P2P Tools

Object-based Image Segmentation – OBIS Tool

User's Manual

Version 1.50

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1. Object-based Image Analysis

The object-based image analysis (OBIA) is a powerful method, by which similar pixels around a given point are conglomerated to form an object, instead of treating pixels individually. The object-based image segmentation (OBIS) tool is developed based on this concept.

2. K-means Clustering Algorithm

K-means is one of the simplest, fastest and efficient non-hierarchical clustering algorithms. In a set of T data points p_1, p_2, p_3,...p_T; K clusters U_1, U_2, U_3, ... U_K and K corresponding cluster centers u_1, u_2, u_3, ... u_K [note that each cluster contains t_i data points $(0 < t_i < T)$], the mean-square-error function is given by (Zalik 2008):

$$E = \sum_{i=1}^{i=K} \sum_{p_i \in U_i} \|p_i - u_i\|^2 \tag{1}$$

The idea behind the K-means clustering algorithm is to minimize the error function E so that the data point p_i will be assigned to the cluster U_i with the minimum E. The cluster center shifts position adaptively and the iteration will terminate when the cluster center ceases to move and stays at the centroid of the cluster.

The steps for the K-mean algorithm include:

1) Specify the number of clusters and where these cluster centers are seeded.
2) Specify the threshold between clusters.
3) Group each data point to a cluster center in such a way that the error function would be minimal.
4) Compute new cluster centers.
5) Repeat steps 3 and 4 until the cluster center no longer shifts.

3. Euclidean Distance

K-means is most commonly used with Euclidean Distance when the distance between the image data points and the cluster centers is calculated (Jain 2010). Color is defined by three positive primary color values which are Red (R), Green (G), and Blue (B), indicating that the color space is the representation of the primary colors (R, G, B) in a space Cartesian coordinate system as a volume (Wright 2007). Therefore, vector addition should be used when calculating the Euclidean distance between two color points. In a set of T data points p_1, p_2, p_3,...p_T; K

clusters U_1, U_2, U_3, ... U_K and K corresponding cluster centers u_1, u_2, u_3, ... u_K, the Euclidean distance between the first cluster center and any data point can be calculated by:

$$d_{1i} = \sqrt{(u_{1R} - p_{iR})^2 + (u_{1G} - p_{iG})^2 + (u_{1B} - p_{iB})^2} \qquad (i = 1, 2, 3,..., \text{T}) \qquad (2)$$

4. OBIS Program

The Windows-based OBIS tool is developed using C#. In the OBIS program, the K-means algorithm along with RGB color histogram is used for image segmentation. Specifically, the number of clusters and threshold are specified for an image. The image is then segmented into a number of homogeneous regions determined by the clusters. A histogram depicts graphically the number of times that each color is used in an image (i.e., color-frequency distribution) (Wright 2007). Instead of randomly seeding initial cluster centers, they are made to fall on the predetermined color histogram top list points. The cluster centers are well identified in such a way to exceed the specified threshold. This dramatically improves the traditional k-means clustering and makes it more predictable and sensible.

The major steps for using the OBIS tool include:

1) Input
   a. Image: Load the image to be processed.
   b. Number of cluster centers: It is the number of segments, into which the user wants the image to be separated.
   c. Threshold between clusters: It is the minimum Euclidean metric used when selecting data points to serve as a cluster.

2) Run
   a. A histogram of the image is prepared.
   b. Based on the specified number of cluster centers and threshold, centers are identified from the data points.
   c. In the first step, the data points are assigned to cluster centers using the K-means algorithm.
   d. The preliminary clustering performed in step c is revised by taking the center of mass of the data and repositioning the cluster center for the next step.
   e. This process continues until cluster center stops moving.

3) Output

a. The processed image is displayed next to the input image.

b. The processed image can be saved in a selected format.

c. Histogram of the image is displayed.

5. **User Interface and Use of the OBIS Tool**
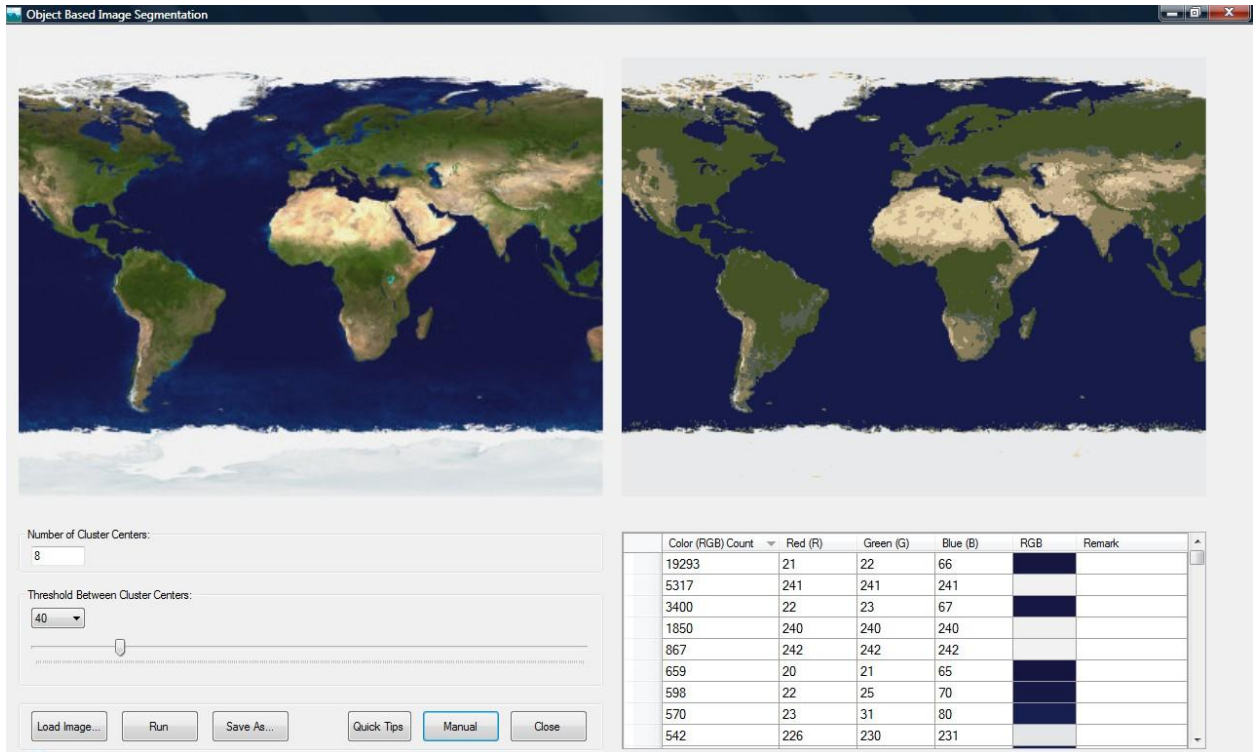
Main interface of the object-based image segmentation (OBIS) tool

1) *Load Image:* This button is used to load image to the interface. The software supports several different image file formats.

2) *Number of Cluster Centers:* This is the number of segments used to group the image. It can be any positive integer.
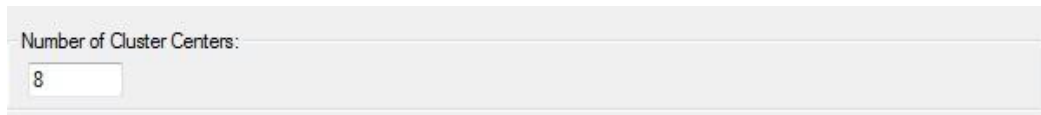
3) *Threshold between Cluster Centers:* This is the limit that is used when identifiying clusters. Two points are considered as separate cluster centers if the Euclidean distance between them exceeds this threshold value. Searching for these points proceeds from the

top to the bottom of histogram. The values range from 0 to 255. The values can be selected by using a combobox or a slider control.

4) **Run:** This button is used to trigger the processing. It is fairly fast in comparison to the amount of data. A "Please wait" form will be displayed until the execution finishes.

5) **Histogram:** This is the source image RGB histogram. For convenience, it is shown in a grid format. The frequency of colors is sorted in a descending order.

Color (RGB) Count ▼	Red (R)	Green (G)	Blue (B)	RGB	Remark
19293	21	22	66		
5317	241	241	241		
3400	22	23	67		
1850	240	240	240		
867	242	242	242		
659	20	21	65		
598	22	25	70		
570	23	31	80		
542	226	230	231		

6) **Save As:** After processing, the image can be saved in several different formats.

7) **Quick Tips:** Brief helpful information is provided.

8) **Manual:** This user's manual provides more details on the software.

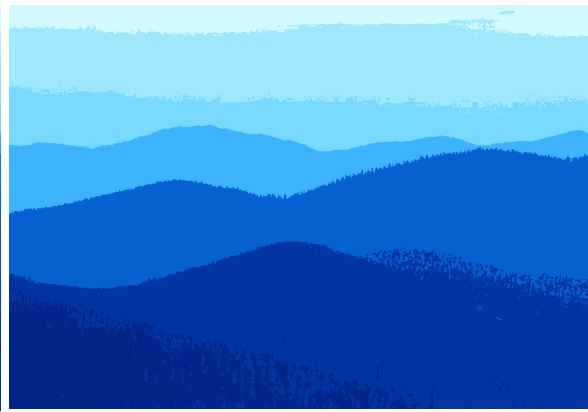9) **Close:** This button is used to close the program.

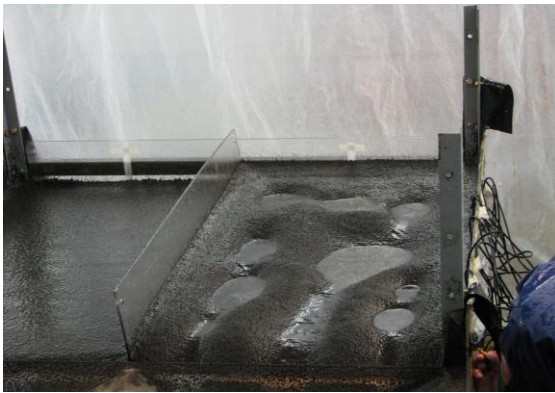6. **Samples for the OBIS Tool**
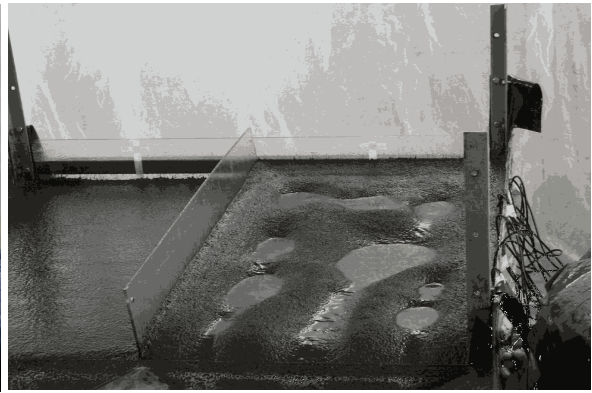
(1) Sample 1

Original Image

Cluster Image (Cluster centers = 7; Threshold = 20)

(2) Sample 2

Original Image

Cluster Image (Cluster centers = 10; Threshold = 20)

(3) Sample 3

Original Image

Cluster Image (Cluster centers = 10; Threshold = 40)

References

Jain, A. K. (2010). "Data clustering: 50 years beyond K-means." *Pattern Recognition Letters,* 31, 651-666.

Wright, Jr. R. S., Lipchak, B., Haemel, N. (2007). *OpenGL SuperBible: Comprehensive Tutorial and Reference*, 4th Ed., Pearson Education Inc., Boston, MA.

Zalik, K. R. (2008). "An efficient k-means clustering algorithm." *Pattern Recognition Letters,* 29, 1385-1391.