

ImageCube: an image browser featuring a multi-dimensional data visualization technique

1 INTRODUCTION

With the rapid development of the imaging technologies over the recent years, advanced visualization techniques for thousands of pictures are making big progress. At the same time, now we can obtain various sets of images which are called multi-dimensional or multivariate datasets via Internet. For example, we can obtain the images of recipes which have a variety of nutritional value, those of cars which have a variety of performance values, and those of medical which have a variety of diagnosis value, based on our specific requests. We think that image browsing techniques featuring multidimensional data visualization techniques are useful to explore such kinds of image datasets. Especially, multidimensional data visualization techniques are useful to explore and analyze features and structures in the datasets, including clusters, outliers or correlations. We think it is interesting to explore and analyze such features and structures of multidimensional values assigned to images while browsing the images themselves.

Among various information visualization techniques, scatterplots is one of the most popular and widely-used visual representations for multidimensional data due to its simplicity, and visual clarity. Scatterplots visualize multidimensional datasets by assigning data dimensions to graphical axes and rendering data cases as points in the Cartesian space defined by the axes. This approach has been widely used in visualization technique such as Rolling the Dice [1], which presents new interactive methods to explore multidimensional data. It applies a metaphor of rolling a dice, since as they implement an animation mechanism as they transform one scatterplot representation into another one by rotating a cubic space.

This poster proposes "ImageCube", an image browser featuring a multidimensional data visualization technique which is similar to Rolling the Dice. ImageCube can show the visualization through interactively selecting two dimensions from the multidimensional datasets of images applying scatterplot. Our implementation of ImageCube assists the dimension selection operations by suggesting interesting pairs of dimensions based on their correlations and entropies. ImageCube is helpful for users to obtain qualitative visualization results to explore and analyze features and structures of multidimensional values assigned to images.

We tested ImageCube with images of recipes and those of cars. Visualization results in the poster demonstrate that ImageCube efficiently supports users to obtain insightful visualizations.

2 TECHNICAL DETAIL

2.1 Definition of Input Images

We suppose that multidimensional values are assigned to input images of ImageCube. Our implementation consumes input data files which describe names of the dimensions, multidimensional values, and URL or path of input images. It then automatically generates and displays the selection menu (see Section 2.3) from the input information.

2.2 Multidimensional Visualization

The dimensionality of the data is often too high to faithfully represent the data. On the other hand, ImageCube represents two dimensions in a single visualization as many scatterplots techniques do. Firstly ImageCube assigns two dimensions to X- and Y-axes to deploy the images, when a user chooses the two dimensions from a multidimensional dataset. Once the user chooses another pair of dimensions, ImageCube redeploys the images by rotation of XY- and XZ-planes, so that images smoothly replace.

2.3 Selection Menu

As described in Section 2.1, ImageCube automatically generates the selection menu featuring buttons of dimensions for X- and Y-axes. Here, a major challenge is how to easily get fruitful visualization results from multidimensional datasets according to user's needs. Therefore ImageCube provides a mechanism to recommend interesting pairs of dimensions so that users can easily select them. Current our implementation shows the recommended pairs by coloring corresponding dimensions on the selection menu.

To realize the mechanism, we need to analyze the numerical features between arbitrary two dimensions. Current our implementation calculates the following two kinds of numerical features between arbitrary pairs of dimensions to obtain interesting visualization results:

- Kendall's rank correlation to obtain results which images are regularly aligned.
- Entropy to obtain results which images are evenly distributed.

Correlation analysis is useful for multidimensional datasets visualization techniques. Actually, it is often applied to dimensional reordering for automatic clutter reduction of Parallel Coordinates [2]. We apply Kendall rank correlation for the correlation analysis. The Kendall rank (τ) denotes the similarity of the orderings of the datasets ranked by each of the quantities, defined as follows:

$$\tau = \frac{4P}{n(n-1)} - 1 \quad (1)$$

which is supposed as following.

- If the agreement between the two rankings is perfect (i.e., the two rankings are the same) the coefficient has value 1.
- If the disagreement between the two rankings is perfect (i.e., one ranking is the reverse of the other) the coefficient has value -1.
- If X and Y are independent, then we would expect the coefficient to be approximately zero.

Entropy denotes a randomness of a set of values. The entropy H of a discrete random variable X with a set of positive values $X = x_1, \dots, x_n$, defined as follows:

$$H(X) = E(I(X)). \quad (2)$$

which yet is used to measure the class data probability density by class consistency method [3]. The measure of entropy could be integrated over the whole image. It is proved that entropy measure

is efficient in class consistency method[3]. In this paper, we use entropy to measure the randomness of visualization result. We use the different colors to expose the visualization trend of the images when users select the variable in selection panel. We can fascinatingly observe the images, by selecting the recommended variable.

2.4 Overlap Reduction

Images may be easily overlapped each other on the display when ImageCube simply places them onto the 2D space. We are trying to solve this problem with the following two approaches.

The first approach has been already presented by PhotoSuifing [4], which supports an occlusion reduction algorithm by using Delaunay triangular mesh technique. It firstly constructs a Delaunay triangular mesh connecting the center points of images in a 2D display space, and then relocates the images by stretching short edges of the triangular mesh.

The second approach is similar to a mechanism presented by Cat[5]. It selects representative images for each overlapped image region, and only displays the representative images. Other images in the overlapped image regions will be displayed in another window, when a user clicks one of the representative images.

3 RESULT

Figure 1 shows the visualization result of images of cars by using ImageCube. Here we can clearly look at the rotation process in Figure 1 (Upper). Figure 1(Center) shows a final visible result of two dimensions "outerWidth" and "displacement", which is the high-correlation pair and therefore images regularly align. On the contrary, images evenly distribute with high-entropy pairs of dimensions, as shown in the final visible result with the dimensions "outerHeight" and "displacement" in Figure 1(Lower).

As future issues, we would like to realize the visualization with selection of three or more dimensions. We are also interested in integration of ImageCube with interactive and adaptive image relocation technique applying Voronoi Diagrams [6]. Finally, we would like to integrate the visualization technique with image analysis techniques in the future.

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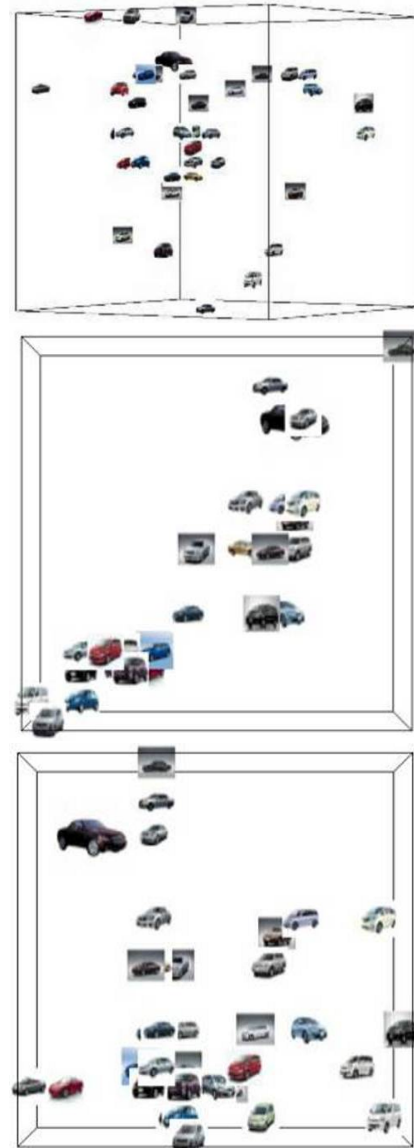


Figure 1: Example. (Upper) Image redeployment by rotation function of XY- and XZ-planes. (Center) A visualization result with a high-correlation pair of dimensions. (Lower) A visualization result with a high-entropy pair of dimensions.