Assignment

Stereo Matching with the Alpha-Beta Swap Algorithm

Deadline: 13/03/2015

(The assignment can be done by groups of at most 2 students)

Introduction

Stereo matching is the problem of finding corresponding pixels, and their depth, in a left-right stereo image pair. These input images are rectified so that the scan lines are epi-polar lines i.e, the location of a pixel in the left and right image is shifted, compared to one another, depending on its distance from the cameras. This offset is called disparity. For each image pair, you will ultimately seek to output a disparity map for the left image indicating the disparity to the right image. Figure 1 illustrates the stereo matching problem; for each pixel the optimal disparity d is to be estimated where $d \in \{0, 1, 2, ..., d_{max}\}$.

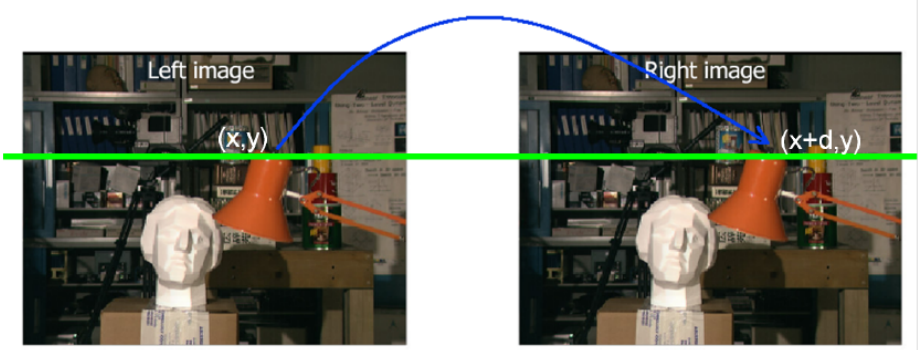

Figure 1: Stereo Correspondence

For this assignment you have to implement the alpha-beta swap algorithm and use it in order to solve the stereo matching problem.

MRF formulation

The problem of recovering an accurate disparity map $\mathcal{L}$ can be posed as an energy minimization problem:

$$\mathcal{E}(\mathcal{L}) = \sum_{p \in \mathcal{P}} \mathcal{D}_p(l_p) + \lambda \cdot \sum_{p,q \in \mathcal{N}} w_{pq} \cdot \mathcal{V}_{pq}(l_p, l_q)$$

where $l_p \in \{0, 1, 2, ..., d_{max}\}$ is the disparity value of pixel p, $\mathcal{P}$ is the set of pixels in the image, $\mathcal{N}$ is the set of undirected edges in the four-connected image grid

graph, $\mathcal{D}_p(l_p)$ is the cost of assigning label-disparity l_p to pixel p, $\mathcal{V}_{pq}(l_p, l_q)$ is the cost of assigning labels l_p and l_q to two neighboring pixels and w_{pq} is the smoothness weight.

In this assignment, as data cost $\mathcal{D}_p(l_p)$ you will use the absolute intensity difference:

$$\mathcal{D}_p(l_p) = |I_{left}(y, x) - I_{right}(y, x - l_p)|$$

as cost $\mathcal{V}_{pq}(l_p, l_q)$ of assigning labels l_p and l_q to two neighboring pixels you will use the truncated absolute difference of the labels:

$$\mathcal{V}_{pq}(l_p, l_q) = min(|l_p - l_q|, K)$$

and as smoothness weight w_{pq} you will use:

$$w_{pq} = \begin{cases} 2 & \text{if } |I_{left}(y_p, x_p) - I_{left}(y_q, x_q)| \leq 8 \\ 1 & \text{otherwise} \end{cases}$$

where y_p, x_p and y_q, x_q are the coordinates of pixels p and q correspondingly. For the parameters K, λ and d_{max} you will use the values 2, 20 and 15 correspondingly.

Question 1

For this question you have to implement the alpha-beta swap algorithm that minimizes the energy of a **multi-label** MRF problem. For that purpose you are provided with the subroutine *optimizeBinaryMRF.m* that optimizes a **binary** MRF. The goal is to use this subroutine to implement the algorithm. Fill with code the function *assignment.m*. You are free to create new functions if it is convenient for you.

Question 2

Use your implementation of the alpha-beta swap algorithm to obtain the disparity map. Report:

- a plot of the energy at each iteration
- the obtained depth map

Guidelines

Each student should submit a single zip file that will contain all the required code as well as the report in pdf format.