PLANT LEAF CLASSIFICATION USING SHAPE FEATURES AND BAYESIAN NETWORK

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DECLARATION

I hereby declare that the material used in this thesis is my own except for quotations, excerpts, equations, summaries and references, which have been duly acknowledged.

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ABSTRACT

Environment pollution and overwhelming development by human in recent decades has lead to rise in global warming which cause the plants are at risk of extinction. Therefore, it is very important to have a plant protection plan to manage and archive them from being forgotten by our future generation. With the rapid development of computer technology, plant classification has broken through the traditional methods, rapid identification for plant can be achieved by the image processing and pattern recognition technology with the leaf images provided. There are several features on the leaf that can be used to perform classification. Among of these features, shape is chosen for classification in the research presented in this report because the shape of a leaf is the most distinguishing feature compared to other features. The research presented proposed an approach to classify plant leaf using shape features extracted from the leaf shape images, which will then be forwarded as an input to classifier. A supervised method Bayesian Network that applied search and scoring metrics approach for structure learning is used as classifier. The experiments result is measured in term of average accuracy and standard deviation. The best accuracy obtained from the method proposed is 71.38%. Although the classifier proposed does not perform well, the proposed features are able to produce an accuracy of 83.56% with Neural Network classifier. This result outperformed most of the work in literature reviews that used different features. This shows that the features proposed is capable to produce better accuracy.

ABSTRAK

Pengelasan Tumbuh-tumbuhan Menggunakan Ciri Bentuk dan Rangkaian Bayesian

Pencemaran alam sekitar dan pembangunan bandar yang tidak terhenti-henti oleh manusia dalam beberapa dekad kebelakangan ini telah membawa kepada kenaikan pemanasan global dan seterusnya menyebabkan tumbuh-tumbuhan menghadapi risiko kepupusan. Oleh itu mempunyai pelan perlindungan tumbuhan untuk mengurus dan merekodkan tumbuh-tumbuhan supaya mereka tidak dilupakan oleh generasi yang akan datang adalah sangat penting. Dengan perkembangan yang pesat dalam bidang teknologi komputer, cara klasifikasi tumbuh-tumbuhan telah berevolusi dari kaedah tradisional ke kaedah yang lebih canggih, iaitu tumbuh-tumbuhan boleh dikenal dengan pantas melalui teknik pemprosesan imej dan teknologi pengiktirafan corak dengan imej daun yang disediakan. Terdapat beberapa ciri pada daun boleh digunakan untuk membuat pengelasan. Antara ciri-ciri tersebut, bentuk telah dipilih untuk manjalankan pengelasan dalam penyelidikan yang dibentangkan dalam laporan ini. Ini adalah kerana ciri bentuk daun mempunyai perbezaan paling besar di antara daun-daun dari spesies yang berbeza berbanding dengan ciri-ciri lain. Kajian ini membentang cadangan menggunakan ciri bentuk yang diekstrak daripada imej bentuk daun dan seterusnya digunakan sebagai input kepada pengelas. Kaedah Rangkaian Bayesian dengan pendekatan carian dan pemarkahan metrik telah digunakan sebagai pengelas. Hasil eksperimen akan diukur dari segi ketepatan purata dan sisihan piawai. Keputusan terbaik diperolehi daripada kaedah yang dicadangkan iaitu menggunakan ciri-ciri bentuk diekstrak dan pengelas rangkaian Bayesian, adalah 71.38%. Walaupun ketepatan menggunakan pengelas dicadangkan tidak menunjukkan prestasi yang baik, namun menggunakan ciri-ciri yang dicadangkan mampu mencapai keytepatan 83.56% dengan pengelas Rangkaian Neural. Keputusan ini mengatasi sebahagian besar pekerjaan dalam tinjauan literatur yang menggunakan ciri-ciri berbeza. Ini menunjukkan bahawa ciri-ciri kami mencadangkan lebih mampu dalam manghasilkan ketepatan yang lebih baik

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CHAPTER 1

INTRODUCTION

1.1 Overview

Image processing is a rapidly growing technologies today, with its applications in various aspects of business. Examples of some of the image processing applications are intelligence transportation systems, remote sensing, biomedical imaging techniques and automatic visual inspection system. Used of image processing in applications in different fields can help to save workloads and reduce cost. Thus, more and more fields start to involve image processing applications in their work place, indirectly it also provides opportunity for Artificial Intelligence (AI) research to make improvement or modification on the current applications. Since image processing has been proved to be useful tool for analysis in many fields, so does the agriculture field use it to analysis parameters like canopy, yield, quality of product, leaves, plants. This research will focus on identify plant leaf types by using image classification approaches.

In this section, a simple description of this research entitled "Plant Leaf Classification using shape features and Bayesian Network" is introduced. Section 1.1 contains introduction about the research and gives a general overview about this chapter. Section 1.2 describes problem background of this research and section 1.3 stated the research questions. Section 1.4 states the objective of this research and research scope is presented in section 1.5. The last section 1.5 describes the organization of this report.

1.2 Problem Background

Plants exist in everywhere we live and they are providing us with oxygen, food and medicine. Other than that, plants also help us to regulate climate change, provide shelters and foods to other living organisms. However, due to the rise in global warming effect plants are at risk of extinction. So it is becoming essential to find a viable alternative method in order to protect the plant types from being forgotten by our future generation. One of the effective way is kept records for each of the plant leaf type. So that in future when the plants is facing critical extinction or no longer exist, there still remain records can be provided to people as references for research or education purpose. Records can be made in either hardcopy or softcopy. Hardcopy records are too risky to keep because they are easy to be destroyed or missing. While softcopy, keep in database are not easy to destroy the data. Although there may have accident happen but compare to hardcopy records, the risk is lower.

Nowadays the imaging and digital data storage technology growth rapidly that we can acquire high definition pictures and store them digitally with less monetary cost. Other methods such as biological method: cell biology and molecule biology, that based on biological characteristics of the plants like cells and tissues structure, or genetics and plants Deoxyribonucleic Acid (DNA) structure of plants required a set of complicated processing steps and expert in that field to work on it all the time. Thus, when compared with biological method, automated or semi-automated leaf images labelling using intelligent systems is the prior choice for users and attract lots of researches in related field. (Agarwal *et al.*, 2006; Zulkifli *et al.*, 2011; Wu *et al.*, 2007).Such systems helps to save man power, botanist expert could reduce their workloads since the system will help them to do the classification.

There are several parts of a plant that can be used to identify plants. Among of these features, leaf is an easier and accurate way to identify plants since leaves are considered as one of the important features to characterize plant species. The classification of plant based especially on leaves is a very challenging task due to the high similarity inter–class and low similarity of intra-class (H. Ling and D.W.

Jacobs. 2009). However, the leaf is an important characteristic of the plant for plant classification which can be collected easily at any season or any stage of plant maturity. Thus, the ability to recognize variations of leaf is still an open challenge for research area to focus on the ability to achieve high accuracy for leaf classification. There are many type of approaches can be applied to classify the extracted plant leaf such as neural network, K-nearest-neighbor, Support Vector Machines and etc. Generally, the classification problems often use empirical method to construct mapping rules. The main problem of applying this method is the lack of sufficient information to construct 100% of correct mapping rules, this lead to a condition where uncertainty occurred. To solve this problem, Bayesian Network will be used to perform the identification for plant leaf based on leaf shapes images. Bayesian Network classifier is based on Bayes' theorem which applied conditional probability in the learning phase to achieve a certain probability sense of correct classification. Conditional probability in Bayes' Theorem helps to solve the uncertainty encounter by classifier which used empirical method.

1.3 Research Questions

There are many aspects need to be concerned in building a Bayesian Network classifier for plant leaf classification. The motivation is to produce a leaf classification approach using leaf shape images and Bayesian Network. In this research, binary leaf shape images are used to extract features. Two research questions derived from the identified motivation:

I. What are the features that can be extracted from the binary leaf shape images that best represents the leaves?
II. How Bayesian Network method can best be tuned to classify leaf images using the features extracted in (I)?

1.4 Research Objectives

The identified research questions give raised to three research objectives:

I. To investigate and identify feature extraction technique applied on the binary leaf shape images that can be used to enrich the shape feature representation of plant leaves.

II. To fine-tune parameters that maximize the predictive accuracy of Bayesian Network in classifying plant leaves.

III. To compare the performance of proposed approach with other approaches found in the literature reviews.

1.5 Research Scopes

I. The research is set to investigate only Bayesian Network to plant leaf classification using shape of leaf and then compare this approach with other approaches.

II. The dataset used is secondary dataset, which is the data was not collected directly through ourselves experiment but is get it online or from other researcher. Since secondary dataset is used in this research, so there might be other researchers are using the same dataset to conduct research too. The details of the dataset used is described in the following subsection 1.5.1.

1.5.1 Dataset

The plant leaves dataset (binary leaf images) used in this research is secondary type dataset. The original owners of this dataset are Beghin *et al.* (2010). The leaves were collected in the Royal Botanic Gardens, Kew, UK. It consists leaves of 100 plant species and there are 16 instances per species, accumulating to 1600 leaf shape images. Thus, there are total of 1600 samples will be used in this research. All image data in dataset contains the binary form of the leaf samples. The color image is not included in the leaf samples. Besides, all the leaf samples have been labeled with its respective types and organized according to its relative feature vectors. There are three set of extracted features that come along with the dataset. These features are shape, margin and texture.

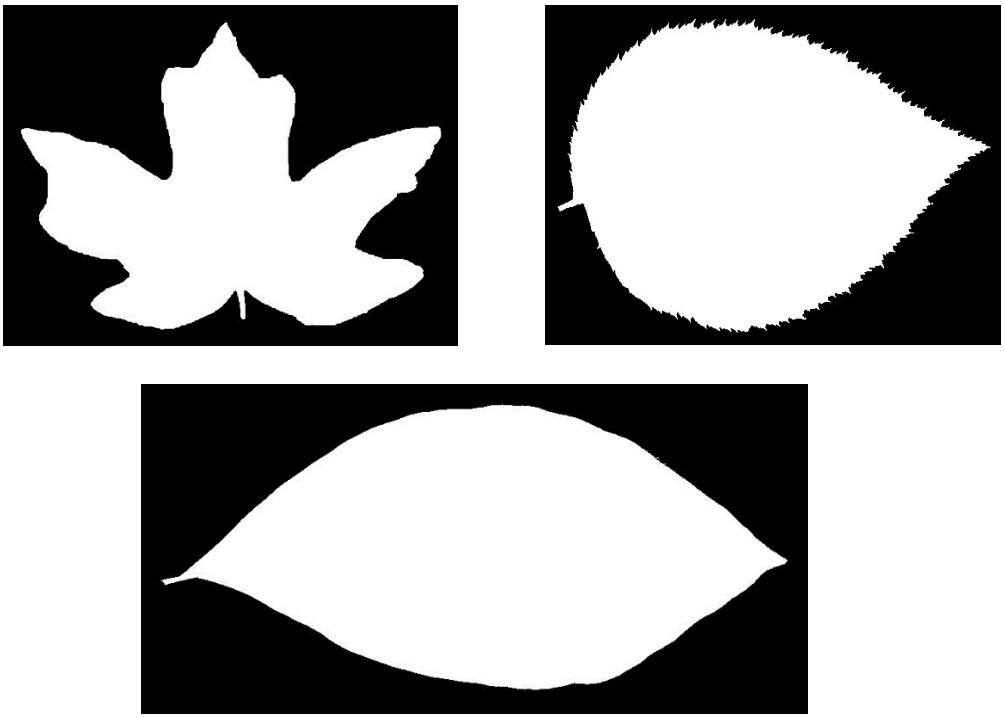

Figure 1.1 Examples of binary leaf shape images from the dataset.

1.5.2 Features Used in Plant Leaves Classification

There are many characteristics on leaves can be used to identify the plant such as shape, texture, color, and margins. Among all of the leaf characteristics, shape analysis will be used as input for Bayesian Network classifier to perform the classification for plant leaf in this research.

1.6 Organization of Report

The report consists of six chapters in total.

- **Chapter 1 Introduction:**
  In this chapter, a general overview of the research is provided which include the introduction of the research, problem background, problem statement, objectives, research scope and organization of the report.

- **Chapter 2 Literature review:**

  In this chapter, research papers that related to this research is reviewed. A brief description about the techniques and methods used in this research is included in this chapter too. Then a conclusion for all the literature reviews in attached at the end of this chapter.

- **Chapter 3 Methodology:**

  This chapter describes image processing, feature extraction techniques used, and the method used to train and test the Bayesian Network classifier. The performance measurements are highlighted in this chapter too.

- **Chapter 4 Implementation:**

  The details of this research experiment setup is discussed here. It provides a clear explanation on the feature extraction steps and experiment settings. Besides, this chapter also does contain pseudo code and flow chart of this research.

- **Chapter 5 Results and Analysis:**

  Chapter 5 is about the result of the experiments carried out in the research. For each set of experiment, the result will be displayed in table form, then result analysis is done.

- **Chapter 6 Conclusion:**

  This chapter summarizes the research and results obtained from the previous chapters and also the future works are discussed.

CHAPTER 2

LITERATURE REVIEW

2.1 Overview

This chapter reviews relevance work that have been done previously by other researchers which is involving plant leaf classification. This chapter contains five sections. At the beginning of this chapter, section 2.1 provide an overview of the organization of this chapter and section 2.2 will introduce about automated plant leaf recognition. Section 2.2 is divided into three sub-sections for analysis of related work on the approaches that have been used by other researchers in solving plant leaf recognition problems. Section 2.3 introduces the feature selection techniques that will be applied in the research. For this research, Bayesian Network will be used for the recognition of the leaves, so a brief introduction about Bayesian Network methods is discussed in section 2.4. Then follow by section 2.5 which describes the strength of plant leaf classification using Bayesian Network and section 2.6 will discuss the platform and parameters use in the research. Last, the summary of this chapter is included in section 2.7.

2.2 Plant Leaf Recognition

Traditional plant leaves identification can be performed manually by botanist expert but it is time consuming and less effective. Thus, automated plant leaf classification is important towards the people whose working in plant leaves field. Many characteristics on leaves such as shape, texture, and venation can be used as features for plant leaf classification. Many studies on automated plant leaf classification using plant leaf image has been done by researchers. Among these studies, various leaf characteristics is/are used to conduct the computer-aided plant

classification system. There are works which consider only shape (Zulkifli *et al.*, 2011; Wu *et al.*, 2007; Hossain *et al.*, 2010; Uluturk *et al.*, 2012, Du *et al.*, 2005; Florindo *et al.*, 2010; Amina *et al.*, 2013), texture (Cope *et al.*,2010; Backes *et al.*,2009) or color information, or take more than one leaf characteristics (Backes *et al.*, 2010; Huang *et al.*, 2008; Zhang *et al.*, 2008; Beghin *et al.*, 2010, Zhang *et al*, 2012; Tsolakidis *et al.*, 2014; Caglayan *et al.*, 2013; Malleh *et al.*, 2013; Rahmani *et al.*, 2015) for classification.

2.2.1 Leaf Classification Using Shape Features

Among several of the leaf characteristics, shape is the most common features used in leaf image classification. A number of related works have been carried out in analyzing leaf shapes for plant leaf classification. There are a few techniques being introduced in the past few years to improve the performance of leaf recognition using leaf shapes.

Zulkifli, Saad and Mohtar (2011) focused on studies the effectiveness of different moment invariants techniques in extracting region-based shape features from leaf images. These techniques are Zernike Moment Invariant (ZMI), Legendre Moment Invariant (LMI) and Tchebichef Moment Invariant (TMI). After that the feature information from the most effective moment invariants technique are classified using General Regression neural network (GRNN). At the end of the experiment, TMI is found to be the most effective feature extraction technique and the features extracted using TMI were classified using GRNN classifier with 100% correct classification rate.

Wu, Bao, Xu, Wang, Chang and Xiang (2007) use leaf shape features information to classify the leaf too. They employed Probabilistic Neural Network (PNN) for leaf recognition. Five basic geometric features of leaf are extracted, they are diameter, physiological length, physiological width, leaf area and leaf perimeter. Then, 12 digital morphological features (DMFs) are derived from these five basic geometric features. The geometrical features information then are trained and

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