

Contents

1	Introduction	1
1.1	Plant Species and Their Identification	1
1.2	The Delimitation of Species by Descriptions	5
1.3	Using Leaves to Diagnose Species	6
1.4	Computational Botany	8
1.5	Aims and Objectives	9
2	Morphometrics: A Brief Review	11
2.1	Historical Background to Morphometrics	12
2.1.1	Phase 1: Classical Taxonomy, Evolutionary Theory and Biometry: The Background for Morphometrics	12
2.1.2	Phase 2: Genetics and Statistical Methods in Evolution, Agronomy and Biosystematics	14
2.1.3	Phase 3: Multivariate Statistics and Morphometrics	15
2.1.4	Phase 4: Geometric Morphometrics	17
2.2	Morphometric Analysis of Leaves	19
2.2.1	Analysis of Conventional Botanical Descriptors	20
2.2.2	Analysis of Leaf Outline Shape	21
2.2.3	Analysis of Leaf Margin Patterns	23
2.2.4	Analysis of Homologous Landmarks and Semi-landmark Configurations	23
2.2.5	Fractal Dimensions and Polygon Fitting	24
2.2.6	Analysis of Leaf Venation Patterns	24
2.2.7	Analysis of Leaf Texture	25
2.2.8	Analysis of Other Features of the Leaf Blade	25
2.3	Morphometrics of Flowers and Other Plant Organs	25
2.4	Applications	27
2.4.1	General-Purpose Species Identification	27
2.4.2	Agriculture	29
2.4.3	Intraspecific Variation, Geographical Distribution, Climate, Phylogeny	30
2.5	Summary	31

3 Feature Extraction	33
3.1 Leaf Shape	33
3.1.1 Study of Existing Techniques for Leaf Shape Analysis	34
3.1.2 Evaluation and Results	37
3.2 Leaf Texture	38
3.2.1 Macro-texture	39
3.2.2 Micro-texture	40
3.3 Margin Characteristics	44
3.3.1 Extracting the Margin	45
3.4 Locating the Apex and Insertion Point	47
3.4.1 Dynamic Time Warping	47
3.4.2 Finding the Points of Margin Symmetry	49
3.5 Venation Patterns	50
3.5.1 Extraction by Evolved Vein Classifiers	50
3.5.2 Extraction by Ant Colonies	53
3.5.3 Results and Comparison of Methods	55
3.6 Summary	56
4 Machine Learning for Plant Leaf Analysis	57
4.1 Incorporating Intra-species Variation into Plant Classification	57
4.1.1 Utilizing the Hungarian Algorithm for Improved Classification of Leaf Blades	58
4.1.2 Comparing Leaf Margins Using Dynamic Time Warping	68
4.2 Combining Different Leaf Features	69
4.2.1 Probabilistic Classification from K-Nearest-Neighbour	70
4.2.2 Automatic Feature Selection	73
4.3 Summary	78
5 Botanists' Vision	81
5.1 Comparing the Eye Movements of Botanists and Non-Botanists	82
5.1.1 Results and Analysis	83
5.2 Reverse Engineering of Expert Visual Observations	86
5.2.1 Related Work	87
5.2.2 Methodology	88
5.2.3 Evaluation	92
5.2.4 Summary	95
References	97
Index	111