3D Scene Reconstruction by Stereo Imaging

MAT 594CP
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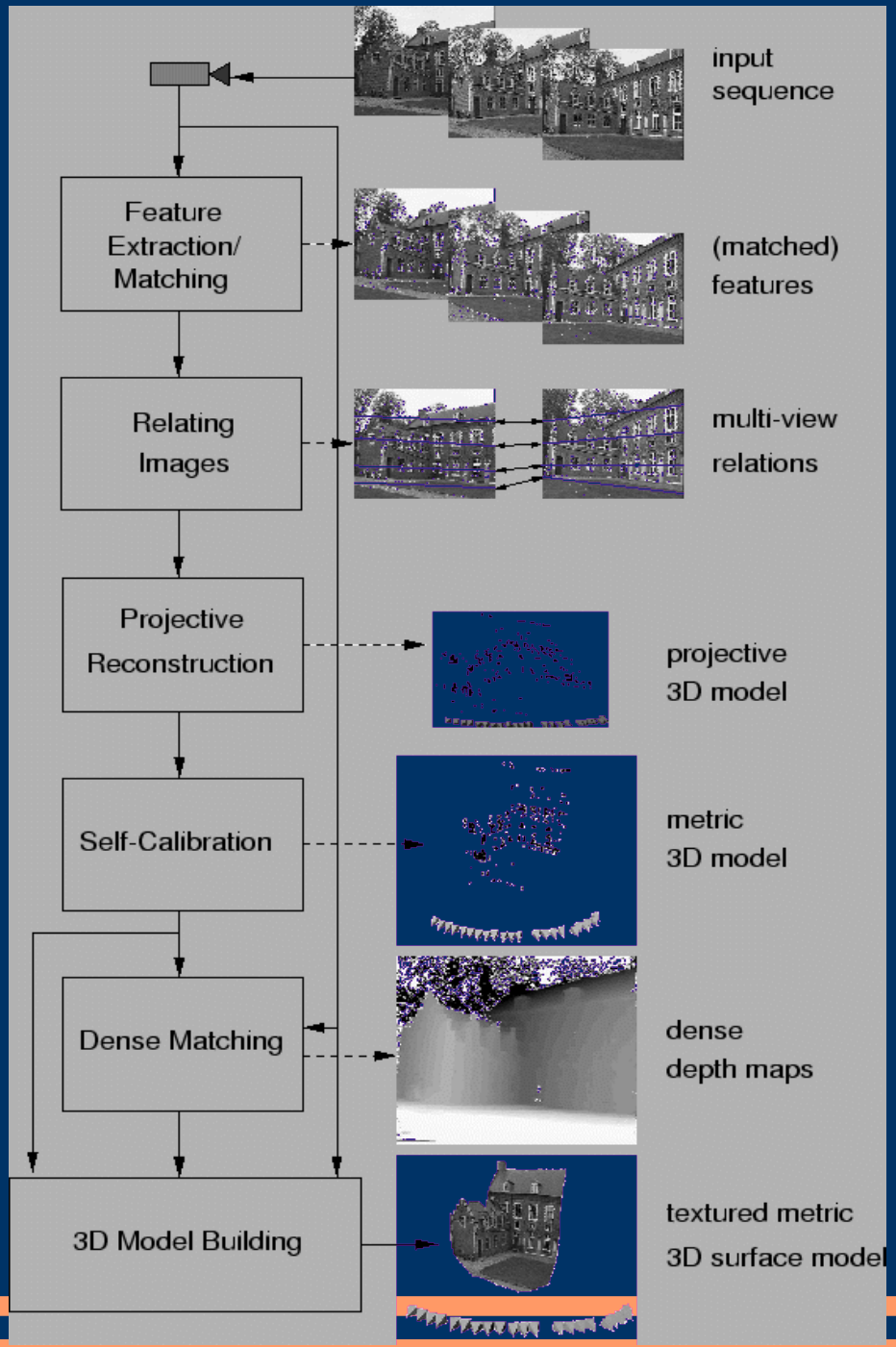
Timeline

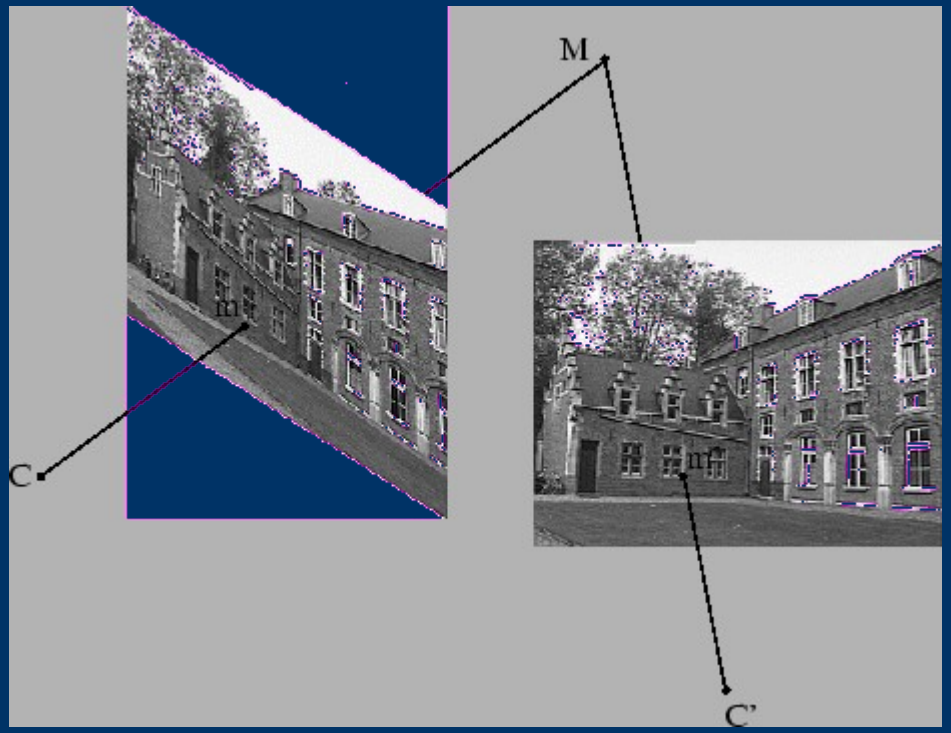
- 04.15: Project Proposal
- 04.22: Test data Set creation(Images and Videos)
- 04.29: Epipolar Geometry Estimation
- 05.06: Self Calibration
- 05.13: Structure Estimation & Refinement
- 05.20: Depth Estimation
- 05.27: Bundle Adjustment
- 06.03: Finishing work.. :)
- 06.10: Report and Final Presentation!!

Overview

- Feature Extraction
- Correspondences
- Projective Reconstruction
- Self Calibration
- Dense Matching
- 3D Modeling!!

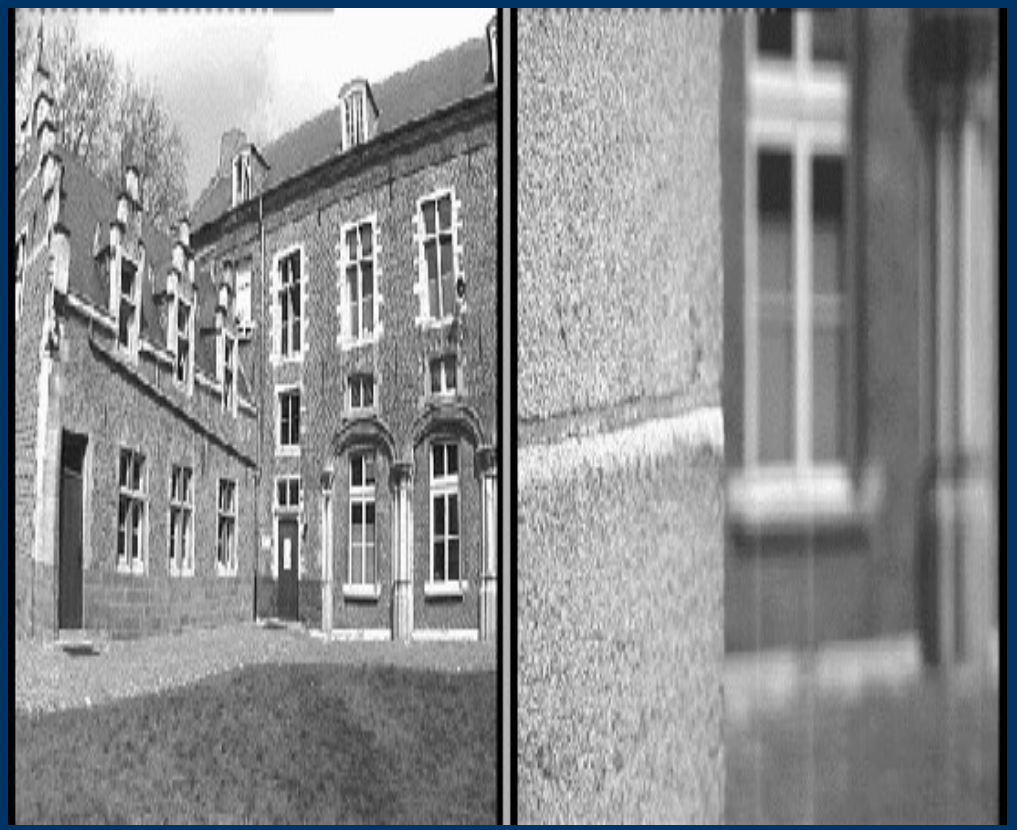


3D from images



- Correspondences
- Relative Camera orientation
- Relation between image points and scene points

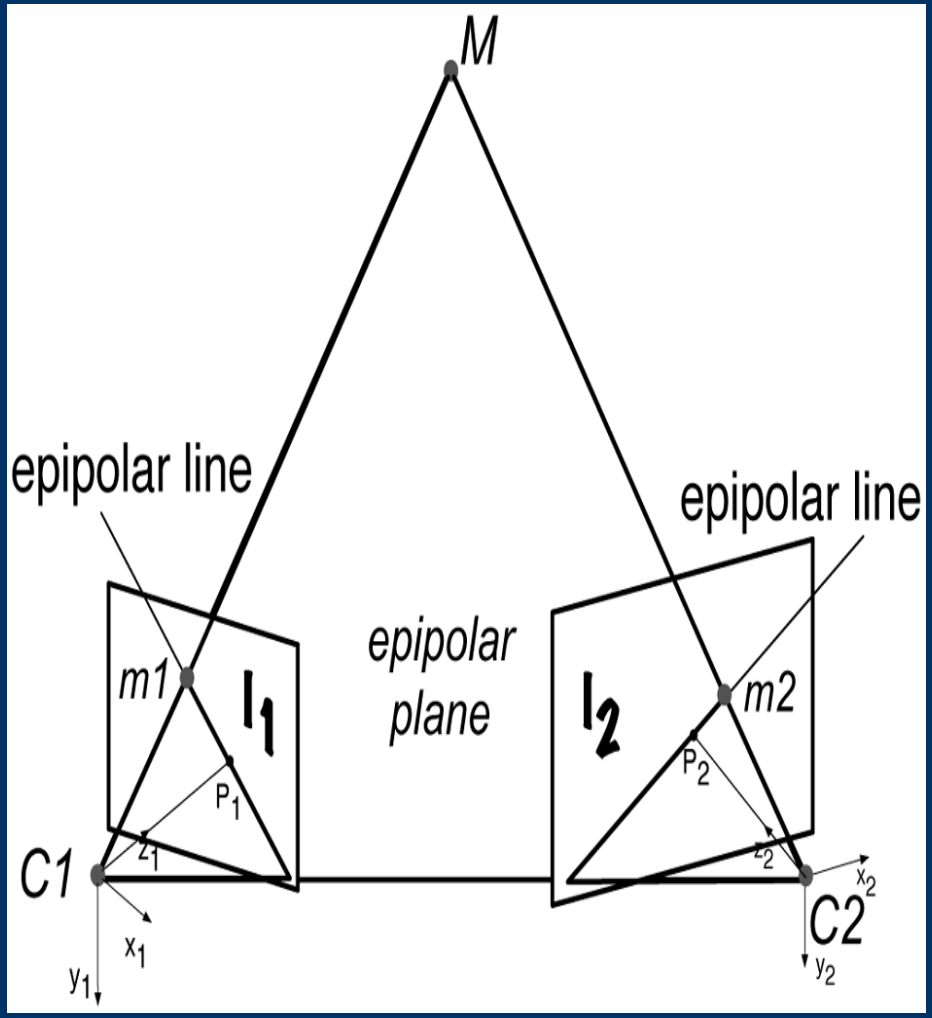
Problems/Assumptions



- Motion/Discontinuities..
- Distortions/Out of focus/Zoom!!

Epipolar Geometry

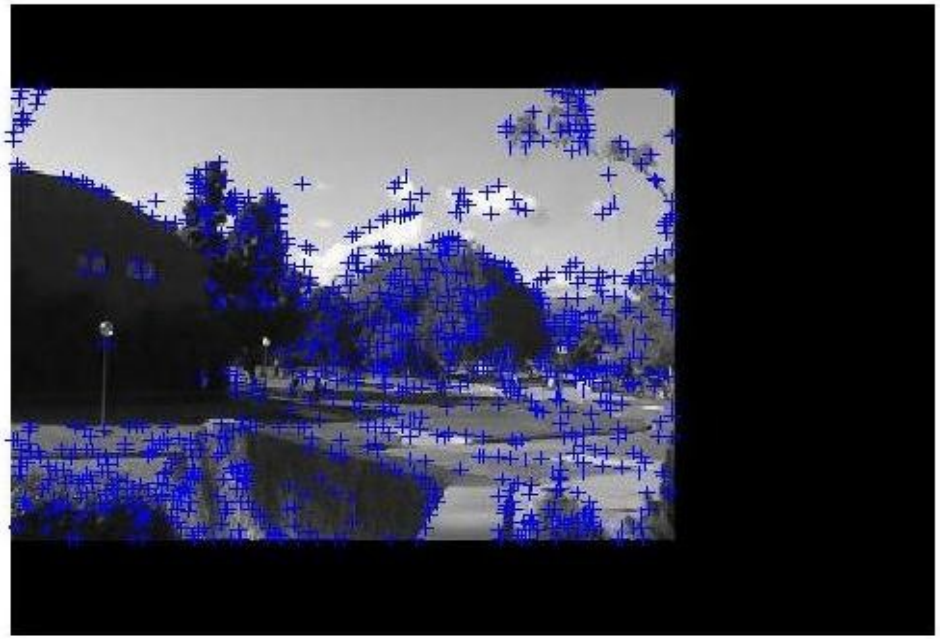
- Fundamental Matrix!!
- Feature Extraction
- Correspondences
- Solution of Equations



Feature Extraction

- Noise Ignored!
  - Prominent feature extraction using harris edge detector...
- Noise Present?
  - Outliers

Correspondences



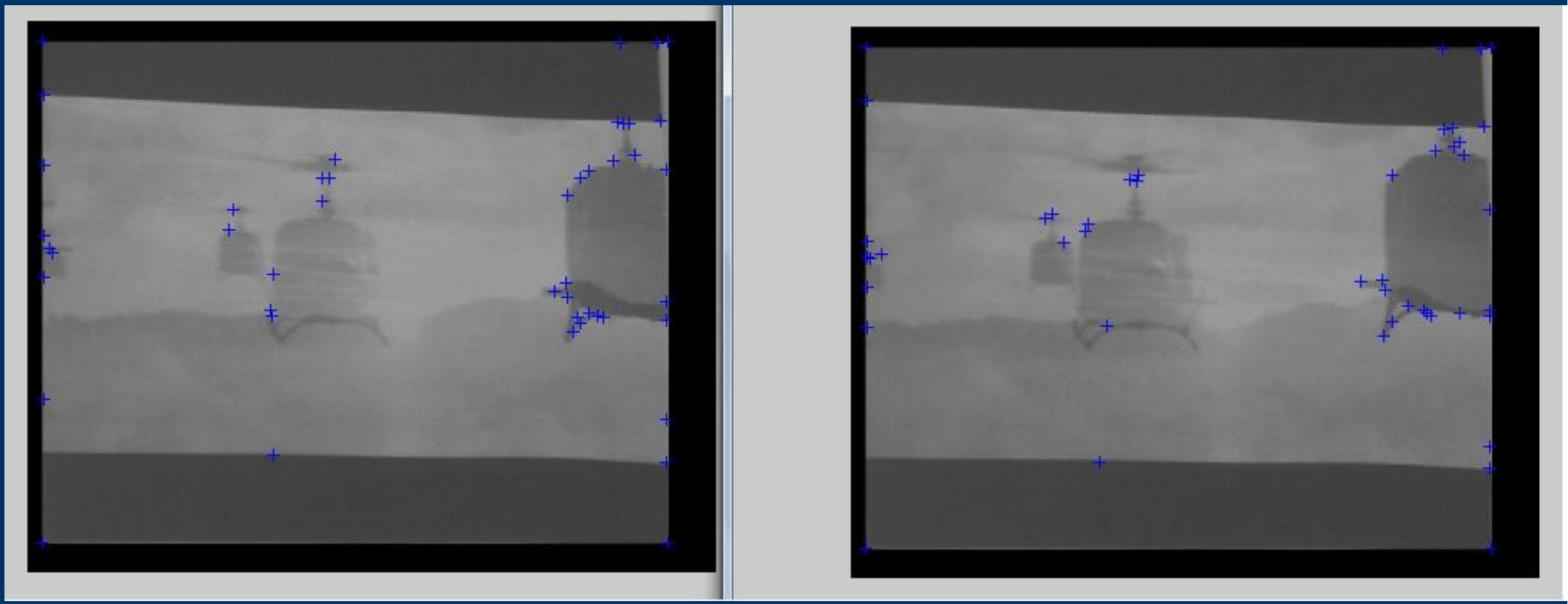
- Window → Cross-Correlation → Threshold
- Issues!!

Fundamental Matrix

Fundamental Matrix, F, captures the transformation between point in I_1 to corresponding point in I_2.

- $x_2^T F x_1 = 0$
- $\begin{bmatrix} x_2 & y_2 & 1 \end{bmatrix} \begin{bmatrix} f_{11} & f_{12} & f_{13} \\ f_{21} & f_{22} & f_{23} \\ f_{31} & f_{32} & f_{33} \end{bmatrix} \begin{bmatrix} x_1 \\ y_1 \\ 1 \end{bmatrix} = 0$
- $\begin{bmatrix} x_2x_1 & x_2y_1 & x_2 & y_2x_1 & y_2y_1 & y_2 & x_1 & y_1 & 1 \end{bmatrix} \begin{bmatrix} f_{11} \\ f_{12} \\ f_{13} \\ f_{21} \\ f_{22} \\ f_{23} \\ f_{31} \\ f_{32} \\ f_{33} \end{bmatrix} = 0$

Issues with correspondences



Issues...

Solution: RANSAC

Step 1. Extract features

Step 2. Compute a set of potential matches

Step 3. While $\Gamma(\#inliers, \#samples) < 95\%$ do

- step 3.1 select minimal sample (7 matches)
- step 3.2 compute solutions for F
- step 3.3 determine inliers

step 4. Refine F based on all inliers

step 5. Look for additional matches

step 6. Refine F based on all correct matches

Self Calibration

- Pair of 3 images are needed to estimate intrinsic parameters to scale ambiguity!
  - No Skew
  - Aspect Ratio = 1
  - Camera center = Image center
- Kruppa's equations/Nelder-Mead Minimisation for eigen-values/Absolute Conics
- Exploit Frames of Video Redundancy...

Structure Estimation

- Initial frame estimation & estimation of camera parameters under assumptions!!
- Traingulation to determine point in 3D..
- Noise effects and least square minimisation.
- Updating structure.
    - Pose of camera knowledge needed/has to be estimated.
    - Relate to other views
- Refinement of structure estimate..

Dense Matching

- Image Pair Rectification
- Stereo Matching & Sparsity!
- Bundle Adjustment

References

- Texts:
  - Multiple View Geometry in Computer Vision, Richard Hartley and Andrew Zisserman,
  - An Invitation to 3D Vision, Y. Ma, S. Soatto, Kosecka, S. Sastry
- Online References:
  - http://www.cs.unc.edu/~marc/tutorial/tutorial02.html

Suggestions

THANK YOU