A Minimal Solution for Two-view Focal-length Estimation using Two Affine Correspondences

MTA SZTAKI
Hungarian Academy of Sciences
Institute for Computer Science and Control

Daniel Barath, Tekla Toth, Levente Hajder
Machine Perception Research Laboratory, MTA SZTAKI, Budapest, Hungary

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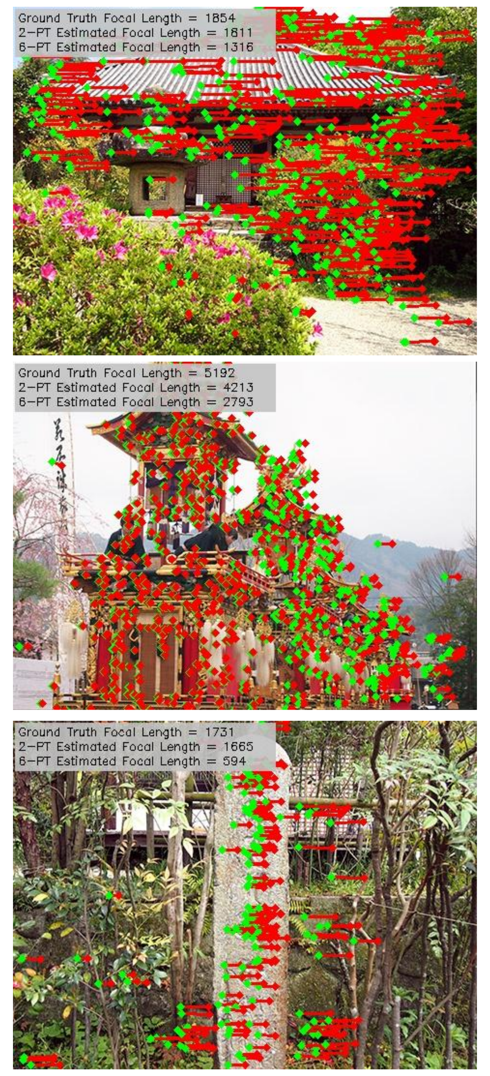
Summary:



1. A minimal solution using two affine correspondences is presented to estimate the common focal length and the fundamental matrix between two semi-calibrated cameras.
2. The obtained multivariate polynomial system is efficiently solved by the hidden-variable technique.
3. We introduce novel conditions eliminating invalid roots. To select the best one out of the candidates, a root selection technique is proposed outperforming the recent ones.

A Matlab implementation is included in the paper.

Epipolar Geometry and Affine Correspondences

Given an affine correspondence ($\mathbf{A}$; $\mathbf{p}_1$; $\mathbf{p}_2$) estimated by an affine covariant feature detector, where $\mathbf{A}$ is a local affine frame and $\mathbf{p}_1$, $\mathbf{p}_2$ are the point coordinates in the two images.

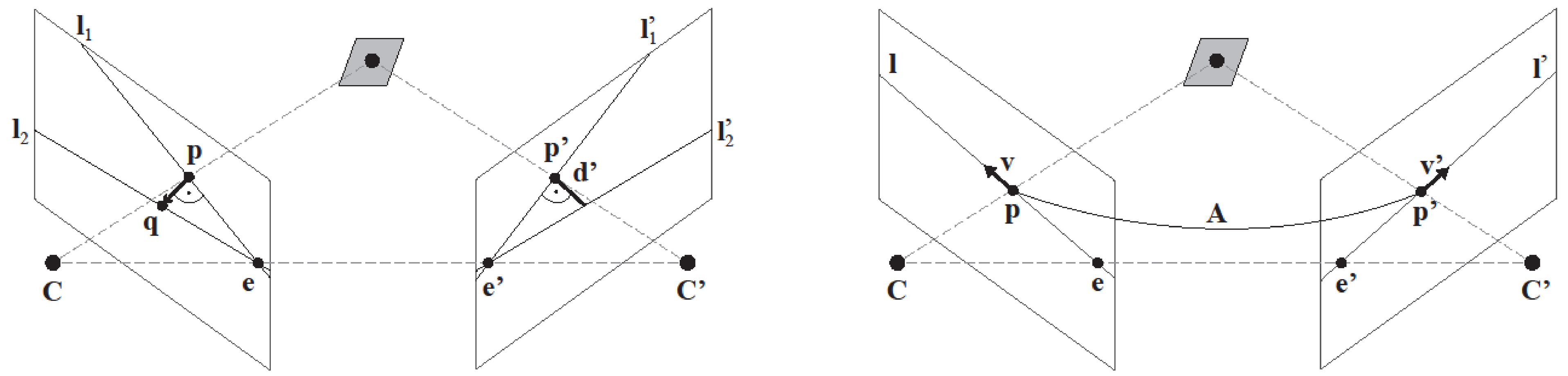


Fig.1. The affinity's scale is determined by the distance of neighboring epipolar lines (left) and the rotation by their directions (right).

Two-point Solver:

An affine correspondence yields three linear constraints for fundamental matrix estimation.

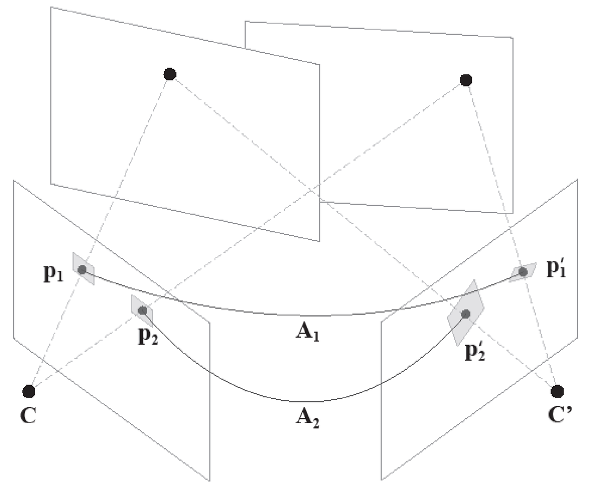


Fig.2. Set up with two affinities.

$C(\tau)$	1 α^3	2 $\alpha^2\beta$	3 $\alpha^2\gamma$	4 $\alpha\beta^2$	5 $\alpha\beta\gamma$	6 $\alpha\gamma^2$	7 β^3	8 $\beta^2\gamma$	9 $\beta\gamma^2$	10 γ^3
1	c_1	c_2	c_3	c_4	c_5	c_6	c_7	c_8	c_9	c_{10}
.	.	.	.	.	.	.	.	.	.	.
10	c_{91}	c_{92}	c_{93}	c_{94}	c_{95}	c_{96}	c_{97}	c_{98}	c_{99}	c_{100}

Table 1. Coefficient matrix of the hidden-variable technique.

Root Selection:

1. All roots for which the indicated surface normals do not look towards the cameras are removed.
2. Focal lengths not satisfying physical limits are omitted.
3. The best candidate root is selected applying Median-Shift which provides Tukey-medians. The mode having the most elements in its cluster is selected as the final solution.

Experimental Results:

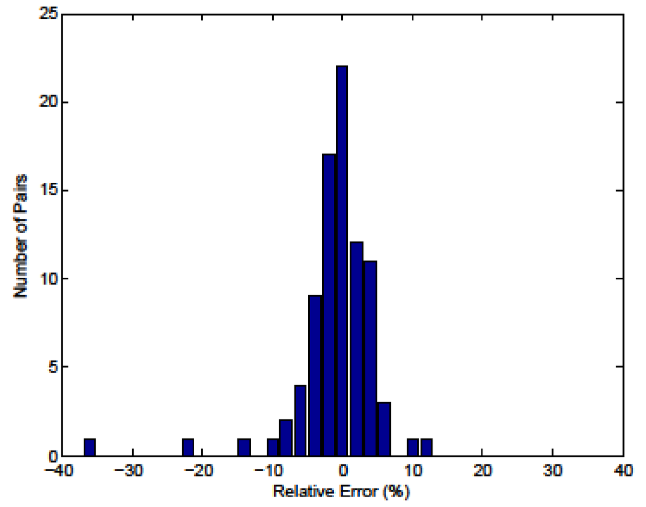


Fig.4. The distribution of the estimated focal lengths' relative errors on 104 real image pairs. The horizontal axis is the relative error and the vertical one reports the number of the image pairs.

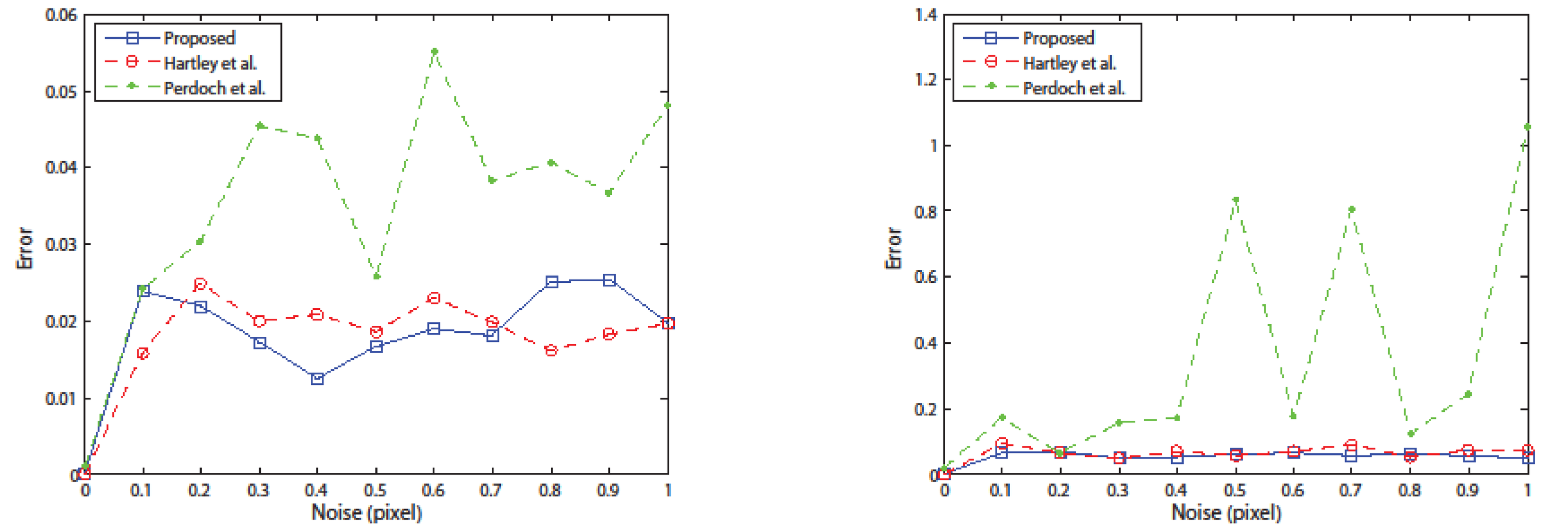
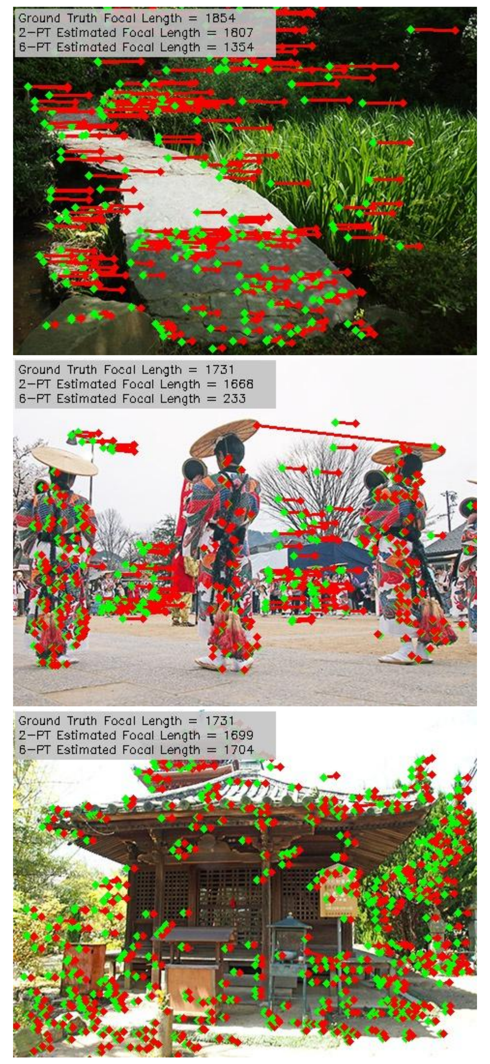


Fig.3. The errors, i.e. the Frobenius-norm w.r.t. the ground truth fundamental matrix, of fundamental matrix estimation. The competitor methods are that of Hartley et al. and Perdoch et al.

Method	Corr #	Mean	Median	σ
Proposed	2	**9.62**	**3.88**	**14.08**
Perdoch et al.	2	44.66	45.89	26.43
Hartley et al.	6	21.79	8.61	27.48

Table 1. Mean and median relative error (%) and the standard deviation of the errors in the estimated focal lengths on real image pairs. *Corr #* denotes the number of correspondences.



Conclusion:

An efficient method is proposed to estimate the unknown focal-length and the fundamental matrix using only two affine correspondences. Compared with the state-of-the-art, it obtained the most accurate focal lengths with fundamental matrices having similar quality as the recent algorithms. Combining the minimal solver with a robust statistics, e.g. RANSAC, allows significant reduction in computation.

barath.daniel@sztaki.mta.hu
http://web.eee.sztaki.hu/~dbarath/