Adaptive Structure from Motion with a contrario model estimations

PIERRE MOULON, PASCAL MONASSE, RENAUDA MARLET

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.

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.

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 \( H_0 \): uniform distribution.
- Strong deviation from \( H_0 \) is deemed meaningful.

AC-RANSAC relies on 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:
  \[
  NFA(M, k) = N_{\text{intra}}(n, k, N_{\text{sample}})P(\text{residual} \leq T_k | M, H_0)^{k-N_{\text{sample}}}
  \]

Expectation: \( NFA(M) = \min_{N_{\text{sample}}} NFA(M, k) \leq 1 \).

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 \( 2 \ast N_{\text{sample}} \) data.

References


Synthetic datasets with GT calibration: