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# Utilizing venation features for efficient leaf image retrieval

JinKyu Park [a], EenJun Hwang [a,*], Yunyoung Nam [b]

[a] School of Electrical Engineering, Korea University, Anam-dong, Seongbuk-Gu, Seoul, Republic of Korea
[b] Graduate School of Information and Communication, Ajou University, Wonchon-dong, Youngtong-Gu, Suwon, Kyunggi-Do, Republic of Korea

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**Abstract**

Most Content-Based Image Retrieval systems use image features such as textures, colors, and shapes. However, in the case of a leaf image, it is not appropriate to rely on color or texture features only as such features are very similar in most leaves. In this paper, we propose a new and effective leaf image retrieval scheme. In this scheme, we first analyze leaf venation which we use for leaf categorization. We then extract and utilize leaf shape features to find similar leaves from the already categorized group in a leaf database. The venation of a leaf corresponds to the blood vessels in organisms. Leaf venations are represented using points selected by a curvature scale scope corner detection method on the venation image. The selected points are then categorized by calculating the density of feature points using a non-parametric estimation density. We show this technique's effectiveness by performing several experiments on a prototype system.


*Keywords:* Leaf image retrieval; CBIR; Classification; Venation; Parzen window

## 1. Introduction

In the last few years, due to the development of digital devices, computers, and network technologies, generating, processing and sharing digital images have become very popular. Consequently, huge amounts of digital images are available. As the number of digital images has increased, the need for sophisticated image retrieval has become extremely desirable. Traditional image retrieval applications have relied on textual information such as file names or keywords describing the image. However, as digital images are becoming so voluminous in number, attaching and memorizing such text information is not manageable any more by human beings. To help alleviate this problem, researchers are working on Content-Based Image Retrieval (CBIR) systems. For example, a CBIR can detect the main objects in an image and then generate automatically some useful information describing those objects including shapes, textures, and colors.

CBIR techniques have many diverse applications. Because of the vast popularity of hand-held devices with any where any place applications, CBIR techniques running on these devices can contribute to the strong trend of ubiquitous information retrieval. For example, during a field trip or visit to a botanical garden, people may encounter some unfamiliar plant. Instead of having to wait until they return home to look up the plant in a botanical book for detailed information or instead of having to carry a set of books with them, these people can get specific information on the spot by either drawing or taking a picture of it with their hand-held device and then using the drawing or picture as input to a query to a remote database by means of their PDA's wireless connection (Kim et al., 2005). As another example, if someone is on a fishing trip and wants to know immediately about the identification of some fish and some specific information about this fish that he has just caught, then he may rely on some CBIR technique by describing the fish's features to an application on his PDA. This application will then, based on the

* Corresponding author. Tel./fax: +82 2 32903256.
*E-mail addresses:* saanin@korea.ac.kr (J. Park), ehwang04@korea.ac.kr (E. Hwang), youngman@ajou.ac.kr (Y. Nam).

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supplied information of features, provide him with information about the fish (Sonobe et al., 2004).

For effective Content-Based Image Retrieval, the CBIR system needs to figure out and then represent most effective feature points from an image and based on those features, provide a match with any similar images from the database. Content-Based Image Retrieval typically uses images' features such as textures, colors, or shapes.

In the case of a leaf image, it may not be appropriate to rely on color or texture features because such features are similar in almost all leaves of many different varieties. Instead, leaf shapes can provide some clue to finding a fewer number of similar varieties. In addition, if we examine the leaf venation, we can easily figure out that specific varieties of leaves have distinct venation patterns. The leaf's venation corresponds to patterns of blood vessels of organisms. In this paper, we propose an original leaf image retrieval scheme which first analyzes the image for the leaf's venation for a first level of leaf categorization and then extracts and utilizes shape features from the image to find similar leaf images from the corresponding categorized group in the database. Leaf venations are represented using points which are selected by the curvature scale scope corner detection method on the leaf's venation image. Categorization is performed by calculating the density of feature points using a non-parametric estimation density.

The rest of this paper is organized as follows. Section 2 introduces related work. Section 3 describes a venation-based leaf image categorization scheme which collects the leaf venation's feature points and then calculates their distribution using the Parzen window (Parzen, 1962). Based on this distribution, the type of leaf venation is identified. Section 4 describes several experiments. The last section concludes the paper and discusses future work.

## 2. Related work

Well-designed image retrieval tools enable people to make more efficient uses of collections of digital images. Typical image retrieval systems in the late 1970s were mainly based on keyword annotation. This approach suffered from many difficulties including the vast amounts of human labor required to provide the annotations and the challenging problem of maintaining annotation consistency among images in large databases. In order to overcome these difficulties, there has been extensive research in the last decade on Content-Based Image Retrieval (CBIR). Examples of some of the prominent systems using this approach are VIRAGE (Hamrapur et al., 1997), QBIC (Niblcack et al., 1993), Photobook (Pentland et al., 1994), and VisualSEEk (Smith and Chang, 1996).

In many CBIR systems, an image is represented by low level features such as color, texture, and shape. Relevant images are retrieved based on the similarity of their image features. A color histogram of an image is frequently used as a color feature. This approach is simple and quick to process. However, this feature represents only a global property of an image. Generally, it is hard to describe a local property such as the shape and direction of an object in an image. Chan and Chen (2004) proposed a color-complexity feature and a color-spatial feature to solve these problems. Texture features can be obtained by applying a Wavelet Transform to an image. This technique is used in several image analysis applications including texture classification and segmentation, image recognition, image registration, and motion tracking (Manjunath and Ma, 1996). In particular, shape-based image retrieval is regarded as an efficient and interesting approach. For example, shape recognition methods have been proposed and implemented for use in face recognition, iris recognition, and fingerprint recognition. In cases where images show similar color or texture, shape-based retrieval can be more effective than other approaches using color or texture. For instance, leaves of most plants are green or brown; but the leaf shapes, themselves, are usually distinctive and can thus be used for identification.

There are shape representation schemes which extract feature values or vectors from an image. These schemes identify an object from an image by extracting its contour and then representing the contour as feature vectors. In these schemes, we should concentrate on some conditions. For example, if we take pictures of an object varying the position of the camera, objects appear a little different from each other in the pictures. The scale of an object in the picture depends on the distance between the camera and the object. The object may be translated or rotated based on the direction from the camera to the object. Though an image is translated, rotated, or scaled, it is good to keep the feature values unchanged in order to identify the object consistently. In other words, the feature values should be invariant to image translation, rotation, and scaling. In this section, we introduce some shape representation schemes, chain-codes, the Fourier descriptor, the Center–Contour Distance Curve (CCD), the Minimum Perimeter Polygon (MPP), and the CSS.

Chain-codes represent a contour as a connected sequence of line segments. The line segments have predefined lengths and directions. There are two types of chain-codes according to the number of directions, four-directional chain-codes and eight-directional chain-codes (Gonzalez and Woods, 2002). Fig. 1 shows these two types of chain-codes. They use numbers to represent directions. There is some research involving representing a leaf contour with eight-directional chain-codes. One of the weaknesses of chain-codes is that a noise in a contour cause changes in the code. A leaf has small teeth at its boundary. These teeth can be considered as noises in shape representation. Gouveia et al. (1997) use a heuristic way: if the angle of the apex is less then 155°, then the apex point is a tooth and is removed from the chain-codes sequence. In this step, chain-codes representation presents an easy angle measuring scheme.

Lee et al. (2003) select Fourier descriptors as a feature vector of an image. They (Lee et al., 2003) approximate a