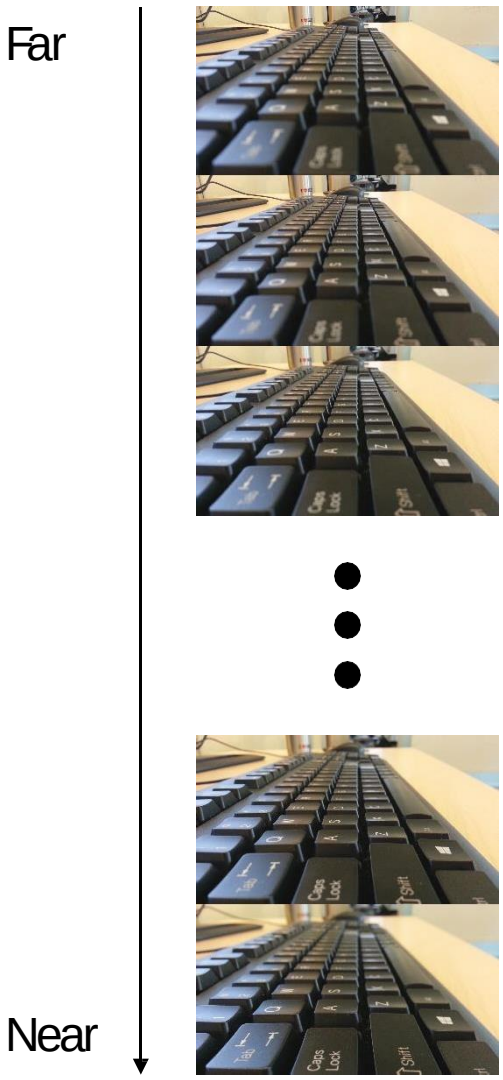
Programing Assignment 1

-Depth from Focus with Your Mobile Phone-

2018.09.19

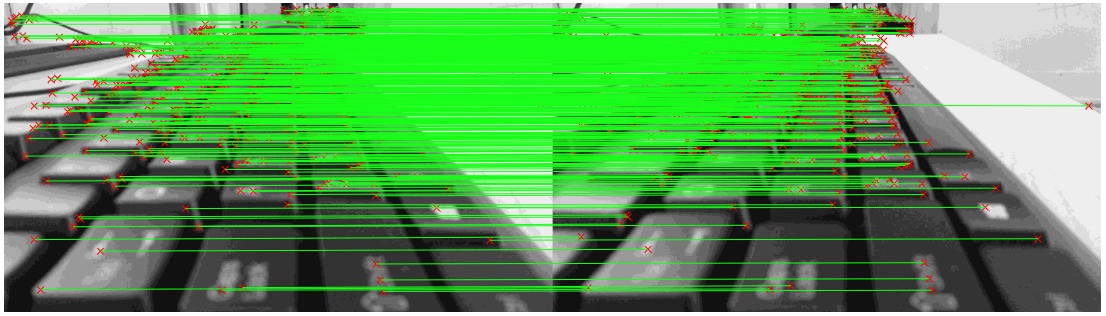
Step 1. Image Alignment

Image Alignment Toolbox – http://iatool.net/



Frame t

Frame t+ 1



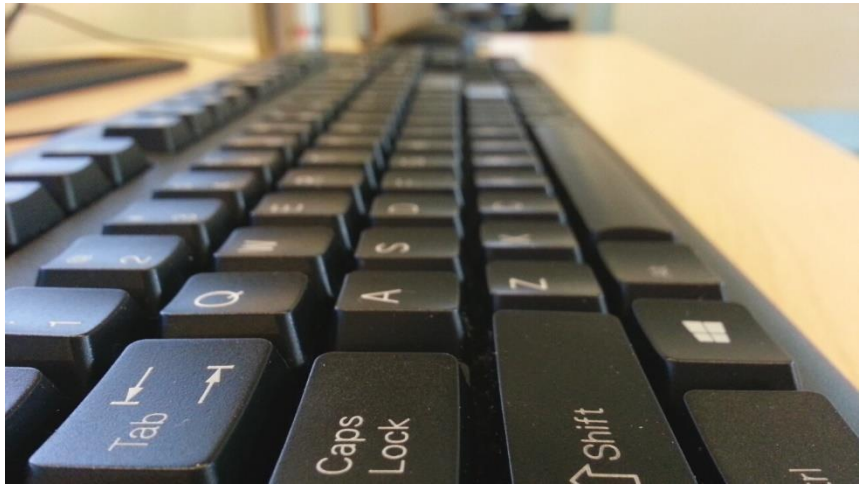
Feature based alignment

Before alignment

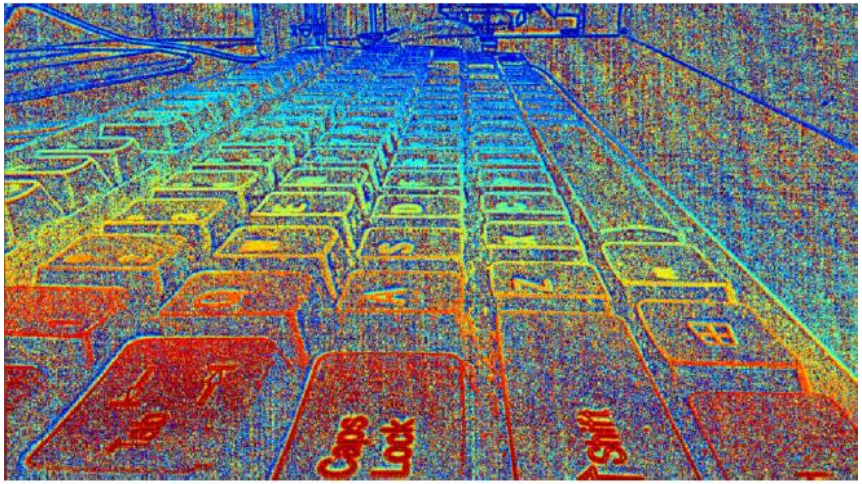
After alignment

Step 2. Focus Measure

Please refer to “A novel algorithm for estimation of depth map using image focus for 3D shape recovery in the presence of noise, A. Malik and T.-S Choi, Pattern Recognition 2008”



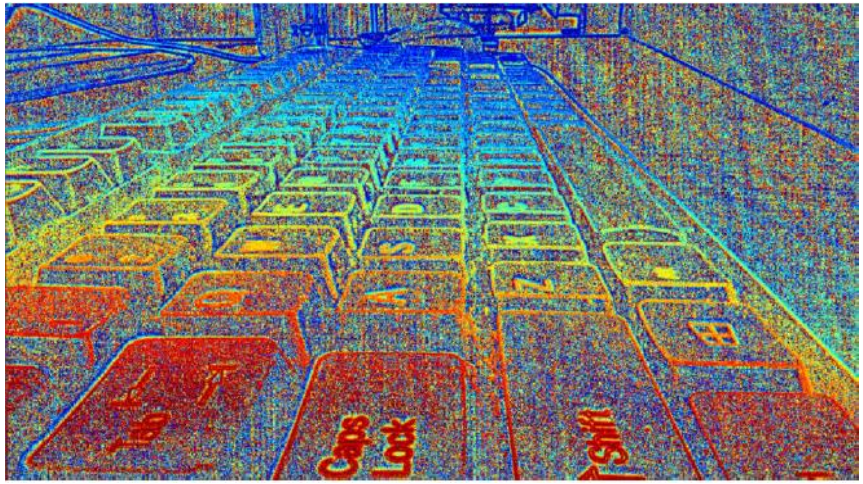
Defocused image



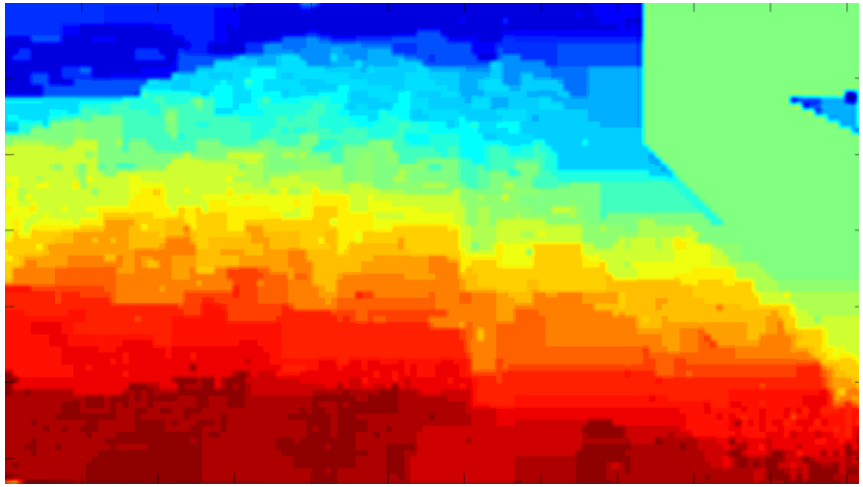
Focus map

Step 3. Graph-cuts

Please refer to "An Experimental Comparison of Min-Cut/Max-Flow Algorithms for Energy Minimization in Vision, Yuri Boykov and Vladimir Kolmogorov, IEEE TPAMI 2004"



Initial focus map

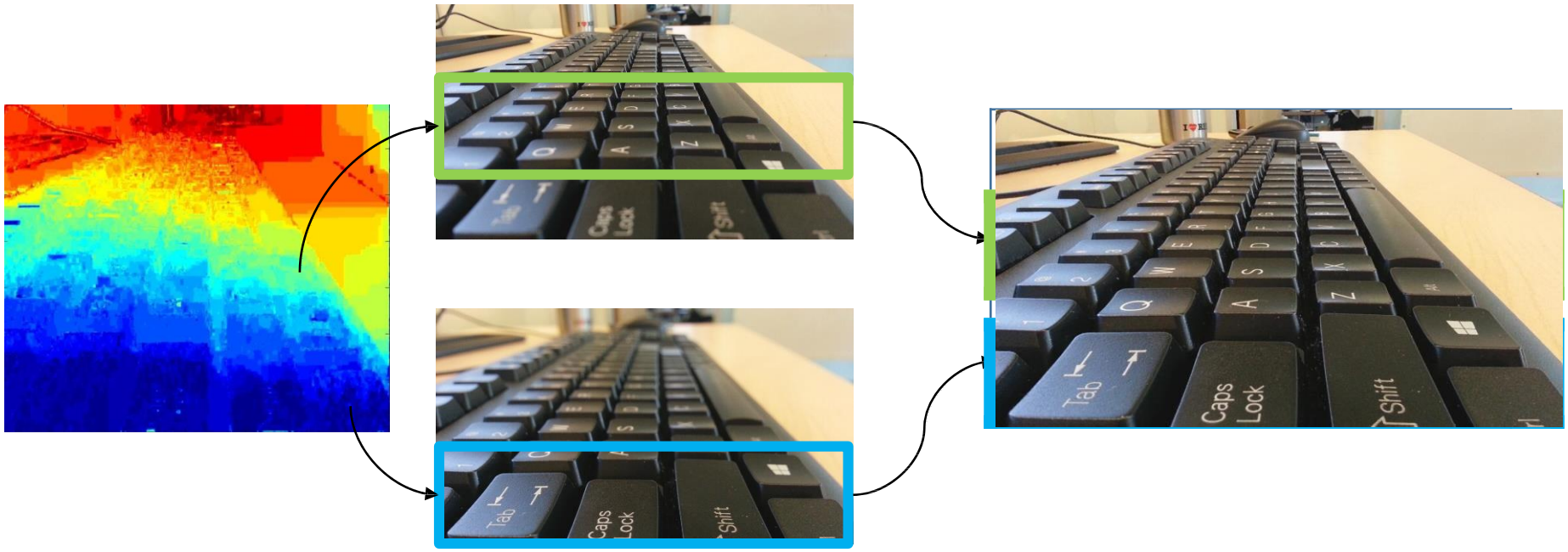


Graph-cuts result

(multi-label optimization : http://vision.csd.uwo.ca/code/)

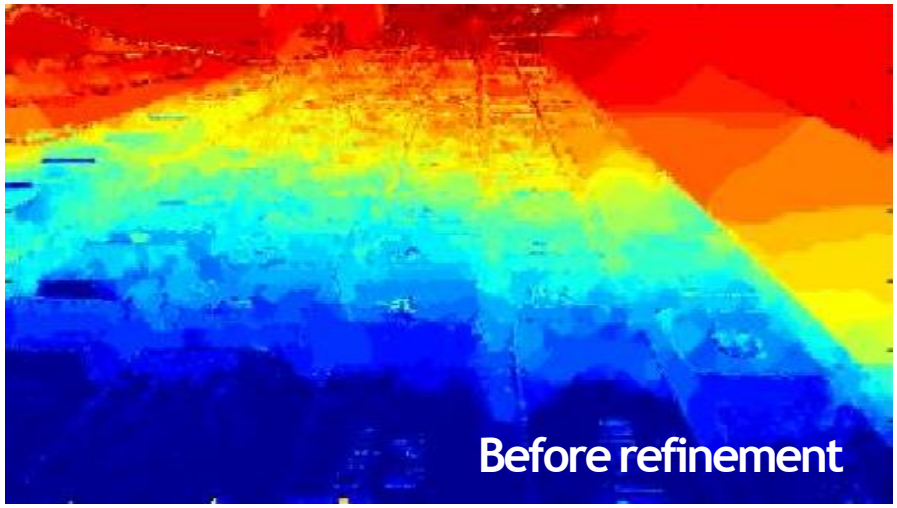
Step 4. All in Focus Image

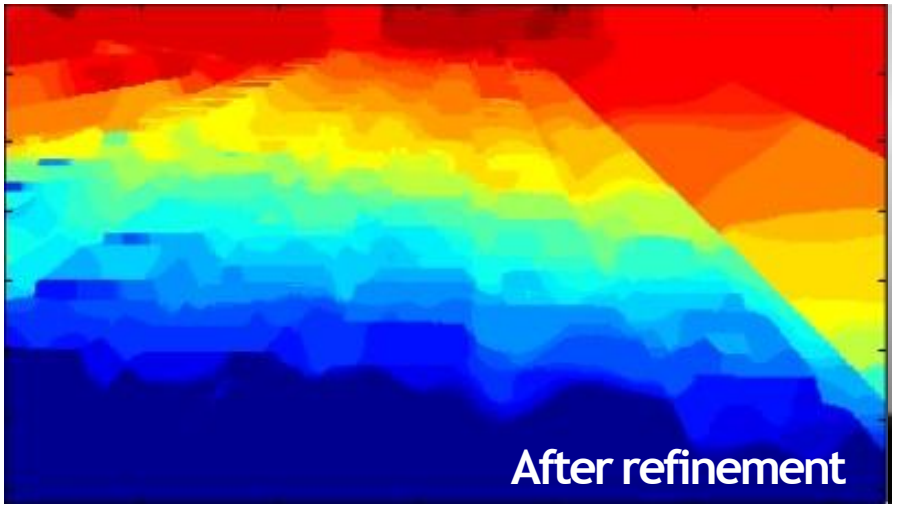
The initial labeling and resulting all-in-focus image are generated by simply finding the index of images that maximizes the focus measure response and combining them to create a label map



Step 5. Depth Refinement

Use the all-in-focus image as a guidance image of weighted median filter. Please refer to course material “Weighted Median Filter”, and Constant Time Weighted Median Filtering for Stereo Matching and Beyond, Ma *et al*., ICCV2013





Extra Credit

1. Implement another propogation method : Color-based Sparse Depth Map Propagation Using Matting Laplacian.

- Sparse defocus map propagation is needed

- Color-based propagation (Matting Laplacian [1]) is adopted
  1) At each edge location, original value must be preserved
  2) Blur discontinuities should be aligned with image edges
  3) In a local small window, pixels with similar colors have similar defocus values

Input Sparse defocus map Full defocus map

[1] Levin et al., "A Closed Form Solution to Natural Image Matting." CVPR 2006

Extra Credit

Color-based Sparse Depth Map Propagation using matting Laplacian

- Objective is minimizing following Energy E:

$$E(d) = d^T L d + \lambda (d - \hat{d})^T D (d - \hat{d})$$

Data fidelity term

Local smoothness term

$\hat{d}(x)$: Sparse defocus map
$d(x)$: Dense defocus map
D : A diagonal matrix where D_{ii} is 1 when pixel i is on the edge, otherwise 0
L : matting Laplacian matrix

$$L_{ij} = \sum_{k \mid (i,j) \in \omega_k} \left(\delta_{ij} - \frac{1}{|\omega_k|} \left(1 + (I_i - \mu_k)^T \left(\Sigma_k + \frac{\epsilon}{|\omega_k|} U_3 \right)^{-1} (I_j - \mu_k) \right) \right)$$

δ_{ij} : Kronecker delta
U_3 : 3x3 identity matrix
μ_k, Σ_k : mean and covariance matrix of colors in window ω_k
ϵ : Regularization parameter
$|\omega_k|$: Size of window

- Optimal d can be obtained by solving the following sparse linear system:

$$(L + \lambda D) d = \lambda D \hat{d}$$

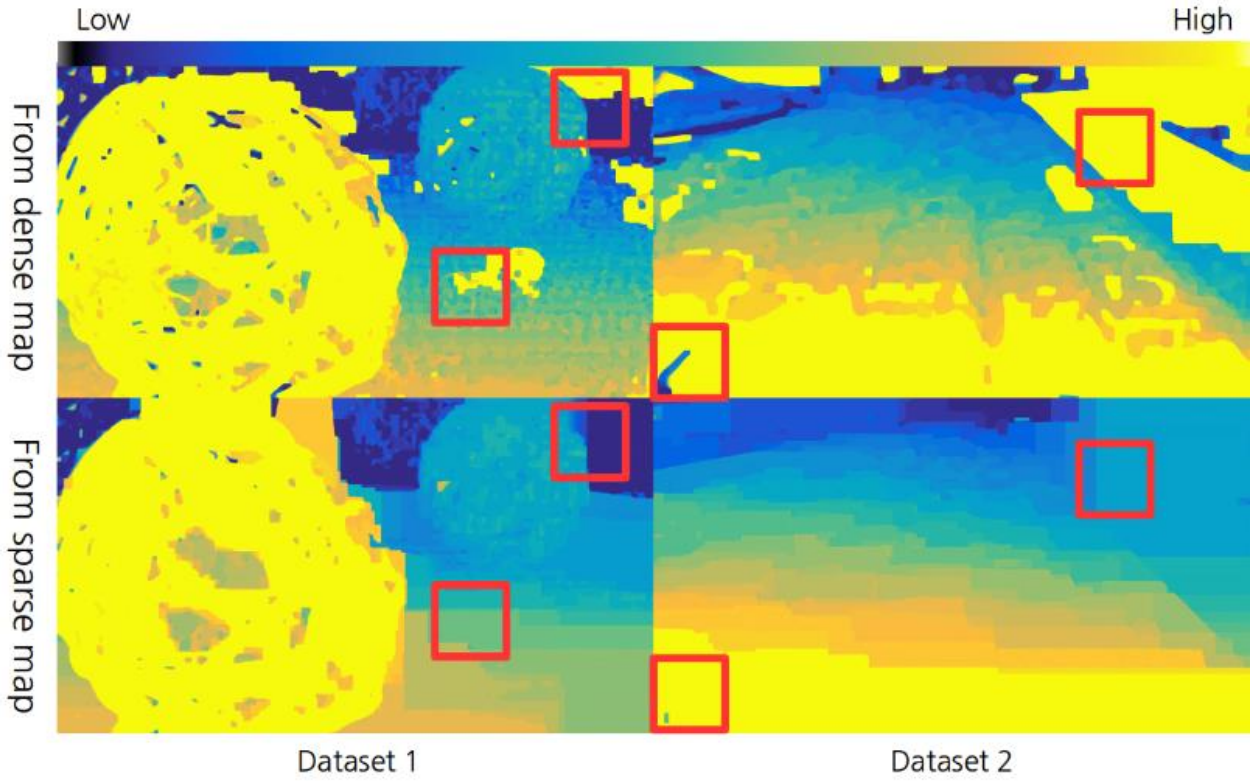
Derived from $\frac{\partial E}{\partial d} = 0$

- More detailed analysis can be found in [1]

[1] Levin et al. "A closed form solution to natural image matting." CVPR 2006

Extra Credit

Color-based Sparse Depth Map Propagation using matting Laplacian



Misclassifications are removed

[1] Levin et al. "A closed form solution to natural image matting." CVPR 2006

Extra Credit

2. Two or three students who show the best depth result will get extra credit. So, students can apply any idea to improve a depth quality.

Due: October 8th 11:59pm

- Code in Matlab
- Report must explain your code, your understanding and your RESULT IMAGES in doc/docx/pdf.
- Send zip file to mcahny [at] kaist.ac.kr
- Zip file naming: PA1_studentID_홍길동.zip

- Read the reference papers and course material [Depth from Focus] carefully
- No delay – just submit what you've done