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Curved Reflection Symmetry Detection with Self-validation

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ABSTRACT

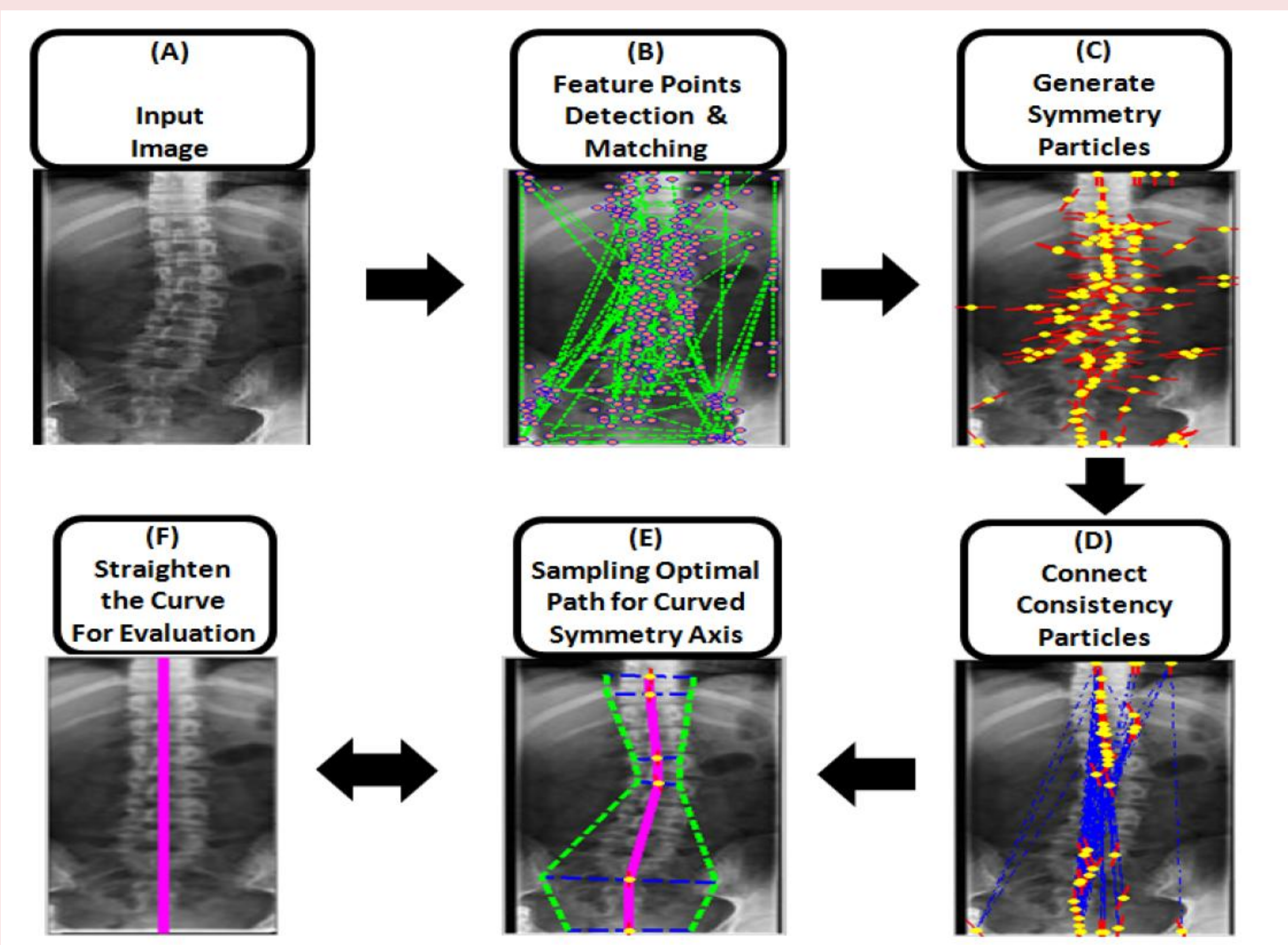
We propose a novel, self-validating approach for detecting curved reflection symmetry patterns from real, unsegmented images. Pairs of symmetric feature points are first detected and treated as 'particles'. Multiple-hypothesis sampling and pruning are used to discover a piecewise smooth path to approximate the curved reflection axis. Our approach also generates an explicit supporting region of the curved reflection symmetry, which is further used for intermediate self-validation.

MOTIVATION

The state-of-the-art approach [1] recognizes symmetric 'particles' and then fits a polynomial function to obtain the curved (glide) reflection symmetry axis. Its weakness is its high sensitivity to outliers during the curve fitting process. We are able to address this problem by a combination of multi-hypothesis sampling and rectified-supporting-region reflection symmetry self-validation.

METHOD

We adopt a bottom-up framework that first detects and matches symmetric points pairs (particles) including inliers and outliers. To approximate a valid curved reflection axis, we then repeatedly sample and discover a **smooth path** going through inlier particles on the image. We explore a set of potential paths using multiple hypothesis sampling and pruning, each path is evaluated by the symmetry score after being rectified.



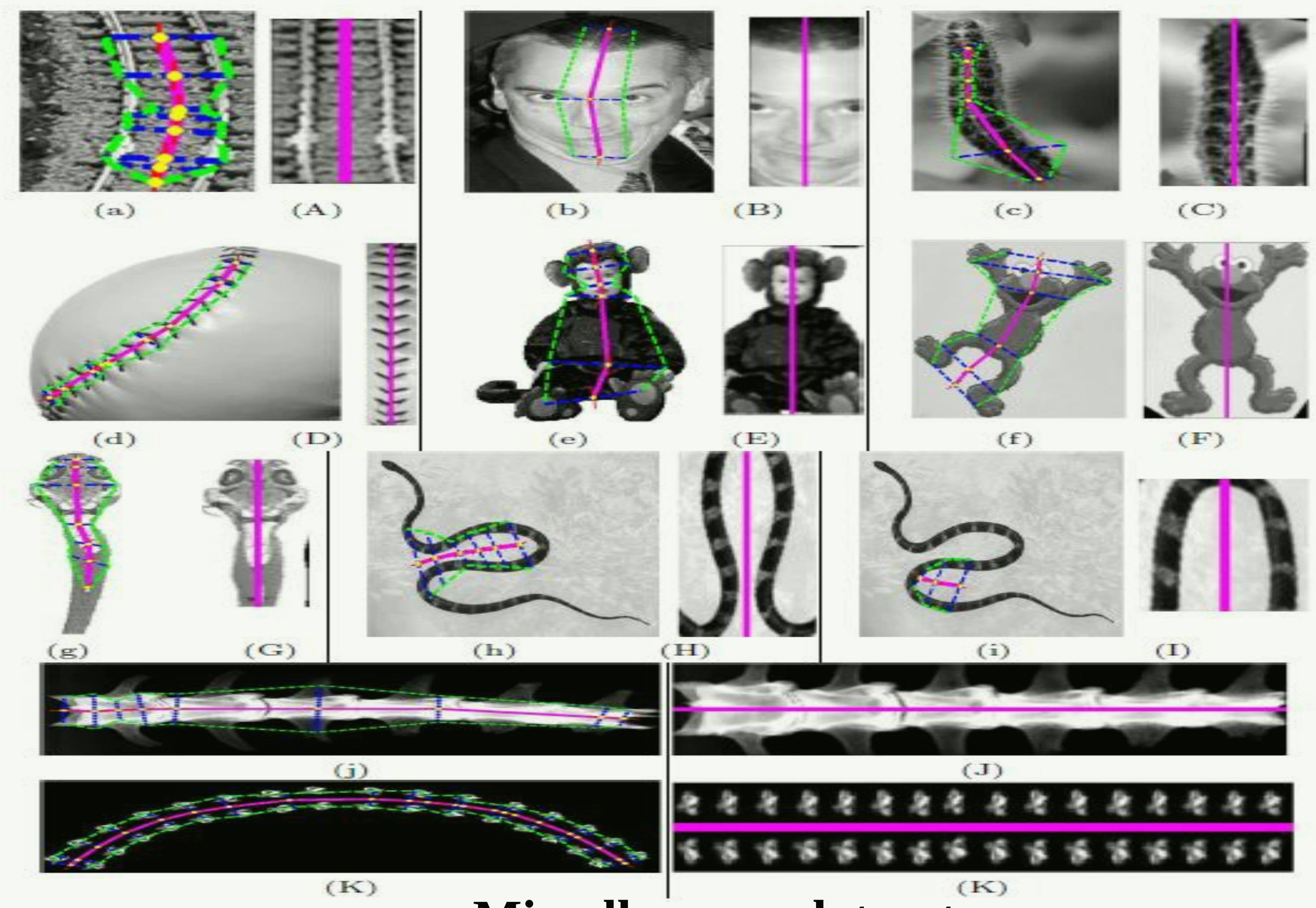
- **(A)** Input image;
- **(B)** Detected SIFT feature points (pink dots) and successfully matched feature point pairs connected using dashed lines;
- **(C)** Representing feature point pairs as yellow particles with red short lines indicating the directions of potential reflection symmetry axis;
- **(D)** Maximally connected components in particle pair-wise consistency graph G;
- **(E)** Sampled optimal path from G;
- **(F)** Rectified region via TPS warping.

QUANTITATIVE COMPARISONS

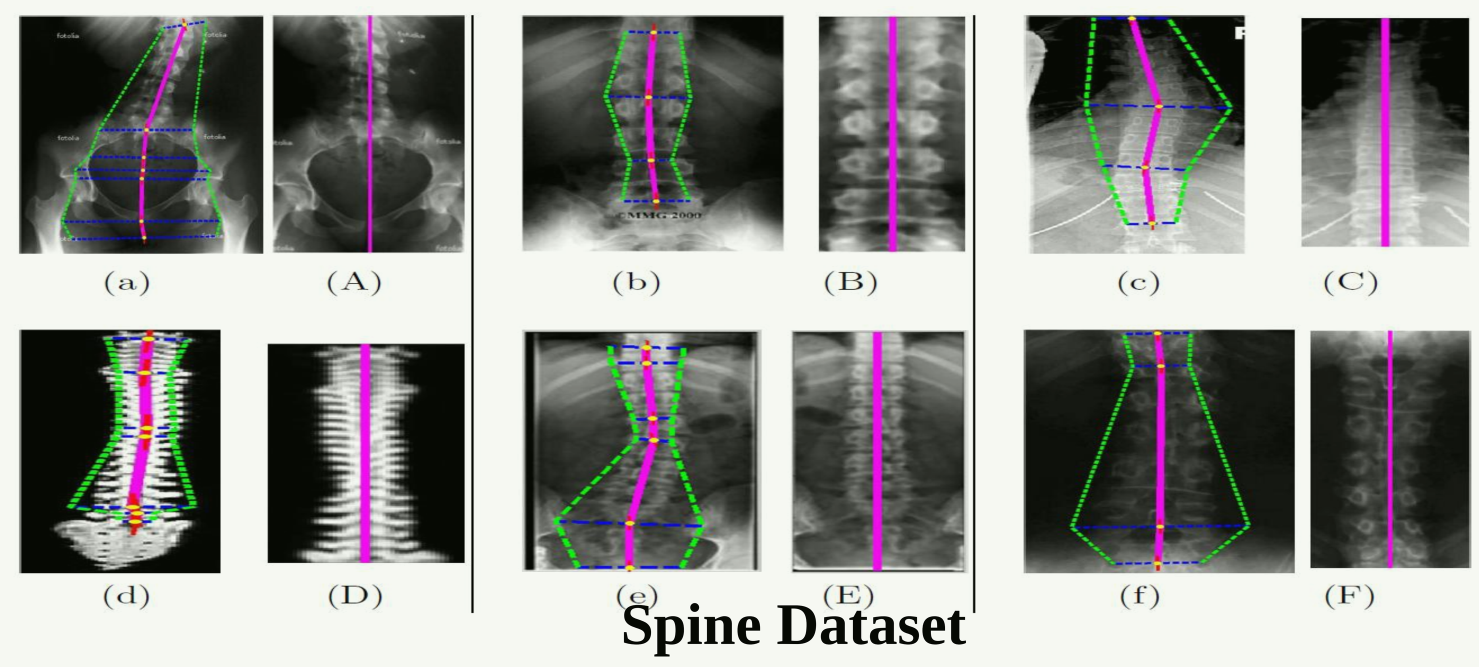
Dataset	Leaf dataset	Spine dataset	Miscellaneous images	Overall
# images	150	30	30	210
proposed	83.3%	80.0%	73.3%	81.4%
Lee & Liu [1]	40.0%	66.7%	70.0%	48.1%

Table 1. Success rates of our proposed algorithm and Lee & Liu's [1].

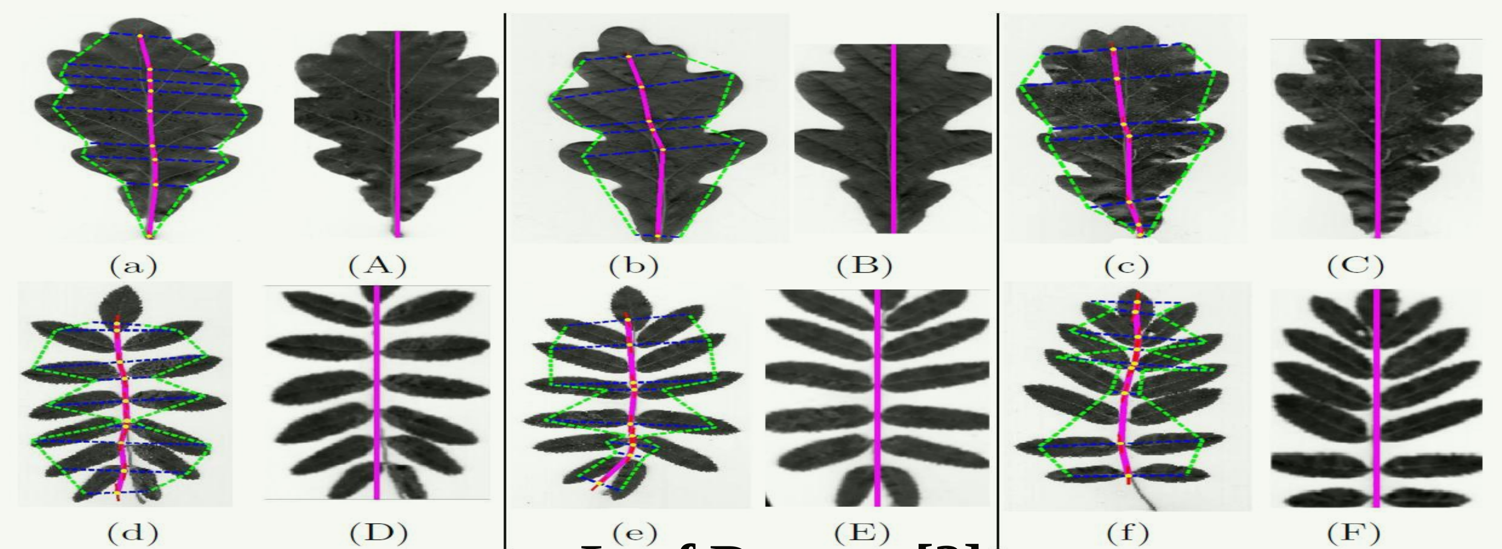
EXPERIMENTAL RESULTS



Miscellaneous dataset

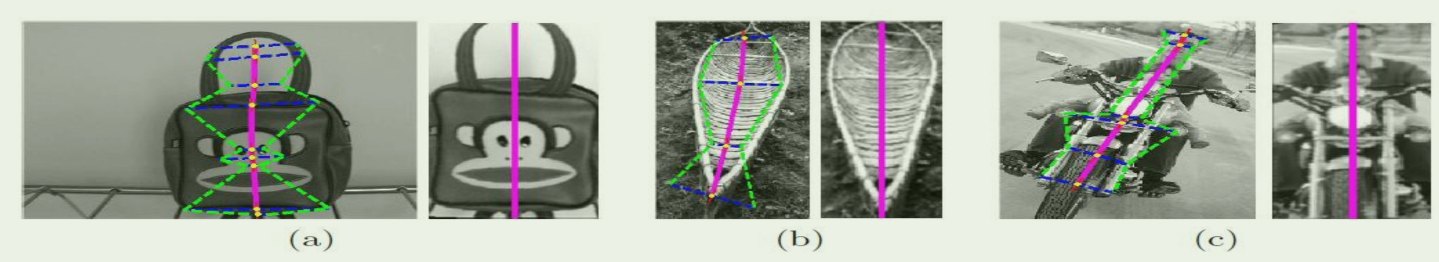


Spine Dataset

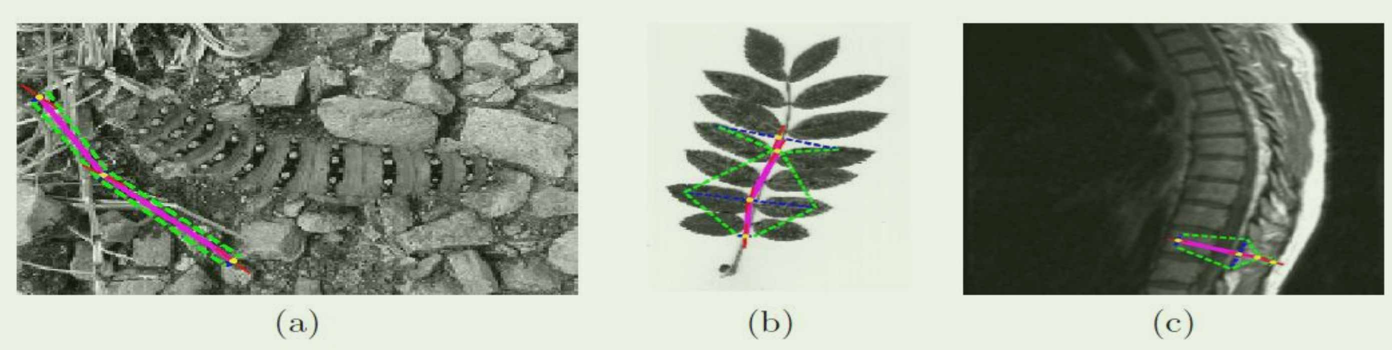


Leaf Dataset [3]

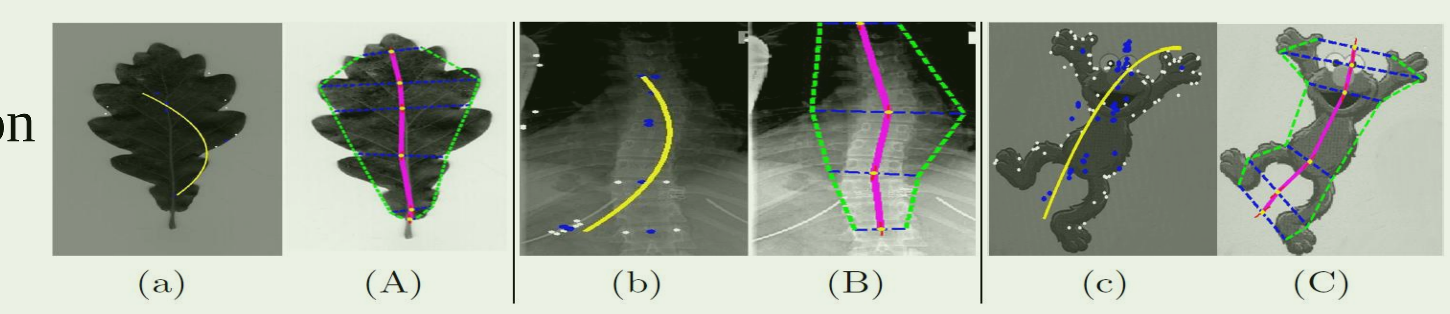
Almost-straight reflection



Failed Cases



Comparison with [1]



CONCLUSION

We propose a bottom-up curved-reflection symmetry detection approach, starting from recognizing symmetric point pairs (particles) in the bottom level and extracting a consistent structure among the particles to form the symmetry pattern in the higher level. We obtain the supporting regions from selected particles and use them for self-validation. Quantitative comparisons on 210 images of different varieties show superior robustness of our proposed method against the state of the art [1] for curved reflection axes and region discovery.

Major Citations

[1] Lee,S. and Liu,Y.: Curved glide-reflection symmetry detection. (CVPR,09).
[2] Loy,G. and Eklundh,J.: Detecting symmetry and symmetric constellations of features. (ECCV,06).
[3] Swedish leaf dataset: http://www2.cvl.isy.liu.se/ScOut/Masters/PaperInfo/soderkvist2001.html

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Project Page: http://vision.cse.psu.edu/research/curvedSym/index.shtml