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Evaluation of the Encoding of Quantitative Data in Multi-temporal Maps Based on Spatial Unit Sizes

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Abstract:

Introduction

With the increasing demand and availability of multi-temporal data also the demand for usable multi-temporal maps is growing. Considering conventional cartographic methods such as small multiples or animations, however, a variety of perceptual problems arise due to viewing time and/or space limitations. Apart from this, only little research has been undertaken in order to find out whether the encoding of change information can also contribute to an improved recognition of changes from maps. Considering quantitative data, such an encoding is typically realized with adapted lightness or saturation of colours or with graduated symbols.

The goal of this paper is to describe and to empirically evaluate an alternative graphical encoding – namely, the adjustment of the size of spatial units (typically, enumeration units) according to the change of numerical values.

Method

The adjustment of the size of spatial units is based on the concept of Value by Area Maps, which has so far almost exclusively been used for mono-temporal maps. However, in addition to this fundamental concept, also the three following, major algorithmic options are considered here.

Firstly, flexible scaling functions for changing the unit sizes can be applied. The most straightforward method is a proportional scaling that calculates the area of a spatial unit by multiplying the area size of the time epoch before with the quotient of the numerical values of the respective time epochs. However, other scaling approaches (such as exponential or range-graded) are possible in order to highlight specific changes in an application-oriented manner.

Secondly, two elementary options of map size displays are possible: On the one hand, the total map size is changed according to the total value change (*Total Change Maps;* Fig. 1, top), and on the other hand, the total map size is kept constant over all epochs of time (*Normalised Change Maps;* Fig. 1, bottom). While the first option shows the variations (i.e., the change factors) in absolute terms, the second one focuses on the relative changes between the given spatial units.

Thirdly, original data values can be additionally integrated into the map by dual coding, in particular, by filling the spatial units with corresponding lightness or saturation of a colour. In order to preserve important changes (or to avoid undesired colour changes for small value changes), an adapted data classification is applied in advance. Fig. 1 also considers such a dual coding.

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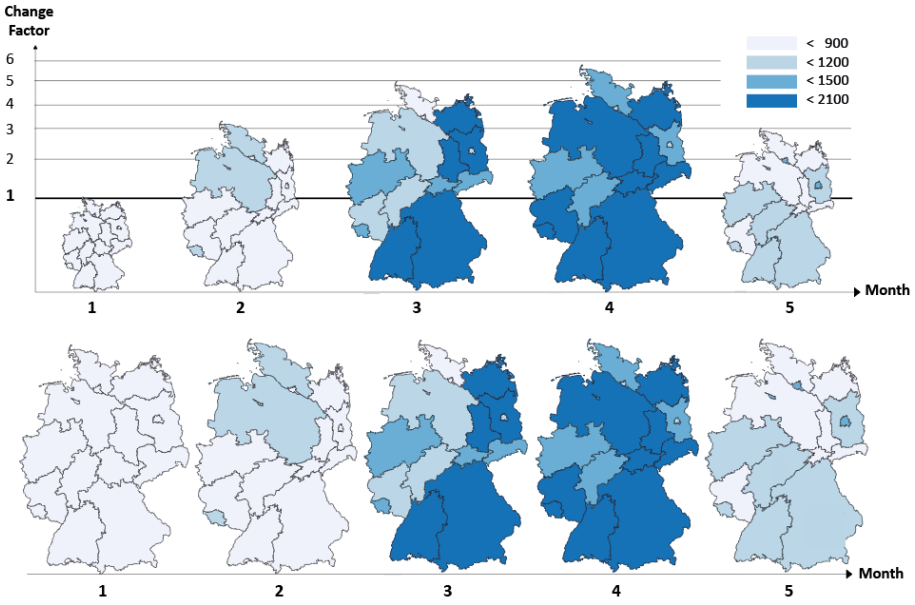

Figure 1. Total Change Map (top) and Normalized Change Maps (bottom)with dual coding. Data: monthly Covid-19 incidence values (source: https://www.rki.de/DE/Content/InfAZ/N/Neuartiges_Coronavirus/Daten/Inzidenz-Tabellen.html)

Empirical Study

As the proposed encoding is rather uncommon and the method allows a variety of parameters, an empirical study is currently conducted for evaluation purposes. In general, it is of particular interest, whether different scaling functions, different total map sizes and the use of dual coding can lead to a compromise between emphasizing certain changes and preserving legibility.

Among others, the following specific research questions are addressed:

- Is there a general understanding of the concept of changing spatial unit sizes according to value changes?
- Can different scaling functions generally lead to a better recognition of changes in a qualitative and/or quantitative manner?
- Is the concept of showing relative changes in Normalized Change Maps intuitively clear to users?
- Does the dual coding actually lead to the acquisition of additional information (original values) – or does it support confusion?
- What are necessary textual explanations that are mandatory by displaying such a map series?

Empirical testing is performed in a two-stage process: Firstly, a qualitative study will give insights about general aspects (such as understanding the concept at all). Secondly, a web-based, quantitative study will deliver insights into the effectiveness of selected map composites.

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