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Enhancement in Visualization of Parallel Coordinates using Curves

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Abstract **-** In this paper I analysis about the visualization techniques of large set of data with parallel coordinates. Parallel Coordinate is an interesting method which can be widely used throughout the world, not only at research area but also other field such as business, market, finance and so on. The aim of this research work is to implement Parallel Coordinate and refinements to Parallel Coordinates using curve. In parallel coordinates visualization of data set is performed by using straight lines. Then lines replaced with the collection of smooth curves across the attribute axis, allowing individual data element to be traced under certain limitations normally impossible due to "Crossing Problem" .Then the notion of spreading out points on axis with few discrete value is introduced, which leads to a simple filter technique when the user selects value on such axis.

In this paper I proposed a new concept of visualization of large set of data with parallel Coordinate. Parallel coordinates were proposed by Alfred Inselberg as a new way to represent multidimensional information. A parallel coordinate's visualization assigns one vertical axis to each variable, and evenly spaces these axes horizontally. This is in contrast to the traditional Cartesian coordinates system where all axes are mutually perpendicular. By drawing the axes parallel to one another, one can represent data in much greater than three dimensions. Each variable is plotted on its own axis, and the values of the variables on adjacent axes are connected by straight lines. Thus, a point in an n-dimensional space becomes a polygonal line laid out across the n parallel axes with n-1 line segments connecting the n data values. In this way, the search for relations among the variables is transformed into a 2-D pattern recognition problem, and the variables become amenable to visualization.

Keywords— *Parallel coordinates visualization, parallel coordinates plot, coloring and Zooming in parallel coordinates, curves in parallel coordinates*

INTRODUCTION

During the 1980's and early 90's, Inselberg and Dimsdale introduced Parallel Coordinates, a representation of multi-dimensional information or data, in which multiple dimensions are allocated one-to-one to an equal number of parallel axes on-screen. An object in a data set is then mapped as a series of points, one per axis, with the position of each point on the axis being dependent on their value in the associated dimension. The points are then joined together by line segments from one axis to its immediate neighbour, forming a poly-line across the set of axes. This process is then repeated for each object in the information set. Parallel Coordinates allows similar objects to be seen as having similar shapes and the basic technique has since been modified with a variety of additional features. For example, Siirtola's version of Parallel Coordinates allows sub-ranges within dimensions to be brushed or selected to highlight particular groups of objects, and these groups can in turn be combined or filtered with other selections on other dimensions. The axes could also be rearranged to enable the user to order the dimensions as they saw fit.

Fua et al developed hierarchical parallel co-ordinates that showed representative paths for groups of similar objects, and used colour shading cues to indicate the spread of the object groups represented by these single lines, thus reducing the clutter and overhead of displaying the full set of co-ordinates. Falkman extended the technique to 3 dimensions with a parallel plane visualisation, though unfortunately this also combined the difficulty of following lines in dense parallel co-ordinate displays with the occlusion problems of 3D representations. Further interactions such as angular brushing have also recently been proposed by Hauser et al, which picks out objects with specific trends between two dimensions rather than objects which are grouped together by value in just one dimension. However, one remaining problem is that if two objects share the same value in a particular dimension, they will share the same point on the corresponding axis, and as such their respective poly-lines will appear to merge and then separate again. Without additional cues such as colour, it is impossible to determine which line is which after the merge and separation effect.

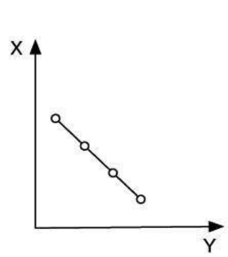

Figure 1.0: The idea of parallel coordinate plots: use of parallel axes layout instead of orthogonal one. The four points on the left are represented by the four lines on the right.

Brushing is a very effective technique for specifying an explicit focus during information visualization. The user actively marks sub-sets of the data-set, for example, by using a brush-like interface element. If used in conjunction with multiple linked views, brushing can enable users to understand correlations across multiple dimensions.

Focus+context visualization. Brushing also is very useful to steer a drill-down into the visualization of really big datasets – by specifying a (limited and limiting) focus, more details can be shown for the selected data-points. This relates to another very important InfoViz concept which is focus-plus-context (F+C) visualization.

Parallel Coordinates Technique and Visualization

Visualization technology is to convert data to graphics showed on the screen by means of computer graphics and image processing, it is a theory, method and technology of interactive treatment .There is a large number of visualization techniques which can be used for visualizing the data. Corresponding to different basic visualization techniques, they may be classed into: geometrically transformed Displays, Iconic Displays, Dense Pixel Displays, Stacked Displays and Graphics Displays etc.. An typical example of geometrically transformed display techniques is well-known Parallel Coordinates visualization technique.

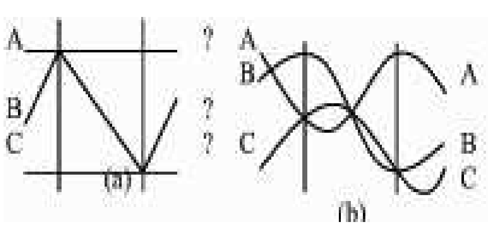

Figure 1.1 (a)Crossover uncertainties result when lines share a point on an axis (b)Curves make the crossings easier to resolve

Color Proportion

Although above methods in some degree improved visual result of parallel coordinate technology, some questions exist all the time. One remaining problem is that if two objects share the same value in a particular dimension, they will share the same point on the corresponding axis, and so that their respective poly-lines will appear to merge and then separate again. Without additional cues such as color, it is impossible to determine which line is desired after the merge and separation effect. Such a situation is shown in the line diagram figure 1.2. and 1.3 To resolving the problem, using a smoothly graduating curve over the parallel coordinates instead of a zigzagging line allows users to discern individual paths through these knots for reasonable numbers of lines. Figure 1.1 is a demonstration.

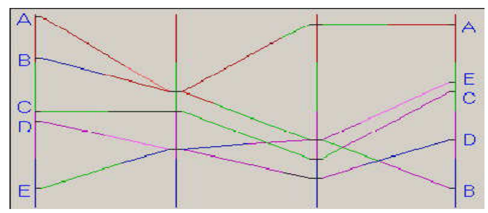

Figure 1.2: Using Color Proportion Method to discern cross poly-lines

Coloring and brushing on parallel coordinates

To make the selections on parallel coordinates we use an automatic approach that is different from brushing directly on parallel coordinates: supposing we want to brush data items from USA with low value of MPG, high number of cylinders etc.; with a classic parallel coordinates based approach we should have to make N different range selections, one per dimension, directly on dimension axes or on a slider; to simplify this operation our system creates an association of colors between points in radviz and polylines on parallel coordinates (in figure 1.3, previously described data are orange polylines on parallel coordinates and correspond to orange points on radviz), allowing the user to use radviz as a brushing tool for parallel coordinates. The system associates a 2D color-map to a rectangular board (in our examples we will use a simple RGB map with increasing values of blue from left to right and increasing values of red from top to bottom), then the radviz algorithm disposes data points on that board, associating to each data point the color of the corresponding point of the board. This coloring is then transferred on parallel coordinates representation (figure 1.3). Users who want to make brushing on a section of parallel coordinates just have to make an association between colored patterns on parallel coordinates and colored points on radviz, performing brushing directly on that. This approach reduces the effort of brushing at 1=N (one mouse click to select one pixel, or click-drag operation to select a region on radviz versus N operations on parallel coordinates). Moreover, many applications that implement brushing based on parallel coordinates allow only to select adjacent polylines; with our approach we can brush different and disjointed clusters and isolate them (e.g., we can compare the previously selected cluster with a new one composed by cars with high value of mpg and low value of horsepower etc, represented respectively as orange and blue points in figure 1.3 and labeled on radviz respectively with 'a' and 'b'). In this step, the real connection between parallel coordinates and radviz is the human perceptual system that allows to find patterns in data and associate polylines on parallel coordinates to points on radviz comparing their color. This can help users to follow polylines and detect patterns in data: different structures of data appear as automatically brushed in different colors. After detecting the structures to select, a user just have to locate the same color on radviz and complete brushing (if needed) adding or deleting some points in the neighborhood.

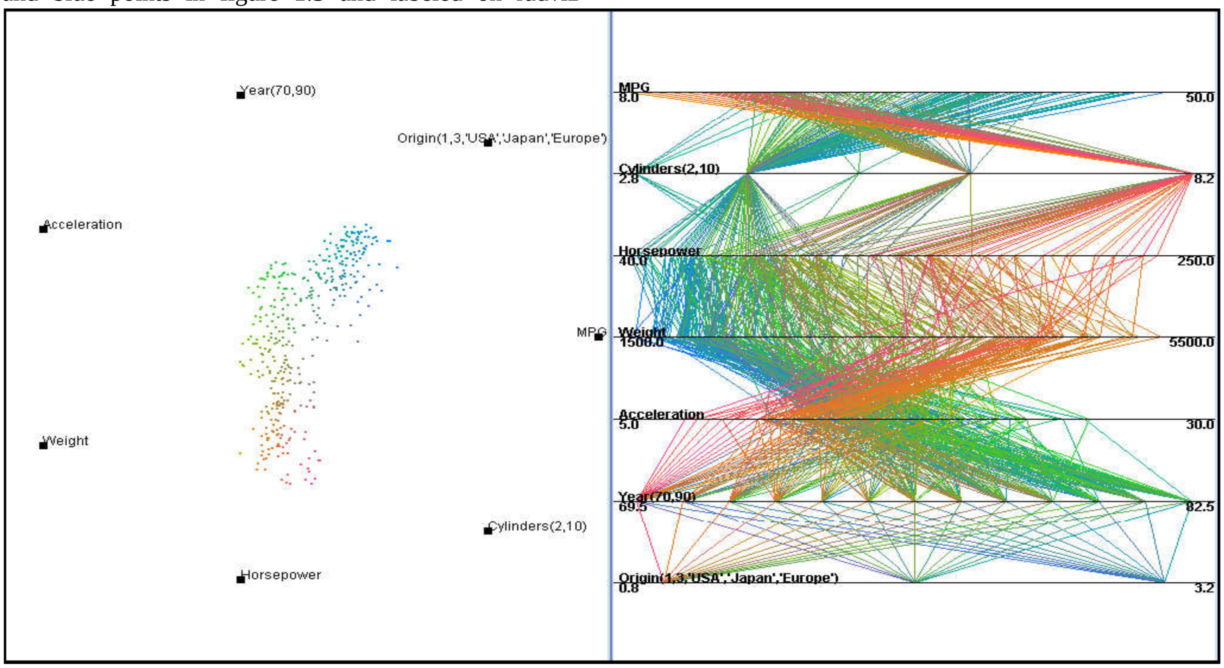

Figure 1.3 Color map based on radviz presentation, applied to parallel coordinates

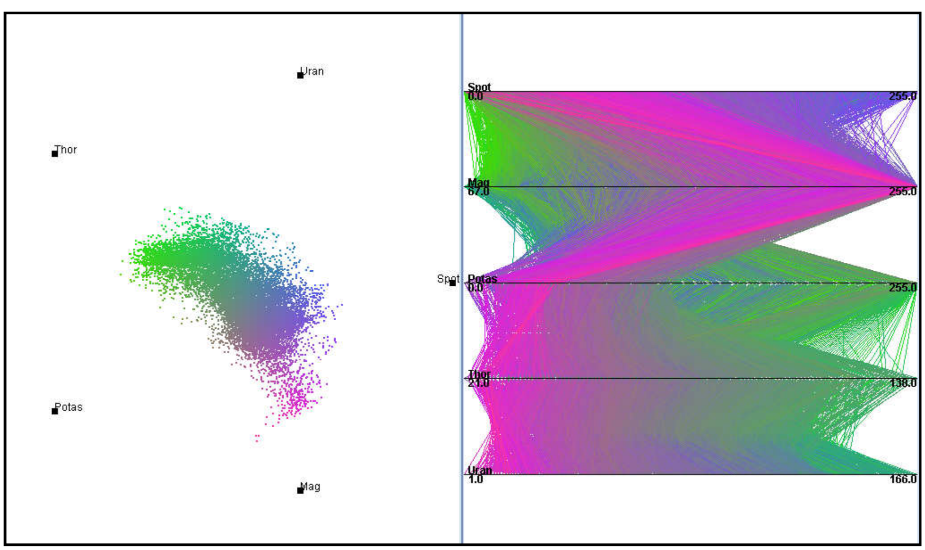

Figure 1.4 Out5d dataset (high clutter on parallel coordinates representation)

Parallel Coordinate Curves

This paper demonstrates a static method for resolving the difficulty of following lines that share common pointson axes, the ‘cross-over’ problem. Our solution is based on the use of curves and the Gestalt principle of good continuation (Wertheimer). Simply put, using a smoothly graduating curve over the parallel co-ordinates instead of a zig-zagging line allows users to discern individual paths through these knots for reasonable numbers of lines. Curves have been used in parallel co-ordinate visualisations previously by Theisel, to show correlations between non-adjacent axes. In their work, additional axes could be placed between two adjacent axes, and the values of the objects on these dimensions act as control points for curves, pulling the curve towards them. Nesbitt and Friedrich used Gestalt principles to improve the animation of dynamic graphs, and Bartram used the Gestalt ‘law of common fate’ (objects moving in a similar manner appear to be grouped) to use animation as a filtering and brushing technique on a scatter plot style visualisation. In our approach though, we use curves solely to help differentiate poly-lines that cross at axes, an occurrence that increases dramatically when using axes with a few discrete values. This technique works well in isolation on a few lines as does brushing, but performs more strongly in conjunction with brushing to distinguish object representations. Indeed, as a spatial variable, curvature can be used in conjunction with any of the previous filtering and brushing methods that distinguish poly-lines with colour variables. The continuous curve approach also has the benefit of reducing the need to have the pixel-accurate steady mouse hand that is sometimes necessary with the brushing interaction techniques in parallel coordinate displays. Figures 1.5 show the effect of applying curves to the data. Note that the technique will not work for large numbers of crossings, as the situation in those circumstances is more akin to the general line-crossing problem shown in graph drawing by Purchase.

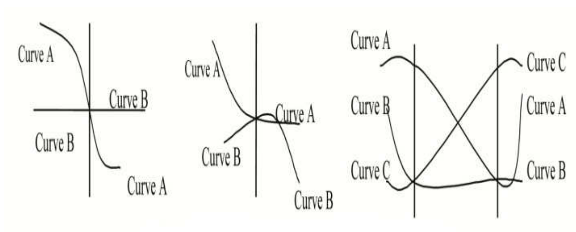

Figure 1.5 Curves make the crossing easier to resolve

One other feature of using curved sections in parallel co-ordinates is an apparent increase in the number of objects displayed in the visualization. For instance, Figure 1.6 there appears to be only one line between the second and third axes, but in the curved representation on the right-hand side there are now two curved sections in the same area.

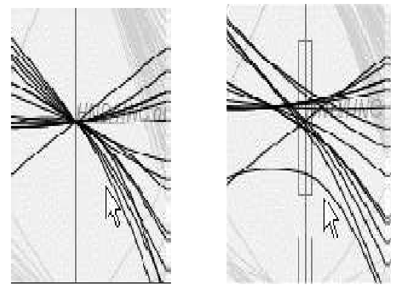

Figure 1.7. Before and after spreading is introduced at an axis point

This occurs because curves are a function not only of the steepness of the original line between two adjacent axes, but also of the gradient of the previous line section (as to ensure a smooth curve over all the axes, the last and first control points of the preceding and following curves respectively must lie on a straight line with the shared endpoint). Thus, two objects that had the same values on two adjacent axes and would overlay exactly when using straight lines, would now diverge slightly in the middle of this section if they had different values on the directly preceding axis. This can be viewed as either a useful or distracting effect, depending on circumstance; distracting in that it increases the number of perceived objects on screen, but useful in that it gives a more realistic presentation of the amount of data that is present.

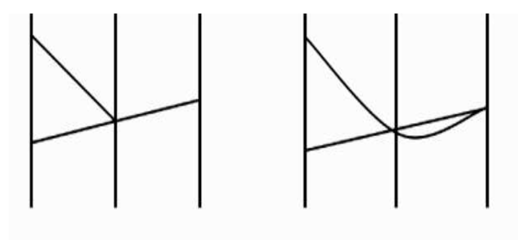

Figure : 1.6 : Curves mean that object representations tend to resolve from each other over shared values

Spreading points and Focus & Context

Although the curves clearly aided the separation of items, it was found that with many curves it became difficult to differentiate them if they were bunched close together along their paths. Methods of separating such curves were needed, and two complementary techniques were developed, which can also be applied to traditional parallel co-ordinates. Firstly, it was noticed grouping was greater around coordinates on axes with relatively few values, as the curves converged on a few designated points on that axis, with much of the axis composed of empty space in between. Thus, if there was empty space available, we decided to ‘spread’ the point out to become a short line along the axis, with a bounding box to clarify that this length still formed one and the same value. Figure 1.7 demonstrates the effect this has, with instead of one complicated crossing point, many simpler crossing points being formed. The spread is calculated by moving the axial crossing point for each line to a point in the bounding box that is proportional to its average position in the preceding and following axes. Thus the curve at the bottom of the bounding box in Figure 1.7 is placed there because it crosses close to the bottom bounds of the preceding and following axes. Also, as the crossing points tend to drift away slightly from the axis, it is also possible to follow straight-line co-ordinates through these situations for small numbers of items, as in Figure 1.8.

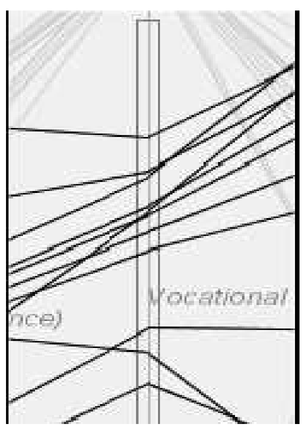

Fig 1.8. Spreading with traditional straight line representations

From this, in some axes it was noticed that there was not enough space to perform the spread effect even when that axis had a relatively small number of discrete values, due to a space being necessary between the points themselves to show visual separation. It was then decided to implement a simple focus+context technique on the axes, with ranges of selected values being given more space to the detriment of unselected items. This would give the selected items the necessary space to perform the spreading technique. It would also further separate curves on axes that already had enough space to spread out shared points. An example of the difference this makes is shown in Figure 1.9, where a chosen data point has expanded under the focus and context effect and a previously impenetrable knot of crossings has been loosened to the point where individual curves can be discerned.

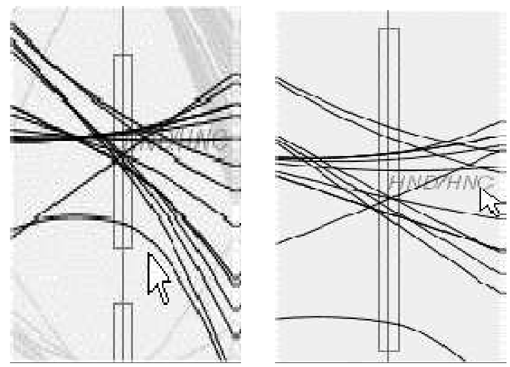

Figure 1.9. Before and after a focus and context effect is introduced.

CONCLUSIONS

Users can get direct information from a mount of data by visualization technique. The ability of a single visualization technique is limited, so combining multiple technique and enhancing the interactive ability is the major characteristics of future visualization system. In this paper, I give analysis enhance the visuality of parallel coordinate technique. In this study I studied some methods integrate with linking and brushing, dimension clustering and dimension ordering etc. It can fully exert the advantage of parallel coordinate technique. Using curves in parallel coordinates best visualization of multidimensional data set can be achieved instead of straight lines.

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