Adaptive Structure from Motion with a contrario model estimations

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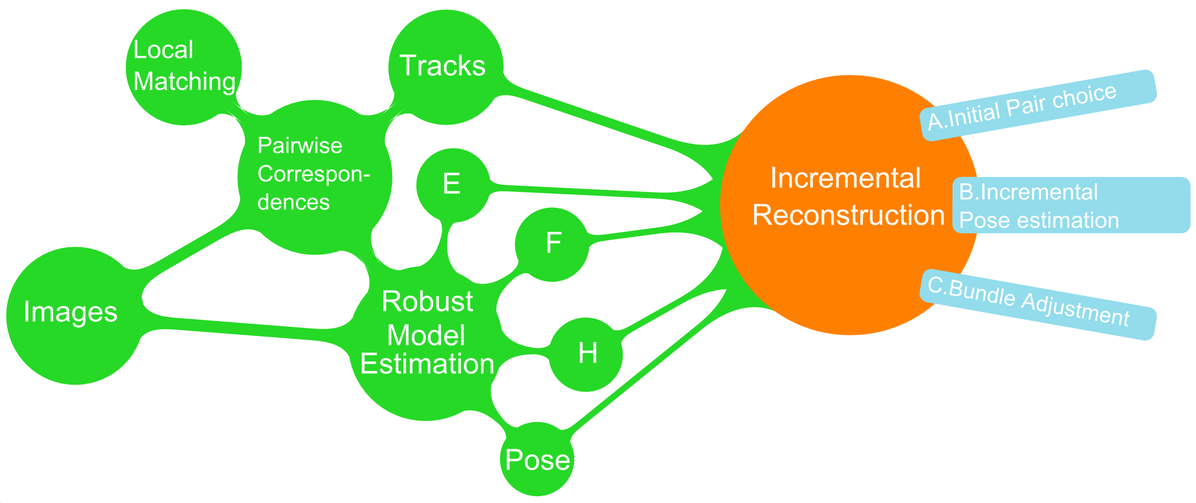
STRUCTURE FROM MOTION: SFM

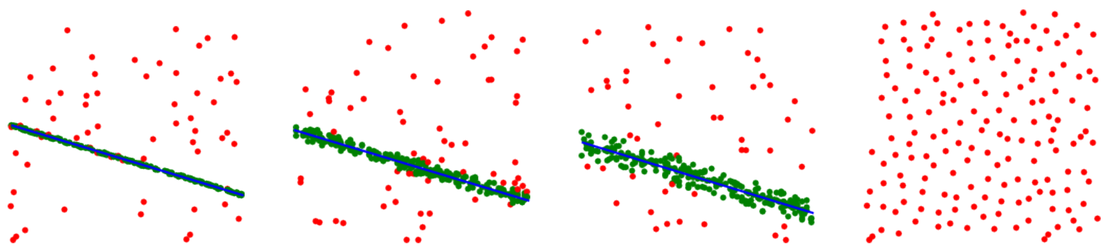
Structure from Motion depends on robust estimation; RANSAC is used to exclude outliers.



ROBUST ESTIMATION THRESHOLD DILEMMA

RANSAC requires the choice of a threshold T, which must be balanced:

- Too small: Too few inliers, leading to model imprecision,
- Too large: Models are contaminated by outliers (false data).



Goal: making T adaptive to data and noise.

Find a model that best fits the data with a confidence threshold T that adapts automatically to noise by using AC-RANSAC.

A CONTRARIO STRUCTURE FROM MOTION

***AC*-RANSAC. A threshold-less rigid model estimation framework.**

- The method answers the question:
  "Could the rigid set of data have occurred by chance?"
- The threshold T adapts for inlier/outlier discrimination.
- It provides a confidence score for each model.

A Contrario criterion [3]:

- Use a background model $\mathcal{H}_0$: uniform distribution.
- **Strong deviation from $\mathcal{H}_0$ is deemed meaningful.**

AC-RANSAC relies on a the following definitions:

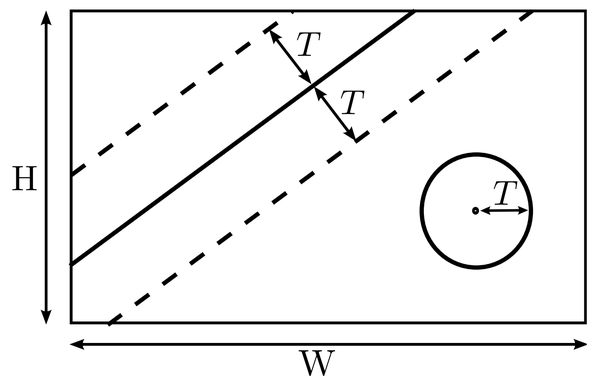
- Number of False Alarms (NFA) measures model fitness to data
- Given model M, assuming k inliers among n correspondences, T_k denotes the k^{th} smallest residual

$$NFA(M,k) = N_{\text{tests}}(n,k,N_{\text{sample}})\mathbb{P}(\text{residual} \leq T_k | M, \mathcal{H}_0)^{k-N_{\text{sample}}}$$

Expectation: $NFA(M) = \min_{k=N_{\text{sample}}+1\ldots n} NFA(M,k) \leq 1$.
RANSAC maximizes inlier count. AC-RANSAC minimizes NFA.

Application to Structure from Motion: estimation of

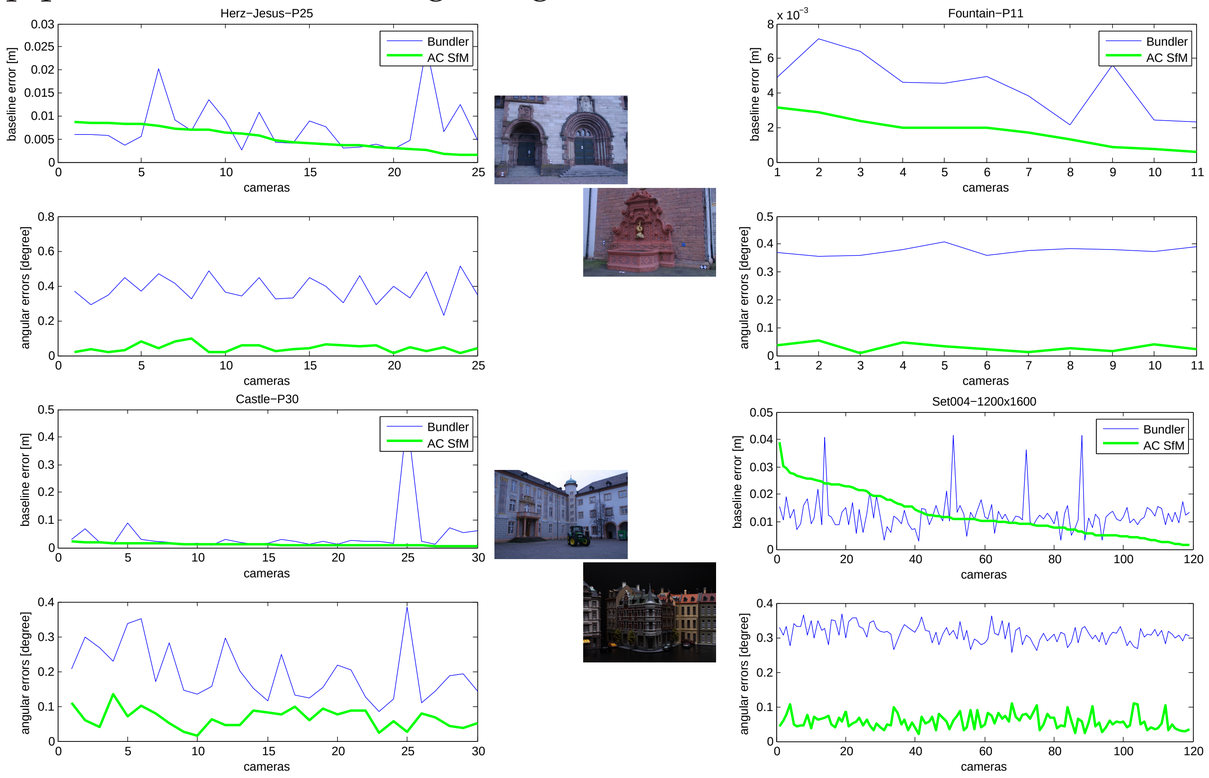
- * Homography
- * Pose/Resection
- Fundamental matrix
- * Essential matrix

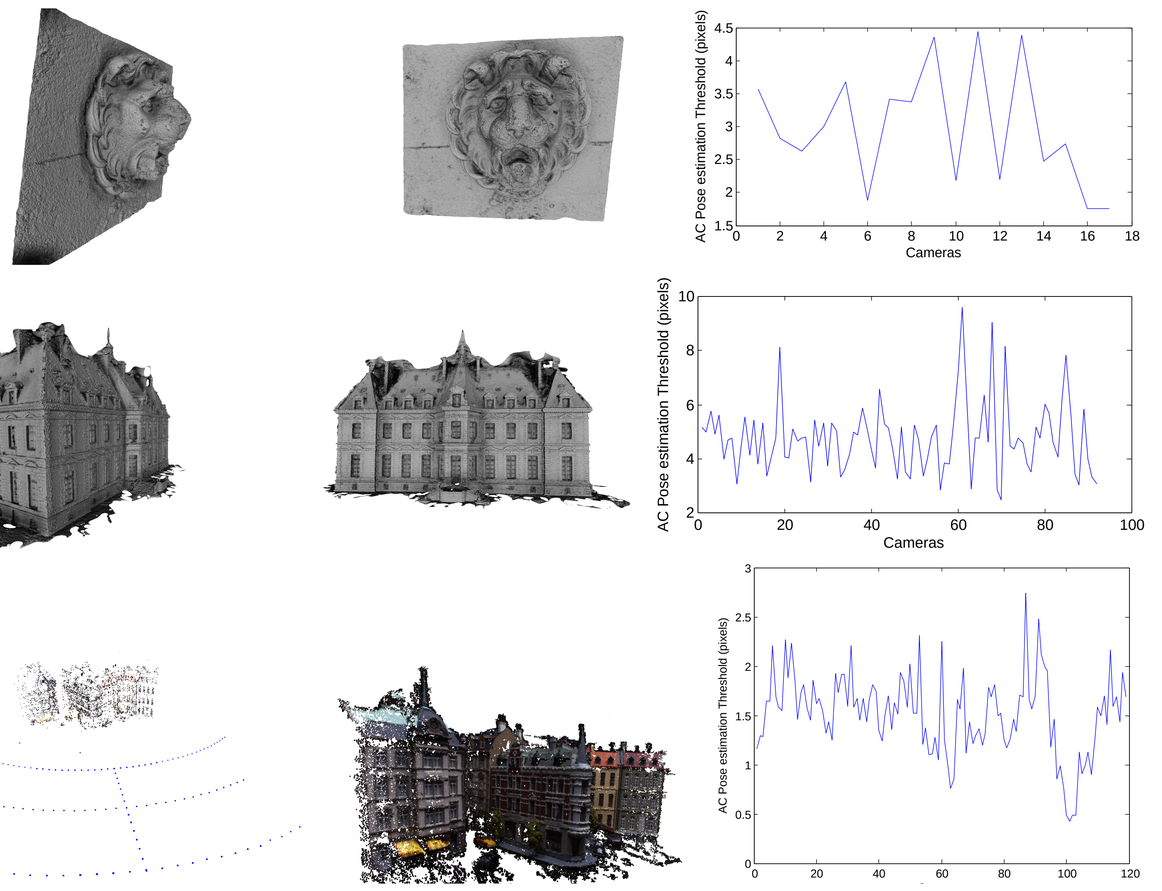


Only assumption: returned model is fitted by at least $2 * N_{sample}$ data.

EXPERIMENTAL RESULTS

Comparable or better accuracy than Bundler [1] using a threshold-less pipeline. Evaluation: rigid registration to GT (rotation+translation).



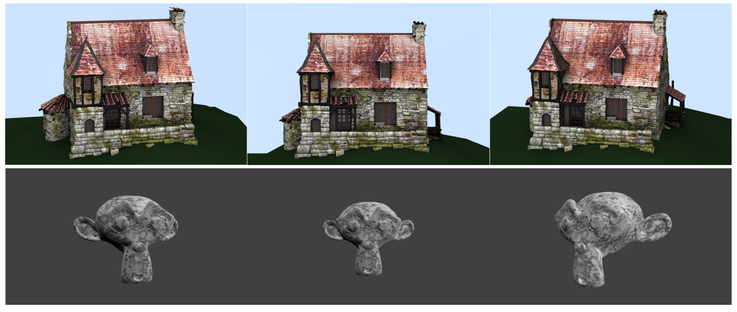


CONTRIBUTIONS

An SfM pipeline built on AC-RANSAC:

- *AC*-RANSAC estimation of E, F, H, Pose,
- Experimental validation showing the benefit of adaptive automatic threshold.
- **openMVG open source library**
  A multiple-view geometry library,
  A collection of 2-view solvers,
  Generic robust estimators: RANSAC, AC-RANSAC.

Synthetic datasets with GT calibration:



REFERENCES

[1] N. Snavely et al. Photo tourism: exploring photo collections in 3D. In *SIGGRAPH 2006*.

[2] C. Strecha et al. On benchmarking camera calibration and multi-view stereo for high resolution imagery. In *CVPR 2008*.

[3] L. Moisan et al. Automatic homographic registration of a pair of images, with a contrario elimination of outliers. In *IPOL 2012*, `http://dx.doi.org/10.5201/ipol.2012.mmm-oh`.