BIL 415 - Image Processing Practicum

HACETTEPE UNIVERSITY
Department of Computer Engineering

Problem Set-4
Fall 2018-2019
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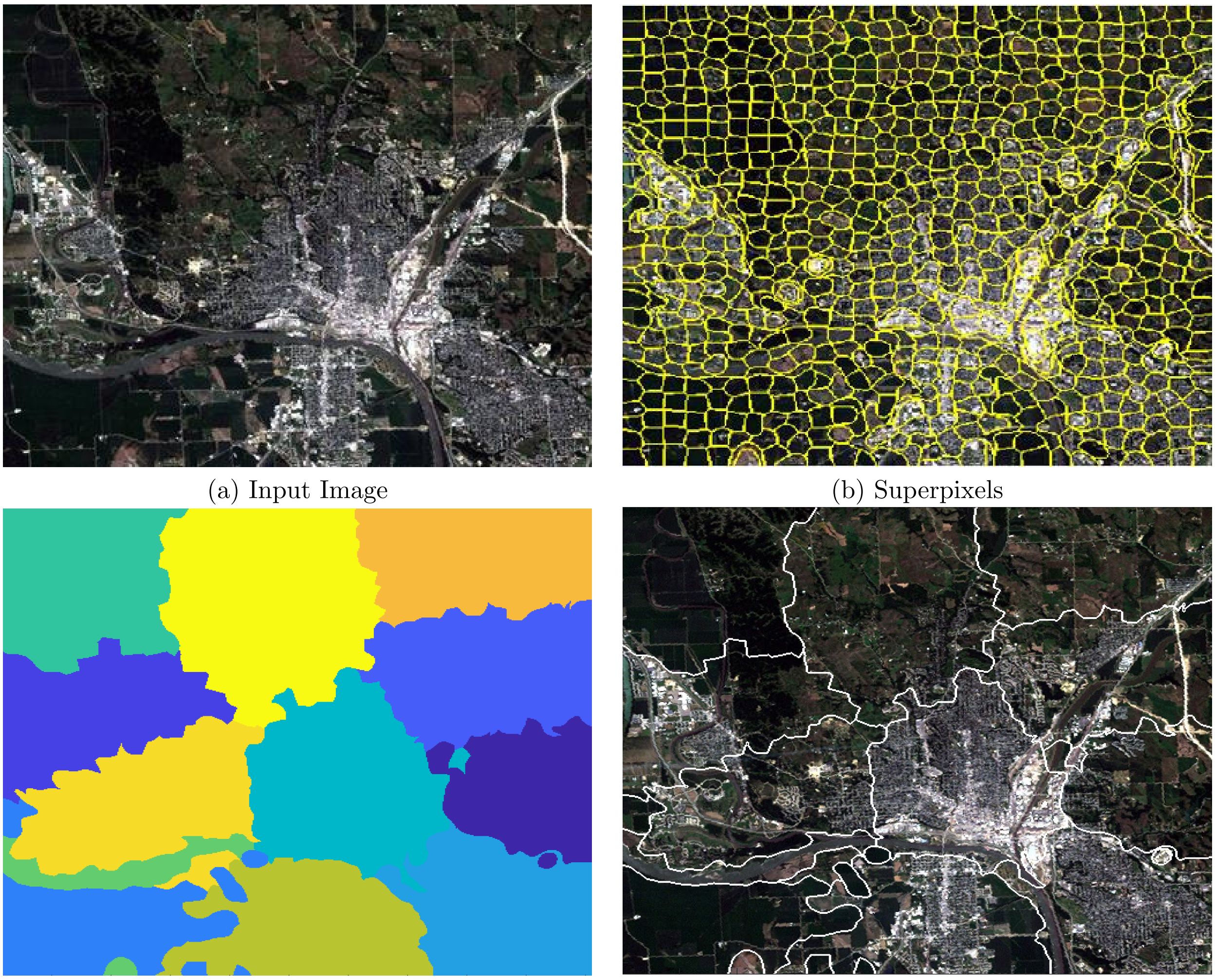
Due Date: 23:00 pm on Friday, December 28th, 2018

Segmentation of Multispectral Remote Sensing Images



(a) Input Image (b) Superpixels (c) Image Labels (d) Image Segments

Figure 1: Example results.

In this assignment, you are going to do image segmentation on multispectral images [1] by using k-means. You will demonstrate how increasing the number of spectral samples in the visible range with a multispectral image can improve k-means clustering performance.

The multispectral images allow the extraction of additional information outside the RGB spectrum that the human eye fails to capture. They include more then 3 spectral bands and different combinations of spectral bands have been utilized for different purposes. The mapping of bands to colors depends on the purpose of the image and the personal preferences of the analysts. You will use multispectral satellite images given from [2].

You are going to create your feature representations by considering different bands of the multispectral image such as the infrared channel. After that, you will compare the segmentation results when you use RGB channels and when you use additional channels. You will see that, by using the multispectral image's additional channels, some regions, that are not segmented by using only RGB channels, will also be segmented and seen as an object on the resulting image.

Background

Clustering is a process that groups data with respect to data similarity so that similar data take part same cluster. In image domain clustering is used for various types of problem e.g. image quantization, image segmentation. A good clustering algorithm must group data to homogeneous subsets as possibble. Similarity is most critical step in a clustering algorithm that determine how the clustering algorithm groups data. K-means clustering is one of the most popular clustering algorithm that groups data to k dissimilar clusters. It is an unsupervised learning algorithm for clustering problem and the main idea is to define k centroids one of each cluster. These centroids is randomly assigned to data space for first iteration. In the next steps, for each data point, distance to these centroids is calculated and data points are assigned to nearest centoids as cluster elements. Then for each cluster, new k centroids are calculated from k clusters. This steps go on until clusters centroids unchange.

PART 1: Segmentation with k-means

Pre-processing

The given bands of the multispectral images contain different wavelengths. There are 4 bands for each satellite image which are taken from Landsat 7. You can find the details of these bands at [3]. In order to get the RGB color format of the bands, it is enough to read related bands as grayscale and then merge accordingly. You will also read the infrared band as grayscale.

Superpixel-Level Features

You will extract superpixels with sckit-image's "slic()" function to get the labels of each superpixel. After that, you will define a feature vector to represent each superpixel. You will not use additional channels while extracting superpixels, only RGB channels.

This feature vector may contain various type of features such as the color histogram of the superpixel, intensities, location or 1st order statistics of these features in superpixels e.g. means of intensities, means of Lab channel values, means of pixel locations etc. You may use all of them or not, you may use other features or not, you will build up your own feature representation. You should explain which feature provides which information and why it is better to use it.

Then, you will segmentate the given image with k-means clustering by using those superpixel representations. *(Note: Do not forget to normalize your features into the same range before concatenating them such as [0, 1].)*

K-means Clustering

You can use sckit-learn's "KMeans" function for clustering. Basically, you will have a matrix that contains the superpixel representations (features) for each superpixel (sample). You will give feature vectors obtained from each superpixel and cluster number to k-means algorithm so that k-means algorithm will produce cluster labels for each superpixel. Then, you will visualize these labels with different colors (see Figure 1 (c)), to see which parts are segmented. You should also visualize the segmented parts on the RGB image as in Figure 1 (d).

PART 2: Infrared Band

Now you will add the infrared channel's information (e.g. means of intensities) of the multispectral image to your feature representations. Then, you will segmentate the image again to cluster the regions in a more accurate way. You will see that some of the regions such as the river/land that is cluttered by the salt/snow or not seen because of the intensity/luminance, will be in the more accurate clusters rather than being/not being in a separate cluster, thanks to infrared channel of the multispectral image. This way, we won't rely on only the color/intensity values or locations and take the advantage of other wavelengths.

PART 3: Additional Bands (Bonus)

You can get an additional multispectral image from [2] and investigate different bands other than infrared channel (Band 4 - Near Infrared) for your feature representation. The information of the bands and usage of them can be found in [3] and [4] respectively. You should give the comparison of using only RGB bands and using other combinations as you did in Part 2.

Details

1. You should do image segmentation on given 3 multispectral images and make comments on the results of each image separately.
2. You can use built-in functions, but you should create your own feature representations for each superpixel region.
3. Your program will take the image bands of each satellite images as input and produce segmentation results for each part separately.
4. You must play with cluster number according to the image content to obtain good results, so at the end you may have a vector for cluster numbers of each image.
5. You must use superpixels with different segment numbers and make observation that how the superpixels and segment count influence clustering results or not.
6. You must comment about your results why they are satisfactory or not.
7. You must analyze the effect of each specific feature to result you obtained. For example, how does infrared channel intensities or spatial information affect the result etc.
8. Implement your code with Python 3 and use libraries from Anaconda. You can install any library that is not in Anaconda as well, such as OpenCV 3.

What should you write in the report?

- Give your resulting images step by step for each part.
- Give experimental results, used parameters and comments on the results in detail.
- Explain your implementation and code as well as your approach to the problem.
- A basic structure might be: 1) Introduction (what is the problem, how do you approach to this problem, what is the content of your report) 2) Implementation Details (the method you followed, the organization of your code, functions and details of your solution) 3) Experimental Results (all results for separate parts with different parameters and your comments on the results) 4) Conclusion (what are the results and what are the weaknesses of your implementation, in which parts you have failed and why, possible future solutions)
- You should write your report in LaTeX

Grading

The assignment will be graded out of 100:

- **60 (part 1):** CODE: 0 (no implementation), 20 (a partially correct solution), 35 (a correct solution) and REPORT: 25
- **40 (part 2):** CODE: 0 (no implementation), 15 (a partially correct solution), 25 (a correct solution) and REPORT: 15
- **25 (bonus):** CODE: 0 (no implementation), 10 (a partially correct solution), 20 (a correct solution) and REPORT: 5

Late Policy

You have three days for late submission. You will lose 10 points from maximum evaluation score for each day (your submitted study will be evaluated over 90, 80 and 70 for each late submission day). You have to submit your solution in deadline date + three days, otherwise it will not be evaluated.

Academic Integrity

All work on assignments must be done individually unless stated otherwise. You are encouraged to discuss with your classmates about the given assignments, but these discussions should be carried out in an abstract way. That is, discussions related to a particular solution to a specific problem (either in actual code or in the pseudocode) will not be tolerated. In short, turning in someone else's work, in whole or in part, as your own will be considered as a violation of academic integrity. Please note that the former condition also holds for the material found on the web as everything on the web has been written by someone else.

References

[1] https://en.wikipedia.org/wiki/Multispectral_image
[2] https://landsat.usgs.gov/
[3] https://landsat.usgs.gov/what-are-best-spectral-bands-use-my-study
[4] https://www.esri.com/arcgis-blog/products/product/imagery/band-combinations-for-landsat-8/