ABSTRACT

Image browsing techniques thus become increasingly important for overview and retrieval of particular images in large-scale collections. At the same time, there are various sets of images which are associated with multi-dimensional or multivariate datasets. We believe that image browsing for such datasets should be inspired from multi-dimensional data visualization techniques. This paper presents ImageCube, a scatterplot-like browser for image collections associated with multi-dimensional datasets. ImageCube locates a set of images into a display space assigning a pair of dimensions to X- and Y-axes. It suggests preferable pairs of dimensions by applying Kendall's rank correlation and Entropy on the display space, so that users can easily obtain interesting visualization results. This paper presents a case scenario that a user finds a preferable car from an image collection by using ImageCube.

Keywords: Visualization, Image Browser, Multi-Dimensional Data

1. Overview

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. We think it is interesting to explore and analyze 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 paper 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. Related Work

Overview and retrieval of image collections are important issues for their owners. Image browsing is therefore an active research topic and therefore recently many novel image browsers have been presented. This section categorizes the image browsers into two groups: browsers for structured/unstructured sets of images.

Many of image browsers for structured sets of images suppose that images forms trees or graphs. PhotoMesa [2] is one of the most famous image browsers for structured sets of images. On the other hand, many of other image browsers for unstructured sets of images scatter the images onto 2D/3D spaces like scatterplots. Several techniques applies dimension reduction techniques such as MDS (Multi Dimensional Scaling) or PCA (Principal Component Analysis) to locate the images so that similarly looking images are placed closer on the display spaces. MIAOW [3] is a hybrid technique that forms hierarchy while it assigns three values to axes of a 3D space. It divides the images according to latitudes, longitudes, and times which the
3. Technical Detail of ImageCube

3.1 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 3.3) from the input information.

3.2 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 display 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.

3.3 Selection Menu

As described in Section 3.1, 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.

3.4 Overlap Reduction

Images may be easily overlapped each other on the display when ImageCube simply places them onto the 2D space. To improve the understanding and usability, ImageCube reduces the number of displaying images by a clustering based on their positions on the display space. It generates groups of images that locate inside a constant radius of circles, and selects a representative image for each group. It initially displays only the representative images, and other images in the group of a representative image will be displayed in another space, when a user clicks one of the representative images.

4. Results

This section shows results of ImageCube applying 100 images collected from Japanese automobile catalog Web site (http://autos.yahoo.co.jp/). We parsed HTML files introducing particular cars, to extract specifications and evaluations of the cars, and download their images. Consequently we obtained a 12 dimensional dataset including the following specification and evaluation values:

- price
- displacement of the engine
- fuel cost
- outer length
- outer width
- outer height
- height of floor
- user evaluation of appearance
- user evaluation of interior design
- user evaluation of engine power
- user evaluation of equipments
- user evaluation of cost performance

Figure 1 shows visualization results by using ImageCube. Here we can clearly look at the rotation process in Figure 1(Upper). Figure 1(Center) shows a final visible result with a highly-correlated pair of dimensions, where images regularly align. On the contrary, images evenly distribute with high-entropy pairs of dimensions, as shown in the final visible result in Figure 1(Lower).

This section introduces a use case scenario with the image collection of cars. First of all, we were interested in correlations between prices and other variables. We checked correlation and Entropy between them, and found that displacement and fuel costs had relatively high correlations with the price. Figure 2(1) shows an example that price is assigned to the X-axis, and displacement is assigned to the Y-axis. The example denotes that they are nearly proportional; luxury sedans are relatively expensive, and station wagons are relatively low cost in this collection.

Figure 2(2) shows an example that price is assigned to the X-axis, and fuel cost is assigned to the Y-axis. Equipment evaluation also had high correlations with the price, but the distribution of the images was not linear. Figure 2(3) shows an example that price is assigned to the X-axis, and equipment evaluation is assigned to the Y-axis. It denotes that equipment evaluation increases proportional to the price of low-price cars, but it becomes flat if the price is higher.

On the other hand, it was our surprise that appearance evaluation was not correlated to the price. Figure 2(4) shows an example that price is assigned to the X-axis, and appearance evaluation is assigned to the Y-axis, where it
seems that expensive cars do not always obtain higher evaluations of appearance.

Be derived from the above surprising result, we were interested in what impact to the evaluation of appearance. Figure 2(5)(6) show examples that outer length or outer width is assigned to the X-axis, and appearance evaluation is assigned to the Y-axis. They denote that outer length or outer width is not well correlated with the evaluation of appearance. Actually, these pairs of dimensions had relatively higher Entropies. On the other hand, Figure 2(7) shows an example that height of floor is assigned to the X-axis, and appearance evaluation is assigned to the Y-axis. The result briefly denotes that appearance evaluations are better if floors are lower, which looks a common trend both for wagons and sedans. Actually, correlation of height of floor to appearance evaluation was relatively higher than others.

Finally, we checked what impacts to the evaluation of cost performance, and found that appearance evaluation was one of them. Figure 2(8) shows an example that appearance evaluation is assigned to the X-axis, and cost performance evaluation is assigned to the Y-axis. This high correlation denotes that appearance is very important for the user evaluation of cost performance. Again, it looks a common trend both for wagons and sedans.

5. Conclusion and Future work
This paper presented ImageCube, a scatterplot-like browser for image collections associated with multi-dimensional datasets. The paper described technical components of ImageCube, and introduced a use case scenario with a real image collection of cars on the Web.

As future issues, we would like to realize the visualization with selection of three or more dimensions. Also, we are interested in integrating ImageCube with image analysis techniques.

References