Pattern Extraction in Segmented Satellite Images By Reducing Semantic Gap Using Relevance Feedback Mechanism

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Abstract

Image Segmentation divides a region into sub regions in such a way that the pixels in a sub region are similar. Satellite image segmentation, an application in image segmentation is to extract the patterns using image retrieval systems. Image Retrieval can be of a wide area in pattern recognition. Content-based can be of best form for retrieval of satellite images. Extraction of high-level features from the images in the form of query or keywords and reduces the semantic gap between the low-level features. To produce better accuracy, Relevance Feed-back based CBIR methods are used for reducing the semantic gap. The overall correlation between the taken satellite image and processed image is identified using Correlation Ratio. This paper focuses on the implementation of K-Means Clustering along with RF mechanism checks the similarity between original and extracted pattern.

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1. Introduction

Image Segmentation is the process of dividing a region into sub-regions or changing the representation into something which is easier to analyze and more understandable. Image segmentation is nothing but pixel classification. It is one of the major task in pattern recognition and still a major issue in image analysis and image
processing for object tracking, face detection, image retrieval. Image Segmentation can be classified into two: similarity and discontinuity. In similarity method, image region is classified into sub regions in such a way that pixels belonging to a sub region are similar and dissimilar from rest of sub regions. One of such similarity method is K-Means Clustering\textsuperscript{3,6} unsupervised algorithm.

Initially uses Text Based Image Retrieval Systems. But, it requires human effort. As an impact of this Content Based Image Retrieval systems came into being. In Content-based, images refers to colour, texture, shape, or any information that can be obtained from image itself\textsuperscript{1,2}(low-level features). When CBIR came into being, the need for a user friendly system became apparent. What the user thinks (human intelligence) is high-level semantics. Low-level features\textsuperscript{16} are used to extract image because, high level features are difficult to extract and moreover they provide additional information about objects in an image. Semantic gap\textsuperscript{2,8} is defined as the difference between low-level features\textsuperscript{4,8} and high-level features. The semantic gap between features totally affects the performance of CBIR systems. Many solutions aims to bridge the semantic gap thus improving the performance of overall system. Two solutions to address this problem are user’s Relevance Feed-back mechanism and Feature Selection\textsuperscript{1}.

Relevance Feed-back\textsuperscript{11} mechanism is the process of providing more and more feed-back using query, keywords to the system by the user. RF mechanism enables to improve the interaction between user and system thus refining the results at each iteration. This can also be applicable in medical-images in which images having similar structure but differ in the way the diseases develops with small differences often create confusions in experts.

Feature Selection can reduce the gap by providing the features in the form of a query and removes irrelevant features. By providing the query for a particular feature, it searches in the database for that feature in such a way that the retrieved images will be closer to the given query.

Finally, the pattern is extracted and a similarity checking is done between the original image and the extracted pattern using Correlation Ratio.

2. Related Work

Ansa Saju\textsuperscript{1} proposes relevance feedback mechanism incorporated in content based retrieval mainly aimed at reducing the semantic gap reduction between features. The efficiency of entire system is calculated using two measures: Precision and Recall.

Shiv Ram Dubey\textsuperscript{3} proposes a novel based defect segmentation of fruit using K-Means Clustering is proposed. This proposed method is carried out in two stages. Firstly, similar pixels are grouped into a cluster. Secondly, the clusters are grouped into specific number of regions. The author proposes this method as the fruit defect identification done by manually requires more time.

Yu sun\textsuperscript{9} proposes a relevance feedback along with online feature selection in content based image retrieval systems for narrowing the semantic gap between those features. In order to guide the online feature selection method, inconsistency measurement is used. Final results show with higher accuracy rate.

Xiaoqian Xu\textsuperscript{11} proposes a novel-based feedback mechanism for retrieval of shapes in spine X-ray images. Along with this, a short-term memory approach is presented for the removal of redundant request of user’s feedback. Similarity of both full and partial shapes of spines are presented using a shape similarity measure. Updation of weight procedure is done to make the images suitable for user’s to provide feedback.
3. Proposed Methodology

The proposed methodology involves six sections: Database Collection, Image Pre-processing, Segmentation, Feature Extraction, Relevance Feedback, and Similarity Checking. Satellite image database of five different classes each with 50 images were taken into consideration. Pre-processing of satellite images are done through filtering functions. Segmentation is achieved by K-Means Clustering. Feature set involves Centroid, RGB range and Shape. Relevance Feedback can be achieved by user’s intention to extract a particular pattern in an image. Finally, Correlation Ratio provides for the Similarity Checking. The diagrammatic representation of proposed method is given in Fig.1 and each section in the proposed method is explained in subsection 3.1, 3.2, 3.3, 3.4, 3.5.

The steps followed in proposed method are as follows:

- Satellite Image is taken from the database
• Do the image enhancement procedures using filtering techniques
• Segment image using $K$-Means Clustering. Here used 3 clusters for processing
• Extract the low-level features of the clusters using query.
• System gives the retrieval results based on query
• The system asks whether user is satisfied with the results. If yes, go with shape extraction of patterns
• Similarity of the retrieved pattern and the original image is checked using Correlation-Ratio
• Else, select the cluster with the pattern and again segment the retrieved cluster using $K$-Means and refine the results using steps 4,5,6,7

3.1 Image Pre-processing

When images captured by camera or any sensing systems, distortions can occur due to change in the intensity levels or due to poor illumination or poor contrast level. Image Pre-processing\(^\text{12}\) can bring out certain features in an image. It can highlight certain characteristics so that the results more accurate and precise than the original image for the application. ‘imfilter\(^1\)’ is used for filtering an image. The ‘fspecial’ command is to create two-dimensional pre-defined filter. Table\(1\) gives certain filter\(^1\) functions used to enhance an image.

<table>
<thead>
<tr>
<th>Value</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average</td>
<td>Averaging filter</td>
</tr>
<tr>
<td>Disk</td>
<td>Circular averaging filter</td>
</tr>
<tr>
<td>Guassian</td>
<td>Guassian low pass filter</td>
</tr>
<tr>
<td>Laplacian</td>
<td>Approximates two dimensional laplacian operator</td>
</tr>
<tr>
<td>Prewit</td>
<td>Prewit horizontal edge-emphasizing filter</td>
</tr>
<tr>
<td>Sobel</td>
<td>Sobel horizontal edge-emphasizing filter</td>
</tr>
<tr>
<td>Unsharp</td>
<td>Unsharp contrast enhancement filter</td>
</tr>
</tbody>
</table>

3.2 $K$-Means Clustering

$K$-Means Clustering\(^\text{10}\) is one of the unsupervised-algorithm. Unsupervised algorithm means the user can define the number of clusters for clustering. It classifies the image into ‘n’ number of clusters as per the user’s decision. Also define K-centroids, each for each cluster. Centroids must be placed as far away from each other. The next step is the calculate the Euclidean distance\(^\text{13}\) between pixels and centroid and assign each of the pixel location to the nearest centroid. When no point is left, early group age is done. Secondly, calculate the new K-centroid location by taking the mean of all the point in the cluster. This process is repeated until no change in centroid happens. The data in each cluster share similar properties\(^\text{13}\).

The algorithm for the $K$-Means Clustering is given below:

• Define number of clusters and K-centroid location
• Calculate the Euclidean distance between each pixel and cluster centroid and assign each pixel to the nearest centroid
• When no more points to process, calculate the new centroid in each cluster by taking the mean of each point
• Repeat the step 2 and 3 until no change in centroid location. At this point clustering stops and clusters are stable.
The aim of proposed method is to segment the satellite images using $K$-Means Clustering and $L*a*b$ color space. Here, used three clusters for segmentation. The steps used to segment the image into clusters are given below:

- Read the RGB level image
- Convert the RGB image to $L*a*b*$ color space because this color space includes all perceivable colors and also enables to quantify the visual differences between the colors. $L*$ represents the Luminosity layer and the color information is available in $a*$ and $b*$ layers only.
- Using $K$-Means classify the colors and the distance between the colors can be computed using Euclidean distance.
- Every pixel in the image obtained from step 3 can be labeled using the cluster-index.
- Group the pixels with the same cluster-index by color into different images, based on number of clusters.

After performing $K$-Means Clustering, next step is to improve the retrieval efficiency of satellite images by narrowing the semantic gap between both low-level and high-level features. This can be done through the stages mentioned below:

3.3 Feature Extraction

The features used for extracting the patterns in an image include Centroid of cluster, Range of RGB in each cluster, shape of a pattern.

3.3.1 Centroid

Centroid specifies the center of mass of a region. It is a 1-by Q vector. The first element is the horizontal component (x-coordinate) and second component is the vertical component (y-coordinate) of center of mass.

3.3.2 Range of RGB

The RGB value ranges from 0-255. The red, green, blue in full intensity makes white. According to the user’s intention, select the cluster with the specified pattern and calculate RGB value at each pixel location from the color histogram. From the retrieved results, find the minimum and maximum range of RGB.

3.3.3 Shape

Select the cluster with specified pattern. Identify points in the cluster where the pattern lies by positioning the cursor with the mouse. Thus, receives unlimited number of points, returns the x and y coordinates in vector format. Create a binary ROI (Region of Interest) mask with the returned coordinate positions. Subtract the original image and the mask to return the specified pattern from the cluster.

3.4 Relevance Feedback

RF mechanism increases the interaction between the user and the system providing feedback to the system. User can decide when to stop the feedback. It involves the following steps.

- Provide feedback to the system in the form of keywords, query, and example
- The user decides whether the displayed images are relevant or irrelevant.
- If they are irrelevant, system learns and tries again. Move to step 2.
- Stop execution, until retrieved images becomes relevant and extract the shape for the pattern in the cluster.
3.5 Similarity Checking

Similarity of extracted pattern and original image is calculated using correlation-ratio. Value lies between 0 and Value nearer to 1 shows high correlation (similarity). Correlation-Ratio shown in equation(3) is calculated from equation(1) and equation(2). Standard Deviation can be find out using

\[ \sigma_i = \left\{ \frac{1}{n_i} \sum_{x_i} \left( Y_i - m_i \right)^2 \right\}^{\frac{1}{2}} \]  

Variance of \( \sigma_i \) is given by,

\[ D^2 = \left\{ \frac{1}{n} \sum_{i=0}^{255} \left( n_i \sigma_i^2 \right) \right\} \]

Where, \( n = \sum_{i=0}^{255} n_i \)

Correlation ratio(CR) can be find out using,

\[ CR = \text{Squareroot} \left( 1 - D^2 \right) \]

4. Experiments and Results

Fig. 2. (a) Original image; (b) Cluster1 formed with feature vector cluster centroid co-ordinate (Centroid : 129.0 115.0) in first iteration; (c) Cluster2 formed with feature vector cluster centroid co-ordinate (Centroid : 139.0 148.0) in first iteration; (d) Cluster3 formed with feature vector cluster centroid co-ordinate (Centroid : 133.0 132.0) in first iteration; (e) Extracted Pattern.
Experiment is done using satellite image database of 5 different classes each with 50 images. These classes include building(50), lakes(50), islands(50), cyclones(50), Glacier(50). Figure 2 shows the result for building dataset. From figure .2. (a) is the original image. Here, we tries to retrieve blue pattern from Fig .2. (a) which is in the form of a bird by giving different feedback in the form of a query. For this, first perform \( K \)-Means Algorithm and extracted first feature ie, cluster coordinate from the formed clusters and the output is shown in Fig .2. (b), Fig .2. (c), Fig .2. (d).

After performing the first iteration, the searched pattern is found in cluster1. So again, segment the cluster1 into three clusters using \( K \)-Means clustering to refine the results by performing relevance feedback with RGB as the next feature in the formed clusters in the second feedback. After performing the second feedback, identify the cluster with the needed pattern and extract the pattern using shape parameter shown in Fig .2. (e). It is the user who decides when to stop the iteration. This can be performed in all kinds of datasets in search for a pattern. Finally, a similarity value of 0.999 is obtained from correlation-ratio showing high similarity between original image and extracted pattern.

5. Conclusion

The experiment is conducted on different image databases in search for a particular pattern. Here shown only for a single image database ie, building. The experimental results shows that the patterns can be well-obtained by reducing (narrowing) the semantic gap between the low-level features and high-level features using the proposed Relevance Feedback mechanism with \( K \)-Means Clustering. Eventhough on each iteration features are extracted, finally a high similarity is obtained between original image and extracted pattern. Future work includes creation of a dataset with similar images.

References