple quantitative variables. It is useful for identifying variables with similar values or spotting outliers among them. Radar charts are also effective for showing which variables score high or low within a dataset, making them suitable for performance visualization. Each variable is assigned an axis radiating outward from a central point. All axes are arranged evenly in a circular layout, maintaining the same scale across axes. Gridlines connecting axis points are often used as guides. Each variable value is plotted along its respective axis, and all values in a dataset are connected to form a polygon. Disadvantages include: (1) displaying multiple polygons (one per data series) can make the chart hard to read, especially if the polygons are filled, as the uppermost shape may obscure others underneath. Transparency may help, but excessive polygons still lead to cluttered visuals; (2) using many variables results in numerous axes, which also reduces readability and adds complexity; (3) this chart type is not appropriate for making precise comparisons of values across variables.

42. Radial Bar Chart, essentially a bar chart plotted on a polar coordinate system instead of a Cartesian one. A key issue with radial bar charts is the misleading length of bars: each outer bar appears disproportionately longer than the previous one, even if representing the same value. This happens because each bar extends along a different radius. Despite this distortion, the chart has strong aesthetic appeal and is often used in design-focused contexts or data storytelling.

43. Radial Column Chart, this chart type plots bars on a polar coordinate system. Concentric circles are used as the value scale, while radial dividers (lines extending from the center) are used to plot each category. Typically, lower values on the scale start at the center and increase with each outward circle. Bars are drawn outward from the center based on this concentric circle value scale. Negative values can also be displayed by setting zero at an outer (rather than central) circle and using all inner circles for negative values.

44. Sankey Diagram, used to display flows and their quantities in proportion to one another. Commonly employed to visually represent the transfer of energy, money, materials, or any isolated system or process flow. The thickness of arrows or flow lines indicates magni-

tude or volume. Arrows can merge or split at various stages of the process. Color can be applied to segment the diagram into different categories or to illustrate transitions between process states.

45. Scatter Plot, plots points on a Cartesian coordinate system to show the relationship between two variables. Each axis represents one variable, allowing for detection of relationships or correlations. Correlation types may be: positive (both values increase together), negative (one value decreases as the other increases), or none (no pattern). The pattern's shape may be linear, exponential, or U-shaped. Correlation strength is seen by how tightly points cluster. Outliers are points that deviate markedly from the general distribution. Lines or curves—commonly known as Lines of Best Fit or Trend Lines—may be added to help analysis and interpolation. This chart type is ideal when dealing with paired numerical data to assess whether one variable affects the other.

46. Range Plot, used to display the range between minimum and maximum values of datasets. This model is ideal for comparing ranges, usually between categories. Note that range plots focus solely on the extremes and do not convey information about data points between the minimum and maximum, such as averages or distribution.

47. Spiral Plot, plots time-based data along an Archimedean spiral. The chart starts at the center and progresses outward. It is a versatile model capable of plotting bars, lines, or points along the spiral path. Spiral plots are ideal for visualizing large datasets and identifying long-term trends, especially for highlighting periodic patterns. Color may be used to distinguish periods and facilitate comparison between them.

48. Stacked Area Chart, functions similarly to a standard area chart but displays multiple data series stacked on top of each other. Each series starts from the value left by the previous one. The entire chart represents the total of all plotted data. Like simple area charts, stacked area charts use filled space to convey whole numbers and are not suitable for negative values. They are particularly effective for comparing multiple variables that change over time.

49. Stacked Bar Chart, this model segments bars one on top of another. It is used to show how a larger category is divided into smaller subcategories and the relationship of each part to the overall total. There are two types: (1) Simple Stacked Bar Charts, which place each segment value after the previous one. The total bar value is the sum of all segment values. These are ideal for comparing the total values of segmented bars; (2) 100% Stacked Bar Charts, which plot the percentage of each value relative to the total within each group. This makes it easier to see the relative differences among quantities in each group. A drawback of this model is that it becomes harder to read as each bar includes more segments. Moreover, comparing segments across bars is difficult because they lack a common baseline.

50. Stem-and-Leaf Plot, this model organizes data by positional value to show data distribution. Positional values are typically listed in ascending order down a "stem" column, usually in tens, though not exclusively. The data for each position is then listed horizontally as "leaves" extending from the stem. This chart is useful for identifying outliers and determining the mode. Since it displays (mostly) raw data, it serves well as a quick reference tool—for example, in public transit schedules. However, this model is limited in terms of dataset size it can accommodate.

51. Streamgraph, a variation of the stacked area chart, except that instead of plotting values along a fixed straight axis, it offsets them around a variable central baseline. The model shows how data changes over time across different categories, using organic and fluid shapes that resemble a flowing river. It is ideal for displaying high-volume datasets to uncover evolving trends and patterns across diverse categories. The main drawback is readability—streamgraphs tend to become messy and cluttered with large datasets. Smaller-value categories are often visually suppressed by larger ones, making full interpretation difficult.

52. Sunburst Diagram, this hierarchical visualization presents data through a series of rings, each sliced to represent category nodes. Each ring corresponds to a level in the hierarchy, with the center circle representing the root node and the hierarchy radiating outward. Slices are divided based on their hierarchical relationship with the parent node. Slice angles may be evenly distributed un-

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der the parent node or scaled proportionally to a given value. Color can be used to highlight hierarchical groupings or specific categories.

53. Tally Chart, a chart used to record and graphically display the frequency of data distribution using tally marks. In building a tally chart, categories, values, or intervals are listed along one axis or column (typically the Y-axis or the first left-hand column). Each occurrence of a value is marked as a tally in the appropriate column or row. Once all data is collected, tally marks are counted and totals are shown in the next column or row. The end result resembles a histogram.

54. Timeline, a graphical way to display a list of events in chronological order. Some timelines use a time scale, while others show sequences without one. The main function is to convey time-related information, either for analysis or for visually presenting a story or historical overview. If scale-based, it allows viewers to see when events occur or are expected to occur, enabling assessment of time intervals between them. It also helps identify patterns within a selected time period and shows how events are distributed across that period.

55. Timetables, they are used as a reference and management tool for scheduled events, tasks, or actions. Organizing data into a table in chronological and/or alphabetical order helps users quickly locate information. Timetables are commonly used to display the arrival and departure times of trains and other means of transportation.

56. Tree Diagram, a visual method to represent hierarchy within a structure resembling a tree. Typically, the structure consists of elements such as a root node, which has no superior. From there, nodes are connected by lines called branches, representing relationships and connections between members. Finally, leaf nodes (or terminal nodes) are members with no further sub-hierarchy.

57. Treemap, provides an alternative way to visualize hierarchical structures while displaying quantitative values for each category based on area size. Each category is assigned a rectangular area, with nested rectangles representing subcategories. When a quantitative value is assigned to a category, its area is proportional to that value and relative to other categories within the same parent category in a part-to-whole relationship. The parent category area represents the total of its subcategories. If no quantity is assigned to a subcategory, its area is evenly divided among sibling subcategories. A disadvantage of this model is that it does not display hierarchical levels as clearly as other hierarchical visualizations.

58. Venn Diagram, visually displays all possible logical relationships between a set of groups. Each group is typically represented by a circle. Inside each group is a collection of objects or entities that share a common characteristic. Overlapping areas between groups are known as intersections, where entities possess all the characteristics of the overlapping sets.

59. Violin Plot, this is used to visualize data distribution and probability density. It combines a box plot and a density plot, mirrored and placed on each side to show the distribution shape. The white dot in the center represents the median value, the thick black bar in the center shows the interquartile range, and the thin black line extending from it represents the upper (max) and lower (min) adjacent values in the dataset. In some cases, the ends of this line are truncated.

60. Word Cloud, a visualization method that displays word frequency within a given body of text by making each word's size proportional to its frequency. All words are arranged into a cluster or "cloud." Alternatively, words can be arranged in various formats: horizontal lines, columns, or shaped forms. They can also be used to display words with associated metadata. Color generally serves an aesthetic purpose but may be used to categorize words or represent another data variable. Word clouds are commonly used on websites or blogs to display keyword frequency or tags. They can also compare two different text bodies. Despite being simple and easy to understand, word clouds have significant limitations: longer words tend to be overemphasized compared to shorter ones, and letters with many ascenders or descenders attract more visual attention. Additionally, word clouds lack precision for analytical purposes and are primarily used for aesthetic reasons.

4.2 Functionality of Visualization Types

The functions are: (1) comparisons; (2) proportions; (3) relationships; (4) hierarchy; (5) concepts; (6) location; (7) part-to-whole; (8) distribution; (9) how things work; (10) processes and methods; (11) movement or flow; (12) patterns; (13) range; (14) data over time; (15) text analysis; and (16) reference tool (see Figure 4).

Breaking down each of these functions there are typologies, which we will try to present, both with and without axis.

(1) Comparisons: This function aims to highlight differences or similarities between represented values. It can be performed using axes, as seen in Bar Charts, Box-and-Whisker Plots, Bubble Charts, Bullet Graphs, Line Charts, Marimekko Charts, Grouped Bar Charts, Nightingale Rose Charts, Parallel Coordinates Charts, Population Pyramids, Radar Charts, Radial Bar Charts, Radial Column Charts, Range Charts, Stacked Area Charts, and Stacked Bar Charts. It can also be performed without axes, as seen in Chord Diagrams, Choropleth Maps, Donut Charts, Dot Matrix Charts, Heat Maps, Parallel Sets, Pictogram Charts, Pie Charts, Proportional Area Charts, Tally Charts, Tree Maps, and Venn Diagrams.

(2) Proportions: These visualizations use size or area to represent differences or similarities between values or parts of a whole. Proportions between values can be found in Bubble Charts, Bubble Maps, Circle Packing, Dot Matrix Charts, Nightingale Rose Charts, Proportional Area Charts, Stacked Bar Charts, and Word Clouds. Proportions in part-to-whole relationships appear in Donut Charts, Marimekko Charts, Parallel Sets, Pie Charts, Sankey Diagrams, Stacked Bar Charts, and Tree Maps.

(3) Relationships: These visualizations illustrate connections between data points or correlations between two or more variables. They may reveal connections, as in Arc Diagrams, Mind Maps, Chord Diagrams, Connection Maps, Network Diagrams, Simplified Chord Diagrams, and Tree Diagrams; correlations, as in Bubble Charts, Heat Maps, and Scatterplots; or complex relationships between multiple variables, as seen in Heat Maps, Marimekko Charts, Parallel Coordinates Charts, Radar Charts, and Venn Diagrams.

(4) Hierarchy: This function shows how data or objects are classified and organized within a system. Common examples include Circle Packing, Sunburst Diagrams, Tree Diagrams, and Tree Maps.

(5) Concepts: This function supports explaining ideas, concepts, or abstract structures, and is represented by Mind Maps, Flowcharts, Illustration Diagrams, and Venn Diagrams.

(6) Location: This function displays geographic data distributions using visualizations such as Bubble Maps, Choropleth Maps, Connection Maps, Dot Maps, and Flow Maps.

(7) Part-to-whole: This function shows how a part relates to the whole of a variable, useful for illustrating category breakdowns, with examples including Donut Charts, Marimekko Charts, Pie Charts, Stacked Bar Charts, Sunburst Diagrams, and Tree Maps.

Figure 4. Information Visualization Functions.
Source: The Data Visualisation Catalogue ([202-])

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(8) Distribution: This is one of the most varied visualization types, showing frequency and distribution within an interval or grouping, as in Box-and-Whisker Plots, Bubble Charts, Density Plots, Dot Matrix Charts, Histograms, Grouped Bar Charts, Parallel Sets, Pictogram Charts, Stem-and-Leaf Plots, Tally Charts, Timelines, and Violin Plots. Geographic distributions are shown with Dot Maps, Connection Maps, and Flow Maps. Population distribution by age and gender is represented by Population Pyramids, and text distributions are visualized using Word Clouds.

(9) How things work: These visualizations illustrate the functioning of an object, system, or process, including Flowcharts, Illustration Diagrams, and Sankey Diagrams.

(10) Processes and methods: These help explain workflows, processes, or procedures and are commonly seen in Flowcharts, Gantt Charts, Illustration Diagrams, Parallel Sets, and Sankey Diagrams.

(11) Movement or flow: This function visualizes the movement or transfer of objects or data, illustrated by Connection Maps, Flow Maps, Parallel Sets, and Sankey Diagrams.

(12) Patterns: One of the most diverse functions, pattern visualizations reveal meaningful structures or trends in data. They include Arc Diagrams, Area Charts, Bar Charts, Box-and-Whisker Plots, Bubble Charts, Candlestick Charts, Choropleth Maps, Connection Maps, Density Plots, Dot Maps, Dot Matrix Charts, Heat Maps, Histograms, Kagi Charts, Line Charts, Grouped Bar Charts, OHLC Charts, Parallel Coordinates Charts, Point-and-Figure Charts, Population Pyramids, Radar Charts, Scatterplots, Spiral Plots, Stacked Area Charts, Streamgraphs, Timelines, and Violin Plots.

(13) Range: Shows variations between upper and lower limits along a scale, represented by Box-and-Whisker Plots, Bullet Graphs, Candlestick Charts, Error Bars, Gantt Charts, Kagi Charts, OHLC Charts, Range Charts, and Violin Plots.

(14) Data over time: These visualizations illustrate information across chronological periods to show trends or changes, as in Area Charts, Bubble Charts, Candlestick Charts, Gantt Charts, Heat Maps, Line Charts, Nightingale Rose Charts, OHLC Charts, Spiral Plots, Stacked Area Charts, and Streamgraphs. They can also display event sequences, as in Calendars, Timelines, and Schedules.

(15) Text analysis: This function reveals patterns or insights within textual data, typically using Word Clouds.

(16) Reference tool: This function provides quick reference for individual data points. Time and date references use Calendars, Gantt Charts, and Schedules; hierarchical or organizational references use Tree Diagrams; and individual data values use Stem-and-Leaf Plots.

4.3 Visualization, Artificial Intelligence, and Library and Information Science (LIS)

The integration of artificial intelligence (AI) into information systems has significantly expanded the analytical and communicative potential of information visualization within Library and Information Science. In AI-supported environments, visualization functions not as a static representational layer but as an adaptive mediation mechanism embedded throughout the information lifecycle.

The visualization catalogue proposed in this study can be understood as a functional knowledge base capable of supporting AI-assisted visualization processes. By aligning data structures with communicative purposes, AI systems may leverage the catalogue to recommend visualization types based on semantic characteristics rather than aesthetic preference.

Although theoretical in nature, the model is transferable to empirical applications and supports both AI-assisted automation and critical mediation. By aligning visualization forms with communicative functions, this work advances a reflective and responsible use of visualization in contemporary information practices.

5. Final Considerations

The purpose of this study is to provide a structured guide to existing types of data and information visualizations and their respective functionalities. Other possible forms of visualization may not have been included in this compilation and could be appropriate for future approaches aimed at explaining this phenomenon in greater depth. Some of the typologies presented may be known by alternative names with equivalent conceptual meaning. In this context, terminology was intentionally consolidated using more popular and linguistically accessible terms within the Portuguese language.

This study contributes to Library and Information Science by reframing information visualization as a functional and epistemological device rather than a purely technical solution. The proposed mapping of 60 visualization typologies into 16 functional categories provides a conceptual scaffold for informed design decisions in digital libraries, bibliometric dashboards, institutional repositories, and open science infrastructures.

Although theoretical in nature, the model is transferable to empirical applications and supports both AI-assisted automation and critical mediation. By aligning visualization forms with communicative functions, this work advances a reflective and responsible use of visualization in contemporary information practices.

The central objective — to explore visualization typologies and their functionalities in a simplified and accessible format — has been addressed through the categorization of their practical applications. The presented content aligns with the needs of disciplines dedicated to information visualization. The diversity of data and information visualization techniques represents a field in continuous development, driven by contemporary demands and the growing need for innovative solutions capable of translating complex datasets into visual outputs such as images, videos, and illustrations.

The interpretability of information is directly enhanced by information design, particularly through the appropriate selection of visualization typology and its functional purpose. Structuring data in an intelligible manner reduces complexity and highlights relevant patterns, contributing to faster, more precise, and evidence-based decision-making. As demonstrated throughout this study, different forms of representation offer specific advantages, promoting more efficient and context-aware data processing, especially in environments that demand the analysis of large information volumes. Beyond improving accessibility, information design supports data comprehension and facilitates strategic decisions. In this context, usability emerges as a fundamental element for maximizing the impact of information in decision-making processes.

This paper is intended to serve as a technical reference, providing clarity regarding the most suitable type of visualization for each scenario within visual communication, data analysis, or decision-support activities.

Beyond its technical contribution, this study may also contribute to more reflective and informed decision-making involving information visualization in contemporary information practices.

Declaration of AI Use

The authors declare that generative artificial intelligence (AI) tools were used during the preparation of this manuscript exclusively to support language-related tasks, including improving clarity, grammar, and academic style, as well as assisting with the translation of selected sections. AI tools were not used to generate original scientific content, design the conceptual framework, perform analysis, interpret results, or draw conclusions. All content was reviewed, verified, and edited by the authors, who assume full responsibility for the accuracy, integrity, and originality of the manuscript.

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