BIL 717 – Programming Assignment 3: Segmenting images using Markov Random Fields[1]

Due date: Wednesday, 2015-05-20, 11:59 PM

Overview

The goal of this assignment is to familiarize you with Markov Random Fields (MRFs). In this assignment, you will use MRFs to segment a given image using a graph-cut-based formulation.

Problem

You are provided some MATLAB files at the course webpage. You will use these files to segment a given image with minimal user input.

(a) Input image   (b) User strokes   (c) Segmentation result
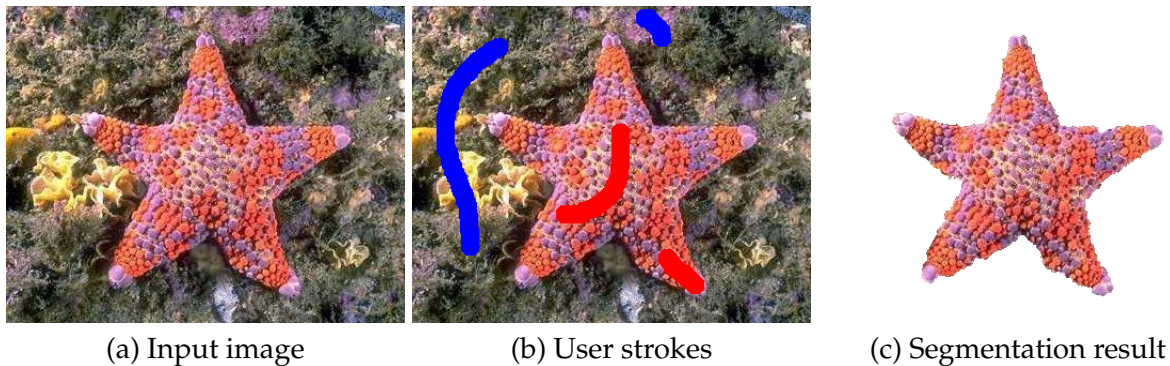
Figure 1: A sample segmentation result.

As Figure 1 shows, the user mark some pixels as belong to foreground (red stroke) and some other as belong to background (blue stroke). These user strokes are then used to build the foreground/background appearance models and the segmentation is accordingly obtained by solving the following energy minimization problem with graph cut:

$$E(\mathbf{x}) = \sum_i \theta_i\left(x_i, z_i\right) + \sum_{i,j \in \mathcal{N}} \theta_{ij}\left(x_i, x_j, z_i, z_j\right) \tag{1}$$

where $\mathbf{x} \in \{0,1\}^n$ is the unknown segmentation labels, $\mathbf{z}$ is the given image and $\mathcal{N}$ denotes the neighbourhood system (4- or 8-connected). The unary potential function $\theta_i\left(x_i, z_i\right)$ is the color likelihood estimated by the learned appearance models via Gaussian Mixture models (GMMs). The pairwise potential function $\theta_{ij}\left(x_i, x_j, z_i, z_j\right)$ is defined as:

$$\theta_{ij}\left(x_i, x_j, z_i, z_j\right) = |x_i - x_j|\left(\lambda_1 + \lambda_2\left(-exp(-\beta\|z_i - z_j\|_2)\right)\right) \tag{2}$$

with $\beta = 2\left(\text{mean}(|z_i - z_j|)\right)^{-1}$, λ_1 and λ_2 representing the regularization parameters. Setting the value of λ_1 to a positive value corresponds to switching on the Ising prior. Setting λ_2 to a positive value let the contrast-sensitive (edge) information guide the segmentation process.

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[1] Adapted from the exercise given by Carsten Rother, Microsoft Research, Cambridge, UK at INRIA CVML Summer School 2010.

Problem 1.1

In the first part of the assignment, your task is to analyze the provided segmentation model. You should try the code with several images of your own with different foreground/background strokes. Your experiments should be designed in a way that you can comment of the effects of the three model parameters (`Parameters.neighborSystem`, `Parameters.lambda1` and `Parameters.lambda2`) on the segmentation results. Please make sure to document and interpret your results in your reports.

Problem 1.2

In the second part of the assignment, your task is to transform the code provided to you into an iterated model as in the GrabCut model we discussed in our class. That is, you should revise the code which uses fixed GMMs-based appearance models for the foreground and the background derived from the users strokes, and obtain a model where the appearance models are updated by the obtained segmentations results, which in return is used to get new results until convergence. You should analyse what the new model doing by examining the results and the segmentation energy at each iteration. Please make sure to document and interpret your results in your reports.

Notes

You can run `main.m` to segment an image. The segmentation codes include some MATLAB mex routines. Thus, you may need to compile them by going into the directory `code/Optimization` and typing `mex GraphCut.cpp graph.cpp maxflow.cpp`.

What to Hand In

You are required to submit all your code along with a report in PDF format (should be prepared using LATEX). The codes you will submit should be well commented. Your report should be self-contained and should contain a brief overview of the problem, the details of your implemented solution and your comments about the experimental analysis on the aforementioned issues. Finally, prepare a ZIP file named `name-surname-pa3.zip` containing

- `report.pdf` (PDF file containing your report)

- `code/` (directory containing all your codes)

The ZIP file should be submitted via email to `erkut@cs.hacettepe.edu.tr`.

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 elses 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.