Segmentation Report - Lab 6 - Computer Vision

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1. Introduction

In computer vision, image segmentation is one of the most widely studied problems [1]. In short, segmentation is looking to divide an image into several regions, where ideally each region corresponds to an object [2]. This area of interest has led to the development of a large number of methods for image segmentation. In this report, 4 clustering methods (k-means, GMM, Hierarchical and watershed) will be applied in different color spaces, in order to evaluate which of the methods is better in a set of selected images.

2. Materials and methods

2.1. Clustering algorithms

In the present report, four clustering methods were used to perform the segmentation in each of the colored spaces: k-means, GMM, hierarchical and watershed.

The K-means algorithm allows the segmentation of an image by means of the realization of several clusters (minimum 2), where each cluster is assigned the pixels that have more similarity. Having each group of clusters, the segmented signal is obtained using a ”reshape”.

the GMM algorithm is similar to the k-mean algorithm. The only difference is the use of Gaussian distributions for the realization of each cluster.

The hierarchical algorithm allows the segmentation of images through a hierarchical grouping that groups the data in a variety of scales through the creation of a dendrogram.

The watershed algorithm allows the segmentation of the image taking into account the magnitude of the gradient. In order not to generate over-segmentation, the minima imposition technique is used for the creation of markers.

```
switch clusteringMethod
    case 'kmeans'
        l=0;
        for i=1:rows
            for j=1:cols
                l=l+1;
                X(l,:)=he(i,j,:);
            end
        end
        [cluster_idx, cluster_center] = kmeans(X, numberOfClusters);
        idxpos=1;
        for i=1:rows
            for j=1:cols
                segs(i,j)=cluster_idx(idxpos);
                idxpos=idxpos+1;
            end
        end
        image(segs)
        colormap colorcube
    case 'gmm'
        l=0;
        for i=1:rows
            for j=1:cols
                l=l+1;
                X(l,:)=he(i,j,:);
            end
        end
        obj=fitgmdist(X,numberOfClusters);
        idx=cluster(obj,X);
        idxpos=1;
        for i=1:rows
            for j=1:cols
                segs(i,j)=idx(idxpos);
                idxpos=idxpos+1;
            end
        end
        image(segs)
        colormap colorcube

    case 'hierarchical'
        he=imresize(he,0.1);
        rows=size(he,1);
        cols=size(he,2);
        l=0;
        for i=1:rows
            for j=1:cols
                l=l+1;
                X(l,:)=he(i,j,:);
            end
        end
        Z = linkage(X);
        cluster_idx = cluster(Z,'maxclust', numberOfClusters);
        idxpos=1;
        for i=1:rows
            for j=1:cols
                segs(i,j)=cluster_idx(idxpos);
                idxpos=idxpos+1;
            end
        end
        image(segs)
        colormap colorcube
    case 'watershed'
        if validForWatersheds
            he=im2uint8(he);
            he=rgb2gray(he);
            hy= fspecial('sobel');
            hx = hy';
            Iy = imfilter(double(he), hy, 'replicate');
            Ix = imfilter(double(he), hx, 'replicate');
            gradmag = sqrt(Ix.^2 + Iy.^2);
            figure
```

```
            imshow(gradmag,[]), title('Gradient magnitude (gradmag)')
            marker = imextendedmin(gradmag, numberOfClusters);
            new_grad = imimposemin(gradmag,marker);
            ws = watershed(new_grad);
            figure;
            imshow(ws == 0)
            figure
            segs=label2rgb(ws, 'colorcube', 'w', 'shuffle');
            imshow(label2rgb(ws, 'colorcube', 'w', 'shuffle'))
        else
            error('Spaces with +xy are not valid for watershed, use rgb, lab, hsv instead.')
        end
    otherwise
        error('Incorrect clustering method, it must be: kmeans, gmm, hierarchical, watershed')
end
```

2.2. Segmentation parameter tunings

For the segmentation with the k-mean and GMM method, the parameter to be established is the number of clusters. In the case of the watershed method it is necessary to establish the number of markers.

2.3. Image preprocessing

```
switch featureSpace
    case 'rgb'
        %nothing happens as the image is already in rgb
    case 'lab'
        he=rgb2lab(he);
    case 'hsv'
        he=rgb2hsv(he);
    case 'rgb+xy'
        validForWatersheds=0;
        for i=1:size(rgbImage,1)
            for j=1:size(rgbImage,2)
                he(i,j,4)=j;
                he(i,j,5)=i;
            end
        end
    case 'lab+xy'
        validForWatersheds=0;
        he=rgb2lab(he);
        for i=1:size(rgbImage,1)
            for j=1:size(rgbImage,2)
                he(i,j,4)=j;
                he(i,j,5)=i;
            end
        end
    case 'hsv+xy'
        validForWatersheds=0;
        he=rgb2hsv(he);
        for i=1:size(rgbImage,1)
            for j=1:size(rgbImage,2)
                he(i,j,4)=j;
                he(i,j,5)=i;
            end
        end
    otherwise
        error('Incorrect color space, it must be: rgb, lab, hsv, rgb+xy, lab+xy, hsv+xy')
end
```

Figure 1. Original image to be tested

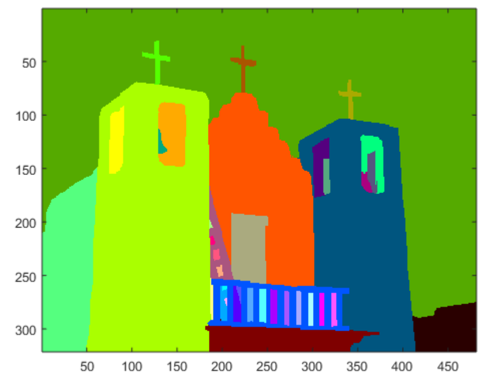

Figure 2. mean segmentation made by humans

2.4. Evaluation

3. Results

3.1. Kmeans

It can be seen that the RGB color space using the k-means method does not have much coverage. This happens because the RGB space does not take into account the image to spatial level.

It is observed that in the HSV and LAB color spaces an improvement in the k-means method is not obtained, comparing them with the RGB space.

Segmentation with the k-mean method is better in the RGB-XY and LAB-XY spaces. This happens because for each of the cases the space of the image if is taken into account. Despite the improvement, the segmentation level is below to the desired level (see figure 2).

3.2. GMM

Using the GMM method, the segmentation improves considerably. The color space that is not efficient is the LAB (see figure 9, 10 and 11).

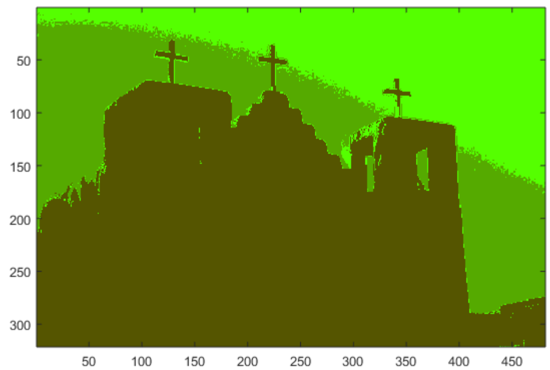

Figure 3. Image clustered by kmeans in rgb space of color

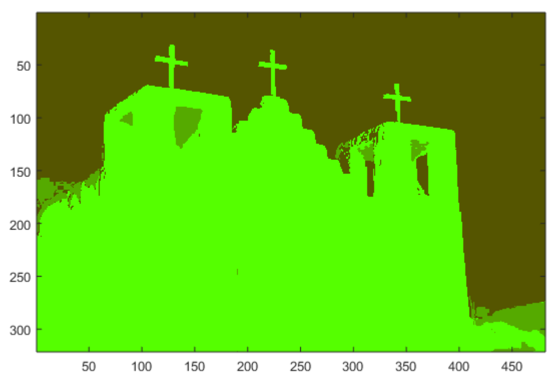

Figure 4. Image clustered by kmeans in hsv space of color

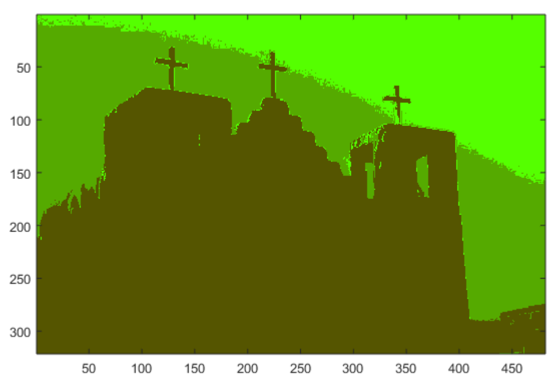

Figure 5. Image clustered by kmeans in lab space of color

3.3. Hierarchical Clustering

3.4. Watersheds

In the method watershed segmentation, results are very close to that of the segmentation image made by humans (see figure 2, 12 and 14), except for the HSV color space, where the results are not very positive. In the LAB space it is observed that an over-segmentation occurs (see figure 14). It should be specified that this can be corrected by increasing the number of markers.

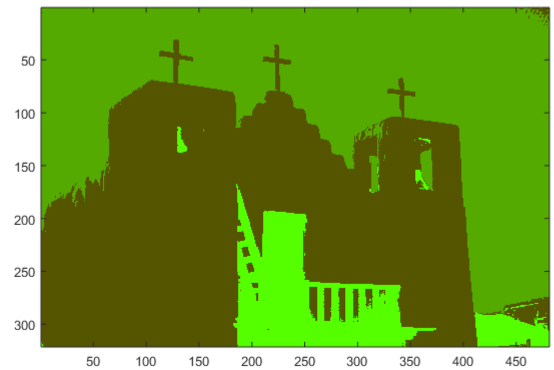

Figure 6. Image clustered by kmeans in rgb+xy space of color

Figure 7. Image clustered by kmeans in hsv+xy space of color

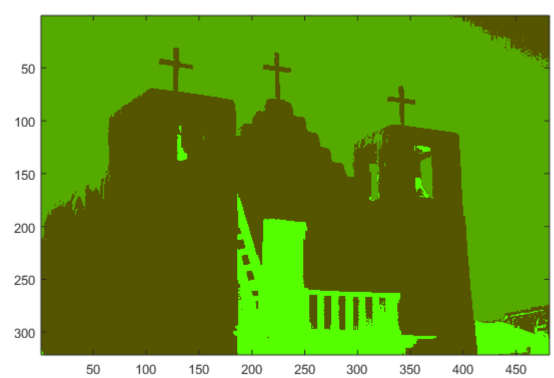

Figure 8. Image clustered by kmeans in lab+xy space of color

4. Conclusions

The watershed algorithm is overall better in time and in accuracy but is difficult to select the hiperparameter H-

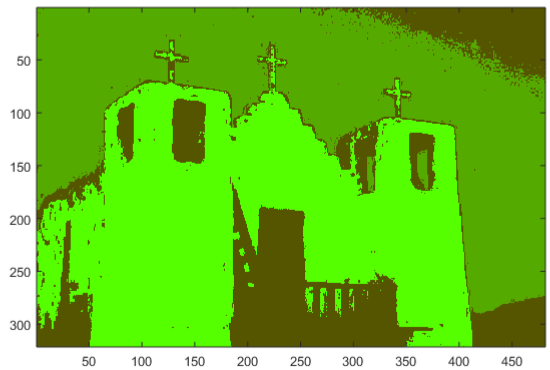

Figure 9. Image clustered by gmm in rgb space of color

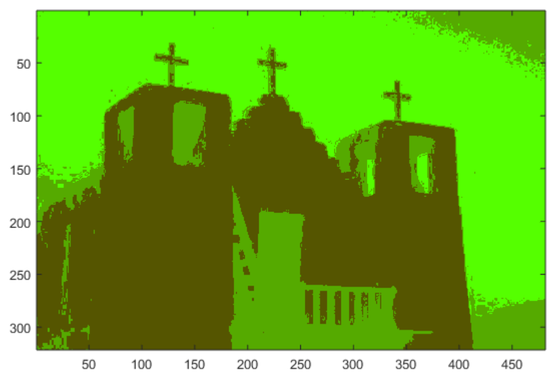

Figure 10. Image clustered by gmm in hsv space of color

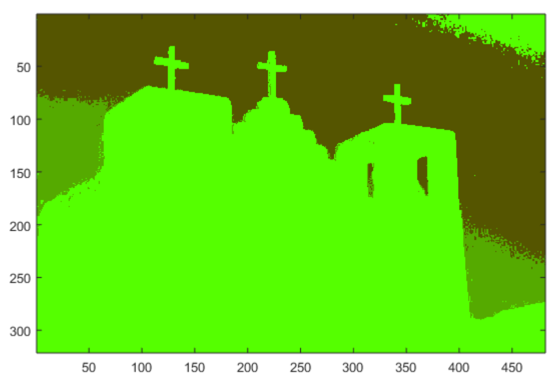

Figure 11. Image clustered by gmm in lab space of color

minima. Selecting a wrong parameter number can lead to bad results.

The algorithm for gmm is heavy time consuming but is a lot reliable because is less sensitive to the hiperparameters than watersheds.

The algorithm kmeans is the heaviest in time but its better when using space dimension along with the color space.

Figure 12. Image clustered by watershed in rgb space of color

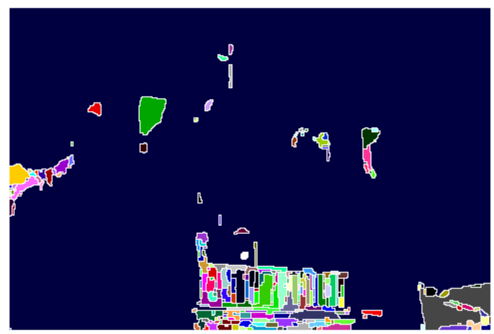

Figure 13. Image clustered by watershed in hsv space of color

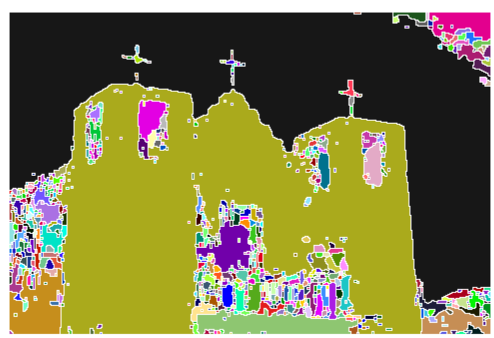

Figure 14. Image clustered by watershed in lab space of color

it consumes less resources so it can handle better the images if time isnt a key factor in the usage.

The space color of the image is a key factor that would determine the well behavior of a clustering algorithm.

References

[1] R. Szeliski, ”Computer Vision: Algorithms and Applications”,

Springer, 2011.

[2] P. Arbelez, ”Computer Vision: Grouping 01”, University of the Andes, 2018