Eurographics Conference on Visualization (EuroVis) (2014)
H. Carr, P. Rheingans, and H. Schumann (Guest Editors)

Composite Indicators Visualization: Exploration of Multivariate Temporal Changes using Radial Visualization

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Abstract

We present a work in progress on visualization of a popular Measurement and Benchmarking method, namely Composite Indicators (CIs). Composite indicators are increasingly recognized as an important tool in policy analysis and public communication and are often used to reflect performances of different units (e.g., countries, regions or organizations). Existing CI visualizations introduce a variety of solutions for the complex challenge of presenting multi-dimensional, time-oriented hierarchic data. Radial visualizations are popular among these solutions because of CI's multi-dimensionality, although different coding is in use. In our work, we aim to shed light on radial presentations for multivariate temporal changes, hoping to produce relevant guidelines for CI visualizations. We introduce some radial design options with static and dynamic time coding, as we explore the design space. In future work, we plan to formally implement, and deploy selected designs.

1. Introduction

A famous quotation from Lord Kelvin says: "If you cannot measure it, you cannot improve it" [Kel83]. Measuring and benchmarking (M&B) are necessary for understanding an entity's (e.g., a country, a region, a company) position and identifying growth opportunities. M&B is a continuous process of monitoring, benchmarking and improving [MJ13]. A composite index (CI), as an M&B method, is a measure derived from a series of observed facts that can reveal relative positions on a regional basis in a given field (i.e. environment, economy, society or technological development). Multi-dimensional complex concepts are summarized into a single indicator. Sub-indicators construct a CI in a hierarchal way, as a weighted variables tree. When evaluated at regular temporal intervals, an indicator can point out the direction of change in different units and over time [NSS*05].

A Composite Indicator might be useful in setting policy priorities and in benchmarking or monitoring performances. The number of CIs in the world is growing year after year [Ban08]. Simplicity and easy interpretation is one of the advantages of CI's, as it produces a "bottom line" [ST02]. On the other hand, there is a need to support deeper insight acquisition (e.g., what is the best practice one should learn from), in order to improve performance [PBAP12]. Domain experts, as well as non-experts, might be interested in making deeper sense of CIs. A clear visualization of a composite indicator is highly needed and recommended [NSS*05]. Visualization of the benchmarking scores of a variety of measures and aspects should enable the evaluation of the effects of policy-makers' actions, understand where they stand and select improvement measures [MJ13].

We specifically look at a CI called Information and Communication Technology (ICT) index, aiming to measure the "information society" and pointing out digital divides.The questions related to performance indicators might be linked to growth potential, as well as to gap risks: Which indicators and variables should be improved? Does a divide exist? What is the gap's size and trend - is it getting wider or narrower? What is the rate of change (Scadias, 2004). Inspired by existing CI's visualizations (e.g. WebIndex and Networked Readiness Index visualizations) we explore radial solutions for presenting CI's time-oriented data.

2. Characterization of the Visualization Problem

Typical Composite Indicator data consists of 3 main properties. ***Time-oriented***: Measurement and benchmarking is a continuous process. Time-oriented data and tasks are the core of Composite Indicator visualization challenge. ***Multi-dimensionality***: Composite Indicators aim to represent a multi-dimensional reality. Since the phenomenon complexity is simplified by the CI's single value, unfolding dimensions is required for sense-making and taking actions as a re-

sult. ***Hierarchy***: the Variables Tree" structure and the user's need for orientation in it must be considered.

Inspired by [AMST11], we structure our view by answering three practical questions: What why and how is the visualization presented?

2.1. What? - time and data

Our data source is taken from TGI (Target Group Index) marketing and media surveys conducted during the years 2002-2012. The data contains information from a representative sample of 30 regions and about 20,000 adults released twice a year (20 time sections all together). Using this data we constructed an ICT Index based on a theoretical growth model, namely "Development of e-commerce markets and measurement priorities: the S-Curve" model [CP99]. As a result, a derived Variables Tree was chosen. Regarding the time dimension, our time primitive in a discrete scale (each time point presents half a year) on a linear arrangement (from past to future).

2.2. Why? - user tasks

For task analysis, we use the formal task model by Andrienko and Andrienko [AMST11]. Tasks are divided into elementary and synoptic tasks. Elementary tasks address individual and separated data elements (values or groups of data) and include: lookup, comparison and relation seeking tasks. Synoptic tasks involve a general view (sets of values or groups of data in their entirely), and are divided into descriptive (including: lookup, comparison and relation seeking tasks) and connectional tasks (homogeneous and heterogeneous behavior). For example:

- What was the percentage of Internet users in city1 in 2010? (elementary, direct lookup)
- Compare the cellular phone owners percentage in city1 to that of city 2 in years 2005-2010 (synoptic, direct pattern comparison)

2.3. How? - visual presentation

Visual encoding is needed for: time, multiple dimensions (CIs variables in a given hierarchic level), items (regions) and values (Indicator score value). Trendalyzer (http://www.gapminder.org/) is famous for its animation use for world's gap exploration. However, its dynamic bubble visualization is not scalable over four dimensions beyond time. Furthermore, it focuses mostly on comparing two dimensions, those being mapped to position (x and y). We wish to examine radial time-oriented visualizations as a way to visualize CIs. Radial visualizations are in use in conveying multidimensional data [DLR09, AAB*13], and are common in CIs' visualizations over the Web (See Figure 1). However, most Web solutions are incomplete for CI exploration purposes (e.g. lack of time dimension visualization). Still, they might be altered to fit our needs.

Two design options are to be examined: classic Radar presentation and Concentric Radial Space Filling (RSF) presentation (Figure 2). Dynamic and static time coding will be

Figure 1: *Examples of radial presentations in Composite Indicators' Visualizations. Left - Webindex by WWW Foundation measuring the Web's global impact; Right - Networked Readiness Index by The World Economic Forum.*

compared. To show hierarchy we will use interaction. The first option was chosen for its popularity in CI visualizations (e.g. WebIndex) and reports (e.g. [BODL13]). The second option, inspired by Keim et al.'s Circle View metaphor [KSS04], suggests another approach which uses RSF presentation. We use the color coding traffic model (green for high values, red for low values) that was shown to be able to simplify M&B complexity [MJ13].

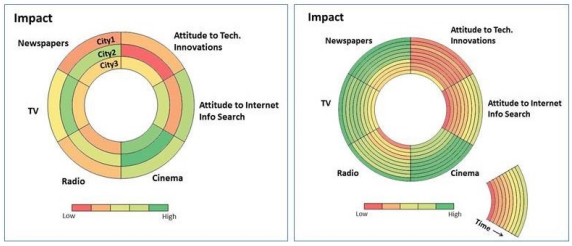

Figure 2: *Concentric Radial Space Filling (RSF) options*

In the simple radar presentation, item (region) can be mapped to color, dimension can be mapped to angle and values are mapped to distance from center. Switching between Item and dimension is also possible. Time can then be mapped to animation or small multiples.

In the RSF presentation, item (or region) can be mapped to the concentric rings, dimension to angles, values to color and time to animation or small multiples (Figure 2, left). Another possibility is to map time to rings and items to small multiples (Figure 2, right). Yet another option might be to map variable hierarchy to rings. Space within ring's interior could be used for more information presentation [DR08].

3. Future plans

We plan to formally examine the various tradeoffs in the mentioned designs. We believe that different designs would be better for different tasks. Evaluation will be done by measuring efficiency (speed and accuracy) and user satisfaction. Based on this evaluation, our ultimate goal is to develop an interactive visualization component for the ICT index and implement it among "real-world" stakeholders.

4. Acknowledgements

This work is done as part of the National Israel ICT project by The Center of Internet Research supported by the Israel Internet Association-ISOC-IL; Bezeq; Appleseeds Academy; LINKS Learning in a Networked Society.

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