Master in
Computer Vision
Barcelona

Module: 3D Vision
Project: 3D recovery of urban scenes
Session 4

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Session 3

Goal: Reconstruction from two images (known internal parameters)

Mandatory tasks:

- Triangulation with the homogeneous algebraic method (DLT)
- Compute the camera matrices from the Fundamental matrix and K
- Recover the 3D points by triangulation
- Compute the reprojection error
- Depth map computation by a local method (SSD cost)
- Depth map computation by a local method (NCC cost)
- Improve the matching cost by using bilateral weights

Optional tasks:

- Depth map computation by belief propagation
- Depth map computation by plane sweep
- Depth map fusion by averaging signed distance functions
- New view synthesis: view morphing

Session 3

Language: MATLAB

Provided functions: lab4.m, euclid.m, apply_H_v2.m, fundamental_matrix.m, ransac_fundamental_matrix.m, ncc_cost.m, normalise2dpts.m, optical_center.m

lab4.m is the guided file with the different steps of the lab session.

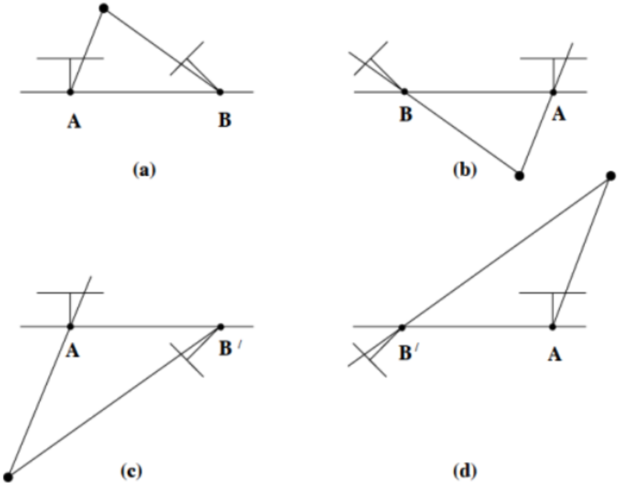
fundamental_matrix.m, ransac_fundamental_matrix.m are part of the solution of lab 3.

To Do:

- Complete the code in lab4.m as indicated in the same file
- Write the functions triangulate.m and stereo_computation.m
- In the report, comment the results as asked in lab4.m

Session 3

Compute the camera matrices from the Fundamental matrix and K



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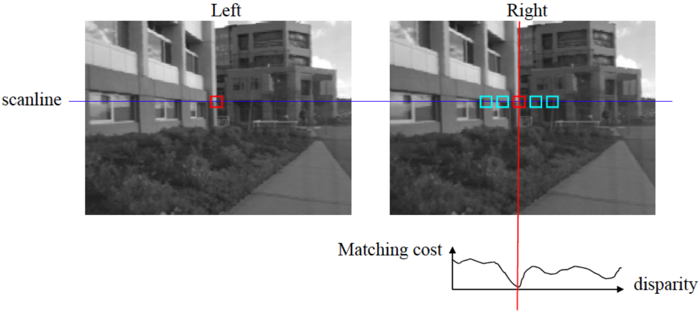
Depth map computation by a local method with **stereo rectified images**



- Try different window sizes
- Try SSD and NCC costs

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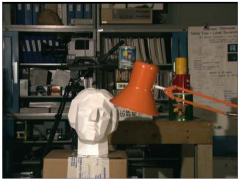
Depth map computation by a local method with **stereo rectified images**

1st experiment: pair of Middlebury images with ground truth data


(a) Reference image.


(b) Target image.


(c) Ground-truth disparity map.

2nd experiment: Castle facade images

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Depth map computation by a local method with **stereo rectified images**

Improve the disparity computation by using weights based on color similarity and spatial distance (as those used in the bilateral filter) using the reference paper below.

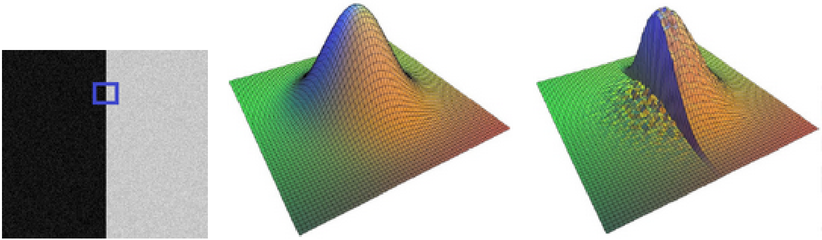
Adaptive Support-Weight Approach for Correspondence Search

Kuk-Jin Yoon, *Student Member, IEEE*, and
In So Kweon, *Member, IEEE*

IEEE TRANSACTIONS ON PATTERN ANALYSIS AND MACHINE INTELLIGENCE, VOL. 28, NO. 4, APRIL 2006

Session 3

Gaussian vs Bilateral weights



Bilateral weights

Weights based on color similarity and spatial distance.

$$w(p,q) = \exp\left(-\frac{|I(p)-I(q)|}{\gamma_c} - \frac{||p-q||_2}{\gamma_p}\right)$$

Modified **cost function**:

$$C(p,p_d) = \frac{\sum_{q\in N_p, q_d \in N_{p_d}} w(p,q)w(p_d,q_d)c(q,q_d)}{\sum_{q\in N_p, q_d \in N_{p_d}} w(p,q)w(p_d,q_d)}$$

where $p_d = p + (d,0)^T$, $q_d = q + (d,0)^T$, and d is the disparity.

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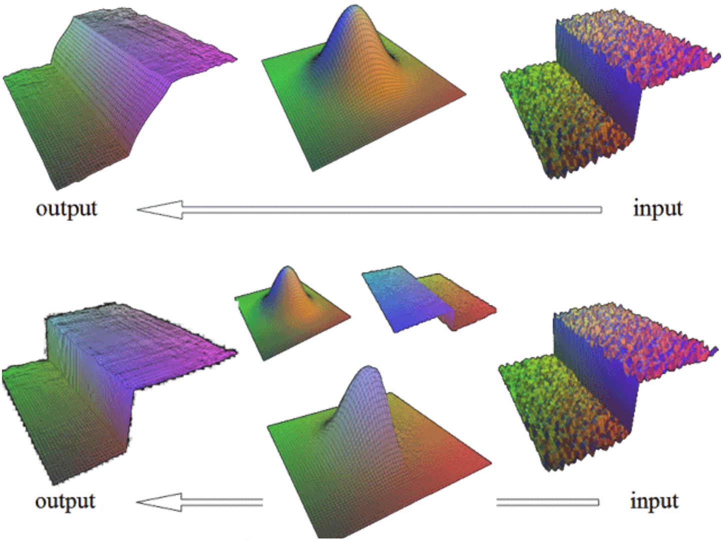
Gaussian vs Bilateral filtering



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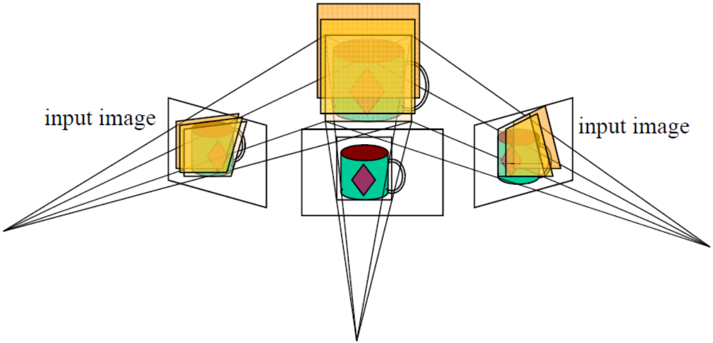
Depth map computation by belief propagation

Use a discrete energy with data and regularization terms and solve it by belief propagation as in module 2.

- Unary potentials: SSD or SAD
- Pairwise potentials: Potts model

Session 3

Depth map computation by plane sweep



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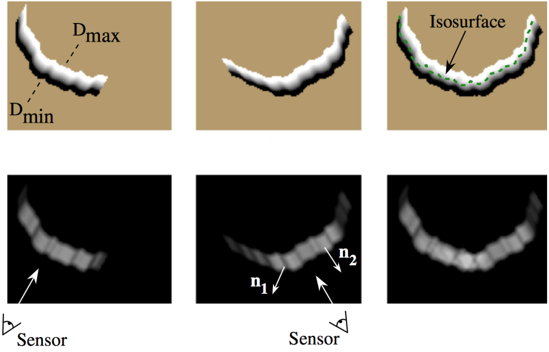
Depth map fusion by averaging signed distance functions

$$D(\mathbf{z}) = \frac{\sum_i w_i(\mathbf{z}) sdf_i(\mathbf{z})}{\sum_i w_i(\mathbf{z})}$$



No need to extract isosurface.

Just consider as surface voxels $\mathbf{z}$ those satisfying $D(\mathbf{z}) \approx 0$

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Depth map fusion by averaging signed distance functions

In a first step you need to estimate depth maps from pairs of images ion general position.
Possibilites for estimating the depth maps:

- Plane sweep method
- Local method + Stereo rectification method
  `http://demo.ipol.im/demo/m_quasi_euclidean_epipolar_rectification/`
  (Returns both rectified images and their corresponding rectifying homographies)

Session 3

New view synthesis: view morphing

Pair of stereo rectified (Middlebury) images with ground truth disparities

$$\mathbf{p} = (1-s)\,(x,y) + s\,(x - d_\ell(x,y),\, y)$$

$$I(\mathbf{p}) = (1-s)\,I_\ell(x,y) + s\,I_r(x - d_\ell(x,y),\, y)$$

Take into account occlusions!

Left-right consistency check: $\|d_\ell(x,y) - d_r(x - d_\ell(x,y),\, y)\| \leq \epsilon$

Evaluation

To deliver **before 9am of the day before** the next lab session:

- **Code deliverable:**
  - READY TO BE LAUNCHED on the provided images
- **Short document (around 10 pages):**
  - Results
  - Problems and comments

Evaluation

Grading:

- Report: **1.5 points**
- Triangulate function: **2 points**
- P, P' from F and K: **1 point**
- Reprojection error: **0.5 points**
- Depth map with SSD: **2 points**
- Depth map with NCC: **1 point**
- Bilateral weights: **1 point**
- Depth maps with facade images: **1 point**
- (Belief propagation): **+1.5 points**
- (Plane sweep): **+1.5 points**
- (Depth map fusion): **+1.5 points**
- (New view synthesis): **+1.5 points**