# Interactive Poster: A Hardware-Accelerated Rubbersheet Focus + Context Technique for Radial Dendrograms

Peter Imrich[1] Klaus Mueller[1] Dan Imre[3] Alla Zelenyuk[3] Wei Zhu[2]

[1] Center for Visual Computing, Computer Science, Stony Brook University
[2] Applied Mathematics and Statistics, Stony Brook University
[3] Environmental Sciences, Brookhaven National Laboratory

## Abstract

*Previous focus+context techniques for radial dendrograms only allow users to either stretch the display along the radius or the angle. In this poster, we present an interactive, hardware-accelerated rubbersheet-like technique that allows users to perform both operations simultaneously.*

## 1 Introduction

Dendrograms are a popular visualization method for illustrating the outcome of decision tree-type clustering in statistics. Most commonly, dendrograms are drawn in a Cartesian layout, as an upright tree. However, this layout does not make good use of space, it is sparse towards the root and crowded towards the leaf nodes (see Fig. 1). The spacing between nodes at different levels in the hierarchy is not uniform, which is due to the shrinking number of nodes from bottom to top. For this reason, long, wide-spanning connecting lines are needed to merge nodes at higher levels. A better layout in this respect is the polar or radial layout, where leaf nodes are located on the outer ring and the root is located in the center, as a focal point. A more uniform node spacing results, leading to a better utilization of space and resulting in a better illustration of the class relationships. Recently, Barlow and Neville [1] presented an empirical user study for tree layouts (with less than 200 leaves) in which they compare some of the major schemes: organizational chart (a standard drawing of a tree), tree ring (basically a pie chart of circular segments), icicle plot (the cartesian version of the tree ring), and tree map. According to the measured performance within a group of 15 users, the three former methods yielded similar results, with the icicle plot having a slight advantage. However, given the much larger number of leaves in our case (1000 and more) and the fact that the tree ring is the most compact of the three winning configurations, a radial layout seemed to be the most favorable one for our purposes (see Fig. 2). Radial graph layouts that illustrate hierarchical relationships are very popular, and for the special application of dendrograms, we know only of one other application using a radial layout, the recent one by Kreussler and Schumann [3]. In their implementation, the radii of the circles onto which nodes can be placed are quantized into a number of levels. The radius at which a (non-leaf) node is placed is a measure of the dissimilarity among its child-nodes, and a linear mapping is used to relate dissimilarity to radius. Leaf nodes, on the other hand, are always placed onto the circle one level below that of the parent node, while the root node is always at the center of the radial layout. Context and focus is provided by mapping the radial dendrogram onto a hemisphere, which can be rolled to expand interesting hemisphere regions in the center of projection. A number of radial layout techniques for hierarchies with a fixed root node are described by Wilson and Bergeron [6]. They show techniques that achieve (i) an equi-spaced grouping of leaf nodes on the outer-most circle, (ii) an equispaced grouping of inner nodes on the inner circles, (iii) a layout in which leaves are spaced on the outer-most circle with respect to their value range; (iv) a density-based layout

Although these layout techniques, and their hybrids, provide some level of flexibility, they are still somewhat static. As mentioned before, users often would like to focus on certain portions of the display, while compressing others, without losing context. Fisheye lenses [5] and hyperbolic zooming [4] have been proposed to provide these capabilities. In the context of tree rings Yang, Ward and Rundensteiner [7] have proposed a system in which users may either perform a polar zoom (i.e. expand the width of one or more adjacent rings while reducing others) or a radial zoom (i.e. expand the arc angle of some adjacent segments while reducing others). Users can perform these operations by pinning down one ring or arc segment and dragging another. A limiting factor here is that users cannot perform both operations simultaneously, which can be awkward in certain instances. To address this shortcoming, our application generalizes these concepts by allowing arbitrary warps of the dendrogram domain, i.e. we allow radial and polar zooms simultaneously.

## 2 Radial Dendrogram Preliminaries

In our implementation, the radii of the circles onto which nodes can be placed are quantized into a number of levels. The radius at which a (non-leaf) node is placed is a measure of the dissimilarity among its child-nodes, and a linear logarithmic mapping is used to relate dissimilarity to radius. Leaf nodes, on the other hand, are always placed onto the circle one level below that of the parent node, while the root node is always at the center of the radial layout.

The above layout process only depends on two user inputs: (i) the desired number of distinct concentric levels (used to reduce the number of nodes and arcs with respect to the resolution of the distance metric, and (ii) the desired minimum size of visible nodes (used to reduce the number of nodes with respect to their population density). However, we should note that the drawn dendrogram is by no means static. At any time user can re-specify and re-compute the tree layout globally as well as locally by manually expanding and collapsing individual nodes and polar zones. We have found that these two user-driven node reduction features make it possible to present clustering composed of thousands of nodes in a

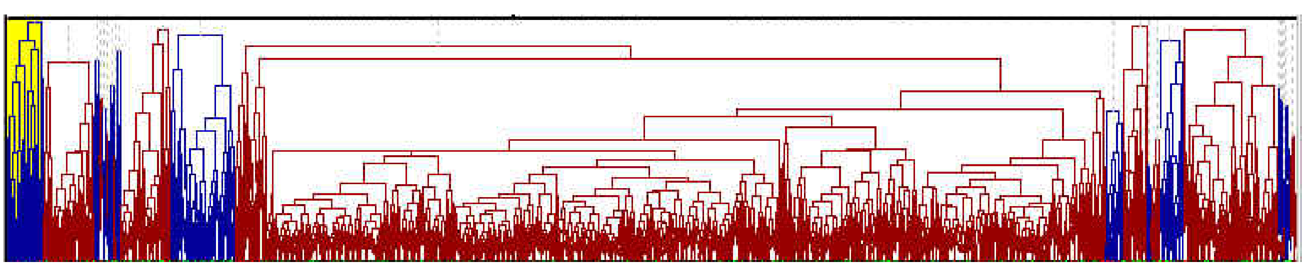

Figure 1: Example of a large dendrogram, drawn in Cartesian layout as an upright tree.

email: {imrich, mueller}@cs.sunysb.edu, {imre, alla}@bnl.gov, zhu@ams.sunysb.edu

space efficient manner. Edges are colored using a rainbow colormap to indicate the number of data elements they carry. More details on this aspect of our application can be obtained from [2].

## 3 Rubbersheet Context + Focus Technique

In addition to the dynamic layout, our dendrogram has the flexibility of non-linear, rubber sheet-like zooming. Here we have aimed to provide a focus+context scheme that is in good accordance with the polar layout of our graph. There were a number of zooming operations that our users found important: (i) enlarge certain levels of the hierarchy on a global scale, (ii) enlarge a subtree, possibly all the way from the leaves to the root, and (iii) zoom into a certain area and gradually reveal more local detail. We have achieved this by allowing users to select an arbitrary arc segment of interest, via specifying two anchor points located on opposite ends of the arc segment's diagonal via mouse clicks. The specified arc segment then expands and shrinks, responding to the mouse motion, while the rest of the dendrogram deforms by opposite, proportional transformations. An example is illustrated in Fig. 2, where Fig. 2a shows an unzoomed dendrogram, and Fig. 2b shows the same hierarchy with a user-specified (green) arc segment, whose outer edge is being compressed towards the center, and whose right edge (looking towards the center) is being pulled further to the right. This has the effect of globally expanding the lower (leaf) level of the hierarchy, as well as locally expanding the subtree captured in the arc segment's center.

A recalculation of the dendrogram layout at interactive speeds would be infeasible for dense hierarchies. Instead, we achieve the real-time speed of this operation by exploiting the texture mapping facilities present on even low-end computers. Upon activation, the dendrogram is first captured into an image and then texture-mapped onto a radial polygonal mesh. As the user drags the mouse, the polygonal mesh deforms which consequently warps the texture. However, the mesh recalculates the layout each time the distortion angle or radius exceeds a predefined threshold (we use 10° and 10% of the maxRad, respectively). This layout-refresh prevents the well-known artifacts of pixelization of overly distorted textures. In addition, leaf nodes formerly collapsed into a common polar zone or node are also optionally uncollapsed in this layout process (or re-collapsed upon compression). The entire process is virtually transparent to the user and enables the warping of dendrograms of almost arbitrary complexity at constant effort, as afforded by the hardware. A look-ahead mechanism could be implemented that computes new anticipated layouts based on the current warping activity of the user.

Arc-segment-based zooming of 2D polar space has two independent degrees of freedom: angular and radial. These two modes, while conceptually separate, define fundamentally the same operation for the texture mapping hardware. Their simultaneous integration gives the dendrogram an elastic, rubber-like feel and allows a compact, flexible, and elegant form of focus+context. It is fundamentally different from fisheye or hyperbolic zooms or the rolling sphere approach of [4]. The former are not specifically designed to work with polar graphs, while the latter does not provide the global enlargement of certain hierarchy levels. Finally, our rubbersheet approach is also different, and perhaps more useful for our purposes, from the method outlined in [7] since it allows both polar and radial zoom to be performed simultaneously.

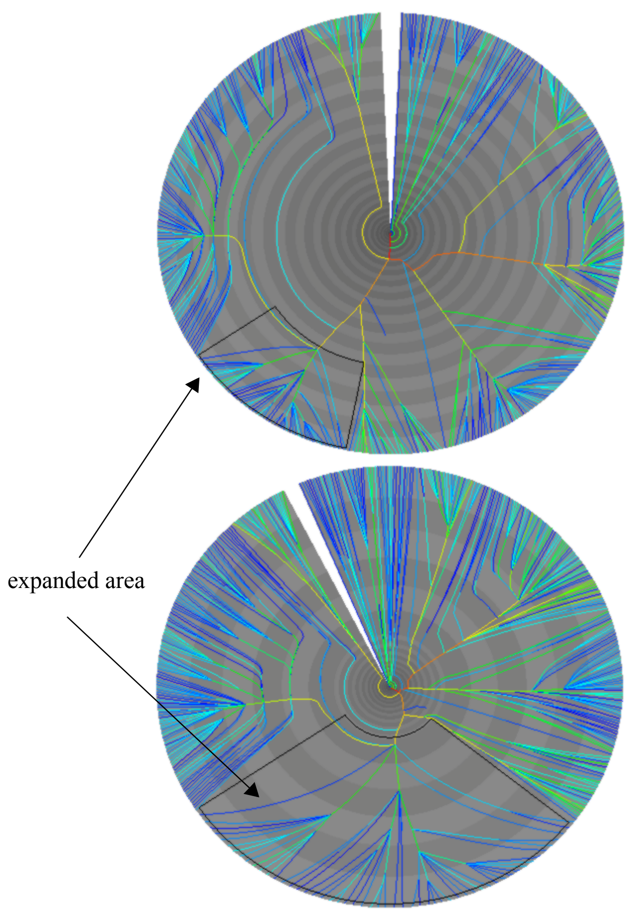


Figure 2: Rubbersheet zooming: (a) unwarped dendrogram, (b) a user-specified arc segment is angularly expanded and radially shrunk. Notice the radial distortion of the dendogram's polar rings.

## 4 Conclusions and Future Work

The application presented in this paper combines several different techniques to support data mining and survey with visual tools. Our rubbersheet technique adds the much needed versatile focus + context to the existing features of our interactive dendrogram application, for example, adjustable level of detail and manual subtree addition, removal, and migration.

### Acknowledgments

We thank the Center for Data Intensive Computing (CDIC) at Brookhaven National Lab for their generous support of part of this work.

### References

[1] T. Barlow and P. Neville, "A comparison of 2D visualization of hierarchies," *Information Visualization 2001*, pp. 131-138.

[2] P. Imrich, K. Mueller, R. Mugno, D. Imre, A. Zelenyuk, and W. Zhu, "Interactive Poster: Visual Data Mining with the Interactive Dendrogram," *IEEE Information Visualization Symposium,* poster session. Available at http://www.cs.sunysb.edu/~mueller/research.

[3] M. Kreussler and H. Schumann, "A flexible approach for visual data mining," *IEEE Trans. Visualization and Computer Graphics*, vol. 8, no. 1, pp. 39-51, 2002.

[4] T. Munzner, "Exploring Large Graphs in 3D Hyperbolic Space." *IEEE Computer Graphics & Applications*, vol. 18, no. 4, pp. 18-23, 1998.

[5] M. Sarkar and M. Brown, "Graphical fisheye views," *Communications of the ACM*, vol. 37, no. 12, pp. 73-84, 1994.

[6] R. Wilson, R. Bergeron, "Dynamic hierarchy specification and visualization," *Information Visualization 1999*, pp. 65-72.

[7] J. Yang, M. Ward, and E. Rundensteiner, "InterRing: An interactive tool for visually navigating and manipulatiung hierarchical structures," *IEEE 2002 Symposium on Information Visualization*, pp. 77-92, 2002.