Construction of Precise Local Affine Frames

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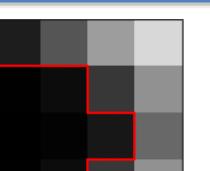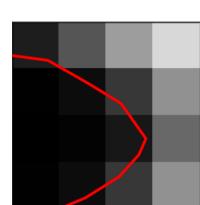
Introduction

- Local Affine Frames (LAFs) [2] are local coordinate systems covariant with affine geometric transformation of the image.
- LAFs are constructed from geometric primitives built on image patches such as MSERs [1].
- LAF have been shown powerful features in wide-baseline image matching.
- **Precision and stability of LAFs, as a function of MSER contour precision, are addressed.**

Problem 1: Contour Refinement

Input:
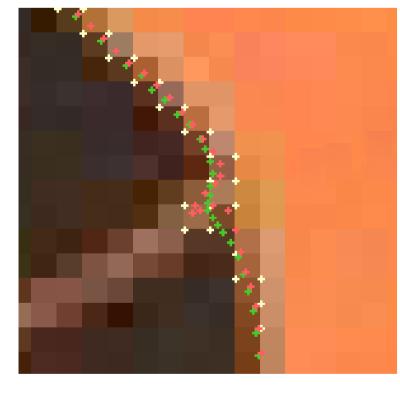The detected region is usually a set of connected pixels with discretised contour.

Output:
Fast reconstruction of discretised contour to sub-pixel precision.

Examples of Contour Refinement
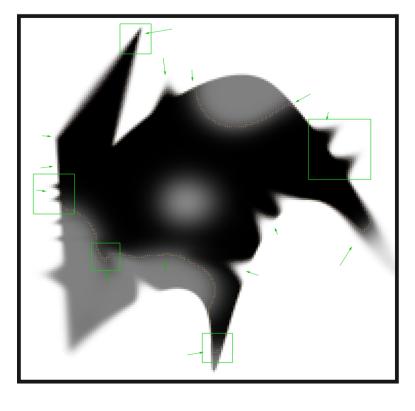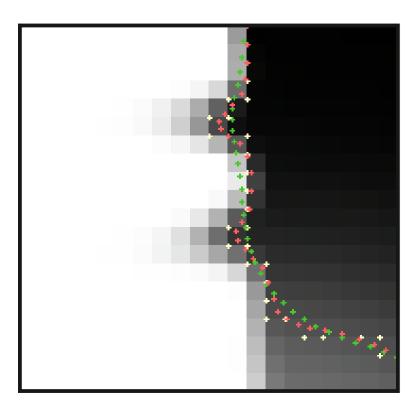### comparison with the reference method

- Proposed method
- Reference method [2] (smoothing)
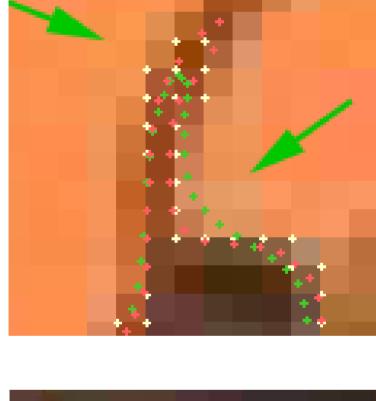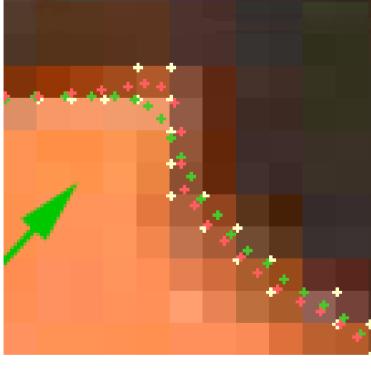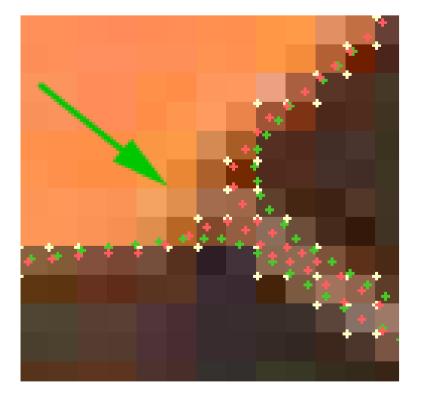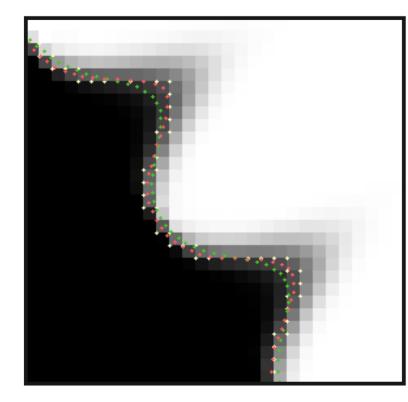- Original contour (MSER discretized isophote)

Contour Refinement Method
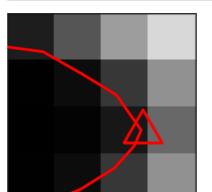
Shifting vertex a (yellow cross) on the original contour to a new position (green cross) based on the intensity in the 2x2 neighborhood.

Red line – gradient direction
Green line – the isophote
Blue line – the discretised region contour

- Approximate the gradient at vertex a of the image intensity function from four neighboring pixels $p_1,...,p_4$ of vertex of contour using Roberts operator.
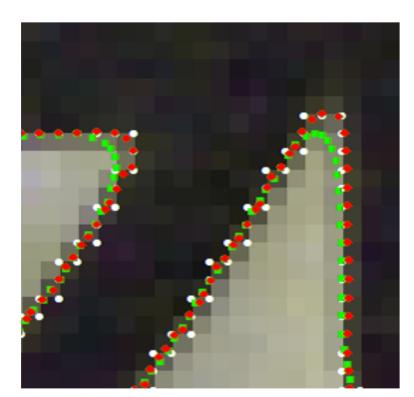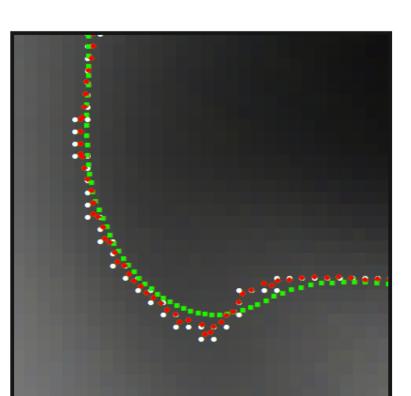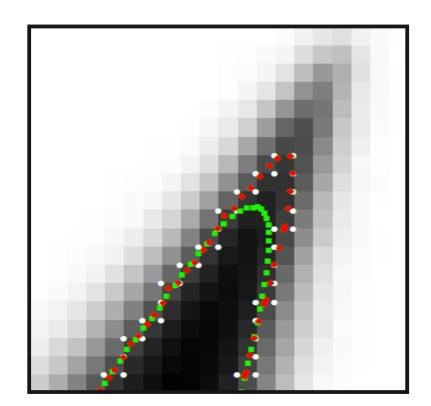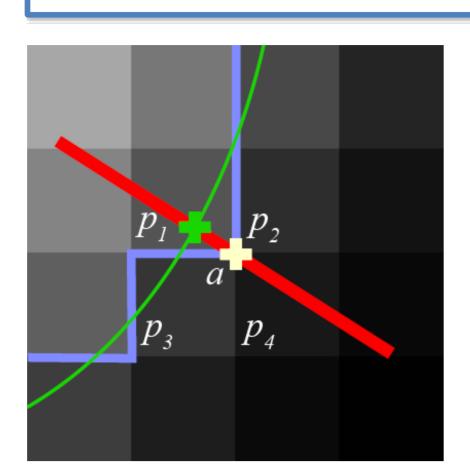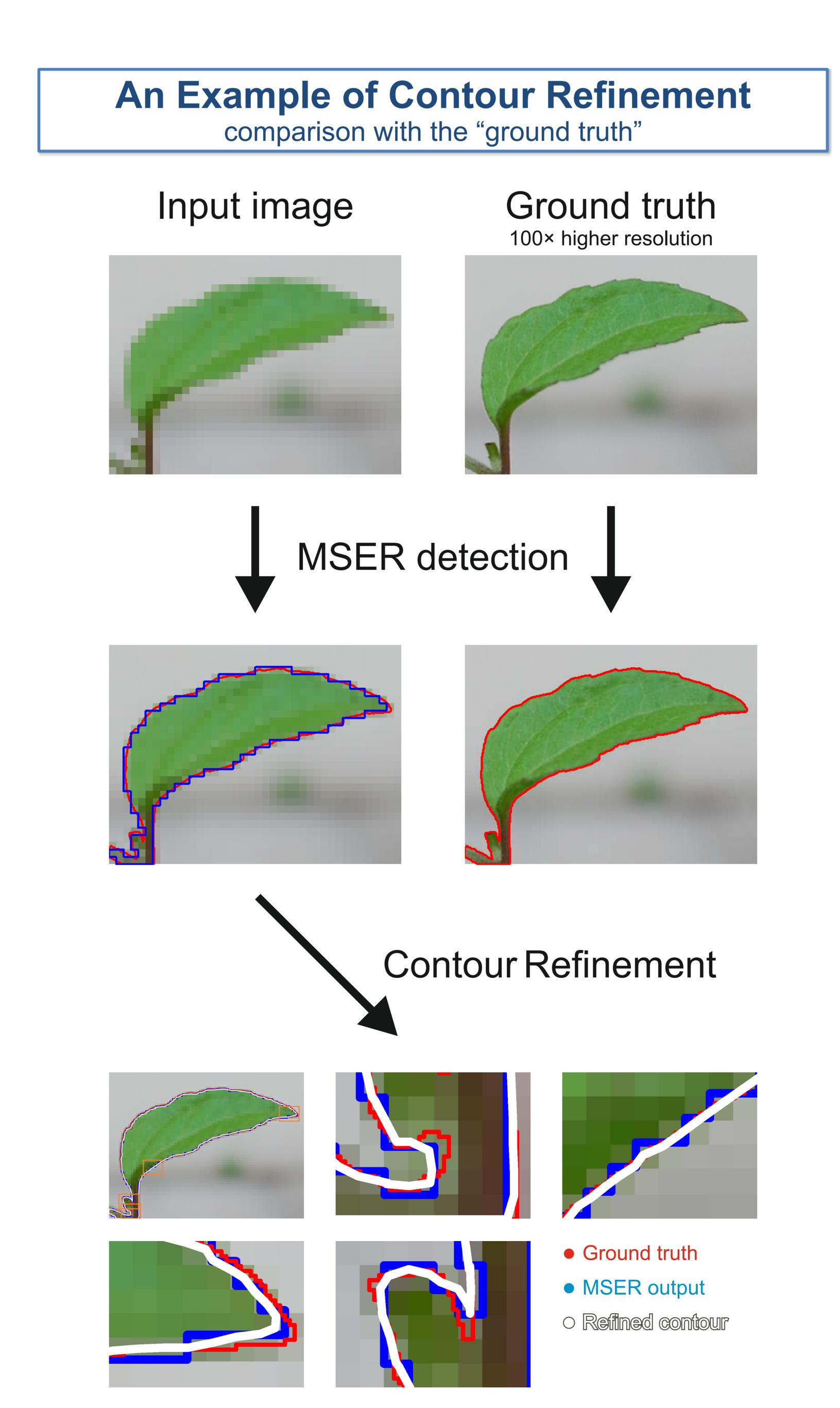- Project center points of pixels $p_1,...,p_4$ to line passing through vertex a in the gradient direction.
- Estimate the new position of the vertex for intensity threshold θ (property of isophote) by linear regression. The regressors are pixel intensities, and positions of projected center points are the regressands.
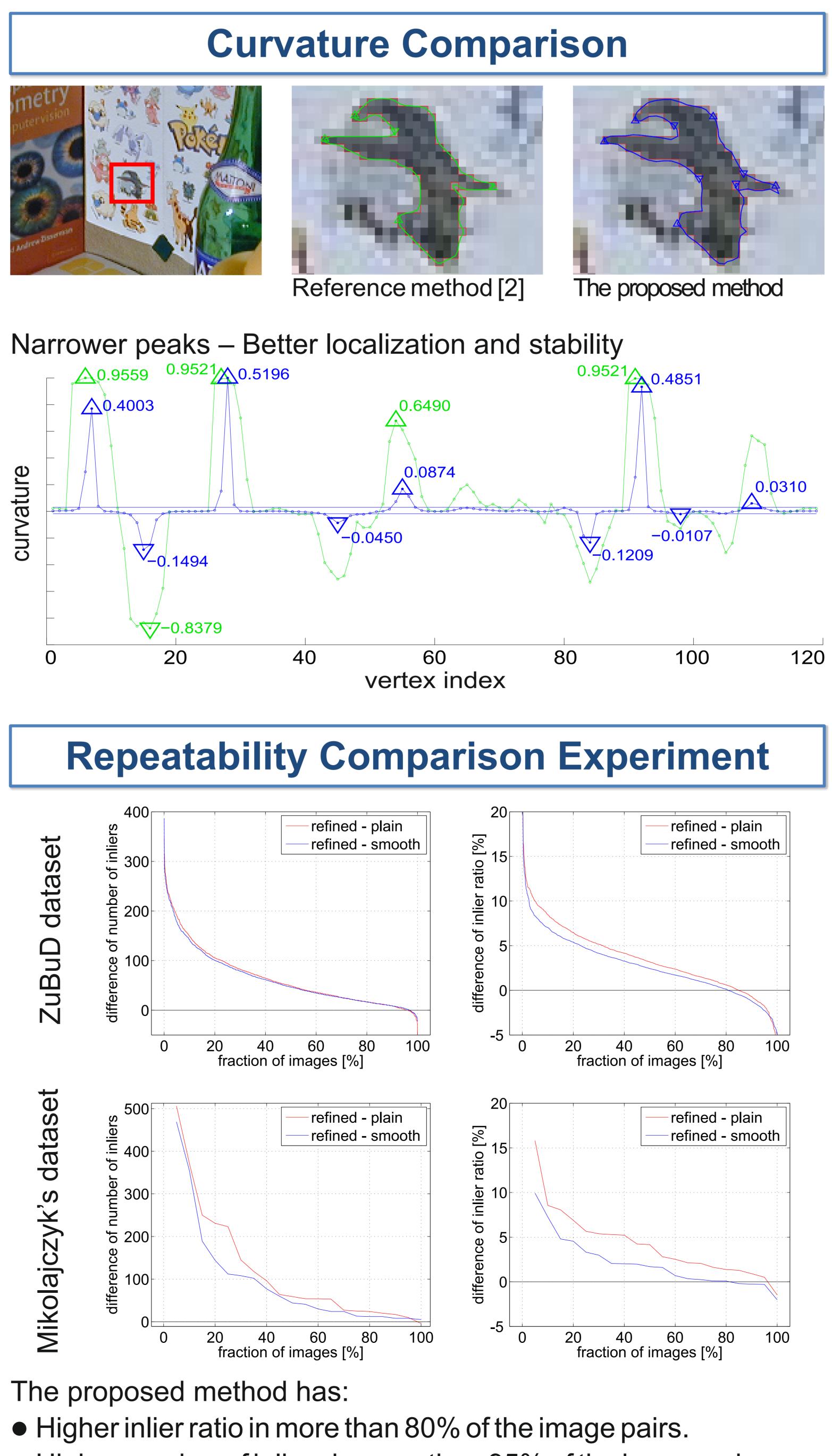
An Example of Contour Refinement
comparison with the "ground truth"

Input image

Ground truth
100× higher resolution

MSER detection

Contour Refinement

- Ground truth
- MSER output
- Refined contour

Problem 2: Contour Primitives Detection
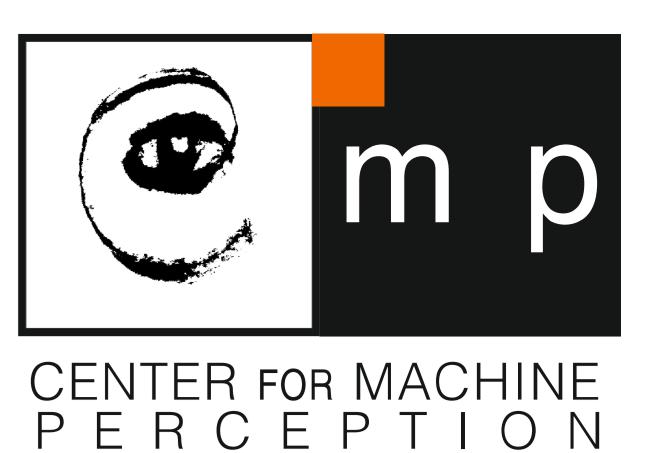
On the refined contour, detect primitives for LAF constructions.
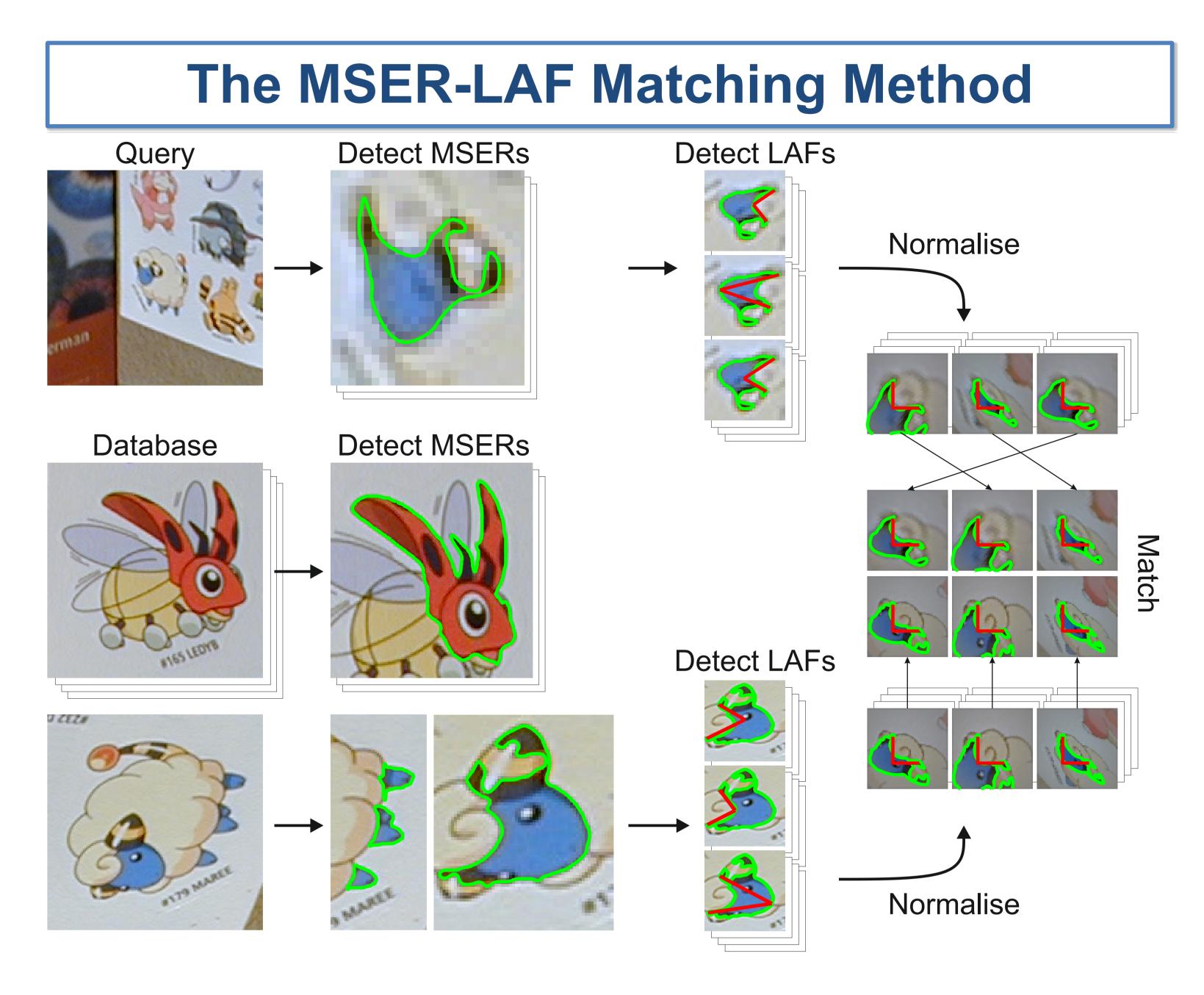
Local Curvature Extrema Detection

1. Smooth the contour and normalize contour shape.
3. Estimate curvature at each contour point.
4. Estimate mean curvature and standard deviation for the contour.
5. Points exceeding 3σ form the set of local curvature extrema candidates.
6. Suppress non-maximum candidates.
7. Pre-images (points before smoothing) are local curvature extrema on the refined contour.

Curvature Comparison

Reference method [2]   The proposed method

Narrower peaks – Better localization and stability

Repeatability Comparison Experiment

The proposed method has:
- Higher inlier ratio in more than 80% of the image pairs.
- Higher number of inliers in more than 95% of the image pairs.

The MSER-LAF Matching Method

Query   Detect MSERs   Detect LAFs

Normalise

Database   Detect MSERs

Detect LAFs

Match

Normalise

Examples of geometric primitives built on MSER are used for LAFs

Conclusions

Problem 1:
- Wide-baseline stereo matching experiments on standard datasets demonstrate higher precision of the refined MSER boundaries.
- Processing time is negligible to region detection time.
- The method is applicable to any discretised isophote.

Problem 2:
- Experimental evaluation shows that proposed detection of contour primitives increases repeatability of LAFs.
- The method is applicable to any contour.

Relevant Publications

J. Matas, O. Chum, M. Urban, and T. Pajdla, "Robust wide baseline stereo from maximally stable extremal regions", in BMVC, 2002

S. Obdržálek and J. Matas, "Object recognition using local affine frames on distinguished regions", in BMVC, 2002

A. Mikulík, "Methods for precise local affine frame constructions on MSERs," Master's thesis, Charles University in Prague, Faculty of Mathematics and Physics, 2009.

Acknowledgments