Image Segmentation using Mean Shift Clustering

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1. Introduction:

Mean shift clustering is an algorithm used to segment images based on color similarity. The pixels which have similar color values are clustered together. This is done by finding out the local maxima in a cluster and using its value for other pixels in the cluster.

2. Algorithm:

The mean shift clustering algorithm has the following steps:

Firstly, all the images are converted into LAB color spaces to get better results.

Step 1- Decide on the parameter values like the minimum number of pixels in a cluster, number of iterations and, range and spatial coefficients.

Step 2- For every pixel in the image, the range magnitude, and spatial magnitude with every other pixel in the image are calculated.

Step 3- If both these magnitudes are less than the corresponding parameters with standard deviation, then the pixels are considered to belong to the same cluster.

Step 4- If the number of pixels satisfying these conditions is more than the minimum number of pixels in a cluster, then it is considered to be a cluster and the current pixel value is replaced with the Gaussian value.

Step 5- Gaussian value of pixel X is computed as follows:

$$G = X \sum_{i=0}^{N} e^{-||X-Xi||^2/h^2} / \sum_{i=0}^{N} e^{-||X-Xi||^2/h^2}$$

Step 6- This process is repeated for every pixel in the image for the specified number of iterations.

The output images are converted back into rgb to see the results.

3. Results:

In the assignment, the hs and hr which are the spatial and range coefficients are taken as 7 and 8 respectively. The minimum number of pixels in a cluster is 40 and the number of iterations is 10.

Five loops are taken, where two loops are used for iterating through every pixel in the image and the other two loops are for iterating through other pixels in the image for each pixel. Another loop is for the iterations.

A variable count is taken, which is used to keep the number of pixels that are likely to belong in the same cluster as the current pixel. When this variable is equal to or more than the minimum number of pixels in a cluster i.e., 40 in our case, then the current pixel value is replaced with the Gaussian value as shown in step 5 in the previous section.

Sample inputs and the outputs after segmentation are as follows:

Fig 1. Mario- input image.

Fig 2. Image after mean-shift clustering.

Fig 3. MM- input image.

Fig 4. Image after mean-shift clustering.

Consider the images Mario input and the Mario image after mean shift clustering. If observed, we can plot many differences:

- Color difference on cap
- Shade difference on the shoes
- Details are not found in the output
- Only one shade of blue in the output

4. Conclusion:

Image segmenting is an image processing technique that can be achieved in many ways like comparing proximity, similarity, symmetry, etc., Segmenting by color can be directly performed on rgb values. But better results are obtained if the rgb images are converted into LAB color space. The mean shift is performed on these images and the results are converted back into rgb values to see the desired results.

5. Observations:

The complexity based on the logic used is $O(n^4)$. While running the images, the run time differs from image to image. If we are processing an image with high density i.e, consider the images MM and Mario attached above, here we can see that the image MM have higher density compared to Mario image. All the pixels in MM are involved whereas in Mario, we can see the pixels at the border are not involved and the pixels involved are the ones shaping the Mario. The runtime for Mario (17 min) is less than the runtime for MM (21 min). In my observation, number of pixels involved in the image are directly proportional to the runtime of the process.

Run time α number of pixels covered in the image.

6. Summary:

The following are the steps performed for mean shift clustering.

- Taking an image and converting into RGB values.
- Converting from RGB to XYZ
- Converting from XYZ to LAB
- Performing Mean Shift on this LAB values and updating the LAB values
- Converting back LAB to XYZ
- Converting back XYZ to RGB
- Converting this updated XYZ values back to Image