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Filter+: Interaction Argument for Web-based Visualizations

Min Lu[1]* Jie Liang[2]† Zongru Li[1]‡ Siming Chen[1]§ Xiaoru Yuan[1]¶

1) Key Laboratory of Machine Perception (Ministry of Education), and School of EECS, Peking University, China
2) School of Engineer and Information Technology, The University of Technology, Sydney, Australia

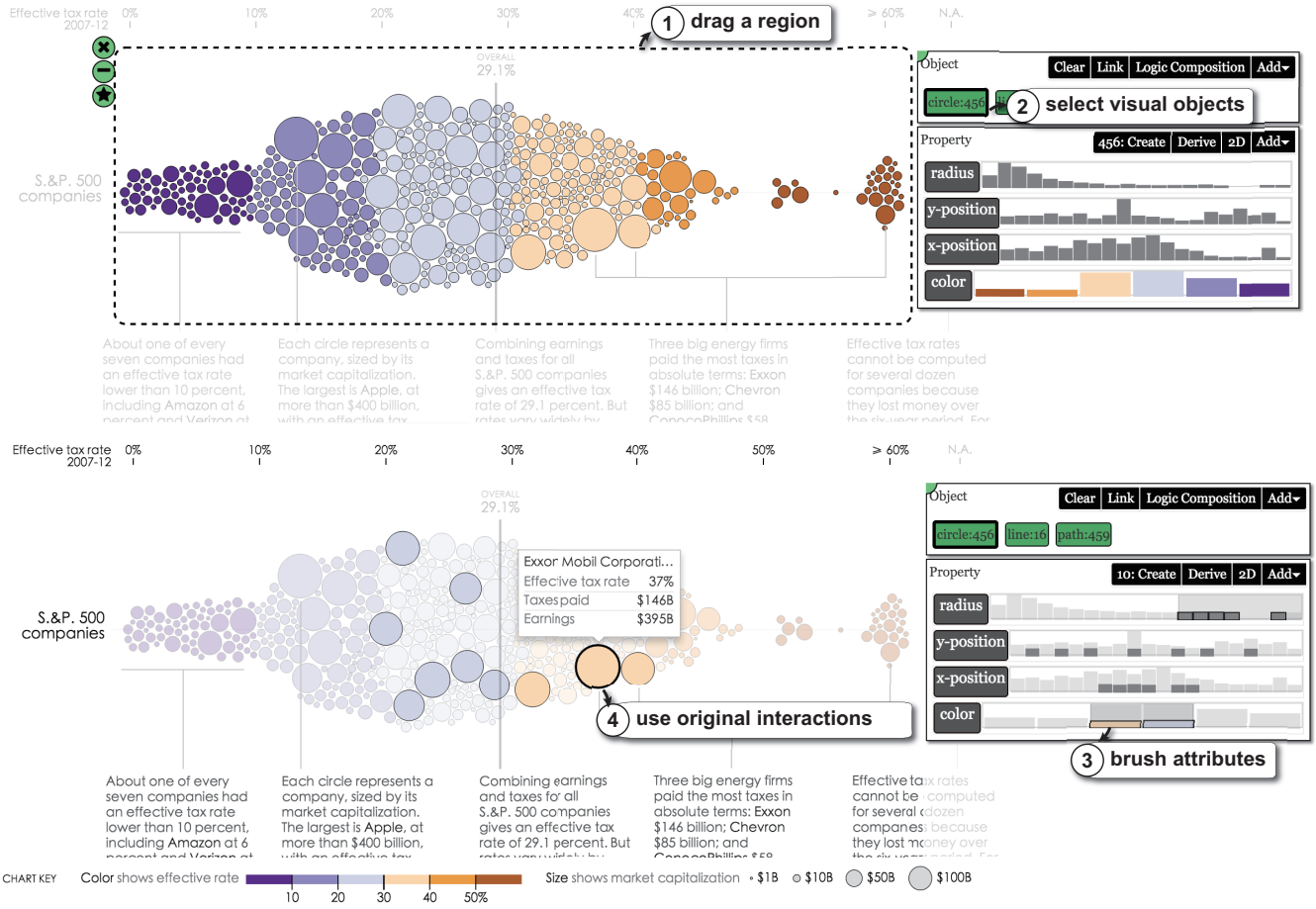

Figure 1: Filter+: applied in the tax rates visualization of U.S. companies in *The New York Times*: (1) drag a region of interest; (2) select the collection of visual objects which represent companies; (3) brush on the attributes color and radius to filter the top 10 companies whose tax rates are from 20% to 40%; (4) use the original hover function to check the filtered companies in detail.

Abstract

Interactions are essential in effective visualization and visual analysis. However, many visualizations available online lack sufficient support of interactions. We introduce Filter+, a visual technique which can be easily laid over existing web-based visualizations and provides flexible interactions with underlying visual objects.

*e-mail: min.lu@pku.edu.cn
†e-mail: jie.liang@pku.edu.cn
‡e-mail: zongru.li@pku.edu.cn
§e-mail: siming.chen@pku.edu.cn
¶e-mail: xiaoru.yuan@pku.edu.cn

1 Introduction

Web becomes a popular platform for visualization. Various visualization toolkits, such as D3.js [3], flourish the construction of web-based visualization. However, developing interactions on the web-based visualizations still requires more or less coding [4]. In this work, we propose Filter+ that enables users to interact with existing visualizations without extra coding.

Traditionally, interactions are highly integrated in visual analytic pipeline, which makes them highly integrated and specific to certain tasks. We propose Filter+, which enhances interactions from the side of end users. Without accessing underlying data and visualization pipeline, Filter+ takes existing visualizations as input and provides interactions with the underlying visual objects, which help

users with visual objects processing.

2 Overview

Figure 2 shows the pipeline of Filter+. With the user **defined** interested region of visualizations on web-page, Filter+ **extracts** the visual objects and their attributes from the HTML DOM. Specifically, Filter+ recognizes the objects inside the defined region and detects the attributes of objects from HTML. Then Filter+ **formats** the set of objects and attributes according to objects' HTML tag. For example, objects with same *tagName* = *rect* are grouped. Filter+ **shows** these group and their attribute histograms as the filtering legends. Meanwhile, Filter+ supports to **customize** the desirable filtering legends based on existed ones, such as delete the unnecessary attribute etc. At this point, the user can **filter** the objects by setting constraints on the attributes of interest. The filtered objects will be highlighted in the original visualization.

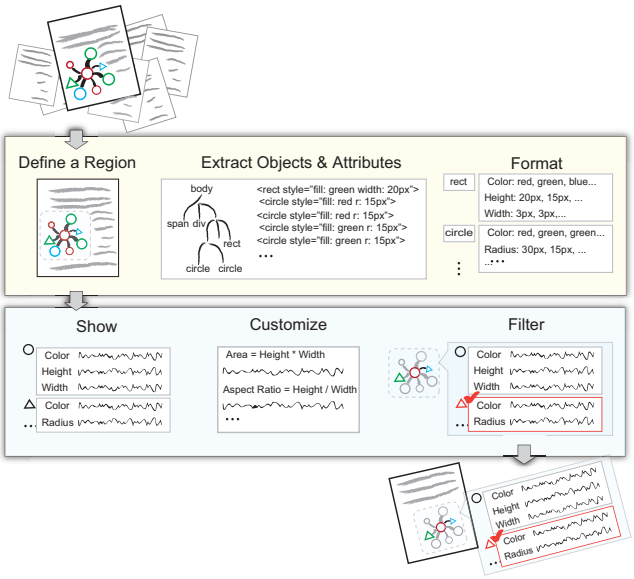

Figure 2: Pipeline of Filter+: with defined region on the web-based visualizations, Filter+ provides filtering interface for the underlying visual objects.

3 Filter+

As Figure 3 shows, Filter+ consists of two parts: the defined region of interest and the filtering interface. An interested region can be defined on the web-based visualization via click-and-drag. After the region definition, the filtering interface supports to interact with the underlying visual objects. As introduced in Section 2, there are two kinds of filtering operands, i.e. objects and attributes. So the filtering interface consists of the object part and attribute part. In the object part, all groups of objects are listed. Each group is visualized as a label. such as a line group line:250. Unnecessary group can be removed by clicking the delete button line:25 which pops up when hovering on label. Given a selected object, its corresponding attributes are visualized in the attribute part. For each attribute, a bar chart visualizes the distribution histogram. Particularly, colors are assigned to bars when it is color attribute. Brushing the attribute filters the objects. Cross filter are supported among multiple attributes. The filtered subset can be saved and created as a new object for further exploration. To distinguish with the original groups, created groups are colored in blue, such as the group of circles with large radius largercircle:22.

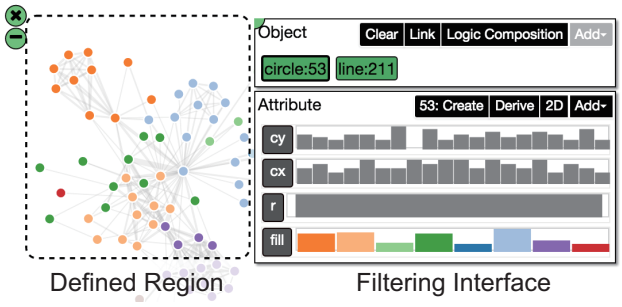

Figure 3: Interface of Filter+: with the defined region of interest, a filtering interface supports to filter based on objects and their attributes.

4 Result

Filter+ can be applied to various visualizations. Taking the tax visualization [2] in *The New York Times* [1] as an example, we demonstrate how it works. The visualization reports the tax rate of U.S. companies. Each company is encoded as a circle, whose size shows its market capitalization and color implies the effect tax rate. In the original visualization, detailed content of a company can be traced by hovering. Figure 1 shows the basic steps of using Filter+. Initially, the user drags an interested region in the original visualization (indicated by a dashed rectangle). Then Filter+ provides an auxiliary interface which summarises the visual attributes of underlying visual objects using histograms. In this case, the *Radius* histogram implies the distribution of company market capitalizations and the *Color* one indicates the distribution of tax rates over companies. Upon the auxiliary interface, the user is able to filter objects with interested attribute constraints. For example, the user sets the attribute constraints on both *Color* and *Radius*, to get the companies with the top 10 largest market capitalizations and median tax levels. Then the filtered objects are dynamically highlighted in the original visualization. With original interaction, i.e. hovering, the user is able to check the detail of the 10 filtered companies.

5 Conclusion

We have introduced a novel visual tool Filter+ which allows users to interact with existing web-based visualizations via filtering. Currently, Filter+ supports the rectangular region, which can be extended to other shapes, such as the circular or arbitrary one. Also, besides to filtering in a single region, Filter+ will be designed to support the comparison among multiple regions in the future.

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