TreeMaps

CSE 591 Visual Analytics

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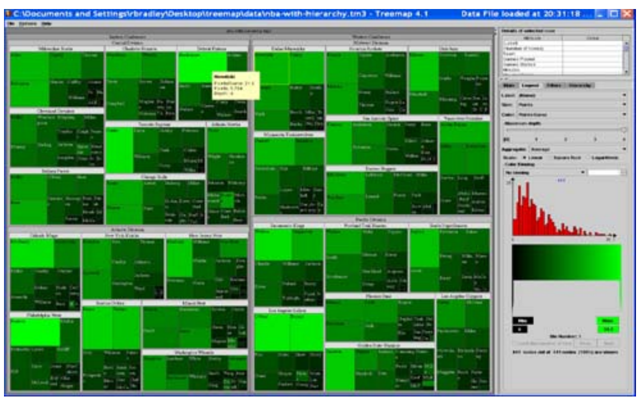
Agenda

- What is a Treemap?
- Treemap Basics
- Original Treemap Algorithm (Slice-and-dice layout)
- Issues for Treemaps
- Cushion Treemaps
- Squarified Treemaps
- Ordered Treemaps
- Quantum Treemaps
- Other Treemaps
- Application of Treemaps (PhotoMesa)
- Conclusion

What is a Treemap?

- Space filling technique to visualize hierarchical data



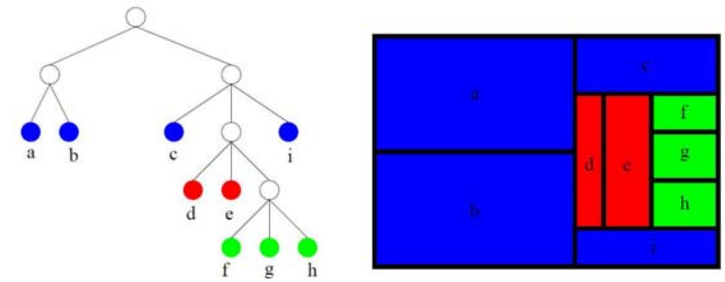
Basics

- Originally designed to **visualize files on a hard drive** and developed by Shneiderman and Johnson.
- Developed from a tree to **get over the limitation** that node and link diagrams use the display space inefficiently.
- The full display space is used to visualize the contents of the tree.
- Each node has a name (a letter) and an associated size (a number).
- **Each rectangle corresponds to an attribute of the data set.**

Basics (cont.)

- The size of leaves may represent for instance the size of individual files, the size of non-leaf nodes is the sum of the sizes of its children.
- The treemap is constructed via recursive subdivision of initial rectangle.
- **The size of each sub-rectangle corresponds to the size of the node**.
- **Color and annotation can be used to give extra information about the leaves**.
- The treemap is very effective when size is the most important feature to be displayed.

Basics (cont.)



Basics (cont.)

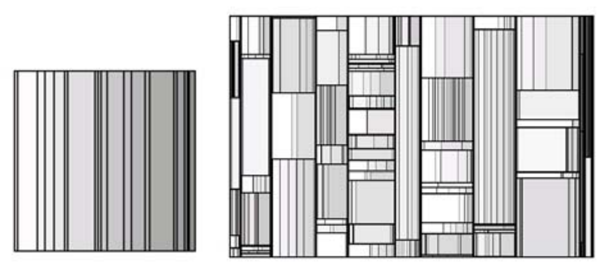
- **Aspect Ratio** (of a rectangle)
  - Max (width/height, height/width).

    The lower the aspect ratio of a rectangle, the more nearly square it is.

    ie. a square has the ratio of 1.
- **Layout of a treemap**.
  - Set of rectangles that makes up the map.

Original treemap algorithm (Slice-and-dice layout)

- The simplest treemap algorithm.
- **At each level, the orientation of lines switches**. (vertical to horizontal or horizontal to vertical)
- Shading indicates the order.
- **The size of each rectangle reflects the size of the leaf.**



Issues for Treemaps

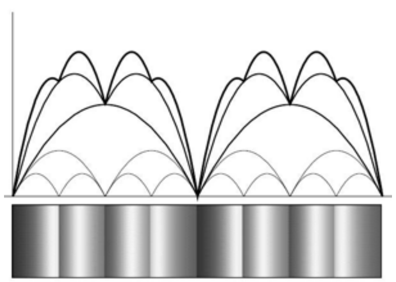
- Treemaps often fall short to **visualize the structure of tree**.
- **Aspect Ratio** difference. ie. Balanced tree. rectangles are difficult to compare and to select.
- Maintain **order**.
- Accommodate changes in the data.
- Difficult to find the data.

Cushion Treemaps Overview

- Compact, space-filling displays of hierarchical information based on recursive subdivision of a rectangular image space.
- **Take advantage of how human visual system is trained to interpret variations in shades as illuminated surface**.
- **Shading** is used to show insight in the hierarchical structure.
- During the subdivision **ridges are added per rectangle to form a surface** that consists of recursive cushion.
- Various coloring options are available to show the size, the level, and other attributes of the leaves.

Cushion Treemap Method to produce the surface.

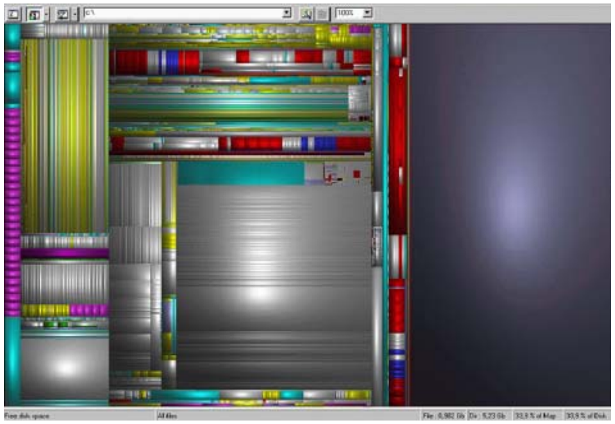
- 1. Subdivide the interval and add a bump to each of the two subintervals.
- 2. Repeat the step above recursively. To each new sub-interval, add a bump again, with the same shape but half of the size of the previous one.
- Use a parabola function to make the ridges have cushion-like shape.
- If we interpret this curve as a side view of a bent strip, and render it as viewed from above, the bumps transform into a sequence of rides.



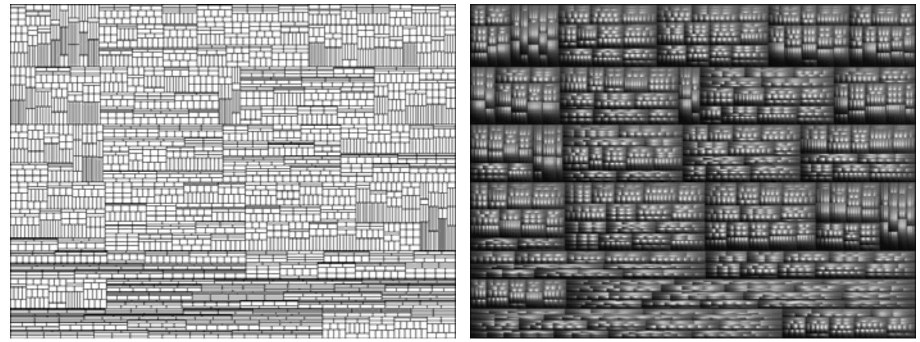
Cushion Treemap Algorithm

- Follows the original treemap algorithm.
- The main input consists of the root of the tree to be rendered, the initial rectangle to be used, and settings for height and parabola function.
- The main extension is that **during the generation of the rectangles, the surface is constructed**.
- The surface is bent in a direction.
- If the tree is a leaf, the cushion is rendered, else the direction is changed and its children are visited.

Cushion Treemap example



Cushion Treemap VS Original Treemap



Cushion Treemap Summary

- Efficient: generation of image takes less than a second.
- Effective: **the structure is visualized much more effective compared with original treemaps.**
- Easy to implement: the algorithm is very simple.
- **Emergence of thin, elongated rectangles**.

Squarified Treemaps Overview

- For large hierarchical structure.
- **Sub-rectangles have a lower aspect ratio**.
- Display space is used more efficiently. The number of pixels to be used for the border is proportional to its circumference.
- **Square items are easier to detect and point at**.
- **Comparison of the size of rectangle is easier when their aspect ratio are similar**.
- The accuracy of presentation is improved.

Squarified Treemaps Method. Squarification Key Ideas.

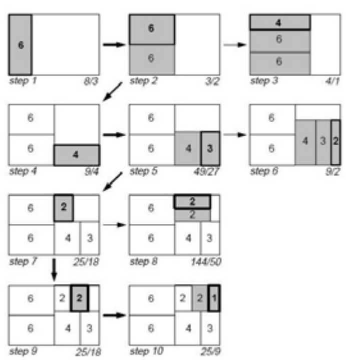
- Do not consider subdivision for all levels simultaneously.
  - Leads to an explosion in computation time.
- Produce square-like rectangles for a set of siblings, given the rectangle where they have to fit in, and apply the same method recursively.
  - **The start point for the next level is close to square, which gives good subdivisions**.

Squarification Treemap Algorithm

- **Split the initial rectangle**. Choose horizontal subdivision if the original rectangle is wider than high, vertical subdivision if the original rectangle is higher than wide.
- **Fill the left half by adding rectangles until we reach the optimum point of aspect ratio.**
- Start to process the right half based on above.
- Apply above recursively to work on the rest of rectangles.
- The order in which the rectangles are processed is important. **Process large rectangles first**.
- An optimal result can not be guaranteed.

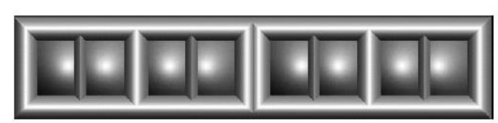
Example of Squarification

- A rectangle with width 6 and height 4
- Subdivided into 7 rectangles(6,6,4,3,2,2,1)

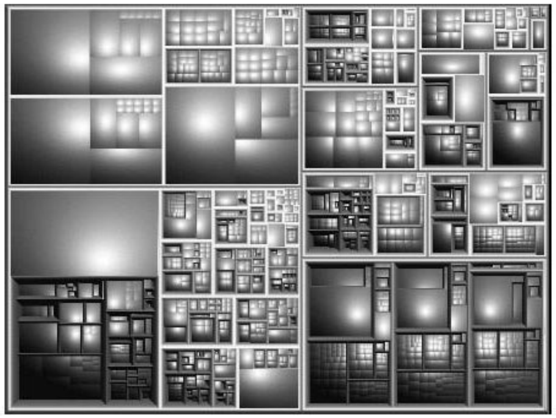


Squarified Treemaps Frames

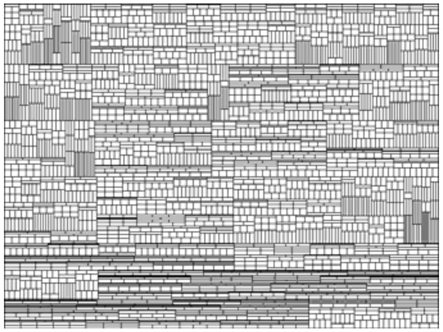
- Additional feature to improve the visualization of the structure.
- Derived from Nesting (maze-like images).
- **Filled in the borders with gray-shades based on a geometric model**.

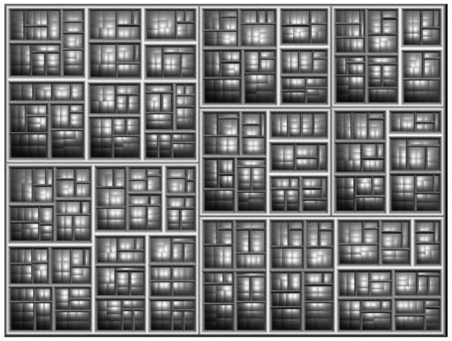


Example of Squarification Treemap



Squarification Treemap VS Original Treemap





Squarification Treemap Summary

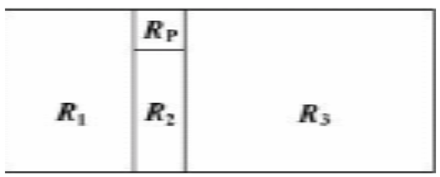
- Rectangles get forced to be **more square**.
- Represent sizes more precisely.
- **Frames** can improve the perception of structure.
- Changes in the data set can cause dramatic discontinuous changes in the layouts.
  - Hard to find items on the treemap by memory, decreasing efficacy for long-term users.
- **Orders are not preserved**.

Ordered Treemap Overview

- Ensures that **items near each other in the given order will be near each other** in the treemap layout.
- Maintaining relatively favorable aspect ratios of the constituent rectangles.
- Roughly **preserves the given ordering of the data (Index).**
- Applicable to a situation where legibility, usability and smooth updating are important.

Ordered Treemap Algorithm

- Inputs: **Rectangle R and ordered list of items by index** having specific areas
- Recursive algorithm. At each step:
- **Select a pivot** item (P)
- If the width of R is greater than or equal to the height, **divide R into four rectangles**, *R*1, *Rp*,*R*2, and *R*3 as shown below.



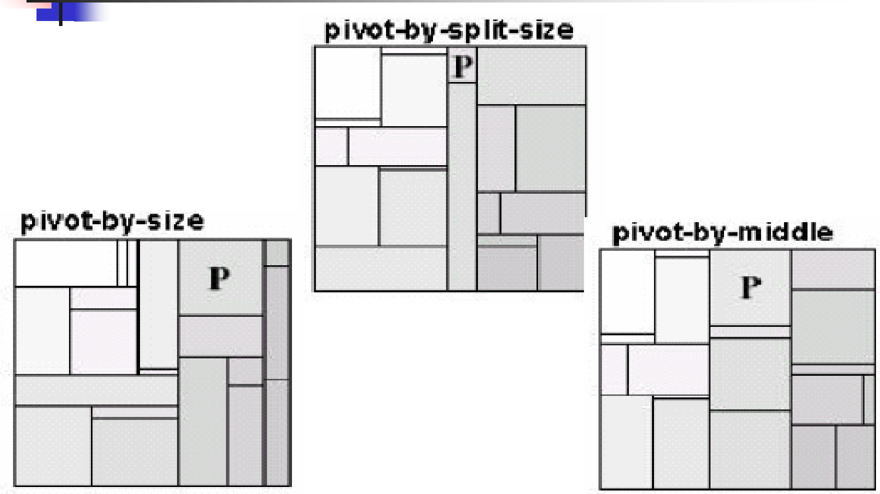
Ordered Treemap Algorithm (Cont.)

- **Divide the list into 3 parts** L1,L2 and L3 to be laid out in R1, R2, and R3.
- If the number of items is <= 4, lay them out in either a pivot, quad, or snake layout,
- Stop If width > = height (For this example)
- Apply recursively.

Ordered Treemap Algorithm Selection of Pivot

- **Pivot-by-size**
  - The pivot is taken to be the item with the largest area since the largest item is the most difficult to place.
- **Pivot-by-middle**
  - The pivot is taken to be the middle item of the list since this is more likely to create a balanced layout.
- **Pivot-by-split-size**
  - Selects the pivot that will split L1 and L3 into approximately equal total areas.

Ordered Treemap Algorithm Selection of Pivot (Cont.)



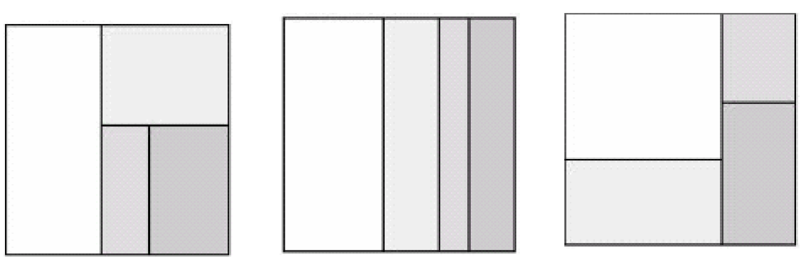
Ordered Treemap Algorithm Dividing the list L

- Divide the items in the list, other than *P*, into three lists, *L*1, *L*2, and *L*3, such that ***L*1 consist of items whose index is less than P and *L*2 have items having index less than those in *L*3**, and the aspect ratio of *RP* is as close to 1 as possible.

Ordered Treemap Algorithm Stopping condition

- If number of items is <= 4, lay them either in a **pivot**, **quad**, or **snake** layout
- **Pick the best layout** whose average aspect ratio is closest to 1.

Ordered Treemap Algorithm Stopping condition (Cont.)

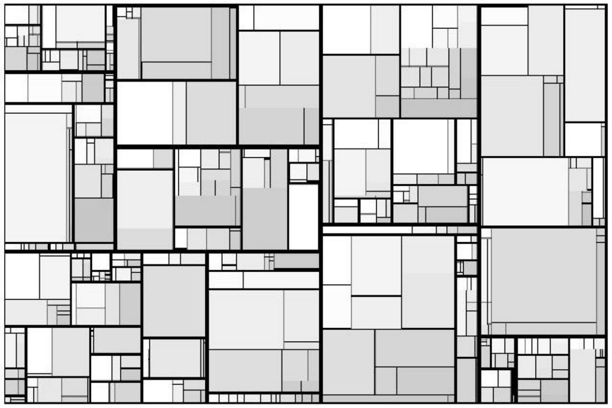


Pivot Snake Quad

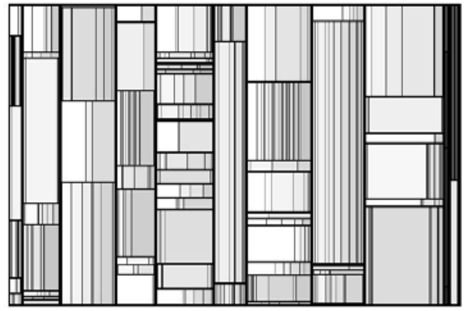
Performance of the Ordered Treemap Algorithm

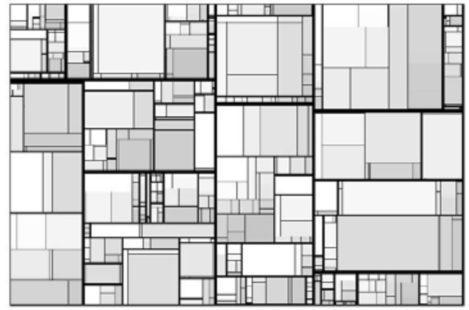
- Pivot-by-size
  - n*log(n) average, n^2 worst case.
- Pivot-by-middle
  - n*log(n) worst case.

Example of Ordered Treemap



Ordered Treemap VS Original Treemap





Ordered Treemap Summary

- **Creates layouts that preserve order** and that update cleanly for dynamically changing data.
- Much **better aspect ratio than the original treemap** algorithm.
- **Left-to-right and top-to-bottom direction** in the layout.
- Tradeoff between aspect ratios and smoothness of layout changes.

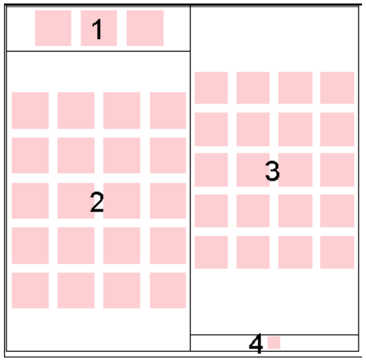
Quantum Treemap

- Designed for laying out images or other objects of indivisible (quantum) size.
- **Guarantees that every generated rectangle will have a width and height that are integral multiple of an input object size**.
- Always **generates rectangles in which a grid of elements of the same size can be layed out**.
- Applied for an image browsing software “PhotoMesa”

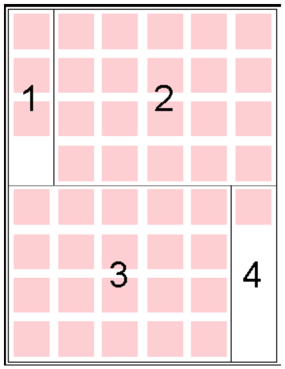
Quantum Treemap Algorithm

- **Directly based on the Ordered Treemap** Algorithm. ie. Uses pivot selection & stop condition
- **Takes an elemental object dimension, and a list of numbers of objects. Returns a sequence of rectangles where each rectangle is large enough to contain a grid of the number of objects requested**.
- Takes extra input that is the aspect ratio of the elements to be laid out in the Rectangle.
- Occasionally produces undesirable layouts due to too much wasted space.

Quantum Treemap VS Ordered Treemap



Ordered Treemap



Quantum Treemap

Quantum Treemap Summary

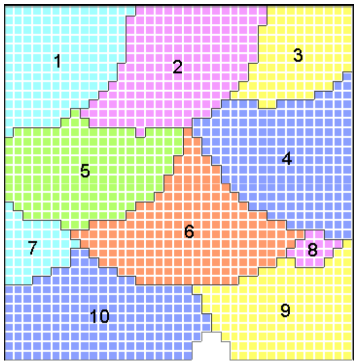
- **Improved version of the ordered treemaps in terms of laying out images or objects.**
- Generated rectangles will have a width and height that are integer multiple of an input object size.
- **All the grid elements will align perfectly with rows and columns of elements running across the entire series of rectangles.**

Other Treemaps

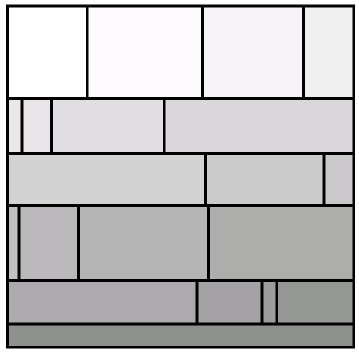
- **Ordered Quantume Treemap**
  - Combined the ideas of Quantum Treemaps and Ordered Treemaps.
- **Bubblemaps**
  - Lays out groups of quantum-sized objects in an ordered position with no wasted space per group, although there is a small amount of wasted sapce for the entire area.
- **Strip Treemaps**
  - Desinged to produce highly readble displyas. Layout has a consistently ordered set of rectangles while still maintaining good aspect ratios.
- **StepTree**
  - extended into three dimensions by the simple expedient of stacking levels of the tree on top of each other in 3D space.
- **Circular Treemaps**
  - don't fill the available space completely.
  - fill the available space to a varying degree which in the case of nested tree structures leads to the problem that circles of the same size could represent files (or folders) of a vastly different size .

Other Treemaps (Cont.)

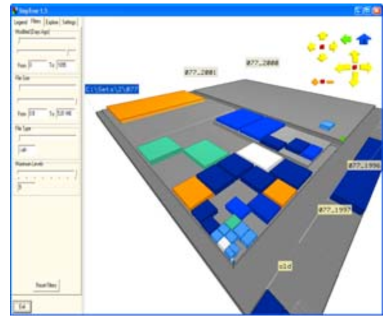
Bubblemap



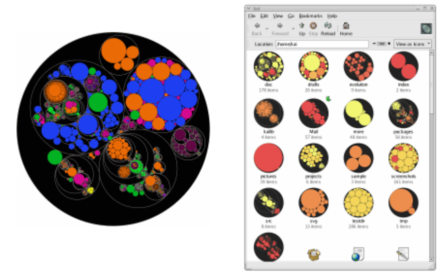
StripTreemap



Other Treemaps (Cont.)



Step Tree

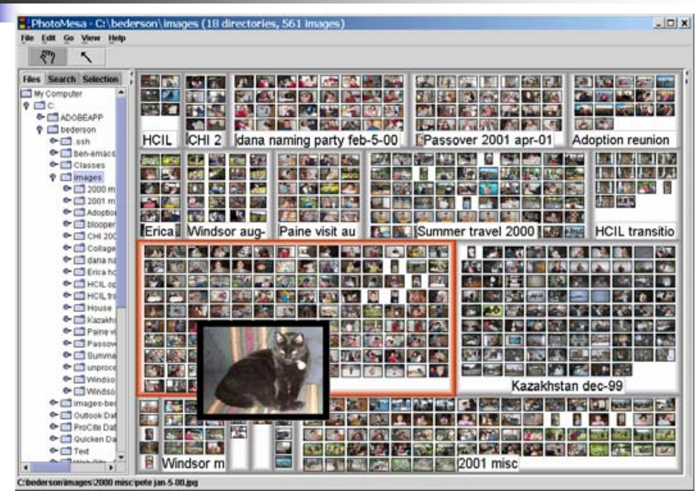


Circular Treemap

Application of Treemaps "PhotoMesa"

- A standalone application that supports **browsing of large sets of images**.
- Allows users to view multiple directories of **images in a zoomable environment**.
- Organizes images in a two-dimensional grid, where images with a shared attribute are grouped together.
- Apply the **quantum treemap**, **ordered treemap, and bubblemap** for images display.
- Originally written in Java, now written in .NET.

Application of Treemaps PhotoMesa screenshot



Conclusion

- **Treemaps represent large hierarchical collections of two dimensional quantitative data in a compact display.**
  - One dimension is mapped to the area of the rectangles and the other is mapped to the color of a rectangle.
  - A label is placed in the rectangles.
- **Each treemap algorithm has its merit and demerit.**
  - Cushion Treemaps
  - Squarified Treemaps
  - Ordered Treemaps
  - Quantum Treemaps
  - Other Treemaps
- **Application.**
  - PhotoMesa
  - Stock Portfolio

References

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