LEAF CLASSIFICATION BASED ON A QUADRATIC CURVED AXIS

Phuchitsan Chaisuk, Krisada Phromsuthirak and Vutipong Areekul

Kasetsart Signal & Image Processing Laboratory (KSIP Lab)

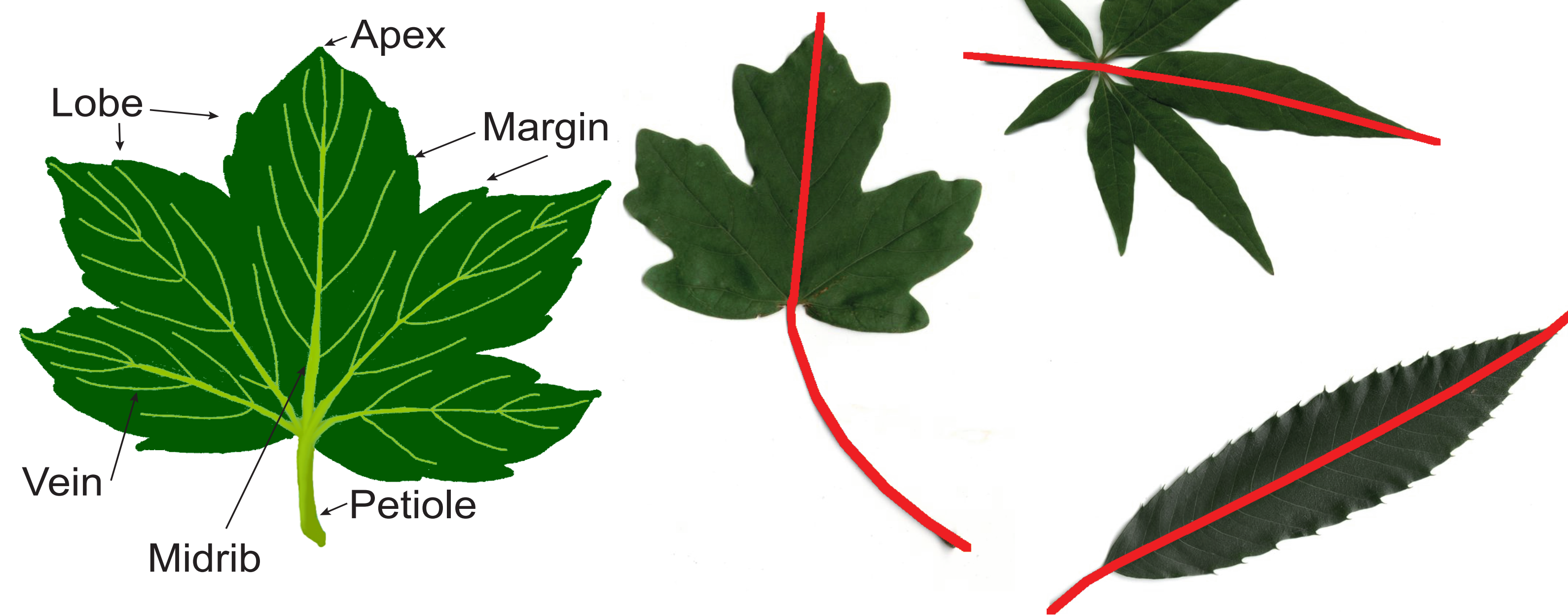Department of Electrical Engineering, Kasetsart University, Bangkok, Thailand

Contact: phuchitsan.c@ku.th

Objective

This work aims to improve leaf classification performance by reducing effects of translation, rotation, scaling, and bending in leaf image using new reference axis, called a Mid-Leaf axis, and contour features.
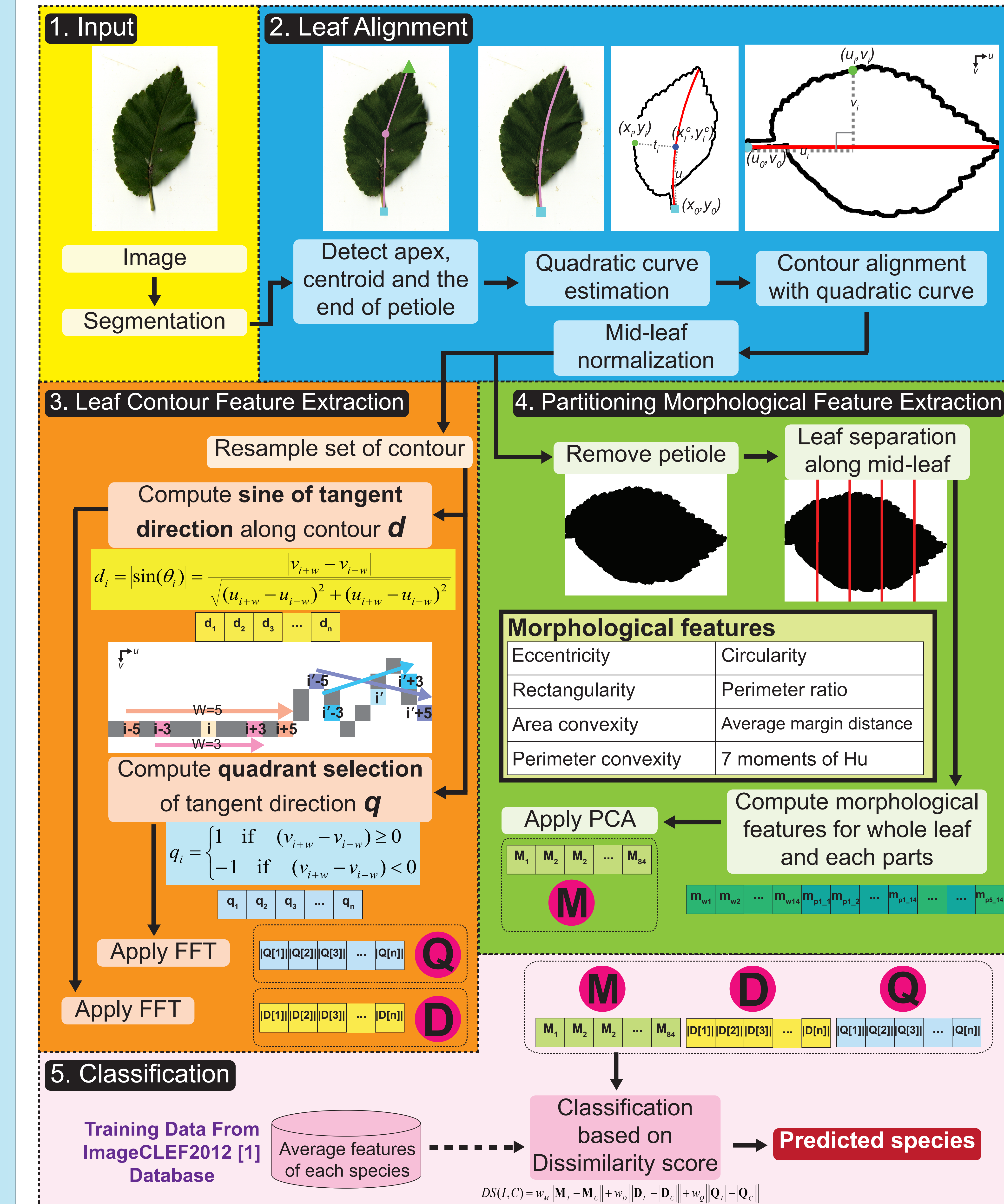
Motivation

Leaf's midrib is an ideal reference which can be found in the nature. However, some leaves lack a midrib such as those with parallel or rotated vein patterns and midrib detection maybe require high-resolution images. Hence midrib detection may not be possible for all cases. Instead of detecting midrib, we propose a new curved axis as a reference, which is estimated from three landmark points of a leaf: an apex, a centroid, and an end of petiole. Because, these three points may not be linearly aligned, so the reference curve is approximated by a quadratic polynomial function.

Apex
Lobe
Margin
Vein
Petiole
Midrib

Acknowledgement

Method

1. Input

Image → Segmentation

2. Leaf Alignment

(u_i, v_i)
(x_i, y_i)
(x_i^c, y_i^c)
t_i
(x_0, y_0)
(u_0, v_0)

Detect apex, centroid and the end of petiole → Quadratic curve estimation → Contour alignment with quadratic curve → Mid-leaf normalization

3. Leaf Contour Feature Extraction

Resample set of contour

Compute **sine of tangent direction** along contour **d**

$$d_i = |\sin(\theta_i)| = \frac{|v_{i+w} - v_{i-w}|}{\sqrt{(u_{i+w} - u_{i-w})^2 + (v_{i+w} - v_{i-w})^2}}$$

| d_1 | d_2 | d_3 | ... | d_n |

W=5
W=3
i-5 i-3 i i+3 i+5
i'-5 i' i'+3 i'+5

Compute **quadrant selection** of tangent direction **q**

$$q_i = \begin{cases} 1 & \text{if } (v_{i+w} - v_{i-w}) \geq 0 \\ -1 & \text{if } (v_{i+w} - v_{i-w}) < 0 \end{cases}$$

| q_1 | q_2 | q_3 | ... | q_n |

Apply FFT → | Q[1] | Q[2] | Q[3] | ... | Q[n] | **Q**

Apply FFT → | D[1] | D[2] | D[3] | ... | D[n] | **D**

4. Partitioning Morphological Feature Extraction

Remove petiole → Leaf separation along mid-leaf

Morphological features

Eccentricity	Circularity
Rectangularity	Perimeter ratio
Area convexity	Average margin distance
Perimeter convexity	7 moments of Hu

Compute morphological features for whole leaf and each parts

Apply PCA
| M_1 | M_2 | M_2 | ... | M_{84} |
M
| m_{w1} | m_{w2} | ... | m_{w14} | m_{p1_1} | m_{p1_2} | ... | m_{p1_14} | ... | m_{p5_14} |

M **D** **Q**
| M_1 | M_2 | M_2 | ... | M_{84} | D[1] | D[2] | D[3] | ... | D[n] | Q[1] | Q[2] | Q[3] | ... | Q[n] |

5. Classification

Training Data From ImageCLEF2012 [1] Database

Average features of each species ⤍ Classification based on Dissimilarity score → **Predicted species**

$$DS(I,C) = w_M \|M_I - M_C\| + w_D \|D_I - D_C\| + w_Q \|Q_I - Q_C\|$$

Result

Evaluate with ImageCLEF2012 Leaf-scan database [1]

Method	Score (%)
Proposed: Morphological feature **M**	52.77
Proposed: Contour feature **D,Q**	53.53
Multiscale Triangular Representation [2]	54.00
Multiscale Arch Height (MARCH) [3]	54.80
Shape, Texture, and Color Features [1]	58.00
Multiscale R-Angle [4]	61.20
Proposed: Combined **M,D,Q**	**64.97**
Proposed: Combined **M,D,Q** with manual reference	**65.64**

Success cases on reference detection | Failure cases on reference detection
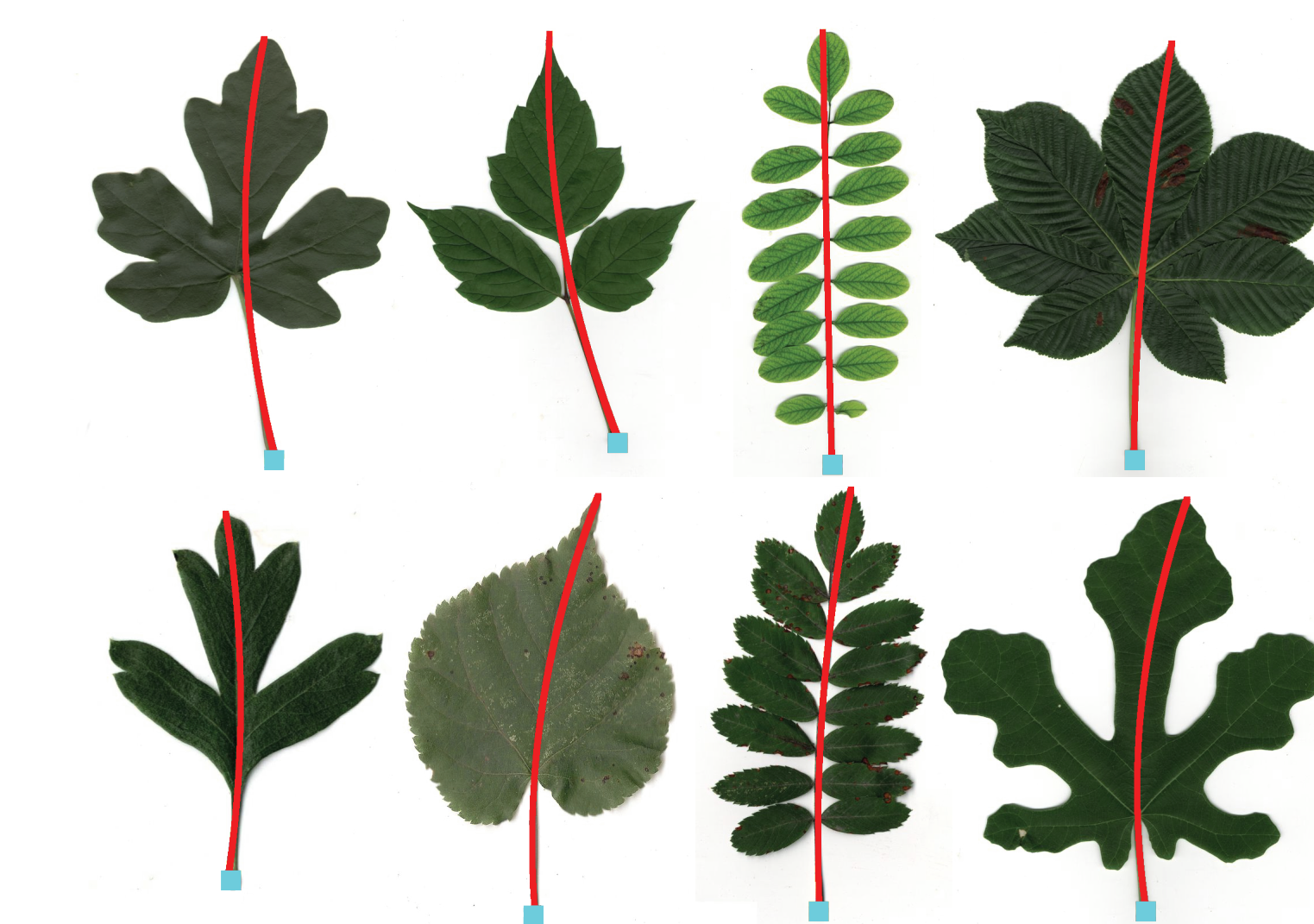
Conclusion

With the new reference axis, leaves are more distinguishable by the combination of the leaf contour feature and the whole/partitioning morphological features. These proposed features are robust to translation, rotation, scaling, and bending. Moreover, the accuracy of the proposed method could be improved by investigating reference detection method or adding new features such as leaf's texture.

Reference

[1] Goëau et al, The ImageCLEF 2012 plant images classification task
[2] Mouine et al, A shape-based approach for leaf classification using multiscale triangular representation
[3] Wang et al, MARCH: Multiscale-arch-height description for mobile retrieval of leaf images
[4] Cao et al, Similarity based leaf image retrieval using multiscale R-angle description