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A STUDY ON MULTIMODAL BIOMETRIC SYSTEMS AND TAXONOMIC IDENTIFICATION OF PLANT SPECIES

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ABSTRACT:

Multimodal Biometric systems play a key role in identification and sometimes in classification of all types. The research is mainly aimed at considering prior researches and presenting the working status and to extend the concepts for Taxonomic identification of plant species. Here, we conduct a review on current state of the art in multimodal biometric systems and methods of identifying plant species.

Keywords: Pattern recognition, local and global features, feature hierarchies, plant biometrics, multi sample and multi algorithm biometrics, leaf shapes, margins, apexes and bases, unimodal systems.

1. INTRODUCTION

Identification using biometrics is based on recognizing patterns[1] of a particular classification system. The system recognizes an individual by determining its correctness using a specific physiological or behavioral characteristic. A number of biometric systems are commercially available for human recognition in the market but, there is no such a biometric system for plant recognition, even though they have many characteristics that are uniquely identifiable at a species level. The goal of the study is to develop a plant species biometric using both global and local features of leaf images.

Various approaches have been proposed for characterizing leaf images. Most of them were based on a global representation of leaf peripheral with Fourier descriptors, polygonal approximations and centroid contour distance curve[15,17,18]. Global representation of leaf shapes does not provide enough information to characterize species uniquely since different species of plants have similar leaf shapes. Others were based on leaf vein extraction using intensity histograms and trained artificial neural network classifiers. Leaf venation extraction[16] is not always possible since it is not always visible in photographic images.

This study proposes a novel approach of leaf identification based on feature hierarchies. First, leaves were sorted by their overall shape using shape signatures. Then this sorted list will be pruned based on global and local shape descriptors. The consequent biometric will be tested using a corpus of leaves, which encompass all categories of local information of leaf peripherals.

Two novel shape signatures full-width to length ratio distribution and half-width to length ratio distribution are proposed and biometric vectors will be constructed using novel shape signatures[18,19], complex-coordinates and centroid-distance for comparison. Retrievals will be compared and the biometric vector based on full-width to length ratio distribution is to be found to be the best classifier. Three types of local information of the leaf peripheral such as leaf margin coarseness stem length to blade length ratio and leaf tip curvature and the global shape descriptor, leaf compactness, will be used to prune the list further[17].

The biometric can be strengthened by adding reference images of new species to the database, or by adding more reference images of existing species when the reference images are not enough to cover the leaf shapes.

2. INTRODUCTION TO PLANT BIOMETRIC

Biometric identification is a pattern recognition based classification system that recognizes an individual by determining its authenticity using a specific physiological or behavioral characteristic[18]. In human recognition, fingerprints, face, iris, speech, gait and hand geometry are the most commonly used biometrics. In contrast, for plants, even though they have many characteristics that are uniquely identifiable at a species level, there is no such a biometric system for plant identification.

Living plant recognition is a promising but challenging task in the field of pattern recognition and computer vision. In recent years, various approaches have been proposed for characterizing leaf images. Global representation of leaf shapes alone does not provide enough information to characterize species uniquely since different species of plants have similar leaf shapes[19]. Others were based on leaf vein extraction using intensity histograms and trained artificial neural network classifiers. Leaf venation extraction[16] is not always possible since it is not always visible in photographic images.

To overcome such impoverished global representation of overall leaf shape in prior research, this study proposes the extraction of local information of the leaf contour, which is shape of the leaf margin, shape of the leaf base and shape of the leaf apex. The study also proposes to look at other representations such as shapes of flowers or similar features.

The biometric system that has been developed to extract the uniquely identifiable global and local features of leaves efficiently is described in this study.

Biometric systems are introduced in the coming sections, they describe the plant species biometric and the proposed solution respectively. Objectives of the study are shown later and this outlines the reminder of the study.

3. BIOMETRICS AND BIOMETRIC SYSTEMS

Identification using biometric methods is based on recognizing patterns of a particular classification system, which is called a biometric[1]. Verification systems either reject or accept the submitted claim of identity by comparing it with the pre-stored data of the same individual while identification systems recognize an individual by searching the matching queried biometric in the entire database. In human context, a variety of biometrics is in use in various applications.

However, whatever the biometric is, it should be universal (each individual should have that biometric), distinctive (biometric should be unique to each individual), permanent and collectable (it can be measured quantitatively).

The Problem: Plant Species Recognition

Plants are basically identified according to their morphological features such as number of ovaries in the fruit or number of stamens in the flower. A number of manual and computer-aided keys for plant identification using morphological features[18,19] are available in the literature. Identifying plants using such keys is a very time consuming task and has been carried out only by trained botanists. However, in addition to this time intensive task, there are several other drawbacks in identifying plants using these features such as the unavailability of required morphological information and use of botanical terms that only experts can understand. Fortunately, in addition to the shapes and structures of reproductive organs, shape, size, texture and color of the leaves also play an important role in plant identification? Although almost all the broadleaf species have unique features in their leaves, there is no identification method that completely relies on the leaves itself in the existing literature and no botanist will agree on such a system. This may be perhaps due to the difficulty in explaining the “exact” features (shape, texture, color, size etc.) in the leaves of each species literally or lack of clear definitions to the available technical terms that describe these features.

In plant identification, taxonomists classify overall leaf shape as shape of the leaf edge, shape of the leaf apex and base as broader categories[19].

Common leaf shapes are:

1. Linear 2. Oblong 3. rhombic
4. Lanceolate 5. Ovate 6. Elliptic
7. Obovate 8. Cuneate 9. Spatulate
10. Oblanceolate 11. Orbicular
12. Reniform 13. Cordate 14. Deltoid
15. Hastate 16. Sagittate

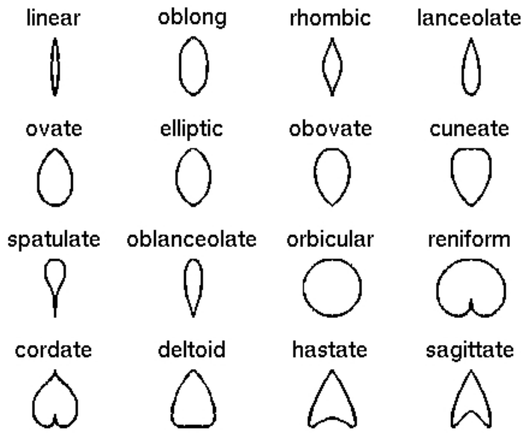

Fig 1: Common leaf shapes

Common leaf margins are:

1. Revolute 2. Entire 3. Repand
4. Senuate 5. Crenate 6. Serrate
7. Doubly Serrate 8. Dentate
9.Denticulate 10. Aculeate 11. Lobed
12. Cleft 13. Incised 14. Palmately lobed

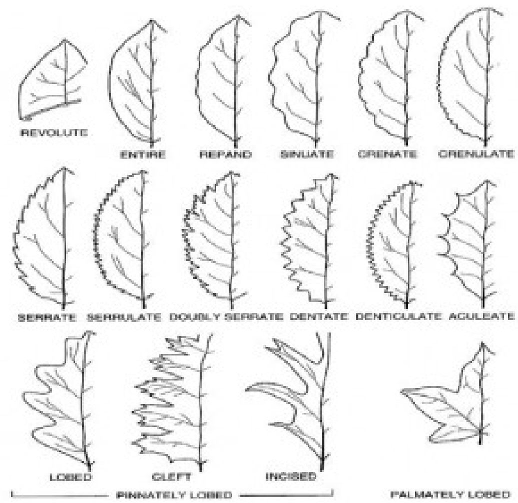

Fig 2: Common leaf margins

Common leaf apexes are:

1. Cuspidate 2. Acute 3. Emarginate
4. Mucronate 5. Aristate 6. Obocordate
7. Acuminate 8. Retuse 9. Obtuse
10. Rounded

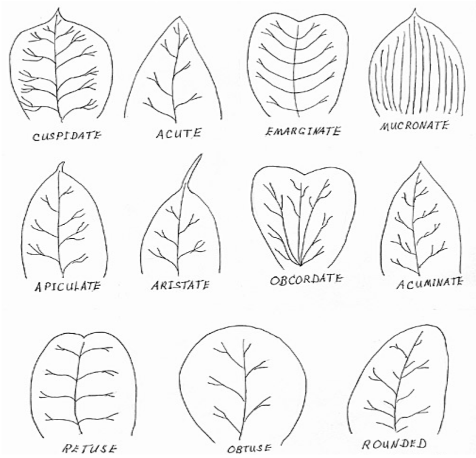

Fig 3: Common leaf apexes

Common leaf bases are:
1. Cuneate 2. Obtuse 3. Cordate
4. Truncate 5. Oblique

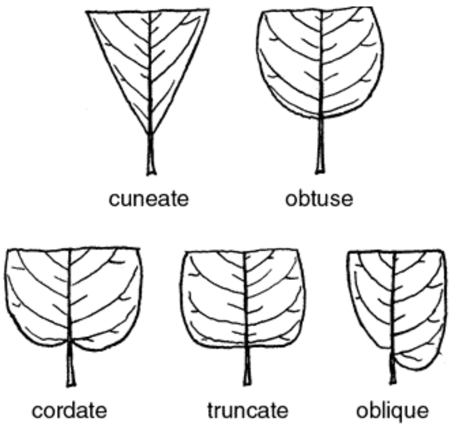

Fig 4: Common leaf bases

These categories are described basically by visual shapes and the definitions of these shapes have no clear demarcations. Therefore, in some situations it is very difficult to classify leaves into these categories.

4. INTRODUCTION TO MULTI MODAL BIOMETRICS

Biometrics refers to the physiological or behavioral characteristics of a person to identify their identity. The increasing demand of enhanced security systems has led to an unprecedented interest in biometric based identification systems. Biometric systems based on single source of information are called unimodal systems. Although some unimodal systems have got considerable improvement in reliability and accuracy, they often suffer from enrolment problems due to non-universal biometrics traits, susceptibility to biometric spoofing or insufficient accuracy caused by noisy data.

Hence, single biometric may not be able to achieve the desired performance requirement in real world applications. One of the methods to overcome these problems is to make use of multimodal biometric authentication systems[2,4,7], which combine information from multiple modalities to arrive at a decision. Studies have demonstrated that multimodal biometric systems can achieve better performance compared with unimodal systems.

This work proposes the study of multimodal biometrics for plant species identification. The different fusion techniques of multimodal biometrics will be studied.

5. MULTI ALGORITHM AND MULTI SAMPLE APPROACH

Multi algorithm approach employs a single biometric sample acquired from single sensor. Two or more different algorithms process this acquired sample. The individual results are combined to obtain an overall recognition result. This approach is attractive, both from an application and research point of view because of use of single sensor reducing data acquisition cost.

Multi sample or multi instance algorithms use multiple samples of the same biometric[10]. The same algorithm processes each of the samples and the individual results are fused to obtain an overall recognition result. In comparison to the multi algorithm approach, multi sample has advantage that using multiple samples may overcome poor performance due to one sample that has unfortunate properties. Acquiring multiple samples requires either multiple copies of the sensor or the user availability for a longer period of time. Compared to multi algorithm, multi sample seems to require either higher expense for sensors, greater cooperation from the user, or a combination of both.

6. MULTIMODAL BIOMETRICS

The term "multimodal" is used to combine two or more different biometric sources of a plant sensed by different sensors[4]. Two different properties of the same biometric can also be combined. In orthogonal multimodal biometrics, different biometrics are involved with little or no interaction between the individual biometric whereas independent multimodal biometrics processes individual biometric independently. Orthogonal biometrics are processed independently by necessity but when the biometric source is the same and different properties are sensed, then the processing may be independent, but there is at least the potential for gains in performance through collaborative processing. In collaborative multimodal biometrics the processing of one biometric is influenced by the result of another biometric.

A generic biometric system has sensor module to capture the trait, feature extraction module to process the data to extract a feature set that yields compact representation of the trait, classifier module to compare the extracted feature set with reference database to generate matching scores and decision module to determine an identity or validate a claimed identity.

In multimodal biometric system information reconciliation can occur at the data or feature level, at the match score level generated by multiple classifiers pertaining to different modalities and at the decision level [4-8].

Biometric systems that integrate information at an early stage of processing are believed to be more effective than those which perform integration at a later stage. Since the feature set contains more information about the input biometric data than the matching score or the output decision of a matcher, fusion at the feature level is expected to provide better recognition results. However, fusion at this level is difficult to achieve in practice because the feature sets of the various modalities may not be compatible and most of the commercial biometric systems do not provide access to the feature sets which they use. Fusion at the decision level is considered to be rigid due to the availability of limited information. Thus, fusion at the match score level is usually preferred, as it is relatively easy to access and combine the scores presented by the different modalities.

Researchers have also investigated the use of quality metrics to further improve the performance. Many of these techniques require the scores for different modalities (or classifiers) to be normalized before being fused and develop weights for combining normalized scores. Normalization and quality weighting schemes involve assumptions that limit the applicability of the technique. In Bayesian belief network (BBN) based architecture for biometric fusion applications is proposed. Bayesian networks provide united probabilistic framework for optimal information fusion. Although Bayesian methods have been used in biometrics, the power and flexibility of the BBN has not been fully exploited.

7. A SOLUTION: PLANT SPECIES BIOMETRIC

Based on the study it is possible to develop a plant species biometric which will use both global and local features that are specific to leaf images of different species[17]. The study can mainly focus on the extraction of local information of the leaf contour characters, which is shape of the leaf margin, shape of the leaf base and shape of the leaf apex. In leaf contours, these characters satisfy all the biometric requirements: universality, distinctiveness, permanence and collectability, mentioned above.

Development of a Multi algorithm biometric system for visual plant identification will help professionals as well as non-professionals to identify plants efficiently and accurately.

Compared to the complex structures of flowers and fruits, leaves are simpler and easily available. On the other hand, leaves of plants are planar and input of their shapes is easy and so the motivation for this research is a system to recognize the unique features of leaves that will be a solution to problem of identifying plants using morphological features. Such a system will promote an interest in studying plant taxonomy and dendrology, and will lift the school biology education standards at various levels. Furthermore, the findings can contribute to enhance the knowledge in the area of computer-aided pattern recognition.

Objectives of the study:

As mentioned above, the goal of this study is to propose a Multi Algorithm biometric system to identify plants using leaf patterns beyond overall leaf shape alone, which prior research has shown to be insufficient for classification.

There are three main objectives.

1. Analysis of existing pattern recognition techniques to identify the techniques and algorithms that can be used to detect leaf contours accurately, to represent the leaf margins preserving both global and local features and to match the leaf shapes efficiently.
2. Propose and develop a method to separate and to quantify the singularities on the leaf contour. Singularities of a leaf contour are the shape of the entire leaf, shape of leaf apex, shape of leaf margin and shape of leaf base.
3. Identify and extract the other parameters from the leaf image that can be used to differentiate leaves. These parameters will be based on leaf size, texture and color.
4. Apply the obtained results to different algorithms and sample the results to create an accurate method of identification.

8. CHALLENGES AND RESEARCH AREAS

Based on applications and facts presented in the previous sections, followings are the challenges in designing the multi modal systems. Successful pursuit of these biometric challenges will generate significant advances to improve safety and security in future missions. The sensors used for acquiring the data should show consistency in performance under variety of operational environment. Fundamental understanding of biometric technologies, operational requirements and privacy principles to enable beneficial public debate on where and how biometrics systems should be used, embed privacy functionality into every layer of architecture, protective solutions that meet operational needs, enhance public confidence in biometric technology and safeguard personal information.

The multimodal biometric systems can be improved by enhancing matching algorithms, analysis of the scalability of biometric systems, followed by research on scalability improvements and quality measures to assist decision making in matching process. Open standards for biometric data interchange formats, file formats, applications interfaces, implementation agreements, testing methodology, adoption of standards based solutions, guidelines for auditing biometric systems and records and framework for integration of privacy principles are the possible research areas in the field.

9. CONCLUSIONS

This study presents the various issues related to multi algorithm biometric systems. By combining multiple sources of information, the improvement in the performance of biometric system is attained. Various fusion levels and scenarios of multi algorithm systems are discussed.

Fusion at the match score level is the most popular due to the ease in accessing and consolidating matching scores. Performance gain is pronounced when uncorrelated traits are used in a multi algorithm system. The challenges faced by multi algorithm biometric system and possible research areas will also be discussed in the research.

REFERENCES

[1] A. K. Jain, A. Ross and S. Prabhakar, "*An introduction to biometric recognition*". IEEE Transactions on Circuits and Systems for Video Technology, vol. 14, pp. 4–20, Jan 2004.

[2] A.K. Jain, A. Ross, "*Multibiometric systems*". Communications of the ACM, vol. 47, pp. 34-40, 2004.

[3] Phillips, P.J., P. Grother R.J. Michaels, D.M. Blackburn and E. Tabassi and J.M. Bone, "FRVT 2002: overview and summary", March 2003.

[4] A. Ross, A.K. Jain, "*Multimodal Biometrics: An Overview*", 12th European Signal Processing Conference (EUSIPCO), Vienna, Austria, pp. 1221- 1224, 9/2004. Prof. V. M. Mane and Prof. (Dr.) D. V. Jadhav International Journal of Biometrics and Bioinformatics (IJBB), Volume 3, Issue 5 94

[5] L. I. Kuncheva, C. J. Whitaker, C. A. Shipp, and R. P. W. Duin, "*Is independence good for combining classifiers?*". in Proceedings of International Conference on Pattern Recognition (ICPR), vol. 2, (Barcelona, Spain), pp. 168–171, 2000.

[6] L. Rukhin, I. Malioutov, "*Fusion of biometric algorithms in the recognition problem*". Pattern Recognition Letter, pp. 26, 679–684, 2005.

[7] P. Verlinde, G. Chollet, M. Acheroy, "*Multimodal identity verification using expert fusion*". Information Fusion, vol. 1 (1), pp. 17-33, 2000.

[8] B. Gutschoven, P. Verlinde, "*Multimodal identity verification using support vector machines (SVM)*".Proceedings of the Third International Conference on Information Fusion, vol. 2, pp. 3–8, 2000.

[9] K. Nandakumar, Y. Chen, A.K. Jain, S.C. Dass, "*Quality-based score level fusion in multibiometric systems*". Proceedings of the 18th International Conference on Pattern Recognition (ICPR06), pp. 473–476, 2006.

[10] R. W. Frischholz and U. Dieckmann, "*Bioid: A multimodal biometric identification system*".IEEE Computer, vol. 33, no. 2, pp. 64–68, 2000.

[11] Abbasi, S., Mokhtarian, F., Kittler, J., 1997. *Reliable Classification of Chrysanthemum Leaves through Curvature Scale Space*, Proceedings of the First International Conference on Scale-Space Theory in Computer Vision, Utrecht, The Netherlands, July, pp. 284-295.

[12] Chang, J., Fan, K., 2002. *A new model for fingerprint classification by ridge distribution sequences*, Pattern Recognition, 35, pp. 1209-1223.

[13] Chi, Z., Houqiang, L., Chao, W., 2003. *Plant Species Recognition based on Bark Patterns Using Novel Gabor Filter Banks*, IEEE International Conference on Neural Networks and Signal Processing, Nanjing, China, December, 14(17), pp. 1035-1038.

[14] Cunha, J.B., 2003. *Application of image processing techniques in the characterization of plant leafs*, IEEE International Symposium on Industrial Electronics, 1(1), 9-11 June, pp. 612 – 616.

[15] Fu, A., Yan, H., Huang, K., 1997. *A curve bend function method to characterize contour shapes*, Pattern Recognition 30 (10), pp. 1661-1671.

[16] Fu, H., Chi, Z., 2003. *A two-stage approach for leaf vein extraction*, IEEE International conference on neural networks & signal processing, pp. 208-210.

[17] Im, C. Nishida, H. Kunii, T.L., 1998. *Recognizing plant species by laef shapes – A case study of the Acer family*, Proceedings of Fourteenth International Conference on Pattern Recognition, 2, pp. 1171-1173.

[18] Mokhtarian, F., Abbasi, S., 2004. *Matching Shapes With Self-Intersections: Application to Leaf Classification*, IEEE Transactions on Image Processing, 13(5), pp. 653-661.

[19] Nam, Y., Hwang, E., 2005. *A Shape-Based Retrieval Scheme for Leaf Images*, Lecture Notes in Computer Science 3767, Y.-S. Ho and H.J. Kim (Eds.), Springer- Verlag, pp. 876-887.