Constructing Hierarchical Continuity in Hilbert & Moore Treemaps

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1 Motivation

The Hilbert and Moore treemap layout algorithms are based on the space-filling Hilbert and Moore curves, respectively, to map tree-structured datasets to a 2D treemap layout [Tak and Cockburn 2013]. Both are based on a node partitioning and subsequent recursive rectangular subdivision of the layout [Scheibel et al. 2021] and depend on a set of subdivision templates that are proposed in their original publication [Tak and Cockburn 2013]. Considering multiple snapshots of a time-variant dataset, one of the design goals for Hilbert and Moore treemaps is layout stability, i.e., adhering to the *principle of visual-data correspondence* [Kindlmann and Scheidegger 2014]. Hilbert and Moore treemaps approach stability by placement of nodes along a space-filling curve. This space-filling curve is expected to be continuous across all nodes and hierarchy levels, which has to be considered throughout the layouting process, otherwise resulting in *jumps* of individual layout elements, lowering the measured and perceived stability. In previous studies, this continuity was not ensured and an inferior stability was reported [Sondag et al. 2018, Vernier et al. 2020]. We contribute details to the choice of subdivision templates and their orientation to ensure a continuous space-filling curve.

2 Approach

The high-level algorithm is defined as follows: For each group of sibling nodes, the ordered list of weights is recursively divided into up to four parts, forming quadrants (Fig. 1).

Templates. The original authors proposed eleven templates for two and three cuts [Tak and Cockburn 2013]. We propose to extend this set to include single-cut templates and a no cut template for completeness, adding up to 14 templates (Fig. 2).

Orientation. We further propose to consider a local orientation of the current layout element as well as orientations of the sub-templates that are to be instantiated. We extend the definition of each template to define orientations of its sub-templates.

Curve Affinity. We consider templates to have an affinity to either for Hilbert or Moore curves ($\mathcal{H}$ and $\mathcal{M}$). Further, continuity of the space-filling curve has to hold for all of its child nodes and for all of its sibling nodes. The templates together with their orientations can be interpreted differently, regarding on the local orientation of the space-filling curve being clockwise or counterclockwise (CW and CCW). This virtually extends the templates with horizontally flipped versions.

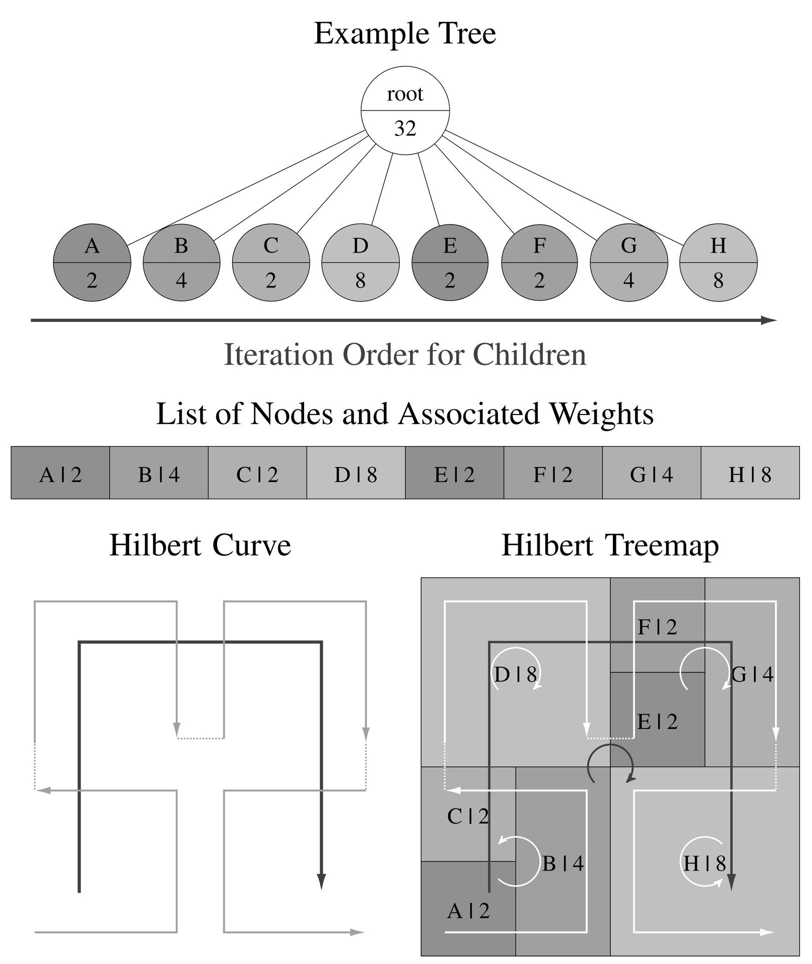

Figure 1: *A layout example for a tree with the node list A–H with associated weights and a summed weight of 32.*

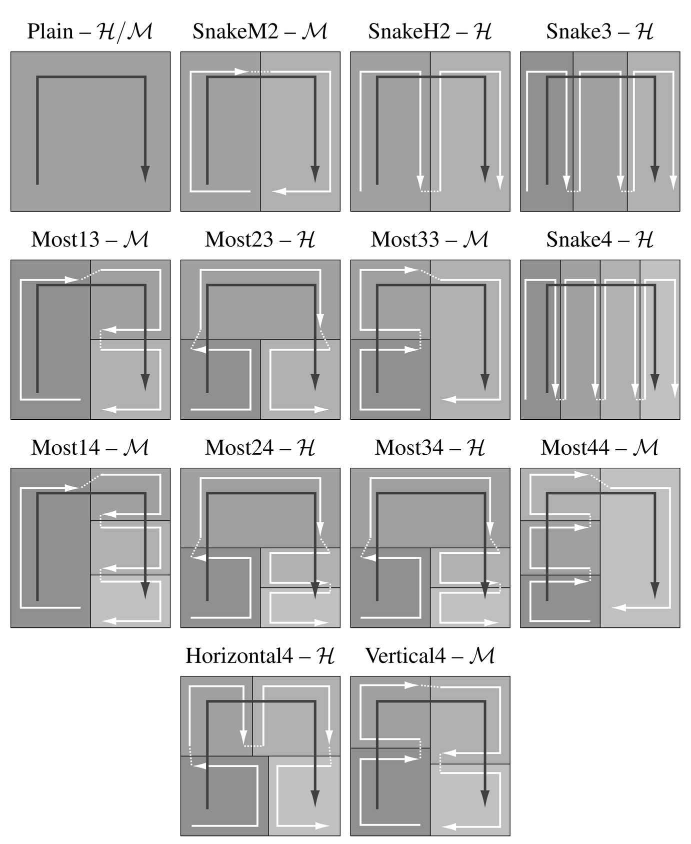

Figure 2: *Layout templates for recursive subdivision of 1, 2, 3, and 4 nodes with their curve affinity $\mathcal{H}$ – Hilbert curve, $\mathcal{M}$ – Moore curve). The line indicate the path and direction of the layouting process for the base level (dark) and the quadrant levels (light).*

3 Continuity in Hilbert & Moore Treemaps

We evaluate the changes in the layouting process using both list datasets and actual tree-structured datasets. The software prototype is available as open source project on GitHub [Scheibel et al. 2023]. Considering run-time performance, these additions do not introduce additional run-time complexity, as they only specialize the handling of templates during subdivision. An extension to the former implementation of Scheibel et al. upholds the linear run time of both layouting algorithms [Scheibel et al. 2021].

Debug Visualization. We show the resulting treemap layouts using a debug visualization: leaf nodes are rendered as colored rectangles where the color is mapped from their index in the datasets to grayscale. The color of one node does not change over multiple snapshots.

Popular Names Dataset. Using this visualization approach, we repeated the study of Sondag et al. using the popular names dataset from The Netherlands [Sondag et al. 2018]. The results are different but we show that the layout process does not introduce *jumps* (Fig. 3).

Software Repository Data. As examples of actual tree-structured datasets we use open source projects from GitHub with up to 100 000 leaf nodes (4). Those examples show that the proposed extensions allow for a hierarchically continuous space-filling curve.

4 Conclusions

By careful consideration of the templates and their orientation during subdivision, the continuity of the space-filling curves is ensured across all nodes and hierarchy levels. For this, we proposed to extend the number of templates, consider an affinity to the space-filling curves, and to further consider local orientations of the sub-templates. These variations have not introduced no increase in the run-time complexity and thus allows to be applicable for tree-structured datasets up to multiple hundreds of thousands nodes. For future work, we imagine to explore additional templates, subdivision approaches, and parameterization. We further see need for thorough evaluations of these and other treemap layout algorithms regarding datasets, parameterizations, and domains, as well as user perception [Fiedler et al. 2020].

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References

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Popular Names Dataset

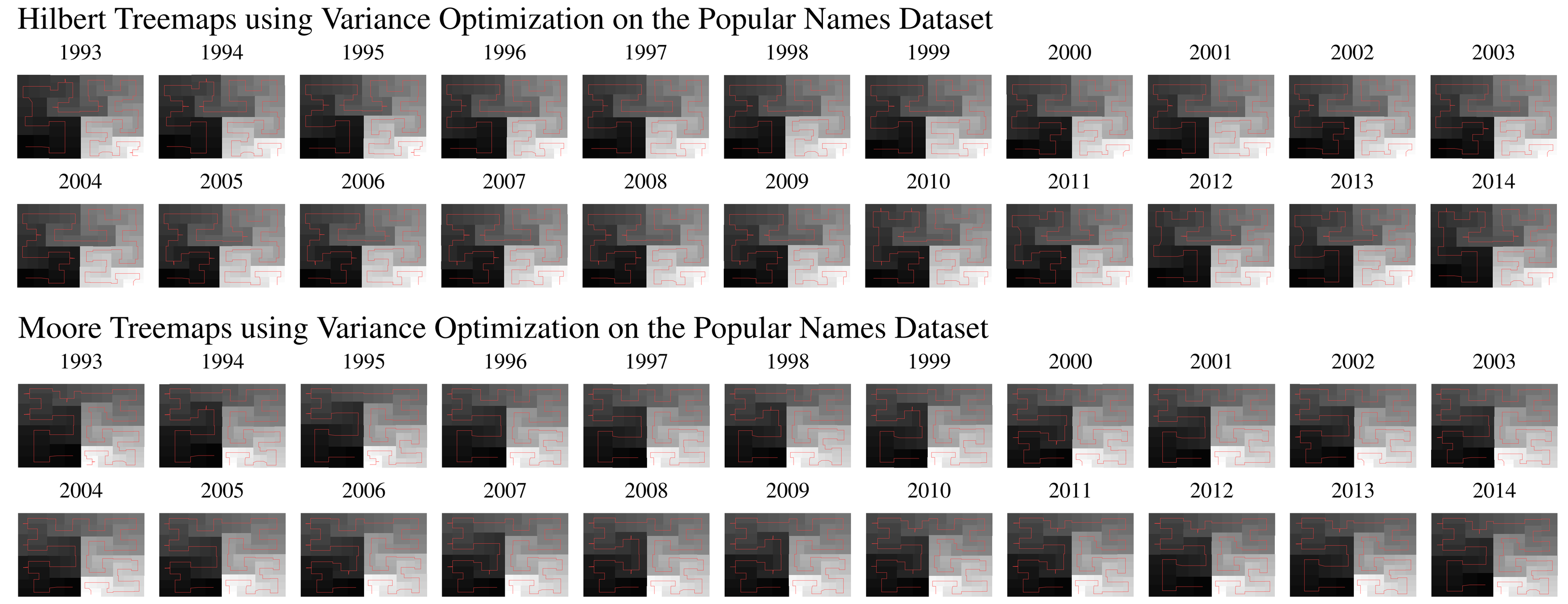


Figure 3: *Hilbert and Moore treemap layouts on the popular names dataset of The Netherlands between 1993–2014 and highlighted space-filling curve.*

Source Code Repositories

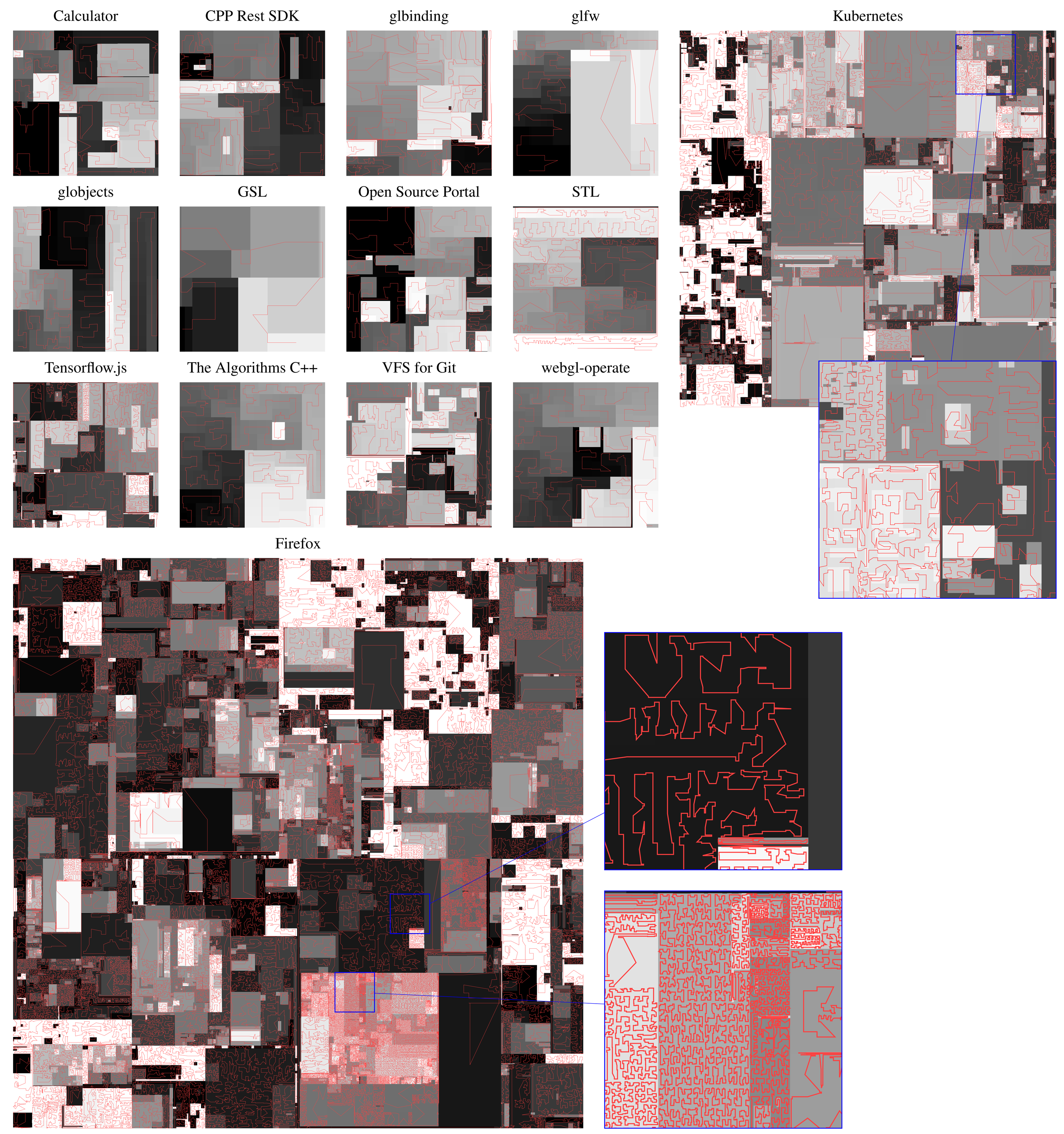
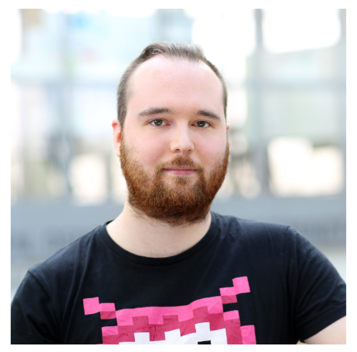


Figure 4: *Layout examples and highlighted space-filling curves for selected software repository datasets using the min-variance weight partitioning with the Hilbert space-filling curve.*



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