A SHAPE FEATURE EXTRACTION FOR COMPLEX TOPOGRAPHICAL IMAGES

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ABSTRACT:

Topographical images, in case of aerial or satellite images, are usually similar in colors and textures, and complex in shapes. Thus we have to use shape features of images for efficiently retrieving a query image from topographical image databases. In this paper, we propose a shape feature extraction method which is suitable for topographical images. This method, which improves the existing projection in the Cartesian coordinates, performs the projection operation in the polar coordinates. This method extracts three attributes, namely the number of region pixels, the boundary pixel length of the region from the centroid, the number of alternations between region and background, along each angular direction of the polar coordinates. It extracts the features of complex shape objects which may have holes and disconnected regions. An advantage of our method is that it is invariant to rotation/scale/translation of images. Finally we show the advantages of our method through experiments by comparing it with CSS which is one of the most successful methods in the area of shape feature extraction

KEY WORDS: Polar Projection, Topographical Images, Shape Feature, Content-based Image Retrieval

1. INTRODUCTION

Image retrieval is the process to find images from an image database that match the properties of a given image called a query image. Image retrieval is classified into annotation-based retrieval and content-based retrieval. Annotation-based image retrieval puts text annotations manually in advance on each image in a database, and uses the annotations when a query is processed. On the other hand, content-based image retrieval (CBIR) extracts features such as color, texture and shape automatically, and uses the features to find images that are similar to a query image[1]. This paper focuses on the CBIR. The methods of CBIR depend largely on the types of images. This means that a method works effectively and efficiently with one type of images may not work well with other types of images. One such type of images that existing methods do not work well with is the topographical images which is the focus of this paper.

Topographical images, compared to other types of images, have the following properties. Firstly, because they, in particular aerial and satellite images, are usually similar in colors and textures, it is difficult to distinguish the color and texture of a query image from those of the images in a database. This makes shape an important feature within topographical image retrieval. Secondly, topographical images are often complex that requires more sophisticated feature extraction than simple shape images. Finally topographical images may have low resolutions and some errors caused by other factors such as reflected lights.

The existing CBIR systems retrieve images by using color, texture, and/or simple shape features[1,4,6]. When these systems are used for topographical image retrieval, it is obvious that the accuracy and the efficiency of retrieval will be dramatically decreased. Therefore new methods are needed to perform CBIR of topographical images.

In this paper we propose a shape extraction method called polar projection (PP) to capture shape features of topographical images. It supports all invariant properties (i.e.,rotation/scale/translation invariance) and can retrieve complex shaped images with holes and disconnected regions, and is tolerant to the pre-extraction error.

A CBIR system with PP can be used to retrieve images such as buildings, maps, aerial photographs, satellite images where shape features have important roles.

The rest of this paper is as follows. In section 2, we briefly review the existing Cartesian projection and curvature scale space (CSS) methods for shape feature extraction. In section 3, we propose the polar projection and describe the feature extraction process and the advantages of PP. In section 4, we show experimental results on PP and CSS respectively, and compare and analyze the advantages of both methods. Finally in section 5, we conclude this paper.

2. RELATED WORK

Shape feature extraction of images can be divided into region-based methods and contour-based methods[2]. Region-based methods use the pixel distribution of both the boundary and inner pixels of regions while contour-based methods use the pixel distribution of only the boundary pixels.

There is one important operation called Cartesian projection used in some region-based feature extraction methods[5]. The operation works on a binary image which has only two values.

The projection operation in the Cartesian coordinates counts the numbers of region pixels horizontally (for X-axes) or vertically (for Y-axes).

This method depends on the orientation of the image. In other words, it is not rotation invariant. On the other hand, topographical images can be taken from any direction. Thus the projection in the Cartesian coordinates is not suitable for topographical images.

There is a contour-based feature extraction method called curvature scale space (CSS)[3]. The CSS is a successful method in the image retrieval area. It has also been extended and advanced by the growth of MPEG[2]. The concept of CSS is that convex and concave segments of a contour are considered as features.

The CSS needs long time to extract feature values of a region[3]. And it is not suitable for a complex object which has disconnected regions and holes and is sensitive to errors of segmentation which will be explained in section 3.

3. POLAR PROJECTION

As mentioned in section 1, we have to use shape features rather than colors and textures in the CBIR for topographical images. Since topographical images are usually complex in shapes, we define a hierarchy of terms, image/object/region, to describe them. An image can have multiple objects, and an object can have multiple regions that can be disconnected and can have holes, and some regions may be embedded in other regions. In this paper, we propose the polar projection (PP) which can extract shape features of topographical images efficiently. PP projects the region pixels from the centroid of an object to the outer boundary in the polar coordinates by rotating the projection direction with a constant angle.

In this paper, we assume the following facts before extracting shape features of topographical images. First the object that we want to extract features has been segmented from the original image. This implies that a image has one object. And the segmented object is represented by a binary image, i.e., 1 for pixels of regions and 0 for pixels of background.

Figure 1 is an example which shows implementation of polar projection for a topographical image.

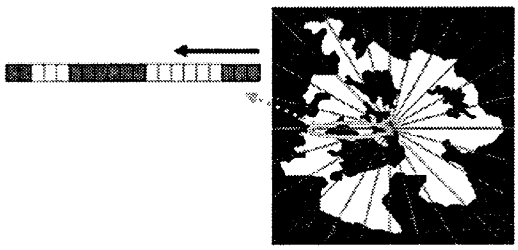


Figure 1. An example of feature extraction using PP

The core of the PP is to calculate the following three attribute values for each direction of the polar coordinate:

- the region pixel frequency, i.e., the number of pixels in the region
- the number of alternations between regions and the background

- the maximum distance, i.e., the distance between the centroid and the farthest pixel

The left part of Figure 1 shows an enlargement of the elliptic portion of the right image. Each rectangle represents a pixel of the image and the right-most pixel is the centroid of the object.

Starting from the centroid pixel, we project along the arrow, and then we find nine white pixels which are region pixels. Thus the pixel frequency is 9. During the projection process, there are changes of colors between the 3-rd black pixel and the 4-th white pixel, between 9-th and 10-th, between 15-th and 16-th, and between 18-th and 19-th. Therefore, the number of alternations between regions and background is 4. Finally we can find the 18-th pixel is the farthest region pixel from the centroid. So the maximum distance is 18.

PP has the following invariant characteristics. First it can extract features of an image regardless of rotation of the image (i.e., rotation invariant). Second it can extract features without regard to the scale of an image (i.e., scale invariant). To do that, we use the ratio of the extracted attribute values to the average of values extracted in all directions. Third we can extract the features regardless of location of the region in an image (i.e., translation invariant). This is because if the region is moved to another position, the centroid is also moved.

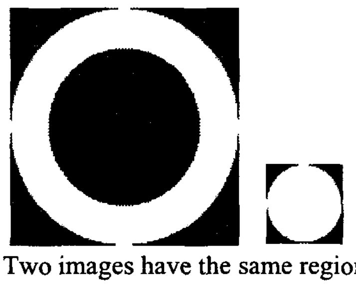


Figure. 2. Two images have the same region pixel frequency

We now compare our approach with two existing methods to show the power of our approach. Firstly, we compare the Cartesian projection with our approach to show the ability of processing complex images. The Cartesian projection used only the pixel frequency as a feature value. This is not enough to retrieve complex shaped images which have holes and disconnected regions. In contrast, our approach is more powerful because it uses not only the region pixel frequency but also the maximum distance and the number of alternations. The maximum distance can be used to catch boundary information of an object, and the number of alternations to figure out holes and disconnected regions in the object.

Figure 2 shows the importance of the last two attribute values as well as the region pixel frequency. In Figure 2 although two images are completely different, i.e., the left image has a hole but the right does not, the pixel frequencies in the two different images are the same because the number of pixels from the centroid of both objects to each direction are identical. To distinguish the two images, we check the number of alternations between regions and background and the maximum distance while projection in each direction. The number of alternations is 2 in the left image but 1 in the right image.

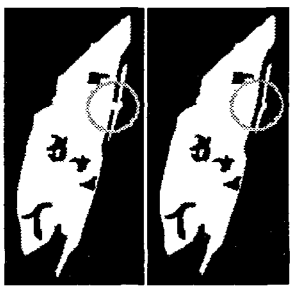


Figure 3. An example of segmentation error

We now show the error-tolerant ability of our method by comparing it with CSS. Because a topographical image is usually taken from the sky or the atmosphere, it has low resolution and lacks color information, unlike the images of product catalogs, signboards and so on. Therefore it is difficult to detach an object exactly from the image. In other words, there can be errors in the process of segmentation. For instance, due to segmentation errors an object with a region might be divided into two regions as seen in Figure 3.

Then the contours of two objects are not the same at all. In the case of the CSS method, the attribute values from the two images are completely different. However if there is a little difference between the features extracted by PP, they are actually as different as the difference. Like this, PP can cope with segmentation errors.

4. EXPERIMENT

As mentioned in section 3, PP can extract features from an image regardless of rotation/scale/translation of an image. Figure 4 shows the result of experiments and the advantages of PP.

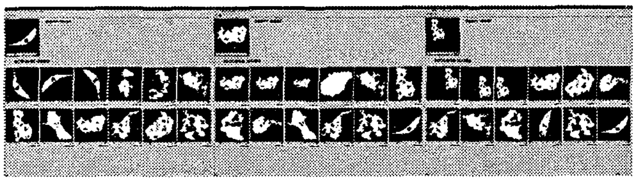
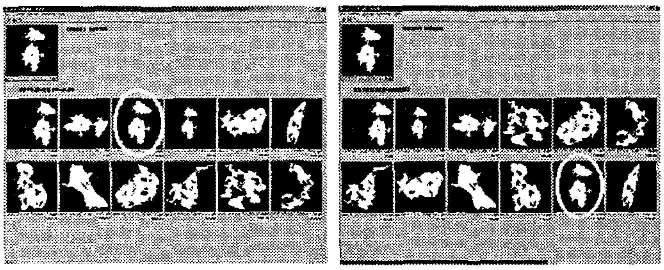


Figure 4. rotation/scale/translation invariance of PP



(a) PP (b) CSS

Figure 5. Topographical image retrieval

Figure 5 shows a query result for topographical images by using PP and CSS respectively. The result shows that both are rotation/scale/translation invariant. The image which has disconnected regions due to segmentation errors is retrieved third in Figure 5(a). Although the image is still similar to the query image, it is ranked at the eleventh in Figure 5(b). This ranking indicates that the image is regarded as a completely different image from the query image.

Therefore the above experiment shows that the polar projection is robust to segmentation errors which occur frequently in topographical images and can retrieve the desired images efficiently.

5. CONCLUSIONS

In this paper, we introduced a shape feature extraction method, called polar projection, suitable for topographical images. This is an extended and improved method from the existing projection using the Cartesian coordinates. It performs projection from the centroid of an image object towards the outer boundary in the polar coordinates. And the three features are extracted in the direction.

The polar projection has the following advantages which we have verified through experiments. 1) It can retrieve the images similar to a query image regardless of rotation, scale and translation. 2) It is robust to segmentation errors and can also extract shape features from the images which have disconnected regions. 3) It can also represent holes in a region by the number of alternations between the region area and the background area. Especially, the second and third advantages cannot be accomplished by the CSS.

6. REFERENCES

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7. ACKNOWLEGEMENTS

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