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Effect of Similarity Measures on Image Retrieval Systems

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Abstract-Image distance measure is the method of comparing two images in content based image retrieval systems. Content points out to any information that can be derived from the image itself. The present study discusses representation of various features like color, texture and shape in the image databases and various distance measure used to compare the feature vectors to rank images according to the user interest. Choice of appropriate similarity measure plays an important role in reflecting the user interest in the result production process. Selection of distance measure depends highly upon type and dimensionality of feature vector. The presents study provides the detail of various similarity measures and their effect on the performance of image retrieval systems.

1. INTRODUCTION

Earlier, techniques to search images from large scale database were based on textual annotation of images. Textual annotation of images is a technique in which images were first annotated with text and then searched using a text based approach from traditional database management system which is a manual task. Annotating images manually requires huge amount of manual labor and is very big-budget task. Annotating image completely depends on the annotation understanding which means different people may interpret same image differently and this is the reason which cause mismatches in retrieval processes. The difficulties faced by text-based retrieval became increasingly more severe as they are limited to search the metadata that is tagged to the image or video which means data will not return if text queried is not annotated with the same tag as attached with image or video or if the desired object is not a main part of the image or video [4].

Resultantly, need to manage these images and locate the target images in response to queries of user has become a noteworthy problem [1]. This need formed the driving force behind the emergence of content based image retrieval techniques in early 1990's. Content based means technology makes direct use of the content of image or video. Content based image retrieval is also known as content based visual information retrieval (CBVIR) and query based image content (QBIC).

Content based image retrieval extract the feature of the image or video themselves rather than the user generated metadata which means the technique is independent of manual work[1][2].

2. IMAGE DISTANCE MEASUURE

A. Dimensions: Color, Texture, shape

Image distance measure uses various dimensions such as color, texture and shape to compare the similarity of two images [3]. If distance is zero it shows that image matches exactly with the query. Distance greater than zero indicates various degrees of similarities between the images.

3. COLOR SIMILARITY MEASURE

Color similarity measure is one of the most widely used techniques as it does not rely on image size or image orientation. It compares the color content of one image with the color content of other image.

IBM developed earliest commercial content based image retrieval system known as query by image content (QBIC). It helps user while giving query as they can specify percentage of color by selecting up to five colors from a provided color table and can also indicate the desired percentage of each color. QBIC gives the image that is closest with the image having specified colors. The images returned as a result have very different compositions even if colors in those images are very similar.

A. Color Histogram:

Another technique, color histogram is used to represent color [4]. In this technique user gives a sample image and image with low color histogram distance is returned. QBIC defines its color histogram distance as-

$$d_{hist}(I,Q) = \big(h(I) - h(Q)\big)^T A\big(h(I) - h(Q)\big) \quad (1)$$

where, h(I) and h(Q) are the k-bin histograms of images I and Q respectively, A is a k x k similarity matrix.

Similarity values in this matrix can be close to one or close to or equal to zero. In matrix similar colors should have similarity values close to one on the other hand different color should have similarity values close to or equal to zero.

B. Color Layout

It is another possible distance measure. In this technique, to represent a query user begins with an empty grid and selects colors for each of the grid squares from a table. Now, according to the color layout distance measure the images that were estimated most similar to the query will be returned as results. This measure uses a grid square color distance measure in which a grid is used. Now, each grid square of the query is compared with the grid square of an image that is matched and then the result is combined to give a single image distance.

$$a_{gridden\_color}(I,Q) = \sum_g \hat{a}\, color(C^I(g).C^Q(g)) \quad (2)$$

where, $C^I(g)$ represents the color in grid square g of a database image I and $C^Q(g)$ represents the color in the corresponding grid square g of the query image Q.

Colors in a grid square can be represented as:-

1. mean color in the grid square
2. mean and standard deviation of color
3. a multi-bin histogram of the color

4. TEXTURE SIMILARITY MEASURE

Image should have similar spatial arrangements of colors if it has similar texture to a query[5]. In texture similar measure, distance does not depend on color of the image. For color and texture similarities distance measures can also be developed.

There are two features of texture distance measures:-

1. Texture representation
2. Defines similarity in connection with that representation.

For summarizing the texture of an image, texture description vector is used. It is a texture representation. Examples of texture description vector are vector of Haralicks's five co-occurrence-based texture features and Laws' nine texture energy features. It is commonly used for single texture images. For more general images, we calculate texture description vector at each pixel about that pixel. A clustering algorithm is used to group the pixels. It finds different texture categories and assigns them a unique class. As pixels can be assigned a unique class there can be various texture distances which can be defined. One of the texture distances is pick-and-click distance. User selects a texture from fixed set or by clicking on a pixel of the query image having a textured region. Now, texture description vector is used for the representation of selected texture. As texture description vectors are correlated with database so selected texture is compare with it. The distance measure is defined by:-

$$d_{\ pick_{and_{click}}}(I,Q) = min_{i\in I}\,||T(i) - T(Q)||^2 \quad (3)$$

where T (i) is the texture description vector at pixel I of image I and T (Q) is the texture description vector of selected texture or selected pixel. For achieving faster retrieval, process of indexing can also be used.

Another texture measure is a generalization of the gridded measures. In this measure same method is applied to the query image as well as the database image. Method involves calculating texture description vector by placing a grid over a query image. The gridded texture distance is given by:-

$$d_{gridded_{texture}}(I,Q) = \sum_g \hat{a}_{texture}\,(T^I\,(g), T^Q\,(g)) \quad (4)$$

where, $\hat{a}_{texture}$ can be Euclidean distance or some other distance metric.

A. Texture Histogram

Texture histogram is similar to color histogram. Advantage of texture histograms is rotation invariance[6]. It specifies number of pixels in each texture category according to their texture description vector. A line finder is texture histogram measure. In this measure angles are used to produce texture histogram. It is mostly used to detect line segment. At first, pair of line segment that touch or almost touch are searched and then angle between those pairs is calculated.

5. SHAPE SIMILARITY MEASURE

Shape is not the feature of an image. It is associated with the region of an image. For shape similarity measure identification of a region is required. In most of the cases this is done manually but automated segmentation is also possible. Many times, shape similarity measures are invariant to translation and to size but in some cases rotational invariance is also needed. It means object can be identified in any orientation. There are three categories in shape measures. Shape histogram, that exclude images that cannot be matched but it have some flaws[7]. Boundary techniques, it is more specific and forms a boundary of a shape and then search images with similar boundaries. Sketch matching, it is even more specific and search for set of images involving one or more than one object that matches with a given query. These three categories are explained below:-

A. Shape Histogram

Projection matching is one of the histogram matching in which horizontal and vertical projection of shapes is used.

Let, number of rows in a shape is m and number of columns is n. In the histogram every row and column becomes a bin. Bin stores count that is number of 1-pixels in that row and column. Thus results in a histogram of m+n bins but is only useful if the shapes are of same size. Fixing number of row bins and number column bins helps to make projection matching size invariant. Also, project matching is rotationally variant. To make it rotationally invariant, axes of best-fitting ellipse is computed and shape is rotated until major axis is vertical. Number of possible rotations is two since we are not aware of the top of the shape. Numbers of possible rotations are four if major and minor axes are about the same length. If the computed histogram distance becomes too large incorrect rotations can be ruled out. It is preferred to choose bin with the largest count to be the first bin.

B. Boundary matching

In boundary matching algorithm boundaries of the query shape is represented. In discrete case, shape is represented by a sequence of m points < V_0, V_1, …..V_{m-1} >. From this sequence of points, a sequence of unit vectors V_k and a sequence of cumulative differences l_k are computed.

$$V_K = \frac{V_{k+1} - V_K}{|V_{k+1} - V_K|}$$

$$L_K = \sum_{i=1}^{k} |V_i - V_{i-1}|, k > 0$$

To define a shape distance measure we use descriptors (a_{-M}, a_0,…… a_M) The Fourier distance measure is given by

$$d_{Fourier}(I, Q) = [\sum_{n=-M}^{M} |a^I - a^Q|^2]^{1/2} \quad (3)$$

where Q is the query shape and I is the image shape to be compared to Q.

C. Sketch Matching

It searches for full color or gray-scale images that match with given query shape. Query in this is a rough sketch of the major edges in an image. To obtain an intermediate form the color images are preprocessed. Immediate form is known as abstract image.

The query image is converted to the normalized size, binarized, thinned, shrunk which is known as linear sketch. A matching algorithm is used to match the linear sketch and abstract image. Both the images are divided into grid squares and for grid square of query image correlation is computed with respect to grid square of database image. The result for that query is given by maximum correlation over all the shifts.

6. **CONCLUSION**

In this paper, we have described effect of similarity measures on image retrieval systems in various dimensions namely, color, texture and shape. Working of different similarity measures and measures that are more specific in terms of obtaining output of a query image is explained.

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