Quantitative Approach for Assessing Infographics in Atlas Cartography

Jakub KONÍČEK, Vít VOŽENÍLEK, Radek BARVÍŘ, Alena VONDRÁKOVÁ

Abstract: *Infographics have become a widely utilized concept in contemporary cartography for visualizing a wide range of data. Despite this, there is a lack of comprehensive scholarly studies addressing the theory of infographics, and cartographers have not yet established a precise definition or unified classification for them. Consequently, cartographic production lacks clear rules and methodologies for systematically incorporating infographic elements. This paper introduces a systematic approach for precisely quantifying and evaluating static cartographic products from the domain of atlas cartography with a focus on their infographic style. The proposed methodology was validated through practical assessments of map samples from various atlases, which were compared with samples of infographics. Case studies analysed input patterns related to spatial components, visualization attributes, and additional design elements. Four indicators—area coverage, graphic load, visual attractiveness, and colourfulness—were defined and quantified by using of GIMP graphic software and recalculated through predefined mathematical formulas. The resulting values provide a quantitative description of tested images in terms of their infographic style. This innovative methodological approach contributes to the unification of contemporary approaches for defining and assessing infographics in maps, atlases, and broader cartographic production.*

Keywords: *infographics, atlases, evaluation, methodology, concept, cartography*

Introduction

In the contemporary era, the rapid expansion of modern information technologies and the Internet has become a pervasive influence on daily life. As of early 2023, approximately 5.16 billion people globally, accounting for 64.4% of the world's population, were Internet users, marking an increase of nearly 98 million users in one year (Datareportal 2023).

The Global Internet Survey (2021) by GWI revealed that 61% of working-age respondents primarily use the Internet for information seeking, with communication with family (55.2%) and searching for news (53.1%) following closely. The escalating number of users corresponds to an increase in the volume of presented information. Krum (2013) indicated that the daily data amount in 1980 equated to 44 newspapers with 85 pages, and this has quadrupled since. Presently, IP traffic, denoting data flow across the Internet, has become a significant metric in Internet technology (HG Insights 2023).

The surge in available information has led to a growing proportion serving as a source for end-users. The heightened interest in information search and the expanding social network user base emphasize the need for effective presentation, particularly in visually appealing graphical formats. The idea that people comprehend information more quickly when expressed graphically dates back to the 18th century, as demonstrated by Playfair's use of graphs for economic data. Experts like Tufte (2001), Lancaster (2008), and Wright (2014) assert that the human brain processes visual information more effectively than other forms.

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The trend of presenting large amounts of interconnected information is deeply rooted in cartography, where various methods, including textual descriptions, tables, graphs, charts, diagrams, and maps, are actively implemented. Infographics, a term commonly associated with information presentation, lacks a precise definition, leading to terminological vagueness (Popelka, Voženílek 2013, Voženílek, Vondráková 2018).

Despite disparate interpretations, infographics are not objects of research but rather tools for data presentation than evaluation of term itself. This paper seeks to redefine infographics through a quantitative evaluation of chosen map layouts in atlas production, introducing an original infographic evaluation method and delineating the role of infographics in mapmaking.

State of art

The definition of infographics remains a nuanced and evolving subject, marked by diverse interpretations across disciplines such as data visualization, graphic design, and cartography. According to Smiciklas (2012), infographics serve as a tool to visualize data, simplifying complex information for enhanced comprehension. The research underscores the cognitive efficiency of graphical representations, with studies by Cleveland (1994) and Koponen and Hildén (2019) indicating the human brain's adeptness in processing visual data.

Esteemed experts, including Card et al. (1999), Tufte (2001), Heller and Holmes (2006), categorize infographics as explanatory graphics, encompassing various graphical elements to convey intricate information (Newson and Haynes 2005). However, terminological discrepancies persist, with some scholars treating infographics and data visualization interchangeably. Krum (2014) advocates for a clear distinction, emphasizing that data visualization involves processing and visually representing large datasets, while an infographic integrates data visualizations, illustrations, text, and images into a cohesive design. Jacobson (1999) introduces the infographics as the art and science of preparing information that people can use effectively and efficiently.

Debates surround the nature of infographics, questioning whether they are standalone graphic objects, part of larger graphics, or expressions of arbitrary versus statistical information. Resolving these questions requires rigorous research, quantitative evaluation, and the establishment of uniform terminology to advance our understanding of infographics across disciplines.

Addressing these questions requires in-depth research focused on quantitative evaluation of a wide range of infographics. The introduction of uniform terminology, practically applied concepts and the quantification of evaluation approaches clarifies the view of the discussed topic not only from the field of cartography. Therefore, this article should be considered as a small contribution to the overall solution of the whole issue of infographics. Before proposing a definition, this paper operates with the common notion of infographics — *a visual representation conveying a definitive explanation through thematically and visually cohesive graphic elements*

Objectives

The paper aims to establish a distinction between maps and infographics and seeks to determine a quantitative crossover between these two concepts through newly designed evaluation approach. It proposes a quantitative evaluation of images, focusing on infographics characterized by spatially oriented components, as defined in the literature review. The developed evaluation involves detailed quantitative assessments using mathematical formulas based on image characteristics. The aim is to provide particular and measurable characteristics of map layouts in terms of their implementation of infographic style. By determining the quantitative level of infographic style in maps, the paper contributes to defining the gap between maps and infographics and to facilitate the integration of modern approaches in cartography.

To achieve the above-defined aims, the authors decided to develop a methodological approach called the *Infographic evaluation method (IGV)* for maps based on a quantitative visual analysis method for evaluating images depicting spatial data in graphical form (maps, spatial infographics). It aims to find answers to the research questions mentioned earlier and parallel to establish a boundary between the terminological definitions of maps and spatial infographics based on the visual characteristics of given sample map pages from atlases in comparison with images in infographic form.

The *IGV* methodological procedure of image evaluation for identifying and assessing infographics in an image depicting primarily spatial data undergoes validation with a case study on selected representative map pages of different graphic, linguistic or thematic designs, foreign origin, and year of publication. Thus, the achievements provide a characterization of the evaluated image, which will contribute to the specification of the issues of infographics (not only) in spatial visualizations.

Methodology

The *IGV* approach consists of an initial division of the evaluated atlas page into four unique components which represent the specific role of each element inside the layout. The so-called indicators are calculated based on the precisely determined image characteristics for each of the established components.

More specifically, the methodological approach is based on four components defined by a combination of seven elements assessed within four quantitative indicators, which serve as evaluated variables in the multicriteria analysis for each tested map. The proposed methodological procedure includes specific terminology, thus the authors have compiled it for clarity in Tab. 1.

Tab. 1. *Overview of IGV terminology*

Term	Types	Description	Data acquisition
Component	Spatial design (SPD) Quantitative visualization (QTV) Illustrational design (ILD) Text Notation (TXT)	a consistent attribute of infographic characteristics	Elements categorized into types based on their graphical and thematic parameters.
Element	Map Chart Scheme Table Illustration Image Block of text	a specific graphical segment of an evaluated layout	Identified and selected parts of evaluated layout based on their graphical borders
Indicator	Area coverage (α) Graphic Load (ß) Visual attractiveness (γ) Colourfulness (δ)	a quantitative principle for evaluating of components	Computed through specific mathematical formula based on measured parameters of elements

Components

The component is a group of elements based on their nature. In the *IGV* approach, four components are defined, providing the most comprehensive description of atlas pages from the perspective of infographics. The selection of components within maps and infographics is meticulously undertaken to aptly depict the salient features and pertinent data. This process is governed by scientific principles to ensure accuracy, clarity, and utility in conveying information. The practical testing of given map pages is based on measuring indicators related to these four components, which dividing given map page based on their visual and thematic category. Components serve to group and properly compute indicators.

Spatial Design (SPD) – pertains to graphical representations strategically oriented towards spatial information. Encompassing both conventional and innovative cartographic or graphically processed data, these visualizations, primarily conveyed through maps, serve to depict and elucidate spatial information. The constituent elements integral to SPD predominantly comprise maps.
Included elements: Map

Quantitative visualization (QTV) - succinctly captures the essence of visualizations that focus on representing quantitative data in various structured forms, including graphs, diagrams, and schemes, all logically connected to the overarching theme. This alternative name emphasizes quantitative aspects and aligns with the key characteristics of the elements mentioned below.
Included elements: Chart, Scheme

Illustrational Design (ILD) - involves visual components such as pictures, symbols, and paintings. While these elements provide contextual complementarity, they do not inherently convey additional informational value. Instead, their role is to serve as supplementary graphical elements, contributing to the illustrative enhancement of the thematic presentation within the map pages.
Included elements: Illustration, Image

Textual Notation (TXT) - incorporates elements such as captions, titles, explanations, and various textual components designed to elucidate content through written description. The execution of these textual elements may prioritize visual and typographic appeal, facilitating the conveyance of information by emphasizing the content itself rather than relying solely on artistic processing.
Included elements: Text, Table
The schematic assignment of the specified elements to components within a schematic map page in several versions is visually represented in Fig. 1.

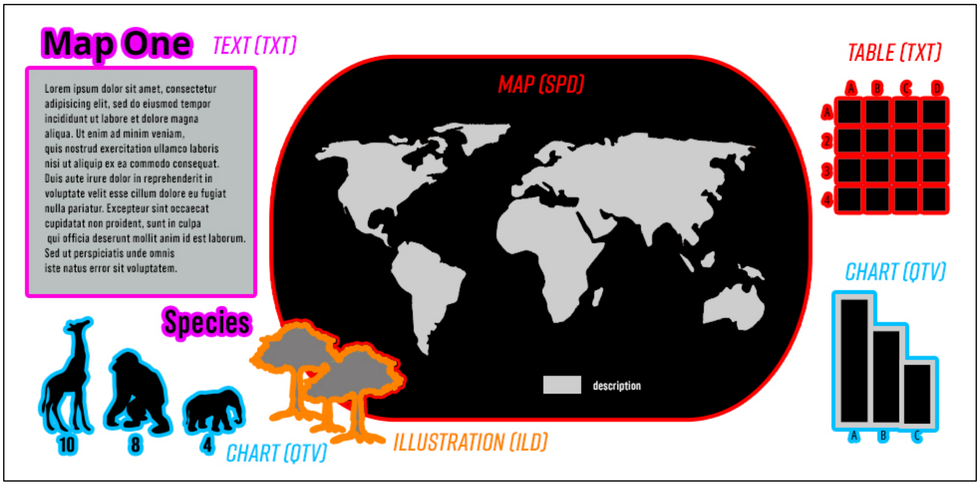

Fig. 1. *Example of element selection illustrated on a schematic evaluated map Components SPD (in red), QTV (in blue), ILD (in orange), and TXT (in pink) are differentiated and labelled with colours.*

Elements

Elements are fundamental building entities or objects of the assessed map sheet, presenting information through their content and attributes. The enumeration of elements stems from the conceptualization of map compositional elements and typical components of infographics that most succinctly and frequently represent information. Defined elements serve as foundational compositional components of infographically processed map pages and may encompass a larger group of similar character sub-elements. Therefore, each element represents an entire group to which they belong.

The map operates as a fundamental building component of an infographically processed atlas page, where its dominance and artistic execution may vary. The map field encompasses the scale (if specified) and all subsidiary map elements that materially constitute it (including cartographic diagrams, symbols, map elements, internal texts or accompanying descriptions within the map field, and more). The delineation of a "map" occurs along either the essential compositional elements of the map (map field, legend, scale, print scale) or along the internal frame of the map. The title of the map is considered as a text because of its variety of graphical representation and the role of complex elements, which could affect results negatively. Further clarification of the selection methodology is provided in Chapter Collecting of input data. The map element includes only depictions that visually align with the traditional conceptualization of a map.

The chart element uses graphics to show categorical, quantitative, or non-spatial qualitative information. It often includes graphs and diagrams, such as pictocharts, which represent quantitative values with size and show qualitative details visually. When delineating the chart element, it includes the graphical representation of the phenomenon, including axis labels and values.

The scheme represents elements graphically depicting processes, structures, or relationships, contributing to a better understanding of complex themes. Primarily focused on illustrating workflows, structures, or timelines, it may also include schematic representations of intricate concepts, issues, or phenomena accompanied by descriptions directly associated with the visualization. In the atlas map page, the smallest enclosing frame for a scheme consists of the main graphical content and immediately adjacent descriptions.

The table element encompasses tabular text representation in various graphic forms. The fundamental condition for including a graphic element of infographics in the table element is its ability to identify rows and columns arranged in a grid and graphically linked, containing quantitative or qualitative values. The selection of this element involves identifying the graphical representation of the table, including its content and background.

The illustration element visually complements the central theme, typically involving vector avatars, graphic creations in various visual styles, icons, or standalone symbols without any additional qualitative or quantitative information. Illustrations are demarcated by a minimal enclosing frame identified by their graphical rendering.

The image element visually enhances the thematic content through photographs or thematically focused images. Distinguished from illustrations by their heightened graphical expressiveness, the demarcation of the image equals the coverage area of the element itself.

The text block includes all standalone (graphically separated) text blocks, headlines of all levels, scale indicators, or captions for the aforementioned elements. However, it excludes axis labels or content directly integral to the designated elements. Identification of the text block is based on distinctive colour information that sets it apart from the surrounding background.

Schematical examples and a determination overview of elements with optimal selection in a layout are shown in Fig. 2.

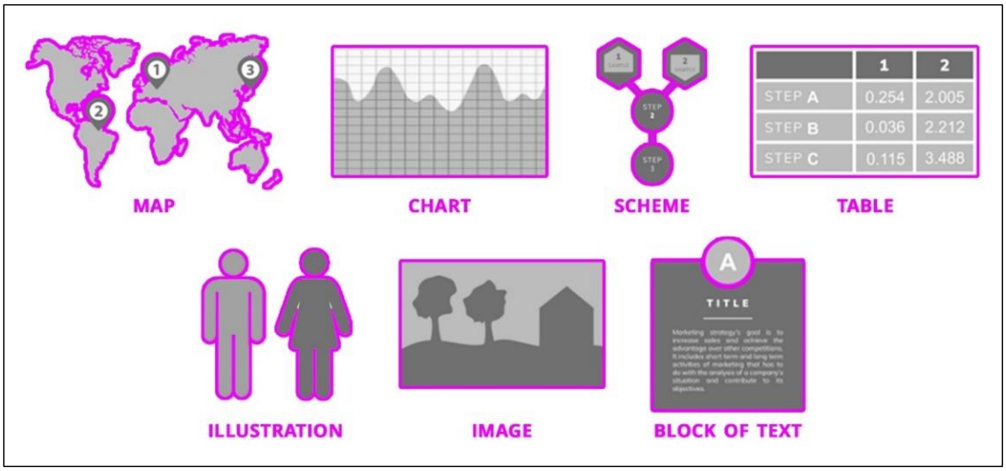

Fig. 2. *Schematic representation of IGV elements with emphasis on the optimal application of the bounding frame selection within the map sheet (in pink).*

Indicators

An *indicator* is a quantitative measure of specific attributes of elements found on atlas pages, utilizing the characteristics of *IGV* obtained through practical measurements. Indicators provide a numerical description of atlas pages, drawing from empirical measurements and calculations. This approach facilitates a comprehensive thematic analysis of elements within the evaluated image through metric analyses and allows easy expansion with potential parameters. The primary objective of *IGV* indicators is to utilize indicator values to gauge and assess the presence of infographics on map pages. The nature of these indicators could assist in distinguishing between maps and infographics based on their values. A typical numerical description of the map or infographic should emerge after properly calculating indicator values for each component.

The process of obtaining the value is as follows: 1. acquiring the value of the component parameter based on the measuring through GIMP; 2. associating the values of elements with the corresponding component; 3. calculating the indicator value for the components; 4. evaluating the results.

IGV approach defines **four indicators** for all components:

Area Coverage (*α*) represents the proportion of the component's area to the total area of the entire sheet. Once all the elements of the measured component are selected, the number of pixels is subtracted from the histogram using the "Pixel Count" characteristic under the Pixels item, and their ratio to the total pixel count of the image is calculated (Fig. 3 (A)).

The calculation formula is described in Eq. 1:

Eq. 1 ***α = (Area of the component / Total area of the sheet) * 100***

Area Coverage (***α***) is obtained according to the calculation Eq. 1. A high value of α does not imply significant prominence of the component within the entire image, only a relative size of an element in a map.

Graphical Load (ß*)* expresses its graphical content in terms of richness and complexity within the image. The graphical content, based on Barvíř, Voženílek (2021), is influenced by features and descriptions, the density of their occurrence, parameters (shape, size, fill), and spatial distribution. The resulting value of a graphic load is independent of the area. *ß* is computed using the freely available tool for GIMP - GMLMT (Fig. 3 (B)), and *ß* value corresponds to the output generated by this tool after computation Eq. 2, which shows a graphical load of component in comparison to graphical load of the whole page.

The calculated value of the ß indicator represents the graphical load of the component, indicating its graphical structure and the proportion of visual significance. The higher the value corresponds to the more sophisticated object. With increasing complexity of the component, its prominence in the whole image also increases. A more complex component is thus more dominant in the image but also requires a longer time to understand its contents.

The calculation formula corresponds to Eq. 2. The resulting value is presented as a percentage.

Eq. 2 ***ß=GMLTMvalue***

Visual Attractiveness (*γ*) conveys its visual distinctiveness and the ability to attract the reader's attention. Indicator ***γ*** is calculated using the contrast of the component and its surroundings, considering the size of the component in comparison to the total image area (see Eq, 3).

The standard deviation of the colour information of the element increases with growing contrast: as we add more contrast to the image, we spread the histogram in a way that the overall tendency of the data set is to have a greater distance between the values of individual pixels and their average (Fig. 3 (C)). The standard deviation of pixel values in the image is actually one way to quantify contrast. This procedure is called RMS (root-mean-square) contrast because the standard deviation calculation is based on the root-mean-square (Keim 2020).

The calculated contrast determines how prominent the component is for the user in terms of its visual presentation in the context of the entire image. A component with higher contrast relative to the contrast of its surroundings and size is visually more attractive to the user (Vondráková 2016). The indicator quantitatively points out how attractive the component in the map in the term of visual perception. The calculation also considers the component's area because the mere colour distinctiveness compared to the surroundings (the remaining area of the map without the measured element) does not necessarily mean that the element is perceived as the most distinct. Its distinctiveness is significantly influenced by its size.

Eq. 3: ***γ = abs(Contrast of a component – Contrast of a component surrounding) × (Area of a component / Area of whole map page)***

Colourfulness (*δ*) expresses its chromaticity. The value of *δ* indicates the ratio of representation of unique RGB colour tones in the given component, calculated through formula Eq. 4. The more colours are represented, the higher the value of *δ*. Colourfulness significantly influences how visually appealing an image is. Colourfulness is determined in the GIMP software using the Colourcube Analysis tool (Fig. 3 (D)). The parameter "Number of unique colours" provides the exact count of RGB colours in the selected area of the component. To calculate *δ*, it is normalized to the maximum value of RGB colours (256*256*256 = 16 777 216), where the maximum colour combination of the model is achieved to express its colour dominance. Colourfulness, and the colour itself, is also an important indicator of the graphic characteristic of a component (Voženílek and Vondráková 2018). If colourfulness is concentrated only on selected components and suppressed in the rest of the image, their dominance in context with other indicators will be higher for the reader.

The resulting δ value is measured in percentage and it signifies the ratio of represented colours within the evaluated element. The calculation formula is described in Eq. 4.

Eq. 4: $\boldsymbol{\delta = (\textit{Number of unique colours in a component}/16\ 777\ 216)*100}$

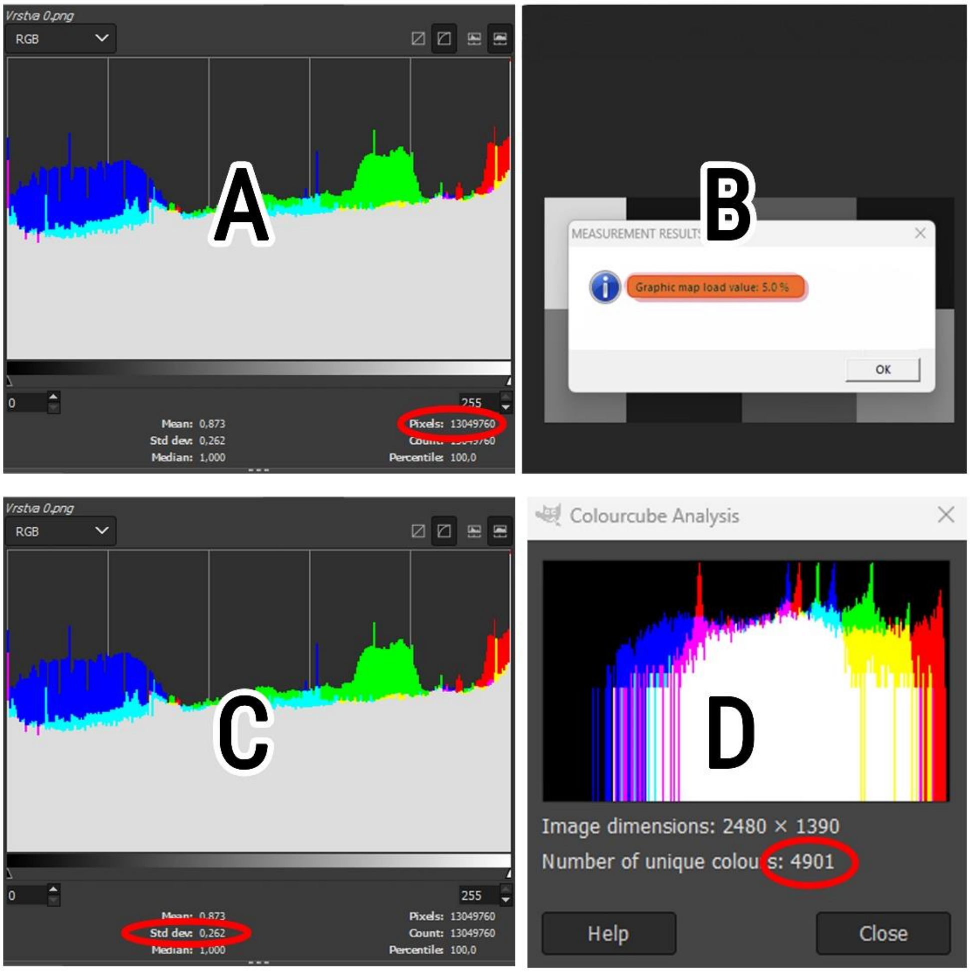

Fig. 3. A: *Histogram values with the pixels indicating the number of pixels of the IGV element.* ***B:*** *The result of the graphical load of the chosen element in percentages which is an input to IGV measurement.* ***C:*** *Subtracting colour channel values based on the Std dev value in the image histogram.* ***D:*** *Determination of the number of unique colours of the element in the GIMP program. (values are not relevant in all cases, it is just an example)*

After achieving all parameters indicators are computed based on given mathematical formulas described at chapter Indicators. Subsequently, the so-called *IndicatorScore* need to be computed, expressing the graphical dominance of individual components based on the acquired indicator values.

IndicatorScore represents the overall graphical dominance of each component based on the values of indicators *α, ß, γ,* and *δ*. This value allows us to identify which components exhibit graphical dominance in the image.

The formula for computation is ***IndicatorScore = α+ ß + γ + δ*** – sum of all indicators for a concrete component. Final result is in percentage and show the value of each component as a result of mathematical operation.

In order for the components, and subsequently the maps, to be comparable, it was necessary to normalize the resulting values, as the measured values were of different ranges, making interpretation difficult. Standardization by standard deviation was chosen, which is the most common method of standardization. In the literature, the term "standardization" often refers specifically to this type of adjustment of values of the j variable (i.e., the *j-th* column of matrix *X),* where the new value is obtained by subtracting the sample mean of this variable from the original value and dividing by the standard deviation of this variable. The range of the new variable will be approximately from -3 to 3, assuming the original variable followed a normal distribution (Holčík et al. 2015). Alternatively, the minimum/maximum standardization could be appliable as well to show values in an interval <0,1>.

A broad interpretation of the component values allows us to assess the graphical orientation of the map based on given quantitative characteristics. For example, a high rating in the SPD component suggests a spatially oriented map layout, which is desirable for map or spatial oriented infographic specification. More balanced values of all indicators may indicate a higher affiliation to the infographic than to the map. Additionally, comparing evaluated infographic pages enables the determination of quantitative characteristics for both maps and infographics.

Subsequently, the resulting *IndicatorScore* values are processed within a matrix to derive the overall evaluation of the input map page. In this study, we refer to this derived value as *LayoutsScore*, reflecting its determination of the visual richness of the map page in terms of infographic characteristics.

LayoutsScore represents the comprehensive graphical attribute of the evaluated map sheet, encompassing all its components. It is computed as the weighted average of the *IndicatorScore* values for each component, allowing for an assessment of the visual distinctiveness of the sheet.

The weights assigned to each component were determined based on the characteristics observed in infographics, as outlined in the chapters Introduction and State of art. Specifically, the emphasis lies on the quantitative visualization and illustration aspects. The weights were established as follows: *SPD (0.25), QTV (0.5), ILD (0.5),* and *TXT (0.25),* enabling the differentiation of the roles of additional infographically characteristic elements within a map.

Eq. 5.: ***LayoutsScore = IndicatorScoreSPD*** × ***0,25 + IndicatorScoreQTV*** × ***0,5 + IndicatorScoreILD*** × ***0,5 + IndicatorScoreTXT*** × ***0,25***

The results of formula described in Eq. 5 needs recalculation into normalized values. Both the measured and computed values for all maps and infographics are stored in a single metric, allowing for standardization. Post-standardization, the values are expected to fall within the interval (-3, 3), facilitating easier comparison of the evaluated products.

Case study

The IGV evaluation process is based on the quantification of four established indicators, expressing the visual characteristics of the evaluated map through their values. Since it is a descriptive unit composed of multiple parts, a multi-criteria analysis approach was adopted for their computation. This method involves decision-making among various alternatives (in our case, whether it is a traditional map or an infographic-style map) using multiple indicator (*α, ß, γ,* and *δ),* each assessing components with a specific weight. It results in a single specific outcome (Kalina et al. 2014).

Data preparation

Before applying the evaluation process, a set of sample pages was established. Practical implementation of the IGV was conducted on a sample of a total of 14 map pages and 10 infographics from various authors, exhibiting diverse thematic focuses, graphic designs, language mutations, and spanning different time periods (Fig. 4). The evaluation encompassed both pages originally in digital form and those originally printed, the latter of which were subsequently digitized through high-quality scanning. All data were prepared to ensure consistent graphic characteristics with the same resolution (150 DPI) and a unified .JPG format. Images underwent no alterations in terms of graphics or content. However the JPG format is a lossy format, its usage for storing image information is among the most common. The compression is based on discrete cosine transformation, which identifies the least significant features of the image and discards them without significant loss in image quality. While the mathematical details are intriguing, they are deemed non-essential for the expected reader (Šrámek et al. 2011). Hence, for the reproducibility of this research, data evaluation was specifically conducted in this format.

The selection of sample pages was an expert choice made by the authors of this article, focusing on meeting the following criteria: the evaluated sample should always include representatives of the general concept of spatial infographics (see State of the Art); or modern map layout; or classic atlas map pages (see overview in Fig. 4). To supplement the sample, images with the definition of infographics in maps were generated through artificial intelligence Midjourney – in both groups, infographic and atlas as well in two examples per each type (*A9ai_DIGITAL* and *A10ai_DIGITAL* for atlas pages and *I9ai_DIGITAL* and *I10ai_DIGITAL* for infographics). Both groups of examples were generated by prompt defining the classic style and modern style of infographic/atlas map page.

To examine how the presented metric responds to different input representations of the assessed image (original digital form vs. scanned version), four of map page samples were determined, each existing in identical or similar forms both digitally and in print (*A5d–A7d_DIGITAL* vs. *A5–A7_SCAN*). The printed form was defined by a specific method of conversion through scanning into a digital format, enabling its inclusion in the IGV.

Software

The graphic processing and value extraction from map pages for the following indicator calculation were carried out using the GNU Image Manipulation Program (GIMP), which is a freely available raster-oriented multi-platform graphic program operating under the GNU General Public License (GIMP 2023). All tasks related to obtaining values for input into the calculations (see chapter Indicators) were performed using GIMP version 2.10.36. These values were subsequently transferred to a tabular format with predefined formulas in Microsoft Excel from the Microsoft Office 365 package.

Due to its open structure, the GIMP program can expand its functionality, a feature utilized by the Graphic Map Load Measuring Tool (GMLMT), which exists in the form of a Python script specifically designed for the GIMP graphic editor. By running the code, the tool is automatically integrated into the user interface and can be utilized as needed Barvíř, Voženílek (2021). For information retrieval from the image, the implemented histogram function was employed, providing a comprehensive data characteristic. To visualize the results and perform subsequent visual analysis, the online tool Flourish Studio was used, offering a wide range of data visualization options.

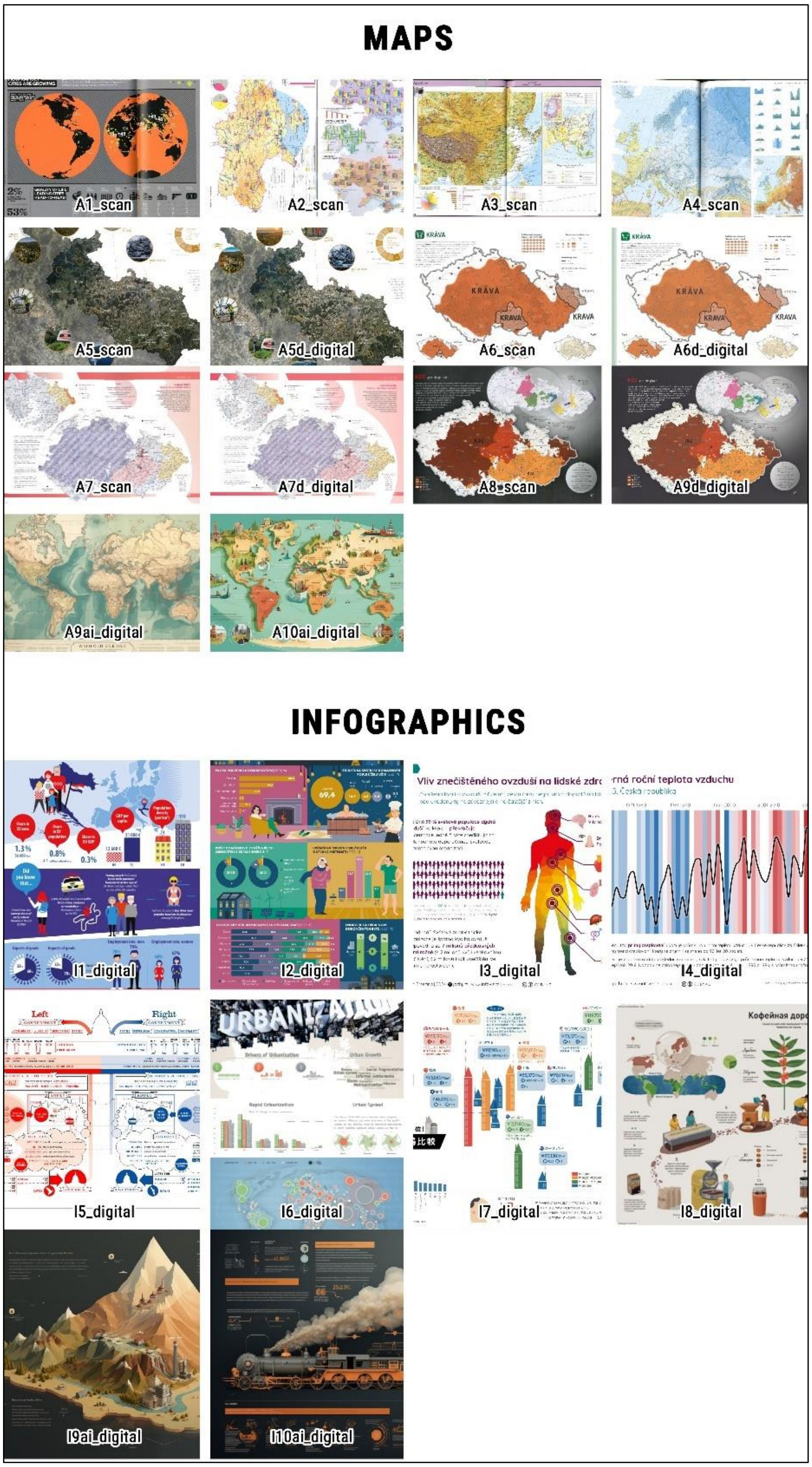

Fig. 4. *Overview of samples of tested map pages and infographics. Better resolution available on https://bit.ly/IGV_samples*

Collecting of input data

Measurements involving either original images or scans of map pages stored in the RGB model at a resolution of 150 DPI. No alterations were made to the colour or dimensions of these pages. To ensure consistency in the data input for indicator calculations, the sample sizes were standardized *to 2480 px × auto* (automatically recalculated dimension based on the sample's proportions), thus providing a uniform sample size suitable for common digital screen resolutions.

To facilitate the accurate selection of elements within the samples and to capture representative colour information from the images, the samples underwent pixelation into a regular *20 × 20 px* mesh while preserving the original resolution. This approach ensured the retention of representative graphic and visual information across all samples, and it reduces a human mistake during the selection process.

Considering the importance of colour information in the measurement process, two specific approaches were considered during the selection process in the GIMP program: *1) selecting elements with the same background as their surroundings, or 2) selecting elements with a different background colour than their surroundings*. The pixelation process ensured the preservation of colour information within the marked elements at the pixel level. The marking process is illustrated in versions C and D in Fig. 5, where the pixelated image displays similar characteristics to both versions of the schematic maps from different samples. Consequently, areas of selected elements could be segmented into layers and incorporated into the evaluation process based on predefined criteria and measurement methods.

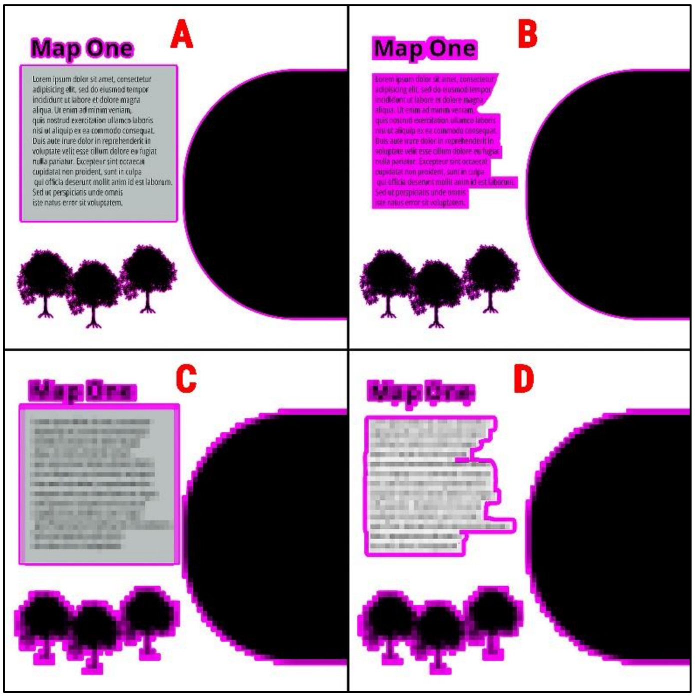

Fig. 5. *Schematic example of element selection on a sample image with a background (A) and without a specific background (B) at full resolution. The IGV approach applies element selection after pixelation for elements with a background (C) and without a background (D).*

Measurement

The first step in the practical data acquisition involves loading the desired raster file of the map page into the graphic software GIMP based on predefined format JPG. Using manual selection based on specified rules (see Chapter Components and Chapter below), all map elements were identified, classified, and distributed into separate layers. The Magic Wand and Magnetic Lasso / Intelligent Scissors tool significantly assisted in element selection, allowing the selection of pixels based on a specified colour value, simplifying the labelling of objects in the image. The entire image of the map field was preserved in a separate layer.

The values of colour and dimensional properties of elements were extracted from the Histogram tool, which allowed determining values of the element's coverage area (including its surroundings) using the Pixel Count and contrast – Standard Deviation value. The value of the graphic content of the element was directly provided by the GLMT tool. The number of colours in the element was precisely indicated by the Colourcube Analysis tool. After recording the values in a table and inputting them into predefined formulas in Microsoft Excel, specific indicator values for all components were obtained for each page separately.

Results

Based on the conducted measurements of parameters of individual elements in chosen atlas map pages, it was possible to calculate indicator values for specified components according to defined mathematical formulas (chapter Indicators).

Given resulting values were subsequently visually analysed in three different forms:

1) clean resulting numbers for comparison of the size of *IndicatorScore* value for each evaluated sample separately;
2) normalized with standard deviation standardized for comparison of *IndicatorScore* and *LayoutScore* within all values for the whole list of sample pages;
3) normalized with minimum/maximum standardization showing *IndicatorScore* and *LayoutScore* in a measurable scale <0,1>.

The first factor examined was to determine how differently the IGV metric reacts when evaluating scanned versus original digital pages. Given that scanned pages typically carry more colour information and may slightly distort the image, it could be expected that they would achieve higher values in the measurements. This assumption was only partially confirmed, specifically with the *A6_scan* sample, whose maps were visually richer and more pronounced. The remaining difference was caused by the *A5d_digital* map, which, compared to its scanned counterpart, contained additional visual elements falling into the ILD and TXT components in the original rendition, and was also processed in a different size ratio. Other differences were not significant. Based on this assessment, it is still possible to conclude that scanned images generally achieve slightly higher indicator values, which, however, are comparable to the tested original digital samples within the study. The difference in *IndicatorScore* values for the samples is shown in Fig. 6. In an interactive format, along with additional visualization and description, the comparison of obtained values is available at the following link https://flo.uri.sh/story/2168046/embed.

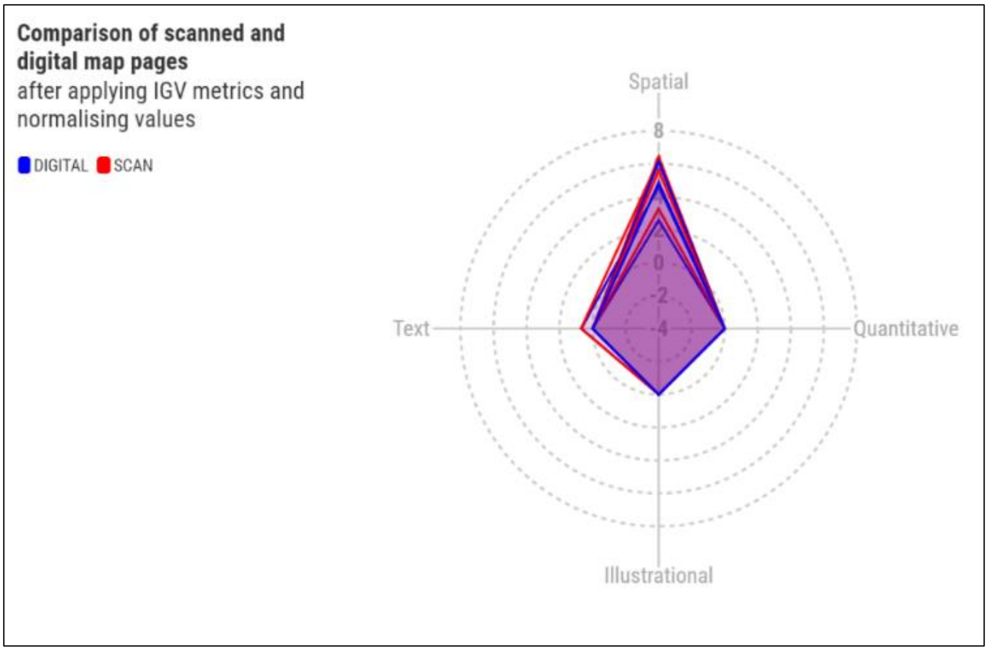

Fig. 6. *Difference between normalised values of scanned and digital samples of the similar map pages within the components*

The main aim was to quantitatively assess the overall set of atlas pages and contextualize the resulting values with those obtained from the evaluation of infographics, which serve as typical examples corresponding to the defined criteria. From the obtained values, it is clear that atlas pages generally exhibit high SPD values, indicating that the sampled page is the most dominant and prominent element of the entire image, whereas for the group of infographics, the distribution of values is more even. Through visual analysis comparing the intensity of the *IndicatorScore* component value in terms of its value and the image itself, which showing the intensity of *IndicatorScore* corresponds to the dominance of the image in reality.

Fig. 7 depicts the normalized intensity of *IndicatorScore* for all tested map pages and infographics, with the colour intensity indicating the increasing intensity of the *IndicatorScore* value for a given component of the sample page.

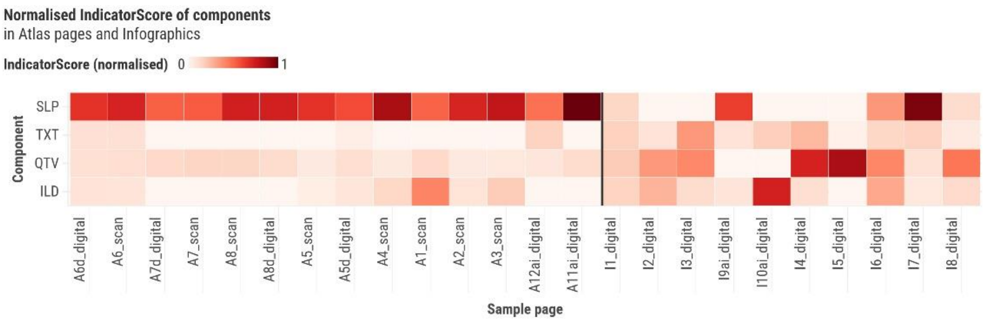

Fig. 7. *Intensity of IndicatorScore among the sample pages and their components*

The detailed visual examination of the *IndicatorScore* component values through a Radar Chart (available online at https://flo.uri.sh/story/2167976/embed) allows for interpretation that atlas pages primarily visualize and emphasize spatially oriented elements while backgrounding supplementary image elements, which corresponds to the traditional concept of atlas cartography. On the other hand, infographics exhibit a wider range of used elements and a spread of visual dominance across multiple elements, unless it is a narrowly thematically focused visualization – as was the case, for example, with samples *I4*, *I5*, or *I7_digital*, where one element visually dominated.

The value of *LayoutScore*, by virtue of its calculation expresses, in a transferred sense, how similar the sampled pages are in terms of infographic characteristics. Based on the necessary standard deviation normalization, computed from the input matrix of all measured component values, it is possible to define precise positions on the scale corresponding to the range (-3, 3) for the evaluated map pages and infographics. The arrangement of the tested sample pages based on the achieved *LayoutScore* is depicted in Fig. 8.

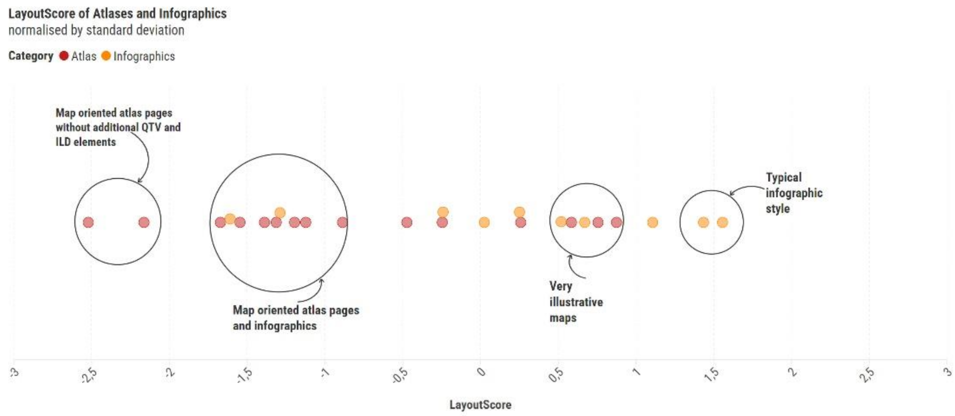

Fig. 8. *Visual comparison of LayoutScore of evaluated atlas pages and infographics*

Through visualization, clusters can be identified, which, upon examination, unite similar characteristics and properties. It is conceivable to interpret that primarily infographics achieving higher *LayoutScore* values – in this case around *(1-1,5*), correspond to a sample of infographics that had consistent representation of *IndicatorScore* values for all components in the image.

When examining visual clusters within the interval of values *(0,5; 1),* these consist of highly illustrative map pages with pronounced elements represented in multiple variants. The same can be said for infographics corresponding to these values.

Around value *0* are visible map pages and infographics that combine multiple elements with approximately equal visual prominence, regardless of their size. From the evaluated sample, these are images whose components are similarly extensive, and their contrast among each other is not significant.

Values within the interval *(-1, -2)* on the provided scale predominantly visual cluster map pages and infographics where one or more elements mostly fall into one or two concepts, with both their size and visual prominence being high. In the cartographic context, they approach the traditional concept of atlas pages.

The minimum values on the scale are represented by samples of maps that are explicitly map-oriented and, regardless of their graphic processing, focus on cartographic visualization and descriptive text without additional supplementary elements.

An overview of measurement results along with further visual characteristics of each tested map is provided in the online version at https://flo.uri.sh/story/2167994/embed. The dataset containing all measured data is also available online due to its extensive volume at https://flo.uri.sh/story/2322876/embed.

Discussion

The assessment of map graphic content from both qualitative and quantitative perspectives within a unified methodological framework is not a conventional area of cartographic research. Most scholars focus on evaluating specific methods, their variations, implementations, limitations, or specific aspects of map sheets. A limited number of researchers engage in a more comprehensive examination of maps from an overall conceptual perspective, such as analysing the elements contained in map sheets or the presentation of specific elements.

A reliable approach for evaluating and comparing images, whether maps or infographics, is through a well-designed survey (Beitlova et al. 2020). This method allows users to discern the diversity or similarity of the images effectively. Konicek, Rocha (2022) conducted one of the initial international surveys to explore the knowledge surrounding spatially oriented infographics, aiming to refine the terminology related to maps, spatial infographics, and infographics. Several surveys have been suggested and performed (e.g., Koua, Maceachren, Kraak 2006; Faisal, Cairns, Blandford 2007), significantly impacting the evaluation of infographics independent of maps or the analysis of their content. So far, no survey has been conducted with a structured approach or definitive definition of infographics specifically in the context of cartography.

Among the existing approaches to evaluating cartographic works, particularly noteworthy are Quantitative Content Analysis (QCA), used in the study of thematic map design as described by Muehlenhaus (2011), and methods like Visual Summary, which enable more efficient segmentation of complex input data through visual representation based on principles similar to those of the affine diagram method, practically applied by Mason et al. (2016) in research on uncertainty visualization. However, both of these approaches are narrowly focused on manual image segmentation and subsequent subjective evaluation and visualization of collected parameters. Artificial intelligence (AI) methods are not currently directly applied to map page evaluation. Their application in cartography is primarily associated with the segmentation and classification of image data from remote sensing for purposes such as predictions or simulations (Kuhn, Roelofsen 2017). Sadílek (2021) attempted to use Machine Learning methods to identify artistic styles of maps, although the approach and technology employed were deemed unsuitable for the given task.

In the context of identifying infographics in maps and the styles applied to their creation, it is essential to utilize multifactor metrics that allow for a combination of qualitative and quantitative assessments. The multicriteria assessment approach aims, within the context of quantitatively evaluating the input image, to apply the *IGV* methodology, demonstrated through map pages processed in an infographic style. For this reason, individual elements are categorized into thematically chosen concepts specifically related to the issue of infographics. Along with the proposed indicators, the objective is to quantitatively capture and describe the evaluated image in a manner that either approximates or diverges from the previously only theoretically described concept of infographics (see chapter Introduction and State of art).

The presented methodology, in its current form, gives a brand new approach of determining the "infographicness" of map pages within the context of the tested sample – through normalization using the standard deviation of all component values and also from the perspective of other studies when using "clean" output values or normalized values using min/max normalization within one unified interval.

The application of *IGV* entails manual delineation of elements within the assessed image, a process susceptible to significant subjective influence by the user, thus potentially resulting in varying assessments of the same image across different users. However, for the entire tested sample, normalization of values should not pose problems in terms of comparison or descriptive statistics. Subjectivity removal is expected through the launch of a semi-automatic online tool utilizing the introduced metric, which is currently under development.

The *IGV* methodology is expected to undergo further expansion and refinement, leveraging its multicriteria assessment principle. This approach allows for effective refinement of results, with plans underway to implement it into a semi-automatic online tool for assessing various image sets.

Conclusion

The visualization and infographic processing of map pages in atlas production is currently a topic associated primarily with the development of artistic, creative, and graphic styles, as well as the need to present a wide range of data within limited graphical space. The understanding of infographics among most experts often refers to a specific type of visualization with engaging graphic content, which enhances informational value and adds a certain level of attractiveness to the work. Just as infographics can be found in economics for visualizing statistical data, in history for explaining the chronological development of historical events, and in advertising for presenting products intended for sale, they can also be found in cartography on maps and atlases. However, the problem lies in their identification and differentiation from traditional cartographic works.

Contemporary authors characterize infographics primarily by *engaging illustrations*, *data visualizations*, and short thematically related *texts*. When are applied in the context of atlases and cartography, their purpose must be enriched with the *visualization of spatial data*. It is from this perspective that the presented *IGV* methodology emerges, which, through the calculation of indicators such as *Area Coverage* (assessing size), *Graphic Load* (evaluating complexity), *Visual Attractiveness* (capturing prominence), and *Colourfulness* (representing colour richness) for components such as *Spatial Design* (visualizations of spatial data), *Quantitative Visualization* (data visualizations), *Illustration Design* (illustrations), and *Text Notation* (texts), can describe the degree of infographic style in the tested atlas sheets.

The presented case study confirmed that by computing the *IndicatorScore*, it is possible to determine whether a given image is more focused on presenting spatial information through maps or if it is more illustrative, statistically oriented, or descriptive, based on the value for each specific component. Through the visual analysis of the obtained values using Radar Charts or non-spatial Heatmaps, it is possible to identify the visual pattern of the map or infographic.

By quantifying and subsequently visualizing the *LayoutScore*, it is possible to identify the abstract degree of infographic style in the map page. From the aforementioned testing, it can be argued that higher *LayoutScore* values correspond to a higher degree of similarity with the concept of infographic processing.

The described *IGV* methodology represents a supporting tool that is suitable for the evaluation of map pages or infographics and the subsequent description of them. On the basis of a representative sample of evaluated maps, it can be concluded that the proposed IGV methodology provides relevant results that are suitable for the creation of a descriptive characteristic of the evaluated image and its use for the expression of infographic style in maps. No other cartographic research has yet presented such similar evaluation methodologies. The *IGV* approach is intended to provide a precise definition of infographics in cartographic production, which serves to establish their rules, methods, classification and concrete definition as a basis for their proper production.

IGV methodology quantifies infographic level of atlas pages and gives comparison of graphic dominance of design elements in evaluated layout and other graphic products at the same time. The result should serve cartographers or graphic designers as a source of objective reflection on their own products from an applied design perspective. In addition, the results should also be suitable for comparison with original samples. That's something that can usually only be achieved by means of user testing.

The outcome of the proposed methodological approach can serve as a valuable feedback for variety of authors in evaluating their own cartographic outputs. Through visual quantitative assessment of their products, they will gain insights into the graphic balance of their maps from the perspective of modern infographic trends based on *IndicatorScore* of components, and simultaneously, they can compare their creation with other outputs using *LayoutScore*. Based on these characteristics obtained in this manner, authors will enhance their work and align maps with the newest infographic trends.

The *IGV* methodology is a small contribution to establishing rules and specific quantitative foundations for the use of terms and the creation of infographics not only in atlas cartography, and with continued research and improvement will become a solid component and assistant in modern cartographic creation.

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