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Towards Optimizing the Sunburst Visualization for Smart Mobile Devices

Ragaad AlTarawneh[1], Shah Rukh Humayoun[1], Abdel-karim Al-Jaafreh[2]
Computer Graphics and HCI Group
University of Kaiserslautern
Gottlieb-Daimler-Str. 67663 – Kaiserslautern, Germany
[1]{tarawneh,humayoun}@cs.uni-kl.de,
[2]aojaafreh@gmail.com

Abstract. Visualizing large hierarchies is one of the key applications in the information visualization field. The sunburst visualization is one of the space-filling techniques that produce compact representations for large trees via using some of geometry features and solid areas to show the hierarchy. However, the limited screen sizes and interaction styles of current mobile devices bring new challenges for such visualization techniques. Therefore, optimization and customization in the existing techniques are needed in order to make them suitable for the current mobile paradigm. In this paper, we propose some optimization solutions and interaction options for the sunburst visualization in order to increase the viewers' ability in understanding large tree hierarchies and to enable them in interacting more intuitively with the resulting visualization. We also report results of a brief preliminary user study that we conducted with 15 participants.

1 Introduction

Smart mobile devices (i.e., smartphones, tablets, smart watches, etc.) are now an essential part of our daily life activities. The current mobile paradigm is different from the desktop paradigm in many ways due to different factors such as limited screen sizes, new interaction styles (e.g., multi-touch gestures interaction) [3], mobility, context awareness, etc. Many times it is required to represent the data in visual forms in order to give the users the ability to get insight about the data more accurately and efficiently. However, the limited screen sizes of mobile devices and the current mobile interaction styles bring new challenges for visualization techniques. This become more critical when visualizing hierarchical data, as in this case the main concern is to handle the large-seized trees over the limited display sizes.

The Sunburst visualization is a well-known approach in space-filling techniques due to its intuitiveness in conveying the hierarchical behavior of large trees [10]. That's why it has been used in many different domains, e.g., some utilization can be found in [9, 10, 14]. The Sunburst technique could also

be useful to be used on mobile devices due to its compact representations for large trees and presenting the resulting visualization in a circular fashion, which lowers the changing affect of the overall view when rotating the mobile device. However, optimizations and new interaction styles are required in Sunburst technique in order to increase its suitability for the current smart mobile devices.

Targeting this concern, we focus on proposing some optimization solutions and interaction options in the Sunburst (i.e., a *colorization* approach, a *focus+parents-levels-overview* navigation approach, zooming interaction, and a *labeling* scheme) while keeping in mind the limited screen size and the interaction styles of the current mobile devices. These proposed optimization solutions and interaction options would increase the readability of large tree hierarchies and help the mobile users to interact more intuitively and efficiently with such visualizations. We also report a preliminary user study that we conducted to measure users satisfaction level towards our colorization approach.

The reminder of the paper is structured as follows: First, we briefly provide some related work. Then we present our proposed optimization solutions and interactions options, followed by the user study. Finally, we conclude the paper.

2 Related Work

Space-filling techniques can be subdivided in two categories: the *Space-Division* layouts and the *Space-Nested* layouts. In the case of Space-Division layouts, the parent-child relation is depicted implicitly by attaching the children to their parents. The Sunburst algorithm, originally proposed by Stasko and Zhang in [10], uses radial or circular space-filling techniques. A general image in the developer community is that the radial layout methodology conveys a better hierarchy structure without sacrificing the efficient screen-space usage [4, 10]. Whereas in Space-Nested layouts, the child-parent relationship is drawn using nested boxes in which the children are placed within their parent nodes. Few examples can be found in [2, 12, 13].

Yang and Matthew utilized the Sunburst technique to build a tool for supporting the circular distortion to make it more interactive and scalable [14]. In [6], Rodden presented a nice interactive representation to visualize the sequences and the paths that users tend to follow while using the Youtube website.

Recently, researchers have started working in the direction of visualizing data on touch devices and smart mobile devices using different approaches,

e.g.: Sadana and Stasko in [8] provided their approach of visualizing interactive scatterplots on tablet devices; Baur et al. presented TouchWave in [1] for visualizing stacked graphs on touch devices; while Rzeszotarski and Kittur presented TouchViz in [7] for visualizing multivariate data on tablet devices.

3 Optimizing the Sunburst for Mobile Devices

In this section, we provide details of our proposed optimization solutions and interaction options to make Sunburst suitable for the smart mobile devices. As a case study in this paper, we visualize the hierarchical structure of the software system of a robot called RAVON [5] (see Figure 1). The RAVON software system contains four main packages (i.e., *libraries*, *projects*, *tools*, and *others*), where each package contains a group of sub-packages except the "other" package. In total, RAVON has 3152 software files and are divided by three extensions (i.e., ".cpp", ".h", and ".hpp").

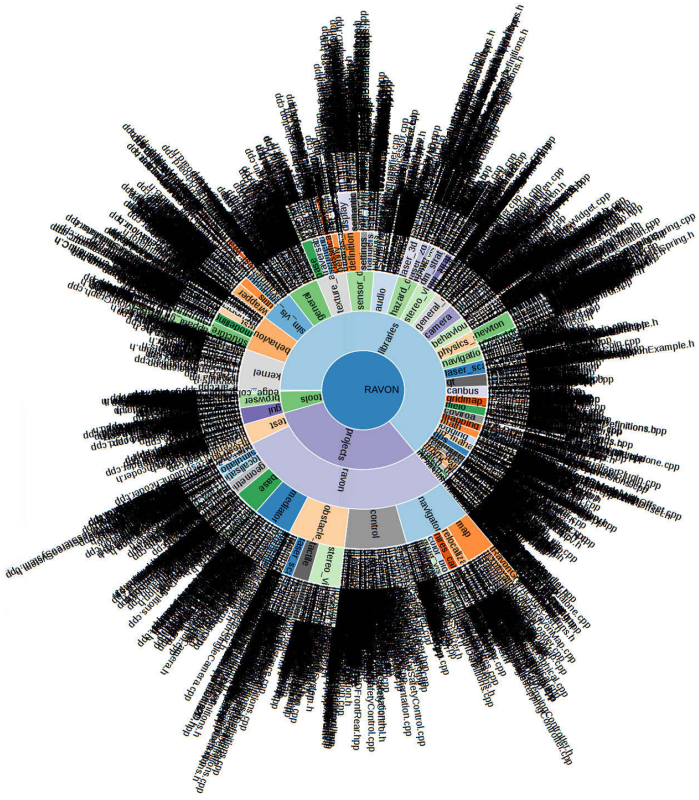

Figure 1. Visualization of the RAVON software system hierarchical structure using the standard Sunburst. It also shows the labels of nodes, which are either packages or class names.

3.1 Enhancement of the Sunburst Colorization Style

Generally, space-filling techniques use solid areas to represent nodes where each node has a specified color. Colorization is the first thing that is noticed by human eyes [11]; therefore, we focus on enhancing the Sunburst visualization using the color dimension strength. For this, we create a new dimension for the visualized node, based on not only the size dimension but also on the color dimension. In this regard, we have two meanings for the colors in our visualization: the *branching* and the *depth*. Each node takes a color based on its parent's color where the brightness of this color depends on this node's depth level.

For example, our case study the RAVON software data structure has four branches (i.e., *libraries*, *projects*, *tools*, and *others*). Therefore, the resulting visualization has four different colors (see Figure 2). These four parent nodes are the darkest nodes in their branch while the children of these parents are lighter in color compared to them and so on until the leaf nodes, which are the lightest nodes. This solution also helps the viewers in keeping the overall structural map in their mind when they browse the lower level of details, as the colors of lower branches indicate their parent branch.

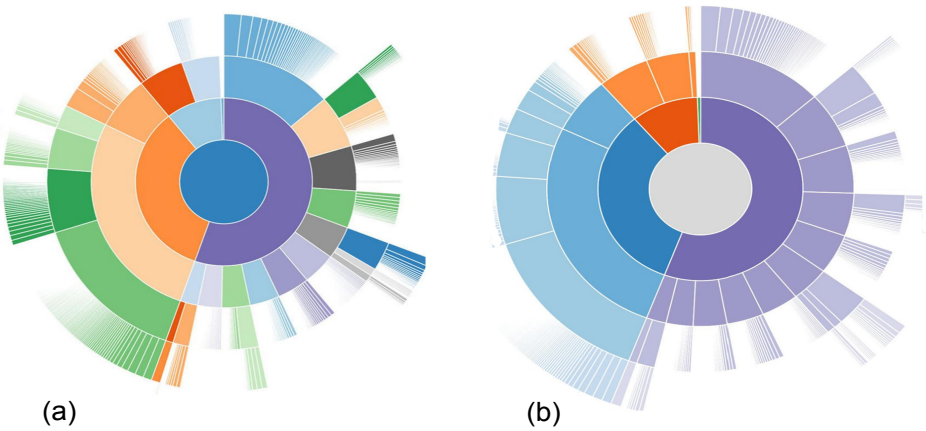

Figure 2. Sunburst before (a) and after (b) the application of our *colorization* approach.

3.2 The Focus+Parents-Levels-Overview Navigation

In order to navigate intuitively through the different levels of details, we propose a navigation style called the *focus+parents-levels-overview* navigation. This navigation scheme combines the *folding* and *unfolding* interactions with a customized form of *focus+context* approach while keeping the requirements of limited screen sizes and the interaction styles of smart mobile devices.

In this regard, when users tap on a particular node, a new view is provided to show its children and lower levels, where the root of this new view is the selected node. However, instead of visualizing the selected node as the root node in the center of the visualization we visualize the selected root and its siblings in a circular fashion inside the new presented view, as shown in Figure 3.b. When users navigate to further lower levels, all the parent nodes and their siblings are visualized one by one in a circular form at the center of the newly created view (see Figure 3.c). In the case if the parent node and its siblings have the same color then the parent node is highlighted in the inner circle (see Figure 3.c).

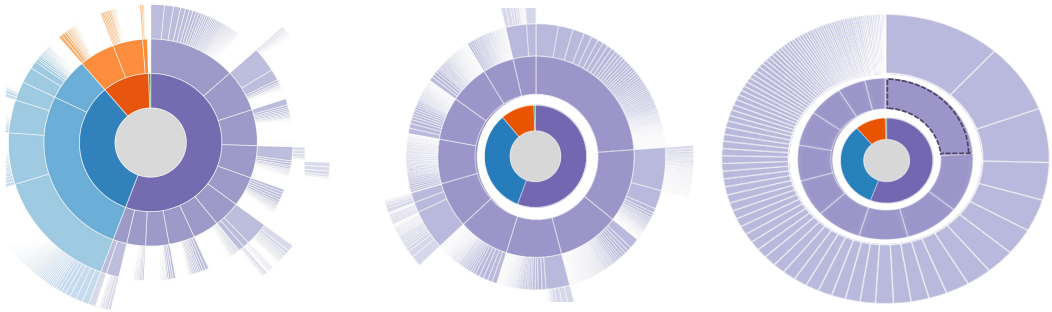

Figure 3. (a) Sunburst using our *colorization* approach showing the overall RAVON software structure. (b) The new view after tapping the "libraries" node, here the inside circle shows the parent node and its siblings. (c) Further navigating the "kernel" node, here are two parent-level inside circles where the "kernel" node is with highlighted border in order to show it as the root of this view.

Taping on any inside parent circle brings the user back to that level of details, where the root is supposed to be the parent of the tapped circle in the newly created view. While double tapping any particular node in an inside parent circle brings the user to the level of details where the double tapped node is supposed to be the root of the newly created view.

This *focus+parents-levels-overview* navigation approach provides several benefits in the context of mobile devices. In desktop environments, normally a separate view is provided to give the overall context so that users do not lose the context when they navigate deep in the hierarchy. Providing a separate overall view is not so feasible in the case of mobile devices. Our approach gives users the important overall context, i.e., all the parents and their siblings, which is enough for having an idea about the overall hierarchy. This also endorses the current mobile paradigm theme, i.e., showing only the relevant and necessary information while hiding the less important information. Also, our *colorization* scheme helps here users in understanding their current level of navigation.

Overall, our proposed navigation approach not only saves the space without affecting much the visualized information, but it also provides intuitive interactions with the resulting visualizations that are more suitable for the current mobile paradigm.

3.3 Zooming

In the cases of large trees (e.g., our RAVON case study), it is sometimes difficult to see low-level details in the produced visualization due to the limited screen sizes of mobile devices. Therefore, it is needed to provide instant distortion and zooming facility so that users can directly explore the hierarchy and other details from the current level of details. In this regard, we provide two options:

In the first option, we provide instant zooming interaction to any view level. This activates when viewers apply long press on any part of the Sunburst visualization, which results in zooming of that particular part. For this, we divide the overall Sunburst circular view into six slices and the corresponding slice of long pressed is then zoomed (see Figure 4.a). The selected area can also be further zoomed by again applying the long press interaction on the previously zoomed area. This time we divide the already zoomed slice into further three slices for providing further zooming. By simple tapping on any particular node in the zoomed area would open the new view where the tapped node would be the root of the new opened view. On the other hand, tapping any place outside the zoomed view would close the zoomed window and would show the current view.

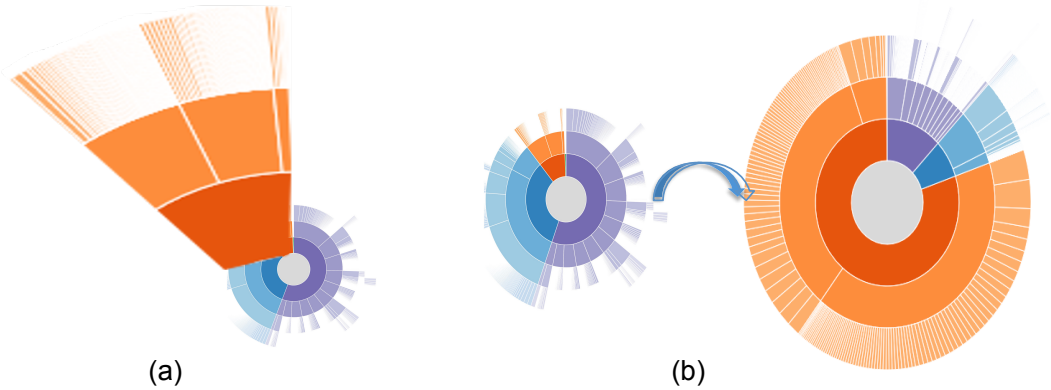

Figure 4. (a) Long pressing on a particular part of Sunburst brings a new view showing the selected slice in zoomed form while the overall Sunburst is scaled down and shown at the bottom side of view. (b) In the second option, long pressing on a particular first-level children node enlarges this node and its further children nodes inside the Sunburst while scaling down other sibling nodes and their children nodes inside the Sunburst.

In the second option, long pressing a particular first-level children node of the current view enlarges this node and its children inside the Sunburst while scaling siblings of the selected node and their children inside the Sunburst. Figure 4.b shows the new view after long pressing the “tools” node (i.e., in orange color) in the original view. This new view scales up the “tool” node and its children while scales down siblings of the “tool” node and their children. Tapping any area outside the enlarge part would bring back the original view.

3.4 Enhancement of the Sunburst Labeling Style

We also focus on optimizing the labeling style in the Sunburst in order to make it suitable for mobile devices. The basic idea is to show the nodes’ names in the visualization without causing extra occlusion. For this, we propose two options:

3.4.1 The External Labeling

In this labeling style, we enhanced the solution proposed by [6] in which labels are visualized using the external SVG elements outside the sunburst. In our case, the top SVG elements (as shown at the top side of Figure 5.a) show the path from the overall root node of the tree to the root node of the current view. However, we enhanced it by showing the labels of all the one-level children nodes of the root node of the current view at the bottom of the view in a scrollable horizontal bar (see Figure 5.a). This option not only helps in reducing the cluttering that might appear in case of large hierarchies, but it also increases the interaction speed with the visualization. Moreover, this light solution offers some natural interactions with the resulting visualization. For example, tapping a label in the bottom horizontal bar highlights the corresponding node in the view while double tapping a label opens a new view making the selected node as the root node of the new view. On the other hand, swiping over the nodes in the view highlights the corresponding labels in the bottom horizontal bar.

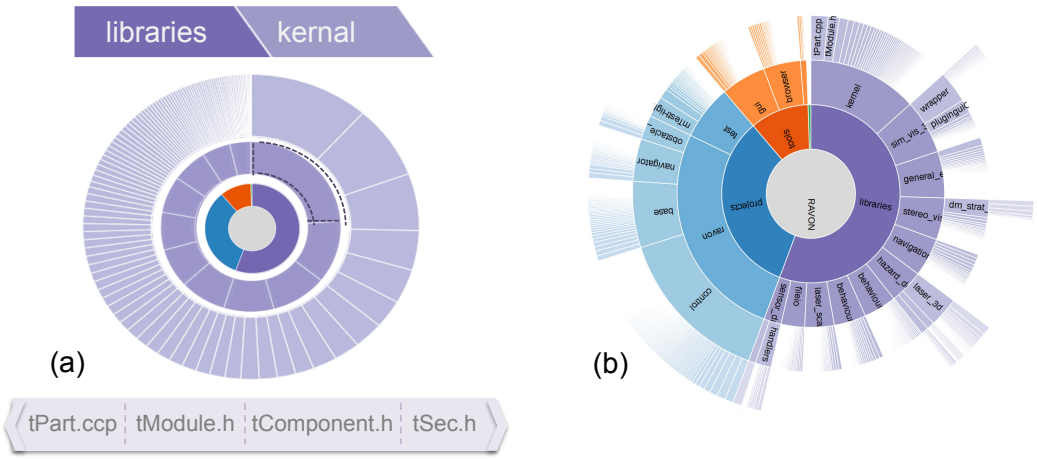

Figure 5. (a) Labels visualizing using the external SVG elements on the top of the Sunburst while the scrollable horizontal bar at the bottom shows names of one-level children nodes. (b) Application of the internal labeling.

3.4.2 The External Labeling

Sometimes it is necessary to show labels inside the nodes. However, using this option with normal node-label length leads to extra cluttering and extra noise in the resulting visualization, as it is shown in Figure 1. Therefore, this solution is not suitable for mobile devices. To optimize this solution, we propose to show only those labels that could fit inside the geometry of their nodes (see Figure 5.b). However, through zooming option, users would be able to see other nodes' labels when they are in the zoomed form, as then these nodes would have more geometrical area.

4 The Preliminary User Evaluation Study

We conducted a preliminary user evaluation study in order to measure participants' satisfaction level towards our colorization scheme. In this study, 15 students participated with an average age of 25 years. Most of these participants were from the software engineering background with expertise in software systems architecture and software metrics, as our case study visualization was based on the RAVON software system. The evaluation study consisted of the following task and goal:

- **Task:** Test the colorization affect.
- **Goal:** The goal of this task was to get the users' feedback with regard to the influence of adding the colorization styles on conveying the hierarchy clearly.
- **Configurations:** The RAVON software system was visualized on a tablet device using two different visualizations: the first one was with

random colors while the second one was with the proposed colorization approach. These both cases are shown in Figure 2.

At the end of the test, we asked the participants to give their feedback through closed-ended questionnaires based on a likert-scale (between 1 and 5 where 1 meant strongly disagree while 5 meant strongly agree and the sixth option was "Don't know").

We asked the participants whether they used the variation in colors to understand the tree structure. In this regard, 12 participants out of 15 participants agreed that they used the variation in colors to detect the hierarchy (see Figure 6). Most of them reported loudly during the test that it is easy to detect the hierarchy levels or branches using the variation in colors. While in the case of using random colors in the provided visualization (see Figure 2.a), participants were almost neutral as they used the containment representation provided by the Sunburst visualization to get the hierarchy rather than using the color cue.

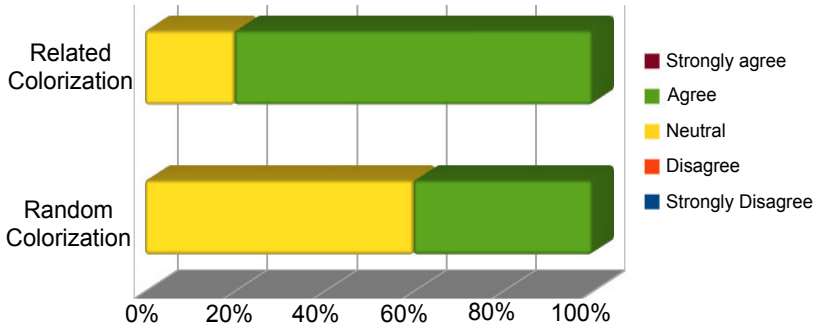

Figure 6. Participants' feedback regarding their preference of using the color cue in finding the tree structure.

5 Concluding Remarks

In this work, we proposed some optimization solutions and interaction options for the sunburst visualization in order to make it more suitable and readable on smart mobile devices. For example, we proposed a *colorization* approach in which each branch has its own color and the levels in a branch have different brightness values of the same color of their parent. This solution was inspired from the work of Tennekes and Jonge in [11]. Using this solution with our *focus+parents-levels-overview* navigation approach provides an intuitive solution for mobile users to understand and navigate large tree hierarchy on the limited screen sizes of mobile devices. Further interaction options were provided to make the interaction more natural according to the current mobile paradigm.

The results of the conducted preliminary user evaluation study showed high users satisfaction towards our *colorization* approach, as they agreed that it helped them in detecting the hierarchy more intuitively. However, this was very limited study with focused only on the *colorization* approach. In the future, we intend to conduct large-scale evaluation studies where we would evaluate all the proposed optimization solutions and interaction options using different data sizes and device sizes in order to check the effectiveness and feasibility of our solutions in general on mobile devices.

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