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Plant Recognition System based on Leaf Images: A Systematic Literature Review

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Abstract: Plant plays a vital role in the environment. Nature has enormous members of plants, identifying them and classifying them is an important task for botanists. They are still finding difficulties in recognizing those plants and it is complex, time-consuming, and due to the use of specific botanical terms, frustrating for the non-experts. There are various ways to recognize a plant, like a flower, root, leaf, fruit, etc. But usually, plants are recognized by leaf and their characteristics like shape, texture, vein structure, color, etc. The availability of relevant technologies, such as digital cameras, new techniques in image processing and pattern recognition thoughts, leads to researching plant leaf recognition systems using image processing techniques rather than using the other parts of the plants. Searching of research papers related to the domain was done in the IEEE computer society digital library, Springer Link, Science Direct, ACM Digital Library, Academia, and other research sites using the search terms like plant leaf identification, plant leaf prediction, plant leaf classification, plant leaf recognition, and image processing techniques. Then started to work on the Systematic Literature Review (SLR) with forty research papers; out of forty, most articles are related and some are not related. Then these articles are filtered and sorted to SLR. Nineteen papers which are published in the past ten years and mostly related to my topic and methodology, were selected to perform SLR. Then the methodologies of the studies were analyzed to identify different preprocessing and feature extraction methods that researches have employed to identify leaves. Then classification accuracy was compared with related papers and traced the optimal range of the accuracy for leaf recognition, which will be the benching accuracy level for the suggested study.

Keywords: plant leaf recognition, image processing techniques, feature extraction, systematic literature review

Introduction

Plants are the essential natural sources of the earth. Plants play a crucial role in human life by providing shelter and by maintaining a healthy breathable environment. There will be no existence of the earth's ecology without plants. However, recently, several species of plants are at the danger of extinction. To protect plants, a plant database classification is essential. In a manual identification process, botanist uses different plant leaf characteristics as identification keys such as shape, texture, vein structure, color, etc. But this manual process took more time and complex to adapt. To handle such issues of information about plant leaf, the development of a rapid and competent classification techniques has become an active area of research. An image classification process can generally be divided into the following steps, such as Image Acquisition, Preprocessing, Feature Extraction, and Description and Classification. So these techniques can help the plant classification accurately. This paper discusses the existing feature extraction

techniques and classification techniques in the state of the art and proposed a novel method for plant leaf classification.

SLR is a preliminary study since it only focused on articles in IEEE explore, Springer Link, google scholar, Science Direct. Although the main reasons for this limitation come from our financial and time issues, we can easily guarantee the quality of articles in our review by this limitation. SLR focused on related researches done by various researchers. So it's very helpful to continue doing this research because it includes various research paper's methodologies, technologies, limitations, results, and future works. SLR is a useful tool to know such trends. We thus performed SLR on traceability and report the results in this paper. Before performing SLR, we had several biases in traceability researches according to our daily research activities.

Systematic Liretaure Review

SLR is a useful tool to know trends in the plant leaf recognition system while helping to find the most relevant papers within the research domain. It involves identifying, evaluating, and interpreting available research relevant to a certain research question. In our SLR, we are posing the following research questions;

- RQ1: How can a classification help to increase the accuracy of the plant leaf classification? And what type of classification can be used?
- RQ2: How to recognize plant species using image processing techniques that can help botanists and scientists?
- RQ3: What are the appropriate features for plant species recognition in feature extraction?

To refine the number of studies considered in our SLR, we support our question with a set of inclusion and exclusion criteria.

- Research papers in ACM digital library, IEEE computer society digital library, Springer Link, Science Direct, Academia sites were included.
- Articles published from 2010 to 2019 were included, and other articles were excluded. Note that this research was started at the start of November 2019.
- Plant leaf recognition related software and image processing technics were included, and others were excluded.
- Research papers that methodology deviates from image processing techniques were excluded.
- Different types of research methodologies were included.

Search Strategy.

Article papers were identified from searches of Google scholar, IEEE Explore, Springer Link, ACM digital library, Science Direct, and Semantic Scholar. And we searched keywords such as plant leaf identification, plant leaf recognition, plant leaf classification, and plant leaf prediction.

Sources

According to the tertiary study accomplished previously, the following databases were identified as the most relevant databases which contain studies more appropriate to the research domain. Hence, the search was performed in the following databases.

1. IEEE Xplore (http://ieeexplore.ieee.org)
2. Springer Link (https://link.springer.com)
3. Science Direct (https://www.sciencedirect.com)
4. Academia (https://www.academia.edu)
5. Research Gate (https://www.researchgate.net)
6. ACM Digital library (https://dl.acm.org)

Limitations

In this section, different kind of limitation of this review study are discussed,

Some of the papers were irrelevant to the topic selected.

Some of the research papers unavailable to download

Difficulty in filtering papers according to the domain.

Results and Findings

The results are about identifying, analyzing, and comparing research work in the field of plant leaf identification using image processing techniques. A systematic review was conducted driven by research questions and using a welldefined process for data extraction and analysis. The following findings summarize the principal results of this systematic review and provide directions for future research. Following are some conclusions,

1. Most studies were conducted by computer scientists.

2. Most studies used images with a plain background, avoiding segmentation

3. The main research focus on leaf analysis for plant identification

4. The shape is the dominant feature for plant identification

5. Contour based shape description was more popular than the region-based description

6. Multi-feature fusion facilities lead to higher classification accuracy

Figure 1 state about how the SLR is conducted and how the papers are acquire related to our research.

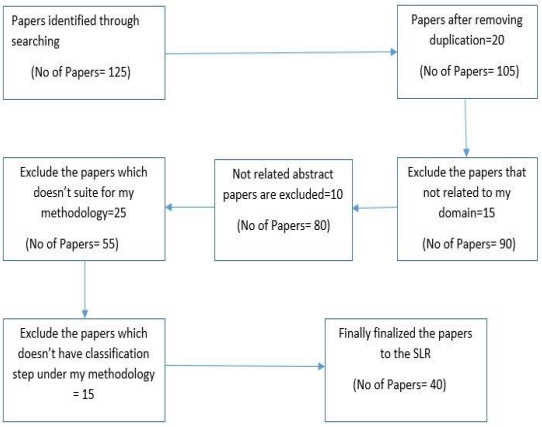

Figure 1: Prisma flow diagram

Data Collection

32 plant species are taken from the database of [1]Flavia leaves the dataset website, which contains 1909 leaves images. Sample leaves images are stated below in figure 2. They have been categorized according to their scientific name and the common names for easily understanding the image. The images are taken in every possible direction that whatever shape it contains must give more accurate results for that leaf classification.

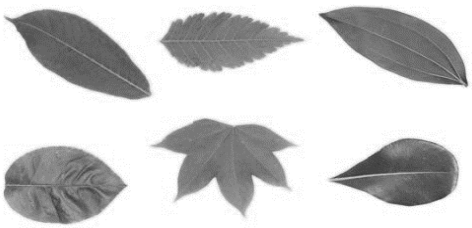

Figure 2: Sample dataset

Methodology

In this research method, we followed the well-known guideline from conducting my SLR. Figure 3 state about the methodology of the research.

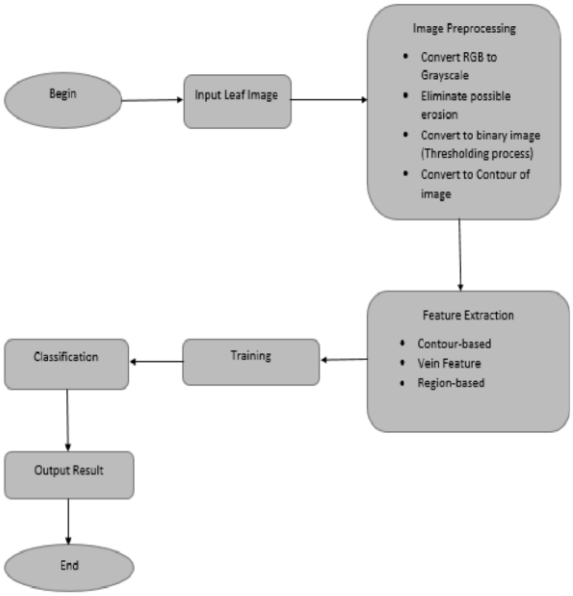

Figure 3: Methodology

In this paper, the research methodology consists of major phases they are image pre-processing, feature extraction, training, and classification.

Image pre-processing consists of convert RGB to grayscale, eliminate possible erosion, convert to a binary image, and convert to the contour of the image.

Feature extraction consists of contour-based, region-based, and vein feature extraction.

Above mentioned phases are implementing using the Jupiter notebook environment in the python.

Image Preprocessing, Feature Extraction, and Classification Approaches

Commonly most of the research papers describe the same image pre-processing techniques that images are converted RGB to grayscale, eliminate possible erosion, convert to a binary image, image segmentation convert to the contour of the image. The above mention techniques are common approaches in image pre-processing incorporated studies.

Table 1: Feature extraction and classification techniques

Category	Techniques	References	Year
Feature extraction	Basic Geometric Features, Digital Morphological Features	[5]	2012
	Curvelet Transform Descriptors (CTD), Local Binary Pattern, Gray Level Cooccurrence Matrix	[6]	2017
	Shape	[1]	2012
		[4]	2015
		[6]	2013
		[8]	2015
		[9]	2017
	Vein	[7]	2019
		[4]	2015
	Contour	[10]	2010
		[6]	2013
		[5]	2018
		[4]	2015
	Gray Level Cooccurrence Matrix	[7]	2019
		[5]	2018
		[3]	2017
Classifications	Support Vector Machine (SVM)	[9]	2017
		[2]	2012
		[11]	2013
		[19]	2014
		[5]	2018
		[18]	2019
	Artificial Neural Network (ANN)	[8]	2015
		[15]	2015
		[13]	2014
	Probabilistic Neural Network(PNN)	[16]	2007
		[9]	2017
	CNN	[12]	2018
		[14]	2018
	KNN	[11]	2013
		[17]	2013
		[9]	2017

One of the relatively superior and competent classifiers is ANN, especially in terms of its accuracy. This is because ANN is pertinent to resolve non-linear problems like leaf pattern recognition. However, previous research revealed that the leaf with an oblong pattern

could increase the error rate of recognition, possibly due to the uniform structure.

SVM is to define decision boundaries of feature vectors on decision planes, which separates features unanimously. Since the distinction in feature between the images is evident, the images will be classified into their respective class with little to no complication. CNN may involve multiple features extraction, and at the same time, providing detail and quick detection and to robust to the noise. KNN classifies images by comparing the input images to the closest training samples from the feature space. PNN classifier trains the loaded feature vector with a higher speed rate as compared to that of a backpropagation system (See table 1).

Conclusion

Plant leaf recognition system using image processing techniques have been continuously proposed and evaluated in the literature. By conducting our SLR about software and image processing techniques, we gathered, classified, and analysed such techniques from research questions (RQs) drawn in the Literature Review. The RQs are based on our SLR mentioned in the Introduction. We reviewed forty articles from the IEEE computer society digital library, Springer Link, Science Direct, ACM Digital Library, Academia, and other research sites and then filtered up to nineteen papers to conduct SLR. We got the results and finding, as we mentioned above.

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