Hemalata Iyer (State University of New York, Albany)
Abebe Rorissa (State University of New York, Albany)

Representative images for browsing large image collections: a cognitive perspective

Abstract
In large collections of images, one of the ways to facilitate browsing is by providing thumbnails of representative images. This paper seeks to examine the issue of choice of representative images within the categories. Towards this end, a study of free sorting of 50 images by 75 participants was conducted, in which they sorted the images into categories and selected a representative image for the categories and also indicated the prominent feature in the selected image. The results indicate that there is reasonable agreement in the choice of representative images and the selection of prominent features appearing in the images. The prominent feature seems to be one of the factors that have a bearing on the way people categorize.

1: Aim and scope of the study
As a result of the ever increasing size of collections in various digital libraries, most information organization and retrieval systems provide interfaces for both directed search and browsing. Directed search is for a user who has a clear idea of what he/she wants and may also possess the necessary tools and skills to search for it. A second type of user is one with a fuzzy idea of a search topic or one with a less well defined information need and query. For these users, browsing is an appropriate method of searching. While much of previous research mainly focused on information organization for directed search and the first type of users, research on exploratory search and browsing and the second type of user is steadily gaining momentum.

One of the means of providing access to image collections (and other documents) for browsing and exploratory search purposes is groupings/clustering, either a priori, at the time of searching, or a posteriori, after search results are obtained. Some browsing systems for large image collections provide an interface with thumbnails of representative images. Hence there is a need to pay more attention to the selection of thumbnails of representative images. Besides, the type of features that should determine the selection of representative images is not well understood.

According to the classical view of categorization and similarity judgment, people often categorize things on the basis of their shared/common features (Tversky 1977). However, if categories are defined by properties that all members share, then no member should be a better example of the category than another member. The cognitive psychology theory of prototypes is significant and has been studied by several researchers including Rips (1975), Rosch (1973), and Tversky (1983). It may be helpful in understanding how people choose stimuli as representatives of categories which, in turn, could be used as one of the factors to systematically pick representative thumbnails in image browsing.

Therefore, the aim of this study was to gain a better understanding of the issues relating to the choice of representative images within categories and the role of prominent features of representative images in the context of categorization.
2: Methods
A study, involving free sorting of images, was conducted. Seventy-five participants were asked to sort a random sample of 50 images into a number of groups of similar images using their own criteria for similarity. The participants formed 659 categories (a mean/average of 8.79 categories per participant) and supplied labels and representative images for 536 of the categories. They also supplied prominent features of the representative images. Participants were instructed to: (a) inspect the images first, (b) sort them into as many or as few categories as they wished using their own general criteria for similarity, (c) label each category, (d) select a representative image representing each category, and (e) pick a single prominent feature of the representative image. The cards were reshuffled before being given to the next participant.

2.1: Data analysis
Free sorting data obtained from the 75 participants were first converted to a dissimilarity matrix. The sorting data consisted of arbitrary category numbers for groups of images sorted together. A computer program by Dunn-Rankin et al. (2002) was used to compute the percent overlap for all possible pairs of images and these constituted a similarity matrix. For images \( i \) and \( j \), the percent overlap is the ratio of the number of participants who put both \( i \) and \( j \) in the same category to the total number of participants (75). The percent overlap values were converted to dissimilarity by subtracting each value from 1 to build a dissimilarity matrix. The dissimilarity matrix was submitted to SPSS for Windows Release 16.0 (2007) to conduct a hierarchical cluster analysis which resulted in the dendrogram (or tree diagram) for the 50 images (Figure 1).

We used hierarchical cluster analysis as an exploratory tool. Hierarchical cluster analysis (HCA) (Johnson 1967) is a statistical method used for classification purposes (Aldenderfer & Blashfield 1984) and a number of clustering methods are available. We chose the average linkage scheme (where distances between any two clusters is the average distance between all possible pairs of stimuli in the two clusters).

50 images were picked as a representative of categories by at least two participants and the highest number of times an image was selected as a representative was 25. In order to determine a representative image for each of the nine clusters identified (see dendrogram), we looked at the number of times each image in the cluster was picked as a representative. The one with the highest frequency was selected as the representative for the cluster. We followed similar procedures to pick the most prominent feature of the representative image for the cluster. Figure 2 presents an example of the representative images and their prominent features.

3: Results and discussion
The data indicated that there was reasonable agreement in the choice of representative images. As can be seen in Figure 1, 9 distinct clusters of the 50 images were identified, the same number as the mean number of categories per participant. However, some of the clusters seem to have sub-clusters where one can clearly see some distinctions. For instance, the cluster labeled Costumes had three distinct sub-clusters which we labeled with individual, group, and clown. To label the clusters in the dendrogram (Figure 1), we chose the most frequent category labels supplied by the participants.
Figure 1: A dendrogram for the 50 images used in the study (image numbers were arbitrarily assigned by the authors as identification codes for the images)

All of the representative images selected by the participants in this study were considered to be typical examples within their respective categories. This further illustrates their significance in the design of browsing systems to large image collections as well. Besides browsing of image collections in information retrieval, the importance of typical examples is recognized in cognitive psychology. Some have argued that prototypes serve as cognitive reference points and form the basis for inferences (Rosch 1975; 1981).
3.1: The relation between prominent features and categorization
A detailed analysis of representative images and their prominent features may also help in further understanding the process of categorization. Our analysis revealed that there is also consistency in the occurrence of the prominent feature in all the images within each of the clusters. Figure 2 presents two illustrative examples, the clusters labeled Expression and Emotions. Even the two clusters that are conceptually as closely related as Emotions and Expression generated two different prominent features, namely “sadness” and “facial expression”, respectively.

<table>
<thead>
<tr>
<th>Category/Cluster Label</th>
<th>Representative image (# in dendrogram)</th>
<th>Prominent feature</th>
</tr>
</thead>
<tbody>
<tr>
<td>Expression</td>
<td><img src="image1.png" alt="Image" /> (34)</td>
<td>Facial expression</td>
</tr>
<tr>
<td>Emotions</td>
<td><img src="image2.png" alt="Image" /> (44)</td>
<td>Sadness</td>
</tr>
</tbody>
</table>

Figure 2: Representative images and their prominent features

The images in the Expression cluster could have also been seen as expressing some kind of emotions or vice versa. That is, the images in the two clusters could have been categorized under one or the other. It seems likely that one of the reasons why they were often categorized in a given cluster was due to the participant’s perception of the prominent feature. What is more, the other images in each of the clusters shared the respective prominent features as well.

Prototype theory helps to shed light on and may help us in understanding and interpreting this phenomenon. Objects are comprised of attributes, and when an individual encounters a new object, the person compares the attributes of the prototype in his or her memory. Then, he or she categorizes the object within the category to which the prototype belongs (Aitchison 1994; Ross 1999). Amant (2005) examined how representative theory can serve as a methodological framework for analyzing websites designed for users from different cultures. Thus
“if, for example, a person’s representative for bird is ‘robin’, then objects that share enough characteristics in common with a robin will be classified/identified as ‘birds’. If not, then the individual will continue to compare that object to other representatives in his or her memory until a match is found and the object can be classified/identified as “X.” Through such a comparative process, the more something resembles a representative, the more likely it will be identified as belonging to the category represented by that representative.” (Amant 2005, 102).

3: Conclusions
The results of our analysis indicate that there is a reasonable agreement in the choice of representative images and the selection of prominent features appearing in the images. The prominent feature seems to have a bearing on the way people make judgments and approximations and thereby in the process of categorization. Thus the idea of prototype theory was used in this study as a framework to understand the phenomenon and the importance and significance of representative images in browsing large image collections. These results have implications in the design of browsing systems for not only image collections, but also retrieval systems that use clustering and visualization of results of queries as a means for improving interactivity of the systems.

References
SPSS, 2007, SPSS for Windows release 16.0 [computer software], SPSS Inc.