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Home Garden Based Ayurvedic Plant Identification System Using CNN, A Review

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Abstract— *Ayurveda, one of the oldest medical systems in the world relies on natural ingredients from plants to treat various illnesses. Since Sri Lanka is blessed with abundant plant resources, there is a need to identify Ayurvedic herbs for medicinal purposes correctly. Unfortunately, many citizens, especially the younger generation, are unfamiliar with these valuable plants. Additionally, the country is facing an economic crisis, leading to shortages of imported medicines. To address these challenges, a system is proposed to identify Ayurvedic plants available in home gardens, enabling the public to use them as remedies. While plant identification systems have been studied extensively, there is limited research on home garden based Ayurvedic plants. This research aims to review existing plant identification systems, the technologies they employ, and their limitations. The study explores the feasibility of using "Convolutional Neural Networks (CNN)," the latest technology, for plant identification. By comparing the accuracy and efficiency of each method, the goal is to select the most suitable approach to implement a home garden based Ayurvedic plant identification system.*

Keywords— **Ayurvedic plant identification system, Convolutional Neural Networks, Machine learning, feature extraction**

I. INTRODUCTION

Sri Lanka has a diverse range of plant species, and among those species, medicinal plants play a significant role. A traditional medical system known as "Ayurvedic" was developed by the ancient people using these invaluable plants. Especially Asian countries such as Sri Lanka has about 3000 years of history of using Ayurvedic plants(Jayalath et al., 2019a) Ayurvedic medicine uses almost every part of the tree, including the leaves, flowers, stem, root, and other organs(Kumar et al., 2017). Hence the plant identification process is very crucial to provide the correct medicine to the patient.

Back in the day, our ancestors had a very wide knowledge of these plants. Nowadays man, however, hasn't been familiar with these plants because of technology and people's busy schedule (Smith, n.d.). The ancient people were extremely knowledgeable of the therapeutic properties and geographic locations of every single plant they needed for medicine. Ayurvedic has been discovered to produce far better results for patients when compared to western medical practices ("Ayurvedic and Western Medicine: Friend or Foe? - Ayurvedic Wellness Centre Pty Ltd," n.d.). Therefore, identifying such plants which everyone is not familiar with is very crucial.

The incorrect identification and usage of these plants may lead man to face various health issues. Also, there is a high risk of these plants being endangered because people tend to destroy these plants due to not having proper knowledge of these medicinal plants. One of the other main problems in this industry is most of the practitioners are unable to identify the plants by observing their features of it (Jayalath et al., 2019b). There is a huge range of resources to study Western medicine techniques around the world. But a very smaller number of books or resources are available to learn about Ayurvedic medicine. So, the knowledge of this area is very less among the general public as well as Ayurvedic Medicine students these days. Apart from that, even though there is no harm to humans by using this natural medicine but consuming the wrong ingredients may cause severe problems. So, there is a need in the country as well as in the world to have a systematic way of identifying and classifying these valuable plants correctly. This may make the work of Ayurvedic medicinal practitioners, botanists, agronomists, forest department officials and also the general public easier and more efficient.

However, a key challenge in this field is the scarcity of expert taxonomists. Taxonomists employ leaf, flower, trunk, and branch characteristics to classify organisms but among them, the leaves of the plants are the most widely used and available organ that can be used to identify the plant. Since the leaves are available throughout the year the plant can be the best choice for the process of identifying the Ayurvedic plant. Deep learning-based CNN approaches, Image processing, Machine Learning, and computer vision can be used to fill out the gap in the shortage of qualified taxonomists. The researchers have used some morphological features

namely colour, shape, texture, area, etc. of the leaves to classify the plants. However, the colour of the leaf cannot be considered a judicious feature when classifying the plants because that varies according to the season and the geographical area in which it grows. Even though quite a lot of research work has been carried out in this area, the high rate of interclass similarity in shape, colour, and texture traits makes this a difficult and unsolvable challenge(Dileep and Pournami, 2019).

The rest of this paper is structured as follows. The related research on this topic is described in Section II. The approach employed to perform this research study is described in Section III. The research study's findings are then provided in section IV, the entire study is discussed in section V, and the conclusion is then presented in section VI.

II. LITERATURE REVIEW

This section describes the 13 most important research publications reviewed during the course of this study. This section is divided into 2 subsections as plant identification using CNN and other technologies in Sri Lankan context and foreign context.

A. Plant Identiifcation Using CNN

1) Research on using CNN for plant identification - Sri Lankan:

Jayanka and Fernando, (2020) have described an Ayurvedic botanical recognition computer system developed in Sri Lanka. CNN were used to develop an algorithm for this project (CNN). The primary objective of the research was to develop a deep learning based technique for the categorizing and identifying Ayurvedic plant leaves in Sri Lanka. In order to train neural networks, images of 17 different species of Ayurvedic plant leaves were acquired from the "Navinna Ayurvedic Medical Hospital's plant nursery. A small dataset with a limited variety of scanned leaf photos was employed for this study. The tested network performs more accurately than the currently used plant leaf categorization methods. The outcomes were extremely impressive, with CNN obtaining an accuracy of 97.71% in distinguishing Sri Lankan Ayurvedic medicinal plant leaves using RGB imagery.

Another research was done by Dileep and Pournami, (2019) on a deep learning-based CNN (Convolutional Neural Network) model for a system called "Ayurleaf." To employ characteristics of leaves namely size, texture, shape, colour, etc., to categorize medicinal plants. This is being tested and trained using the data set known as the "DLeaf" dataset. On the "AyurLeaf"- "DLeaf" dataset, the SVM classifier produced the best classification with the accuracy. "AyurLeaf's" model may be improved to make it appropriate for categorizing leaf image files. The dataset consists of about 40 samples of medicinal plants. The GIMP image editor is used to select and crop only the leaf region, and each image is saved in jpg format. To efficiently extract features from the dataset, a deep neural network modelled after Alexnet is being used. The final classification is done using SVM Classifiers and Softmax. On the "AyurLeaf" dataset, their model had a classification accuracy of 96.76% after completing the five crossvalidations. The algorithm runs through the dataset about 6000 times.

2) Research on using CNN for plant identification ¬- Foreign:

Taslim et al., (2021) have presented an effective way of identifying plants using the technology of CNN. The speciality of this project is that it is capable of identifying 5 different plants available in Malaysia such as cherry, rambutan, mango, papaya and acacia. This network is being trained with the use of a database of leaf photos. Those photos are taken using a mobile phone and for the image classification process, a CNN from deep learning is being used. For the neural network image-classification and network training for identification of leaves, ResNet-50 was the architecture employed. As the final software product, the interfaces for the leaf identification system have been created using MATLAB app designer. Because of that, each training set's accuracy on five leaf classes is recorded as being above which is 98%, indicating that the recognition was carried out correctly.

Another research was done by Putri et al., (2021) on a system for medicinal plant identification using CNN. This included using training data generated on a computer and then integrated into mobile-based software to identify the types and benefits of medicinal plant leaves. This study includes nine different medicinal leaves. There are 180 training data used for this study utilized by grouped by the type of leaf, with 20 data for each leaf. The system initially requires the image of the leaf from the user as input. The image pixels will be read into the matrix by the application, and the colour parameters will be extracted. The shape parameters are then extracted. Then all calculated parameters are being compared with the previous data stored in the dataset. This system is tested with 50 leaf data sets. Out of them 45 of which correspond to training data (5 of each category) and 5 of which were not recognized.

A mobile application using the CNN (Convolutional Neural Network) technology for identifying 33 types of plants using leaves was developed by Venkataraman and Mangayarkarasi, (2016) In this study, the researchers are comparing three CNN named MobileNetV2, MobileNet and VGG19. The average F1 score for our MobileNetV2

plant identification algorithm is 0.992, demonstrating both its excellent performance and applicability. The actual performance of the constructed system on a tablet-style device is 338.1 milliseconds per image. They have deployed the plant recognition program on a Lenovo TAB4 8 with trained CNN models. For the study, they collected about 4483 images of the leaves of 33 leaf types available in the east area of Hokkaido. All most all the models in this study have obtained an accuracy of over 0.98.

Zarrin and Islam, (2019) presented a plant identification methodology using the trees of the leaves with the usage of one of the widely used technologies, the Convolutional Neural Network. The study has obtained a 99.40% accuracy by using this methodology on trees such as lemon, guava, hibiscus, neem, mango, etc. On their local dataset of leaves, which comprises 10,000 photos of leaves, 1000 for each class of tree, experimental findings were conducted. Results indicate that the suggested system offers a useful classification model for distinguishing trees based on their leaves. In this study, the researchers have proposed a deep NN(Neural Network) to carry out the classification of different 44 species of plants. The dataset consisted of 2816 images and the experiment has been done on that. The plant species were collected from different gardens in England.

Also, Lee et al. (2015) have conducted a study using CNN to learn unsupervised feature representations for 44 various species of plants which have been collected from one of the Botanical gardens located in England. In order to develop intuition about the selected CNN model features which is opposing to the solution of "black box", a DN (Deconvolutional Network) is utilized based on the technique of visualization. It was discovered by the researchers that different orders of venations have been selected to specifically represent each plant. The experimental results gained using the Convolutional Neural Network features together with various types of classifiers demonstrate excellence and consistency in comparison to cutting-edge alternatives that rely on hand-crafted features. Also, a new dataset for leaves named "Malayakew" was collected with the full annotation. The CNN model which has been used in this research study is based on the dataset known as "ILSVRC2012" for the pretraining stage. Furthermore, they have revealed that venation structure is a significant trait for identifying distinct plant species, exceeding conventional solutions with a performance of 99.5%.

Furthermore, the deep learning approach using a convolution neural network to identify flower species with better accuracy is proposed by Gogul and Kumar ("Flower species recognition system using convolution neural networks and transfer learning | IEEE Conference Publication | IEEE Xplore," n.d.). To recognize different flower species with high accuracy the deep learning approach using CNN is being used. In this study, the process is from a built-in camera the plant species are captured. Then the extraction of features of the plants is done using a Transfer Learning approach. That is it extracts complex features from a network that has been pre-trained. It is discovered that all manually created feature extraction techniques, including Color Channel Statistics, Haralick Texture, Local Binary Pattern (LBP), Color Histograms, Hu Moments, and Zernike Moments, perform significantly worse when used in combination with CNN as a feature extractor. Recognition of plant species based on floral recognition is still difficult in the field of image processing and computer vision.

Research on using other methods for plant identification – Sri Lankan :

1) Research on using other methods for plant identification – Sri Lankan:

The researchers Perera and Arudchelvam, (2021) have presented a leaf-based plant identification system in order to identify some Sri Lankan Medicinal plants. The images of the leaves have been obtained using the data set called "Flavia Data set". These datasets include pictures of 33 various plants. To improve efficiency the leaves were taken which have a white background. On a white piece of paper, there are between 40 and 70 intertwined images of leaves. The techniques such as pre-processing and feature extraction techniques are used. The suggested method uses a combination of form and colour criteria to compare the query leaf to the database leaves. In the proposed methodology the identification process of the leaves is done using image processing techniques. The image classification steps include Image acquisition, pre-processing, feature extraction and classification. It has found a 90% of accuracy with the use of a trained model and support vector machine in classifying the leaf images.

2) Research on using other methods for plant identification – Foreign:

A novel research was presented by Chaki and Parekh, (2011) on a special automated plant-recognizing system based on the leaves. The leaves of three types of plants are being analyzed by two modelling techniques(shape modelling) namely (M-I)Moments Invariant based and (C-R) Centroid Radii model. The researchers offer 7-moment features that are invariant to rotation, translation, and scaling and can be utilized to describe forms. A region of black on a white background is referred to as a shape. The dataset of this system is consisting about 180 images. It is again divided into 3 classes with 60 each. Class A is named "Pittosporum Tobira." Class B is "Betula Pendula," while class C is "Cercis Siliquastrum." Accuracy levels between 90% and 100% are attained, which are on par with the finest numbers mentioned in

the literature currently in print. A set of 90 images are used as the training set while the other 90 images are used as the Testing set.

Another research was conducted by (Research Scholar GNDEC, Bidar, Visvesvaraya Technological University Belagavi, Karnataka India. et al., 2019) with the main focus of identifying the medicinal plants often utilized in Ayurvedic using WO-DNN. They have proposed an effective and accurate classifier (EAC-AMP) that combines hybrid optimum machine learning approaches to identify Ayurvedic medicinal herbs in this research. In order to compute time and frequency domain features a method known as the symbolic accurate approximation (SAX) is used. Twodimensional binary phase encoding is used to compute shape, colour, and dental characteristics. A whale-optimization along with a deep neural network (DNN) classifier is then used for the categorization process the type of plant. The data set in this framework consists of 928 total photos of leaves from Ayurvedic plants. They used 185 examples for testing and 743 examples of Ayurvedic images for training. An accuracy of 99.8% is provided by this combination of highlights and the whale-streamlined deep neural system classifier.

Furthermore, Wu et al. (2007) have introduced a neural network approach for recognizing plant leaves is presented. To this process, they have used Probabilistic Neural Network with some image processing and data processing techniques to recognize leaves for the classification of plants. This system's methodology is consisting of several methods such as image pre-processing, feature extraction, network training, etc. First, the extracted RGB image is converted into a grayscale image. Then in the feature extraction process, 12 common morphological features have been used such as Diameter, Physiological Width, Physiological Length, Leaf Perimeter and Leaf Area, narrow factor, perimeter ratio, vein features, etc. It is able to classify 32 plants from the images extracted automatically using 1800 leaves. PCA was used by the researchers to extract and process 12 characteristics to create the Probabilistic Neural Network (PNN) input vector. The results after the experiments have proved that the algorithm used in this system is workable and also it has got an accuracy which is greater than 90% for 32 plant types.

III. METHODOLOGY

This section covers the methodology and approach used to perform the research study in depth. Before conducting this review the research areas, approaches and objectives were well identified. Different approaches, including interviews, questionnaires and observations, surveys, focus groups, documents and records, and oral histories, can be used to carry out a study on a particular research topic. Two primary strategies were used to conduct this review.

The diagram below displays the workflow of this paper's writing process.

Figure 1. Workflow of this paper's writing process

Source: Author

A. Handsearching

First, the research topic of this study was identified as "Home Garden base Ayurvedic Plant Identification system using CNN". In order to select the most relevant and contemporary projects, the research done in the last decade was chosen. The resources were gathered from various valid sources like Google Scholar, IEEE Explorer, Research Gate and Science Direct. Books and valid blogs were also referred to get more information. The selections were based on few factors such as the date of publication, inspecting the abstract and later scrutinizing the whole paper. Some criteria used to conduct this study were,

i. The research paper is understandable and in English language.

ii. The research has been done within the period which has been initialized.

iii. The full paper is accessible.

iv. The most cited research work.

"Ayurvedic plant identification system", "Convolutional Neural Network", "plant identification", "feature extraction", and "Image Processing" were among the keywords used either together or separately to retrieve the research papers. Some of the papers had to be dropped because they were of no relevance to plant identification and classification system using CNN.

Based on the criteria mentioned and various research papers, review papers, case studies, and many other conceptual papers were found which is related to conducting this study. After having a good study of each of the topics and abstracts of the papers, 60 research papers were finalized to be used as references for this review. Backward and forward snowballing were used to obtain further research papers. These publications were later deeply investigated, reviewed, and analyzed in order to comprehend those proposed systems, solutions, advantages and disadvantages, also the technologies and methodologies used. Some factors such as the technologies used in each of the research studies, objectives, accuracy levels obtained and future work were analyzed thoroughly as mentioned in table 1. The

information and expertise gained through evaluating, analyzing, and comparing these research works were then used to reach some of the findings on various forms of plant identification systems in Sri Lanka and around the world.

B. Experts

To obtain more precise data and improve the efficacy of this study, the second methodology - interviewing domain experts in the Ayurvedic sector was conducted. The director of the Ayurvedic Hospital Meegoda, Dr Nalaka Delgahagoda and Ayurvedic specialist Dr Nalini Dias were the two domain experts in this research study to gather information regarding the Ayurvedic medicine sector. In order to develop the system to identify Ayurvedic medicinal plants, their requirements were first gathered. Also, according to that, a list of Ayurvedic plants was shortlisted for the study. Then gradually the details of each plant were collected by referring to Ayurvedic books, magazines and publications. Some other insights regarding this study were gathered from the doctors in the Meegoda Ayurvedic Hospital. In addition to this information, the limitations and the challenges in this study were briefed by the domain experts. This research has been conducted according to all the requirements, limitations and research gaps identified.

IV. RESULTS AND DISUSSION

In this systematic review, 150 journal articles have been screened and selected 38 articles contained qualitative information about the existing plant identification systems in the world, the technologies used to develop those and the limitations. Even though there is quite a variety of research papers and publications on different plant identification systems using leaves, a very limited number of research studies were conducted to investigate how that can be used to identify Ayurvedic plants. Only a few studies were investigating the Ayurvedic plant identification systems using CNN specifically. Also, Ayurvedic plant species differ from region to region. Therefore, most of the studies conducted on Ayurvedic plant identification systems were conducted in India and were not that applicable to the identification process in Sri Lankan home garden base plants. The publications selected were thoroughly investigated, reviewed, and analyzed in order to comprehend their proposed systems, solutions, pros and cons, also the technologies and methodologies used. Some factors such as the technologies used in each of the research studies, objectives, accuracy levels obtained, and future work were analyzed thoroughly as mentioned below in the table1.

Table 1. Technologies/Tools, objectives, accuracy levels obtained, and future work
Source: Author

Research paper	Main Objective	Technology/ Tools used	Accuracy	Future Implementations
Lee, S., et al. (2015). DEEP-PLANT: PLANT IDENTIFICATION WITH CONVOLUTIONAL NEURAL NETWORKS.	This research study has been conducted using Convolutional Neural Networks to learn unsupervised feature representations for 44 various species of plants which have been collected from one of the Botanical gardens located in England.	CNN	99.5%	The researchers are planning to carry out this research work into the wild plants.
Akiyama, Y., et al. (2019). Mobile Leaf-Identification System using CNN applied to plants in Hokkaido.	This study proposes a mobile application using the CNN (Convolutional Neural Network) technology for identifying 33 types of plants using leaves.	CNN	98%	The researchers will annotate leaf position in order to train and test the CNN model with no background effect.
Jayalath, H. W. T. K., et al. (2019b). Ayurvedic Knowledge Sharing Platform with Sinhala Virtual Assistant.	This research focuses on creating a chatbot with centralized Ayurvedic information that can respond to user inquiries on Ayurvedic and local medicinal plants. The proposed chatbot is capable of analyzing and understanding the question asked by the user and it can provide a customized answer for that.	Shallow Neural Network (SN), Radial Basis Function (RBF), and Deep Belief Neural Network in the study that follows (DBN) CNN Phyton TensorFlow	90%	
Kumar, N., & Talasila, V. (2014). Leaf Features based approach for Automated Identification of Medicinal Plants.	The main focus of this research paper is to design an automated plant identification system based on leaves.	Image processing, MATLAB	Accuracy depending upon the plant.	
Jayalath, H. W. T. K., et al. (2019a). Identification of Medicinal Plants by Visual Characteristics of Leaves and Flowers.	The article is proposing a robust technique using CNN for the identification of some rare medicinal plants.	TensorFlow	90%	
"Deep Learning for Plant Species Classification Using Leaf Vein Morphometric	IEEE Journals & Magazine	IEEE Xplore," n.d.).		Neural Network Image Processing	94.4%	The work is expected to extend to a larger number of leaf classes with hugely improved efficiency.
Hedjazi, M., et al. (2017). Comparison of CNN with Classical ML Methods.	The study shows that deep learning methods outperform typical machine learning methods even with a modest number of training data.	Transfer learning, Convolution Neural Networks	83%	They intend to assess the performance of various CNN designs and domain-specific technique adaptations. Also, boost performance and add hand-crafted features to our current network.
Hindawi. (n.d.). Deep Learning for Plant Identification in Natural Environment.	The accuracy of recognition utilizing a dataset and deep learning technology.	BP neural networks, CNNs (convolution neural networks)	91.78%	The BJFU100 database will be expanded to include more plant species. These will be added at various stages of the life cycle and will include more detailed annotations.
Grvo, J., & Wei, F. (2013). Plant Identification Through Images: Using Feature Extraction of Key Points on Leaf Contours.	This work presents a feature-extraction method for the investigation of leaf outlines.	Neural network, Probabilistic neural network	92.7%	They are hoping to extract more information from leaf petiole locations and vein pattern patterns.
Howard, A. G., et al. (2017). Efficient Convolutional Neural Networks for Mobile Vision Applications.	This research work presents a new model architecture named "MobileNets" which is based on separable convolutions and also mobile vision applications.			They intend to publish models in Tensor Flow, which will aid in the adoption and investigation of MobileNets.
Dileep, N. S., & Pournami, K. (2019). AyurLeaf: A Deep Learning Approach for Classification of Medicinal Plants.	This research proposes a deep learning-based CNN (Convolutional Neural Network) model for a system called "AyurLeaf." To employ characteristics of the leaves, such as size, texture, shape, colour, etc., to categorize medicinal plants.	CNNs (convolution neural networks), SVM classifier, Alexnet	96.76%	
Perera, R. L. N. M., & Arudchelvam, Y. (2021). Leaf Based Plant Identification System for Sri Lankan Medicinal Plant	This research study presents a leaf-based plant identification system in order to identify some Sri Lankan Medicinal plants.	"Flavia Data set", Image Processing	90%	The researchers are hoping to extend these identified plants using the other parts of the leaves and flowers.
Hossain, M. S., & Amin, M. S. (2010). Leaf Shape Identification Based Plant Biometrics.	This study presents a simple and effective method for categorizing plant species based on photographs of leaves.	Probabilistic Neural network, "ten-fold-cross-validation" technique	91.41%	The researchers are planning to avoid these issues and provide an efficient service from this system.
Zarin, H., & Islam, S. M. R. (2019). Leaf Based Trees Identification Using Convolutional Neural Network.	This paper presents a plant identification methodology using the trees of the leaves with the usage of one of the widely used technologies, the Convolutional Neural Network.	Convolutional Neural Network, NN(Neural Network)	99.40%	The researchers are expecting to extend the number of classes of plants and trees. And also, to use the other parts of the trees such as flowers, stems, and fruits to identify the trees.

When considering all the referred research studies most of the work have been carried out in a similar process. The initial step of the plant identification process using leaves is getting a clear picture of the leaf using a digital camera or a scanner. Some systems required that the images need to be taken in a white background or a very contrasting background (Chaki and Parekh, 2011), (Wu et al., 2007). That it is to make sure the shape of the leaf is correctly extracted for the identification process without any disturbance from the background. So, it was found that to get some accurate and efficient results the images needed to be cropped to train. In the future, the researchers will annotate leaf position in order to train and test the CNN model with no background impact (Hossain and Amin, 2010). Those acquired images are exposed to the preprocessing stage. During the image pre-processing stage some morphological features of the leaves are being extracted such as shape, area, width, height, texture, perimeter, etc. Then the leaf is recognized using different machine algorithms. One of the other main findings of this study is that it is unable to achieve the desired accuracy levels for the leaves which is having similar morphological features (Valliammal and Geethalakshmi, 2011). As per an example the Beetle leaf("Piper beetle"), Thippili leaf("Piper longum") and the Pepper leaf("Piper nigrum") look almost alike and it

might be quite difficult to provide accurate results just analyzing the morphological features.

As a result of the investigation process done upon the research work related to this field various methods and techniques were found that was used for the leaf recognition process. They are briefly mentioned in the below table 2.

Table 2. Technologies/Tools, objectives, accuracy levels obtained, and future work

Method/technique of recognition	Reference paper
Neural network • Moment invariants • Centroid-Radii model	Chaki, J., & Parekh, R. (2011). Plant-Leaf Recognition using the shape-based Features and Neural Network classifiers.
Classifier • Textural features of gray-level co-occurrence • matrices	Wick, M., & Puppe, F. (2017). Plant Classification Based on Leaf Recognition.
Score of cross-correlation • Length of contour points to centroid	("Plant species recognition using leaf contours | IEEE Conference Publication | IEEE Xplore," n.d.).
Neural network • Angle of the tip point • Angle of the lowest point • Standardized matrix • Approximate circle factor • Differential angle of the petiole point • Angle of the leafstalk point • Aspect ratio • Differential angle of the tip point	Gao, Y., et al. (2010b). A Neural network Classifier Based on Prior Evolution and Iterative Approximation Used for Leaf-Recognition.
Roundness, Solidity, Neural network, Slimness, Moment invariants	Wu, et al. (n.d.). Feature Extraction and Automatic Recognition of Plant Leaf Using Artificial Neural Network.
Probabilistic neural network • Aspect ratio • Rectangularity • Ratio of the square of perimeter and the area	Gao, Y., et al. (2010a). An algorithm of excising leafstalk while keeping its main body intact for leaf recognition.
Probabilistic neural network(PNN) • Rectangularity • Circularity • Sphericity • Eccentricity • Axis ratio • Convexity area • Convexity perimeter • Label values of enervation types • Fractal dimension of vein image	Lin, H., & Peng, C. (2008). Machine Recognition for Broad-Leaved Trees Based on Synthetic Features of Leaves Using Probabilistic Neural Network.

Source: Author

Under the second methodology conducted for this research study, several concerns were raised by the domain experts which were interviewed. As for their requirement, the need for an Ayurvedic plant identification system was more for the general public than the students learning Ayurvedic . The main reason for that was there is to make the general public more aware of the valuable Ayurvedic plants that they are not aware of. Also, many of them are not aware of the ways that these plants can be consumed to get better results. So, with that intention, it was found that there is a huge need for such a system for the general public. Also, in order to provide the best service to the people the system was proposed to include the Ayurvedic plants which can be found in the home gardens

themselves. Apart from these, some limitations related to the Ayurvedic plant selection were brought up by the experts. Ayurvedic plant species vary according to the geographical area they are grown. As an example, the plants such as "Bovitiya(Osbeckia octandra)" and "Aloe vera" are different from province to province according to the climate. According to the information gathered from the experts, those trees differ in colour, size and shape according to the climate. So, this can be one of the huge drawback/challenges to gain the desired accuracy level of identification.

IV. CONCLUSION

This qualitative systematic review has analyzed the literature on how the plant identification process can be done using the latest technologies. The different technologies that can be used for this recognition and identification process were discussed in this study. With the results obtained after reviewing the previous research studies, it was found that the latest technology that can be used for this process is CNN. Image acquisition, feature extraction, image pre-processing and the use of a algorithm of deep learning for recognition are all common steps in recognizing a plant using a leaf. The majority of the existing methods in the world used for plant identification are just for the identification and classification process. However, some limitations were discovered when conducting this study.

This study identified a limited number of services provided to the user following plant identification, such as providing additional information about the plant, where these plants can be found, and so on. The biggest issue that may arise while recognizing these Ayurvedic plants using leaves would be the variation of the different Ayurvedic plants from region to region, as well as the

similarity of the leaves in terms of shape, colour, and size. So, to solve the problems encountered by the general public and bridge the knowledge gap about these useful plants, the ideal approach is to build a method to identify these Ayurvedic plants that may be easily discovered in the home garden but are unknown to the general public. It would be a perfect solution to practically all of the research problems addressed by this study. This research work will be pursued in the future to investigate methods of recognizing plants utilizing other organs of the plants as well. In addition to that, this proposed system is expected to be developed and implemented. Finally, it is intended to develop a comprehensive mobile app for the general public to identify a set of Ayurvedic plants which can be found in home gardens using a leaf, also to identify the health benefits of each plant, how they can be consumed and the specific areas those can be found.

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