Multiple Small Maps as an Information Seeking Tool

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1. Why Create Multiple Small Maps?

Although we commonly use maps to convey geographical information, and graphs to convey time series information, there is no common graphical format to convey geographical time series information. Such information is of great interest to both scientists and the general public (for instance, Werschkul, 2004; Plaisant, 2004; Hochheiser & Shneiderman, 2004), but the lack of a visual format may inhibit our understanding of this kind of information. This affects both information display and information seeking.

The core of the problem is dimensionality. Most maps represent space in two dimensions, height and width. Color may be used to easily illustrate a third dimension. Issues of the components of color such as hue, saturation, and brightness, or red, green, and blue have been addressed elsewhere. While useful, color can only convey a limited amount of information in a single map. (Egbert & Slocum 1992; Brewer & Pickle, 2002) Visual devices such as lines, superimposed shapes, and even tiny graphs have been used to increase the dimensionality of geographical visual displays, although these methods require extra space (for example Werschkul, 2004). Extra dimensions are useful because we often want to consider multiple variables at the same time, be they separate measures or similar measures over different times. One approach that has been overlooked is the use of multiple small maps as a way of searching for information. This report briefly describes this approach and a research plan for investigating its usefulness. Attempts at using multiple maps have been made by Brewer & Pickle (2002) and MacEachren, et al. (2003), among others, but neither have tried using more than a few maps at a time. I think it might prove useful to display a large number of maps on a screen, perhaps 100 or more, to allow a user to view many variables across time at once, and then select the ones they wish to study in more detail (following Shneiderman, 1998).

Note that although many types of maps are useful for conveying information, the discussion here is limited to choropleth maps. (These maps contain regions, each of which is drawn with a single color to represent some datum, such as the familiar red-and-blue electoral map.) If these techniques prove useful for choropleth maps, they might be adapted for other types of maps.

2. Creating Small Maps

To use multiple maps simultaneously, the maps must be small, and the more maps we wish to display, the smaller these maps must be. To create small maps, we must compress a full size map. Algorithms for compressing images abound, but most assume that the loss of small details is acceptable. In the case of map compression, this may not be true. Consider a map of the United States, in which some states are much larger than others. The large states are not necessarily more important to the user than the small states, so the compressed map must preserve the information about the small states. These small states must be not only drawn on the map but drawn in a useful way, that is, the state must be recognizable and the information must be conveyed. Once a small map has been created, it can be colored with various data patterns to convey different data. These maps can be drawn at larger sizes to make comprehension easier. Recognizability will be discussed in more detail in a later section.

Maps can be drawn by “hand” or using an algorithm. Hand-drawn maps are the term I use for maps that are created by someone using arbitrary means. These means might include laying grids over maps and making manual adjustments. Cartographers distort maps all the time, and so does the automatic grid algorithm described below. The advantage of an algorithm isn’t that it is more accurate, but that it could end up being fast, particularly for displaying maps at multiple resolutions or displaying novel maps quickly. Maps that are intentionally distorted (such as cartograms) can be created automatically so as to be as readable as possible while conveying the intended information (House and Kocmoud, 1998; Tobler, 1973).

One algorithm (based in part on the maps created by Zhao, et al, 2004) that can be used to create small maps automatically begins with a square matrix that is as small as possible while having more cells than the number of regions in the full map. An evenly spaced grid, with the same number of cells as the matrix is superimposed on the full map. For map construction purposes, each state is assigned a different color. Beginning with the smallest region, the unassigned grid square containing the largest number of pixels of the current region has its corresponding matrix square colored the same as the current region. If a region has no pixels in any grid squares that are unassigned, a conflict has occurred. Conflicts are resolved by splitting the grid at the cell containing the largest number of pixels of the conflicted region. The matrix is also increased in height and width by 1. The process then begins again with the smallest region. Once all regions have at least one grid square/matrix cell assigned, the remaining squares/cells are assigned according to the state with the largest number of pixels in the remaining squares.

This algorithm produces rough, but very small maps. A 12 x 12 map of the 50 United States and the District of Columbia is possible (see Figure 1). Slight adjustments to this algorithm could eliminate some artifacts that tend to appear. This algorithm is not perfect; it is intended as a proof of the concept that maps can be generated automatically. Better algorithms are surely possible, for instance ones that will produce maps of a specified size. Such maps will be useful for the next phase of research, which is testing the recognizability of various maps, and the usefulness of multiple small map interfaces. ("Recognizability" was suggested by House and Kocmoud, 1998, as a desirable trait in a cartogram. Although this interface does not use cartograms, it does use distorted maps. Unlike House and Kocmoud, I think recognizability can be measured and used to compare maps empirically.)

3. Testing Small Maps

Four critical questions about small maps must be answered. First, are these maps recognizable as tiny versions of larger choropleth maps? Second, what parameters are best for creating small maps? Third, do these maps convey the information they are supposed to represent? Fourth, can these maps be used to explore or convey information in ways that are new or better than other methods?

The first two questions are closely related. Both will require testing in which large and small maps are compared. For the question of recognizability, users will have to decide which of several small maps corresponds to a big map, and which of several big maps correspond to a small map (see Figure 2). Success would require accuracy well above chance, although perfect accuracy would not be required. For the question of parameters, different small maps would be compared against each other. This could be combined with the previous experiment, and accuracy for different small maps could be compared. The purpose of comparing different maps is to determine what sizes and levels of distortion are acceptable. For instance, it might be that low distortion results in better accuracy, or that higher distortion, and thus larger small states, is better. (Steinke & Lloyd, 1983 found that map blackness was the most relevant factor for map similarity, so this will have to be controlled.)

The third question can be addressed by presenting users with multiple small maps and asking them factual questions about the data they represent (see Figure 3). For instance, users could be shown the same variable over several years and then be asked how a particular state was changing. Good accuracy will be necessary for the maps to be considered successful.

Finally, the critical question of usefulness. What can we do with multiple small maps that we could not do with other methods? For one, an interface built on multiple small maps could allow users to browse large data sets visually. Second, having many maps on the screen at once would enable easy map comparisons, perhaps using drag-and-drop. Third, multiple small maps may be combined with other interface widgets such as sliders to produce sophisticated tools (See, for instance, Plaisant, 2004).

4. Conclusion

Multiple small maps may prove useful as a method of data visualization and/or seeking. They have the potential to address the problem of highly dimensional data, and simplify searches for information over time. Some basic experiments are necessary to guide the development of prototype interfaces.

References

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Figure 1.

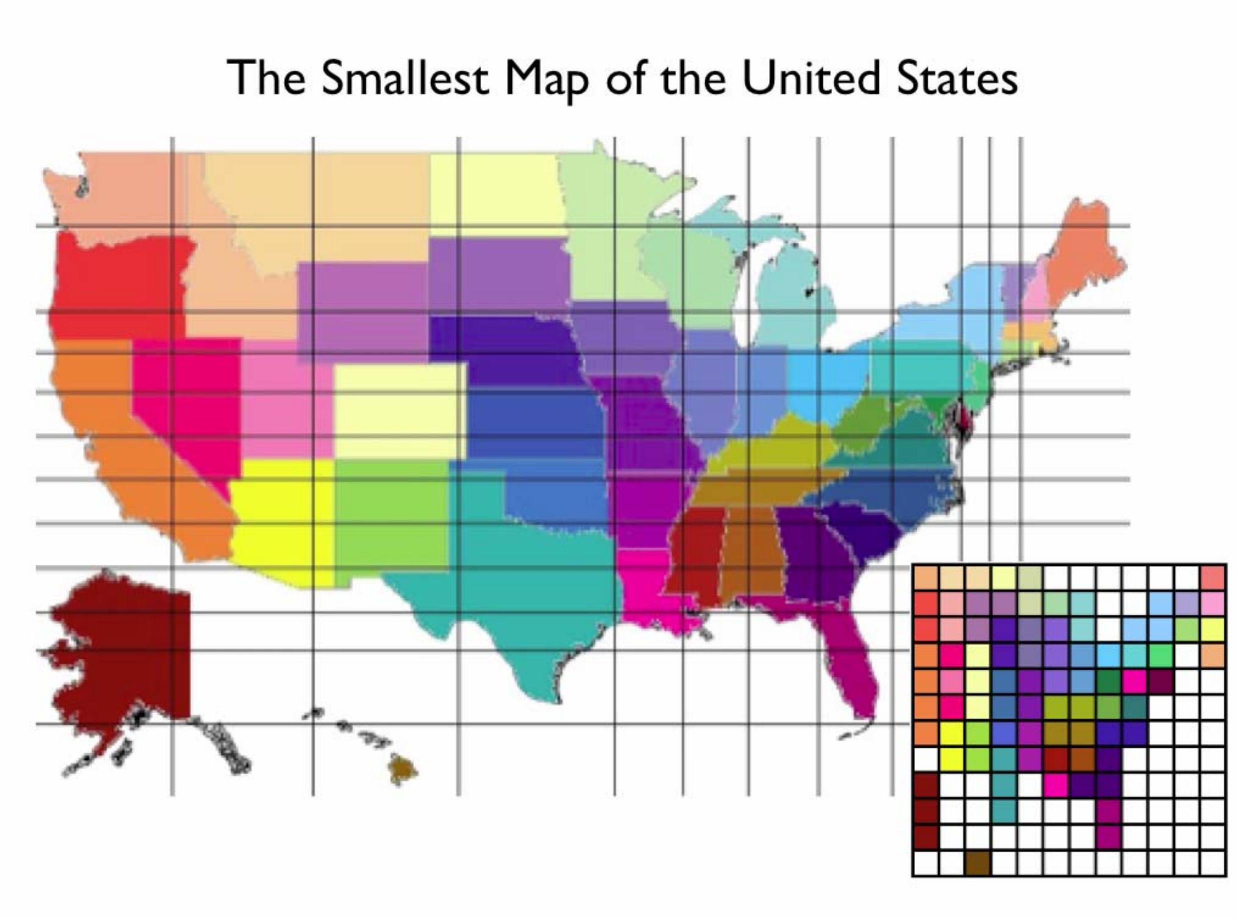

Figure 1. The completed smallest map, just 12 pixels by 12 pixels. Large states like California, Texas, and Alaska appear somewhat small, but should be easy to identify by a person who knows US geography. Note that Nevada has been split in two. This is because Utah was assigned a spot in the middle of Nevada. Splitting the second column would resolve this issue. Also note that because cell (12,3) from the top left was assigned to Rhode Island, the cell to its South, (12,4) was assigned to Massachusetts. Both of these problems could be resolved by splitting cell (2,3), creating a 13x13 grid.

Figure 2.

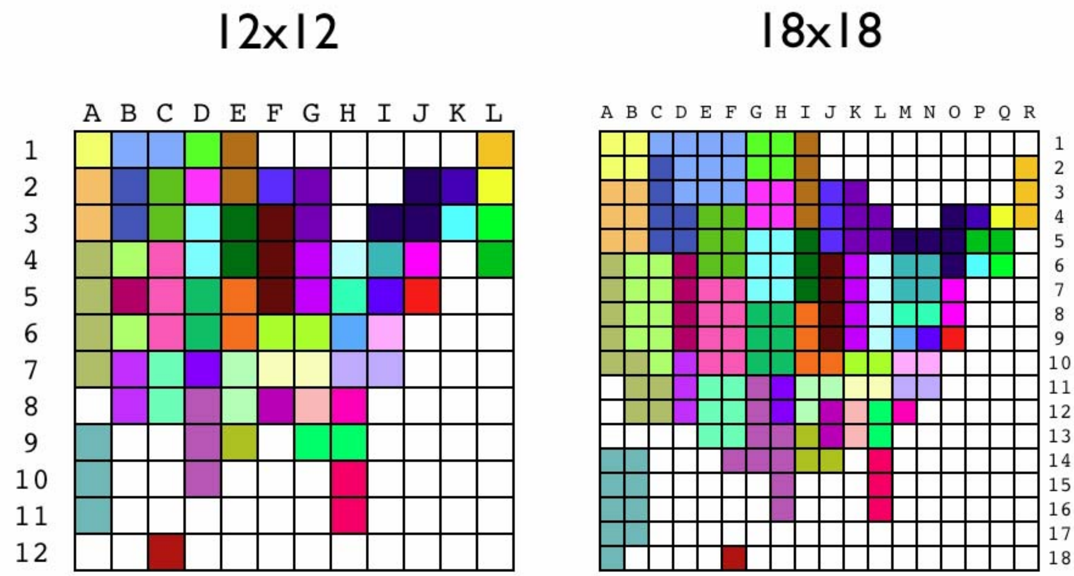

Figure 2. A 12 x 12 map and an 18 x 18 map shown side by side. A different coloring scheme was used for these maps than for the map in Figure 1, but these two maps have identical color schemes. The map on the left is the smallest possible map created using the algorithm described in the paper. The map on the right is the same map, expanded in six places. These maps are drawn the same size on the screen, but the map on the right has a finer resolution. User testing should determine how much distortion is acceptable, and what the smallest recognizable region size is. These maps could be drawn in a much smaller size so that many could fit on a screen.

Figure 3.

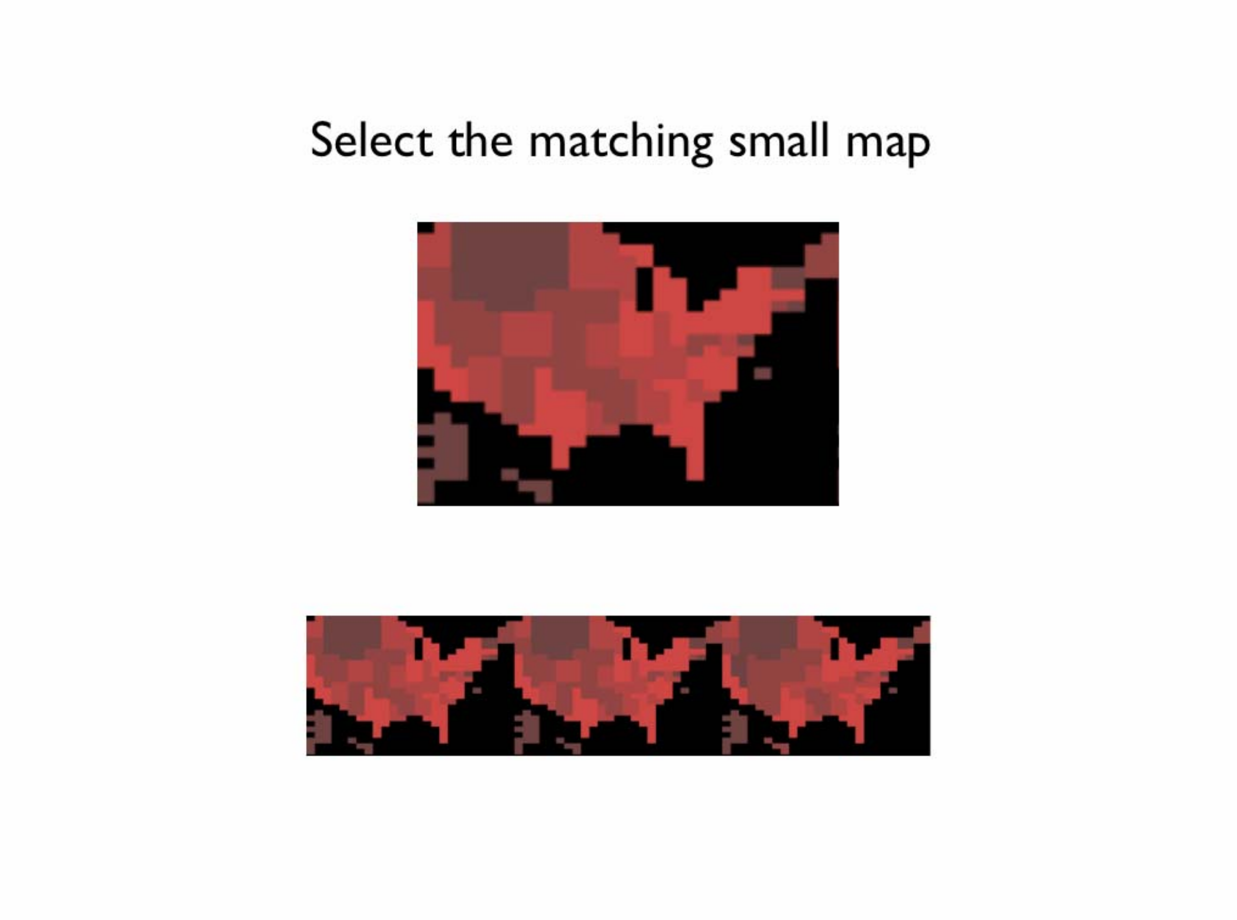

Figure 3. A mock-up of a test question. Users would have to select the small map that matched the larger map, which would be drawn with less distortion. (This item is a trick question, the left and center small maps are both the same as the larger map.)