Adaptive model estimation, a real time demonstration

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Image.

Abstract

We visually illustrate adaptive model estimation through a real-time demo. The setup shows experimentally the advantage of *a contrario (AC)* model estimation linked to our ACCV paper "Adaptive Structure from Motion with *a contrario* model estimations"[1]. It demonstrates a real-time matching and homography estimation by RANSAC and AC-RANSAC. The experiment clearly shows that our AC approach is less sensitive then RANSAC to outliers and noise. Graphs displaying statistics are used to show adaptivity and superiority of the AC estimator.

Introduction

Finding a parametric model among corrupted and noisy data is a common task in computer vision. Robust estimators as RANSAC and variants are the most commonly used tools. This algorithm depends on the choice of a critical parameter, the threshold T. Using a too low T selects few inliers and leads to model imprecision, while choosing a too large T contaminates the selected points with outliers (false positive), and leads to inaccurate model too.

We demonstrate here with AC-RANSAC a user-friendly parameterless method that automatically computes the inlier/outlier discrimination threshold and obtains superior performance in real-time homography fitting with AC-RANSAC.

Demo setup

The demo shows a real-time pattern matching through feature matching and homography estimation. The interface is cut in three main parts, as illustrated Figure 1: the reference pattern, the webcam stream where a printed copy of the pattern is moved by the user, and some graphs showing real-time statistics of model data. Detected keypoints are depicted by yellow circles, homography fitting is represented by the pattern border reprojection (magenta rectangle), and finally robustly validated matches by green lines.

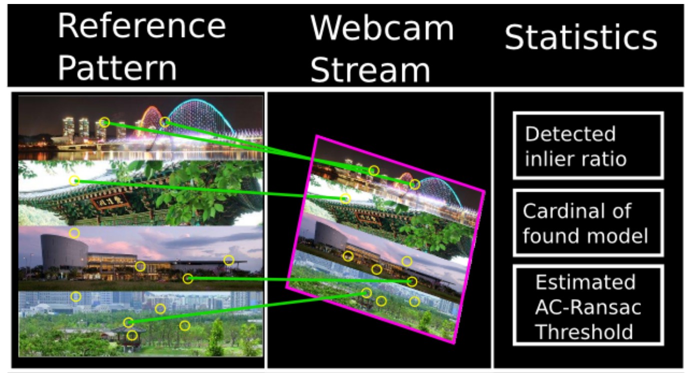

Figure 1: The demo interface configuration.

Three types of statistics are displayed to show evolution through time:

- Ratio of detected inliers: $\#inliers/\#matches$
- Number of valid models found: $\#validity$.
- Estimated AC-RANSAC threshold.

To compare RANSAC to AC-RANSAC we use a color coded display. Magenta color is associated to RANSAC and white to AC-RANSAC. The reprojection of the pattern border enable us to check visually the quality of the fitted homography. To prevent display cluttering, green inliers line, are only shown for AC-RANSAC.

Interesting cases

This demo, as illustrated Figure 2, allows to show different characteristics:

1. While using a threshold-less method, no false positive is estimated.
2. In a classical configuration the AC-RANSAC estimated threshold is around 2 pixels.
3. AC-RANSAC threshold adaptivity is demonstrated by bending the user pattern.
4. Under critical configuration AC-RANSAC is the only one to find a solution.

The demo illustrates adaptivity by looking at statistics: Under classical configuration, the AC-RANSAC threshold is estimated under 2 pixels and works as well as RANSAC. If the pattern is bended (2 times in the middle of Figure 2) and set flat again, the computed threshold increases to maintain a high level of inliers. When the dataset is highly contamined with outliers, only AC-RANSAC estimates a valid solution. In the third display capture, a solution was found by AC-RANSAC almost every time, on the contrary to RANSAC; here contamination is estimated to 85% of outliers. It shows that estimated T depends on each situation, which allows estimations that would be otherwise impossible with a globally-fixed threshold.

A contrario model estimation

Our approach to treat noisy and contamined data is to use a methodology for finding a model that best fits the data with a confidence threshold T that adapts automatically to noise and outliers. For this, we use an *a contrario* model estimation explained in our IPOL and ACCV [2, 1] papers, that works both at small and large scale.

Applied to model estimation, the *a contrario* approach answers the question "Does this model arise by chance?" and thus decides the meaningfulness of a model. The corresponding statistical criterion is data-specific and avoids empirically setting thresholds for inlier/outlier discrimination. It provides a parameter-free evolution of RANSAC, called AC-RANSAC. As a result, the accuracy of model estimation tends to be as good as possible, with less risk of inadvertently selecting too few inliers for a model to be estimated.

Open source contribution

This demo is based on our multiple-view geometry library, *OpenMVG*, that we are to release as open source. It provides an end-to-end C++ library around an extensible, high-quality implementation (with unit tests), of common tools used in multiple-view geometry. One of its goals is to enable durable and reproducible research in the computer vision community. The main contributions of the library is a collection of minimal solvers for n-view rigid geometry constraints and state of the art implementation of recently introduced algorithms: incremental Structure fom Motion [1], threshold-less model estimation [2].

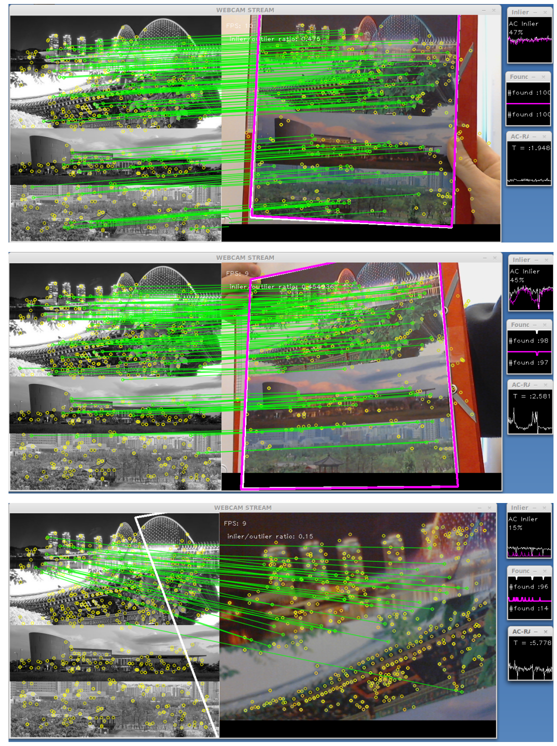

Figure 2: Top to bottom: classic configuration, bended pattern (notice the threshold jump), critical configuration (85% outliers).

Conclusion

We visually and interactively demonstrate the advantages of AC-RANSAC and show that threshold-less model fitting is possible and provides excellent results adapting to a wide range of data configuration.

References

[1] P. Moulon, P. Monasse, R. Marlet: Adaptive Structure from Motion with *a contrario* model estimations. Asian Conference on Computer Vision (ACCV) 2012.

[2] L. Moisan, P. Moulon, P. Monasse: Automatic Homographic Registration of a Pair of Images, with A Contrario Elimination of Outliers. Image Processing On Line. (IPOL) 2012.