Applying Uncommon Visualizations to Government Dashboards

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Abstract: Many governments provide data dashboards to present the state of the countries or administrative activities. Their main target audience is typically the citizens but the dashboard design process is usually top-down and leads to formulaic results. Developing three data dashboard projects for the government of Thailand, we successfully applied two uncommon data visualizations, grid map and connected scatterplot, despite initial resistance from the government agencies. We documented the design process including feedback on the two visualizations and solutions to alleviate their concerns. Academic studies had little success in convincing stakeholders. In both visualizations, animations helped to frame the concept of the uncommon visualizations.

1 INTRODUCTION

Although the government of Thailand is not a leader in open data (Lemieux et al., 2015), there has been an attempt to gather data into a centralized website: https://data.go.th. However, having clean data in machine-readable formats alone does not yield any insights. Open data needs a way to visualize, even as a simple heatmap for its metadata (Carvalho et al., 2015). Common solutions include data dashboards that present the economic or administrative statistics relative to other countries, smaller administrative levels, or historical periods.

A data dashboard is a visual display that consolidates various important information on a single screen so its user can scan the dashboard and perceive the data overview (Few, 2006). With real-time data, it can be used for operational purpose to observe outliers and take immediate actions (Sarikaya et al., 2019). In a dashboard, there are usually many visualization types; each one for a particular function. For example, a dashboard may have both a line chart and a pie chart to show the trend of gross domestic product (GDP) over the last decade and the composition of the latest GDP, respectively. A government dashboard can increase data interpretability (Barcellos et al., 2017), empower the citizens through interacting with data (Bowyer et al., 2019), and even prevent corruption (Petasis et al., 2018).

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In the past three years, we have involved with three government dashboards for different purposes. The main tasks were broad and the data varied so we were able to implement a diverse set of visualization types including a grid map (or a tile grid map) and a connected scatterplot in the dashboards. To our knowledge, we had not seen any prior use of such visualizations in Thailand. Because of their obscurity, there were some reluctance from the government agencies, not unlike many digital transformation initiatives (Schirrmacher et al., 2019). We gathered their feedback and developed the visualizations further to address their concerns. We found that, instead of prior studies, animated visualizations could persuade unconvinced stakeholders.

2 CASE STUDIES

All dashboard projects were unrelated and had different data sources and tasks. However, all shared the characteristic of multiple stakeholders of which one was in charge of project finance and also test users in the first few design iterations. Another group of important stakeholders included end users without any specific details and could cover as large as all the citizens. They were usually involved only in the end of the process.

Dashboard for Spending Data of the Royal Thai Government. The first dashboard was commissioned

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by the Comptroller General's Department (CGD), the Ministry of Finance, to increase the data transparency of the finance of the Royal Thai Government (Ruchikachorn et al., 2019), similar to another project for the federal finance of the United States (Böhm et al., 2012). The budgetary data is geographical and updated on a weekly basis. The main task is to inspect budgetary distribution and locate areas of particular statistics such as provinces receiving large budget allocations.

Thai People Map and Analytics Platform (TPMAP). Developed for National Electronics and Computer Technology Center (NECTEC), TPMAP is a dashboard designed to target geographical areas for poverty alleviation programs in Thailand (Surasvadi et al., 2019). Unlike the government spending dashboard, the data is also hierarchical. The user should be able to not only spot poor population density but also drill down onto lower administrative levels.

Development Index Dashboard. The Institute of Public Policy and Development (IPPD) would like to compare Thailand to other countries and present the results to the general public. The underlying dashboard data were public development data from the websites of the World Economic Forum (WEF) and United Nations Development Programme (UNDP) for the Sustainable Development Goals (SDGs). There were many time series and the analysts at the institute wanted to show their pairwise relations including correlation and trend.

3 UNCOMMON VISUALIZATIONS AND THEIR IMPLEMENTATIONS

There is no thorough worldwide survey on visual literacy, so it is hard to pinpoint uncommon visualizations. In this work, we define uncommon visualizations as the ones that are not readily available in popular commercial visualization applications: Tableau Desktop, Microsoft Power BI, and Google Data Studio. Common visualizations are a treemap, a choropleth map, a pie chart, a donut chart, a bar chart, a line chart, an area chart, a scatterplot, a bubble chart, their stacked and clustered variants—if possible, and their combinations. Hence, we consider a grid map and a connected scatterplot as uncommon visualizations. Although certain customizations in some visualization applications support other visualization types due to their similar visual grammars, we do not count them as common visualizations because those configurations are not expected to be frequently used or even discovered.

Our method was comparable to the selection process of unfamiliar visualizations (Lee et al., 2016), which were manually selected and excluded the visualizations in K-12 curricula such as a pie chart, a bar chart, a line chart, and a scatterplot. Note that a treemap was considered as an unfamiliar visualization but it was available in all commercial visualization applications that we surveyed. We intentionally differentiate the terms because familiarity implies having known, read, or created such visualization beforehand (for example, through classroom materials) while an uncommon visualization may be created via coding or other means but is not taught or directly available for laypeople in any commercial applications.

Federal regulations do not allow any online services that require cloud storage servers outside of the country so we ruled out many cloud solutions and finally decided to self-host the dashboards. All visualizations support minimal interaction, namely, details-on-demand. They were implemented with web standard technologies and a JavaScript library D3.js.

3.1 Grid Maps

A common method of displaying quantitative values over regions is a choropleth map but it may show bias in favor of large areas due to uneven administrative region sizes. Some media outlets use a grid map that presents all regions as equal in size. It can also deemphasize the size of map regions that are more coupled with geopolitical history than with data context.

Several related techniques can be applied to create a grid map. Recently, there is a research project that directly addresses grid map generation (McNeill and Hale, 2017). The proposed technique can have grids or tiles of varied geometries including triangular, rectangular, and hexagonal grids with certain constraints.

For the dashboards, we designed and implemented a hexagonal grid map of Thailand. Among all three regular tilings i.e. tessellations by convex regular polygons, a hexagonal grid provides the highest edge-to-edge connectivity of six compared to three and four for triangular and rectangular grids, respectively. The hexagonal grid is therefore more suitable for a dense map whose regions are well-connected. The central area of Thailand has that characteristic so we picked the hexagonal grid for our grid map of Thailand. The position of each province was manually placed to closely match the mental image of the geographical map of Thailand. Since there were only 77 provinces,

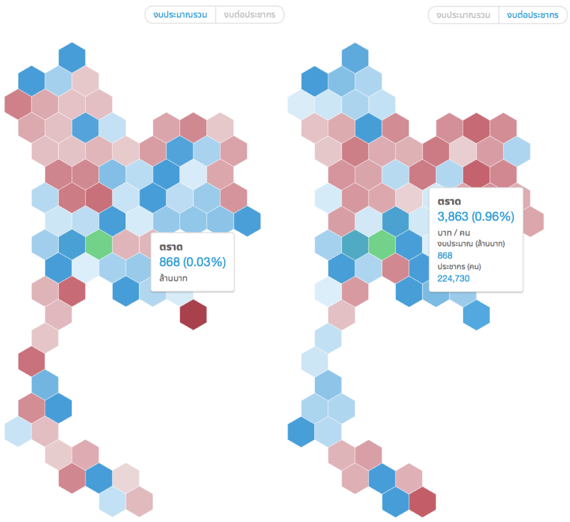

Figure 1: The grid maps of the government spending dashboard with the same diverging color scale (low in red and high in blue) but different measures. As an outlier, Bangkok is shown in green. Both show provincially aggregated budget but the map to the right performs per capita transformation first. Shown are tooltips of the same province, Trat.

it was not necessary to use an algorithm for automatic layout. A grid map example is shown in Figure 1.

3.2 Connected Scatterplots

One polyline in a line chart can represent only one time series while a polyline in a connected scatterplot can represent two time series (Haroz et al., 2016). A correlation between two time series can be visually observed through the direction of the polyline. A polyline between the top-left and the bottom-right corners suggests a negative correlation while the other diagonal direction implies that the two time series are positively correlated.

We implemented and used this visualization in a dashboard that compares Thailand's development indices to other countries' in the region. With a lot of indices, putting two indices on a chart at the same time can provide a good overview of development progression across countries and time frames. The connected scatterplot in Figure 2 tells a story that Thai people work long hours, but the productivity is low. All circles show their tooltips when they are triggered by a mouseover event.

4 PRELIMINARY FEEDBACK AND ITERATIVE DESIGN

As our main concern was not a formal validation of the visualization techniques that had been previously evaluated, we did not try to acquire a large group of users to test a statistical hypothesis (Nielsen and Landauer, 1993). We adopted an iterative design process and tried to apply appropriate validations for all dashboards with the same groups of stakeholders who had provided the requirements (Munzner, 2009). We did not aim to use uncommon visualizations in the projects, but they were appropriate for the tasks and, to the development teams, the visualizations seemed not really unusual. During the first design iterations, we had a feeling that they could feel slightly unconventional but did not expect unenthusiastic feedback from some stakeholders.

The uncommon visualizations, a grid map and a connected scatterplot, were introduced through sketches and later digital mock-ups of higher fidelity. All early prototypes were not interactive and there were quite a few questions regarding the usability of the visualizations. We experienced some common pitfalls in visualization design (Sedlmair et al., 2012) that most government officials had specific visualization types and dashboard designs in mind. Expanding their horizon on visual possibility helped; in our case, we discussed dashboard taxonomy and various types beyond the commonly known (Sarikaya et al., 2019).

There were more questions and doubts about the visualizations after the first interactive prototype had been shown outside of the immediate working team. The connected scatterplot in the development index dashboard received a lot of questions second-guessing whether the general public could read the visual encoding or interpret the data. More specifically, there were concerns that people might not understand that both vertical and horizontal axes showed development indices and the temporal progression did not have to be left-to-right. Besides a short text to serve as an instruction, we added an animated visual cue in the beginning to suggest the direction of time; all points and lines showed up with cascaded delays. Also, the dashboard started with one development index on the vertical axis and the horizontal axis represented year. The users could add an index to the horizontal axis and the data lines would morph to the new positions, serving as a tutorial on the unknown visualization.

We tried to present a previous study as a proof of usability. For instance, a study on connected scatterplots (Haroz et al., 2016) observed many cases of this visualization usage even in mass media and conducted an experiment to confirm its usability. The re-

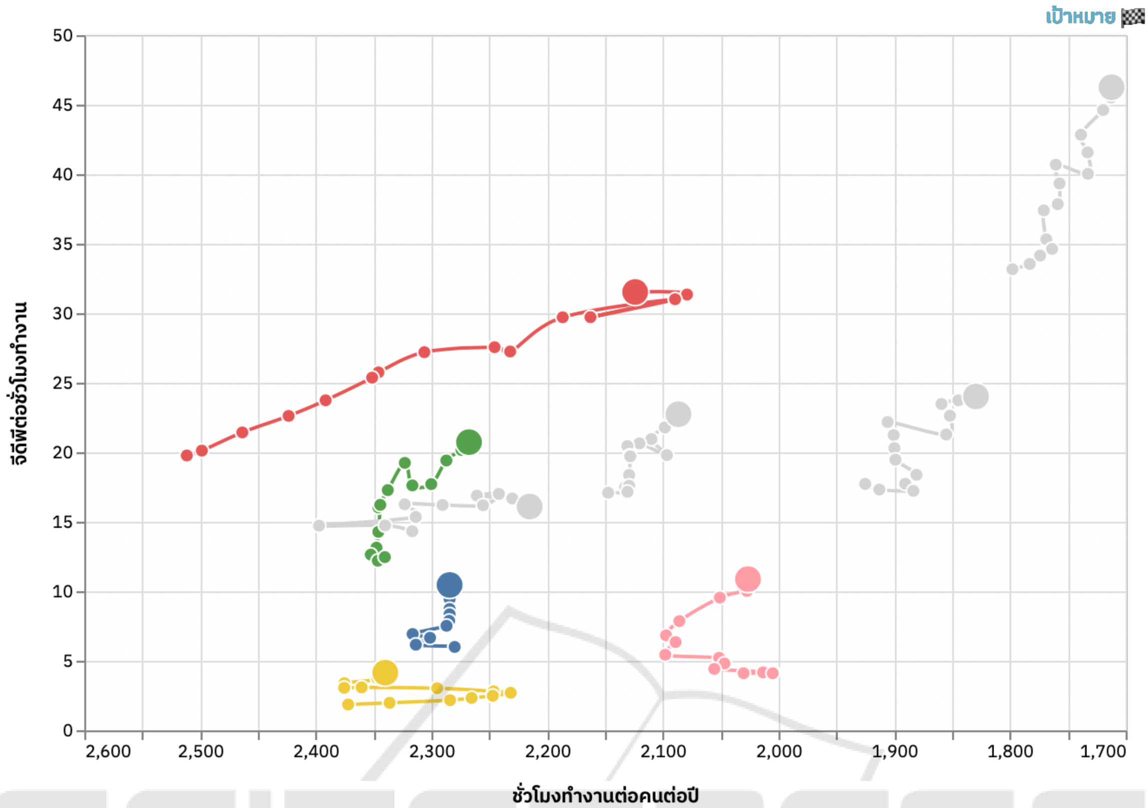

Figure 2: The connected scatterplot of work hours per person per year (x-axis, reversed as lower work hours imply a better quality of life) and productivity measured in GDP per work hour (y-axis). Blue, red, green, yellow, and pink lines represent Thailand, South Korea, Malaysia, Vietnam, and Indonesia, respectively, while gray lines represent continent-level aggregates i.e. Africa, Americas, Asia & Oceania, and Europe.

searchers found that the chart might take some time to recognize but the participants could understand the visual representation with little explanation and even engage with the chart more, compared to a line chart. The early users simply disregarded the study, doubted the study setup, or questioned whether culture or visual literacy played an important role in understanding the encoding of a connected scatterplot. This shows that an academic study, at least from an external source, has little effect to convince stakeholders. This is also in stark contrast to a more objective assessment of unknown visualizations of science community (Dasgupta et al., 2017a; Dasgupta et al., 2017b).

A grid map did not raise any serious issues. A common comment was that it was hard to see the provinces with the most or least poor population as the users had to scan throughout the map. We created another view to sort all hexagons by value. To link both views together, we introduced an animation to morph between the two as depicted in Figure 3.

Other qualitative comments such as aesthetics were taken into consideration during the development process as well. The users might request contradictory adjustments and were unaware of their tradeoff. For example, one asked for all straight lines in a connected scatterplot for accurate portrayal while another preferred more curved and smooth lines without acknowledging the fact that monotonicity might not have been preserved.

5 DISCUSSION AND FUTURE WORK

Our use of animations to show the temporal direction in a connected scatterplot and transitions between visualization types and views was based on previous studies on how people make sense of uncommon visualizations (Ruchikachorn and Mueller, 2015; Lee et al., 2016). The animations of both grid map and connected scatterplot also addressed a comment that the visualizations are not attractive enough. The animations excited some users and invited them to interact. To the users, animated hexagons in a grid map and lines in a connected scatterplot felt more concrete.

Figure 3: The source, an in-between, and the target of the transition from a hexagonal grid map of Thailand in TPMAP to a hexagon list sorted by the data values. Each hexagon's position is linearly interpolated between the source and target positions with cascaded delays.

They were helpful to construct a frame to familiarize themselves with what they do not know (Lee et al., 2016).

Between two uncommon visualizations, adopting a grid map seemed to have less resistance. Although it cannot be directly compared to connected scatterplot in terms of commonness or complexity due to subjectivity and difficulty of such measurement, the relatively easy acceptance of an uncommon map was quite surprising. This could be due to its more obvious benefit compared to a choropleth map and that the hexagons forming as the shape of Thailand still look familiar and less abstract than a connected scatterplot.

To further analyze the reluctance to initially accept the uncommon visualizations, we can refer to other related psychological and sociological topics such as mental models, previously explored in the context of security dashboards (Maier et al., 2017), and face which is a widely referenced sociological concept on how a person behaves within social relations (Zhang et al., 2006). In the case of uncommon visualizations, face can imply the tendency to maintain the status quo or existing systems. Psychologically, this may be the clash between System 1 and System 2 thinking i.e. people tend to fit a new thing within the context of the already known and fail to see the uniqueness unless they are given more time and conditions for slow thinking (Kahneman, 2013). To compete with known visualizations, particularly in an existing system, an uncommon visualization needs not only show clear advantages but also overcome cognitive biases and fallacies such as endowment effect and sunk cost fallacy (Dobelli, 2014).

Another complication that may happen but has never been explored in the context of visualization is preference falsification. A person may publicly express their opinion opposite of their real preference due to social pressure (Kuran, 1987; Kuran, 1997). This may lead slow and then sudden change as evidenced by social movements (Sunstein, 2019). With the same model, unfamiliar and uncommon visualizations may be more popular than anticipated and gain rapid public acceptance as well.

The concepts of preference falsification and diverse thresholds in behavioral science (Sunstein, 2019) can be applied and studied in the context of human-computer interaction and visualization. A common visualization task categorization often implies one user tier of similar experience and expertise. In reality, people have diverse thresholds to understand or interact with a certain interface. Even within a single tier, the users may request a more conventional user interface and interaction because of preference falsification.

For future work, we may study and follow the ISO on human-centered design (International Organization for Standardization, 2019) to reassure stakeholders. Also, we would like to formally evaluate the readability of the grid map and connected scatterplot, specifically in the context of Thailand, to verify whether Thai audience can understand the uncommon visualizations without a training, tutorial, or other visual cues. This can be coupled with visual literacy assessment (Boy et al., 2014). When all the dashboards are released to the public, a larger study to validate the dashboard and the uncommon visualizations can be conducted and we hope this will lead to more adoption of various visualization types beyond the common ones.

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