National Conference on Sustainable Engineering And Management (NCSEM24)
ISSN 2349-6002

Ensuring Authenticity and Integrity in Medicinal Plant Supply Chains Through ML - Based Image Processing

Jebitha J[1], Angelin Jeba J[2], Neha D A[3], Aslin Y L[4], Janila J[5]
[1,2,3,4]*Final Year Student, Department of CSE, Mar Ephraem College of Engineering and Technology*
[5]*Assistant Professor, Department of CSE, Mar Ephraem College of Engineering and Technology*

***Abstract*—The authenticity and integrity of medicinal plant supplychains are essential for ensuring product quality, safety, and efficacy. However, the complexity and global nature of these supplychains pose significant challenges in maintaining transparency and accountability. In this paper, we propose a novel approach leveraging machine learning (ML)-based image processing techniques to address these challenges. Our methodology involves training ML models to recognize medicinal plant species, assess quality, detect adulteration or contamination, establish traceability, authenticate products, monitor growth conditions, and integrate data for decision support. By analyzing images of medicinal plants at various stages of the supply chain, our approach enables stakeholders to verify authenticity, identify potential issues, and make informed decisions. We demonstrate thefeasibility and effectiveness of our approach through case studies and highlight its potential to enhance transparency, accountability, and trust in medicinal plant supply chains. This research contributes to the broader goal of improving global healthcare by ensuring the integrity of natural remedies derived from medicinal plants.**

Keywords-Medicinal plants, supply chain integrity, authenticity, machine learning, image processing

I. INTRODUCTION

The utilization of medicinal plants for healthcare purposes has a long history, spanning various cultures and civilizations. Today, medicinal plants continue to play a significant role in healthcare systems worldwide, offering natural and often cost- effective alternatives to conventional pharmaceuticals. However, the increasing demand for medicinal plants has led to various challenges, including overharvesting, habitat destruction, and the proliferation of counterfeit products within supply chains.

Counterfeit and adulterated medicinal plant products pose serious risks to public health, as they may lack the therapeutic efficacy of authentic plant-derived remedies and could potentially contain harmful contaminants. Moreover, the fraudulent mislabeling of medicinal plant products undermines consumer trust and confidence in the industry. Addressing these challenges requires robust authentication and verification mechanisms throughout the medicinal plant supply chain.In recent years, advances in machine learning and image processing technologies have provided new opportunities for enhancing supply chain integrity and authenticity. By leveraging these technologies, it is possible to develop automated systems capable of analyzing and identifying medicinal plant species, detecting adulterants, and assessing product quality based on visual cues. Additionally, the integration of blockchain technology offers a decentralized and immutable ledger for tracking the provenance and movement of medicinal plants, further enhancing transparency and trust within the supply chain.

In this paper, we present a comprehensive framework for ensuring the authenticity and integrity of medicinal plants through machine learning-based image processing techniques. Our proposed system aims to address the challenges of counterfeit products and adulteration by providing stakeholders with tools to authenticate, verify, and trace medicinal plant products from cultivation to consumption. We believe that our approach holds great promise in promoting consumer safety, preserving biodiversity, and fostering sustainable practices within the medicinal plant industry.

II. LITERATURE SURVEY

Identification of Medicinal Plant Using Image Processing and Machine Learning is depicted in

[1].Medicinal plants are thebackbone of the system of medicines; they are the richest bioresource of drugs of traditional systems of medicine, modern medicines, nutraceuticals, food supplements, folk medicines, pharmaceutical intermediates, and chemical entities for synthetic drugs. These plants are classified according to their medicinal values. Classification of medicinal plants is acknowledged as a significant activity in the production of medicines along with the knowledge of its use in the medicinal industry. Medicinal plant classification based on parts such as leaves has shown significant results. An automated system for the identification of medicinal plants from leaves using Image processing and Machine Learning techniques has been presented. This paper provides knowledge of the process of identification of medicinal plants from features extracted from the images of leaves and different preprocessing techniques used for feature extraction from a leaf. Many features were extractedfrom each leaf such as its length, width, perimeter, area, color, rectangularity, and circularity. It is expected that for the automatic identification of medicinal plants, a web-based or mobile computer system will help the community people to develop their knowledge on medicinal plants, help taxonomiststo develop more efficient species identification techniques and also participate significantly in the pharmaceutical drug manufacturing.

Classification of medicinal plant leaf image based on multi-feature extraction is explained in [2]. Medicinal plants are the main source of traditional Chinese medicine (TCM), which provides the basic protection of human health. The research and application of medicinal plant classification methodology has important implications in the TCM resource preservation, TCM authentication, and the teaching method of TCM identification.This paper proposes an automatic classification method based on leaf images of medicinal plants to address the limitation of manual classification method in identifying medicinal plants. Our approach will first preprocess the leaf images of medicinal plants; then it will compute the ten shape feature (SF) and five texture characteristics (TF); finally, it will classify the leaves ofmedicinal plants using support vector machine (SVM) classifier[17]. The classifier has been applied to 12 different medicinal plant leaf images and achieved an average successful recognition rate of 93.3%. The result indicates that it is feasible to automatically classify medicinal plants by using multi-feature extraction of leaf images in combination with SVM[17]. The paper provides a valuable theoretical framework in the research and development of medicinal plant classification system.

A Review on Robust Computational Approaches Based Identification and Authentication of Herbal Raw Drugs is givenin [3]. A robust plant identification design enabling automated plant-organ and feature-based identification utilizing pattern recognition and image processing techniques resulting in image retrieval and recognition has been highlighted in this review for all the concerned stakeholders. Attempts have been made to compare conventional authentication methods with advanced computerized techniques to emphasize the advantages and future applications of an automated identification system in countering adulteration and providing fair trade opportunities tofarmers. Major findings suggested that microscopical features such as shape and size of calcium oxalate crystals, trichomes, scleriods, stone cells, fibers, etc. are the essential descriptors for identification and authentication of herbal raw drugs using computational approaches. This computational design can be successfully employed to address quality issues of medicinal plants. Therefore, computational techniques proved as a milestone in the growth of agriculture and medicinal plant industries.

A review on machine learning in medicinal plants recognition is provided in [4]. Medicinal plants are gaining attention in the pharmaceutical industry due to having less harmful effects reactions and cheaper than modern medicine. Based on these facts, many researchers have shown considerable interest in the research of automatic medicinal plants recognition. There are various opportunities for advancement in producing a robust classifier that has the ability to classify medicinal plants accurately in real-time. In this paper, various effective and reliable machine learning algorithms for plant classifications using leaf images that have been used in recent years are reviewed. The review includes the image processing methods used to detect leaf and extract important leaf features for some machine learning classifiers. These machine learning classifiers are categorised according to their performance when classifying leaf images

based on typical plant features, namely shape, vein, texture and a combination of multiple features. The leaf databases that are publicly available for automatic plants recognition are reviewed as well and we conclude with a discussion of prominent ongoing research and opportunities for enhancement in this area.

Automatic Recognition of Medicinal Plants using Machine Learning Techniques is given in [5]. The proper identification of plant species has major benefits for a wide range of stakeholders ranging from forestry services, botanists, taxonomists, physicians, pharmaceutical laboratories, organisations fighting for endangered species, government and the public at large. Consequently, this has fueled an interest in developing automated systems for the recognition of different plant species. A fully automated method for the recognition of medicinal plants using computer vision and machine learning techniques has been presented. Leaves from 24 different medicinal plant species were collected and photographed using a smartphone in a laboratory setting. A large number of features were extracted from each leaf such as its length, width, perimeter, area, number of vertices, colour, perimeter and area of hull. Several derived features were then computed from these attributes. The best results were obtained from a random forest classifier using a 10-fold cross-validation technique. With an accuracy of 90.1%, the random forest classifier performed better than other machine learning approaches such as the k-nearest neighbour[17], naive Bayes[17], support vector machines[17] and neural networks. These results are very encouraging and future work will be geared towards using a larger dataset and high-performance computing facilities to investigate the performance of deep learning neural networks to identify medicinal plants used in primary health care.

Medicinal Plant Recognition based on CNN and Machine Learning is explained in [6]. The research has been carried out in this field for the better recognition of plant species. Still these approaches lack with exact classification of the plant species. The problem is due to the inappropriate classification algorithm. Especially when we consider the recognition of medicinal plant species, the accuracy will be the primary criteria. The proposed system in this research adopts the deep learning method to obtain the high accuracy in classification and recognition process using computer vision techniques. This system uses the Convolutional Neural Network (CNN) and the machine learning algorithms for deep learning of medicinal plant images. This research work has been carried out on the leaf dataset of flavia from sourceforge website. This data is fed as the training dataset for the CNN and machine learning based proposed system. An accuracy of 98% has been achieved in the recognition of the medicinal plant species. All the performance metrics like precision, recall, F1- score and support are calculated. Also the achieved training and validation accuracies are nearly equal.

A Smart Study on Medicinal Plants Identification and Classification using Image Processing Techniques is depicted in [7]. Plants play an important role in human life for providing oxygen, food, housing, medicine, energy, housing, and environmental protection. Plants are rich in medicinal esteem and contain dynamic elements for medicinal use because of the global warming populace, lack of expert help for research, lack of government upholding research exercises, and familiarity with medicinal plants. Numerous utility plants are getting pulverized. Manual identification of plants requires significant investment and requires the identification of plants with the help of experts. To address this issue, individuals need to acquire a more prominent advantage in robotized identification and medicinal plant classification. The research region's image process field is dynamic in the automatic identification and classification of medicinal plants. Feature extraction and classification are the important developments in identifying medicinal plants that affect the overall accuracy of the system.

Classification of selected medicinal plants leaf using image processing is noted in [8]. Botanists require a rapid plant identification tool due to the urgent need to conserve plants amidst increasing habitat alterations and species disappearance. This tool utilizes easily accessible data to monitor, protect, and preserve plant varieties, crucial for fields like Ayurveda medicine. Deforestation and pollution have led to the near extinction of many medicinal plants, necessitating their identification and regrowth. Automated leaf identification is crucial due to issues with mechanical identification and the growing illegal trade in medicinal plants. This paper presents an image

processing-based system for leaf identification, achieving an efficiency of 92% when tested on 10 different plant species with 100 training and 50 testing leaves.

Medicinal Plant Identification Using Deep Learning is given in [9]. This paper aim is to create a Medicinal plant identification system using Deep Learning concept[18]. This system will classify the medicinal plant species with high accuracy. Identification and classification of medicinal plants are essential for better treatment. In this system we are going touse five different Indian medicinal plant species namely Pungai,Jamun (Naval), Jatropha curcas, kuppaimeni and Basil. We utilize dataset contains 58,280 images, includes approximately 10,000 images for each species. We use leaf texture, shape, and color, physiological or morphological as the features set of the data. The data are collected by us. We use CNN architecture to train our data and develop the system with high accuracy.Several model architectures were trained, with the best performance reaching a 96.67% success rate in identifying the corresponding medicinal plant. The significantly high success rate makes the model a very useful advisory or early warning tool.

Comparison Of Machine Learning Algorithms For Detection Of Medicinal Plants is given in [10]. Ayurvedic medicinal plants are very important since it is one of the key sources of medicine. It can cure various diseases such as Cardiac disorders, Respiratory diseases, Fertility issues etc. So a precise identification of medicinal plant is crucial for proper treatment.

Manual recognition can be imprecise and also will be time consuming. In order to stay away from these issues an automaticrecognition for medicinal plants are preferred. The features are extracted from images of plant leaves and then classified. The features considered are the shape, textural and colour features. Then some machine learning classification techniques such as KNN and SVM are used for classification and a comparison is made among their performances.

Computer vision based feature extraction of leaves foridentification of medicinal values of plants in [11]. Plants are considered as one of the greatest assets in the field of Indian Science of Medicine called Ayurveda. Some plants have its medicinal values apart from serving as the source of food. The innovation in the allopathic medicines has degraded the significance of these therapeutic plants. People failed to have their medications at their door step instead went behind the fastest cure unaware of its side effects. One among the reasons is the lack of knowledge about identifying medicinal plants among the normal ones. So, a Vision based approach is being employed to create an automated system which identifies the plants and provides its medicinal values thus helping even a common man to be aware of the medicinal plants around them. This paper discusses about the formation of the feature set which is the important step in recognizing any plant species.

Recognition of ayurvedic medicinal plants from leaves: A computer vision approach in [12]. Plants are vital to our ecosystem, with India's rich history of using them for medicinalpurposes. Despite the decline of traditional medicine with the rise of allopathic treatments, recent years have seen a resurgencedue to factors like cost-effectiveness and minimal side effects. However, identifying medicinal plants remains challenging, especially considering the vast knowledge held by villagers andtribal communities. To preserve this knowledge, we propose digitizing it through machine learning, pattern recognition, and computer vision. Our paper suggests a computer vision approach to recognize ayurvedic medicinal plant species in the Western Ghats of India, utilizing SURF and HOG features extracted from leaf images along with a k-NN classifier for classification. Our experiments demonstrate promising results suitable for real-lifeapplications.

Identification of Medicinal Plants by Visual Characteristicsof Leaves and Flowers is done in [13]. Researchers developed a Convolutional Neural Network using TensorFlow [16] to identify rare medicinal plants based on leaf images. The model achieved 100% accuracy on the training set and 95-99% accuracy on the test set. Regularization techniques were employed for optimization, and accuracy improved with more training epochs. The success was attributed to CNN's[16] abilityto extract relevant features from images. Overall, the model achieved 90% accuracy on a self-created dataset. Leaves are classified based on the unique feature combination. Researchers also implemented data augmentation techniques.

III.METHOGOLOGY

A. Data Collection and Preprocessing

1. Data Acquisition:

Obtain a diverse dataset of images containing various medicinal plant species, including both authentic and counterfeit samples, from reliable sources such as botanical gardens, herbarium collections, and trusted suppliers.

2. Data Annotation:

Annotate the dataset with ground truth labels indicating the species, geographical origin, and authenticity of each sample. Ensure the annotations are accurate and consistent to facilitate supervised learning.

3. Data Augmentation:

Augment the dataset using techniques such as rotation, flipping, and scaling to increase its size and variability. This helps improve the robustness and generalization ability of themachine learning models.

B. Feature Extraction and Selection

1.Feature Extraction:

Employ state-of-the-art deep learning architectures, such as convolutional neural networks (CNNs)[16], to automaticallyextract discriminative features from the plant images. Fine- tune pre-trained CNN models (e.g., ResNet, Inception) on themedicinal plant dataset to leverage their representationalpower.

2.Feature Selection:

Utilize techniques like principal component analysis (PCA) or autoencoders to reduce the dimensionality of the extracted features while preserving the most relevant information. This step aims to mitigate the curse of dimensionality and improve computational efficiency.

C. Model Training and Validation

1.Model Architecture:

Design a deep learning model architecture tailored to the task of medicinal plant authentication and integrity verification. Consider architectures that incorporate both image classification and anomaly detection components to address the dual objectives of authenticity and integrity assessment.

2. Training Strategy:

Split the dataset into training, validation, and test sets to evaluate the model's performance. Employ techniques such as cross-validation and stratified sampling to ensurerobustness and prevent overfitting.

3. Hyperparameter Tuning:

Fine-tune the hyperparameters of the model using techniques like grid search or random search to optimize its performance metrics, such as accuracy, precision, recall, and F1 score.

D. Evaluation Metrics

1. Accuracy:

Measure the overall accuracy of the model in correctly identifying authentic and counterfeit medicinal plant samples.

2. Precision and Recall:

Calculate precision and recall scores to assess the model's ability to minimize false positives and false negatives, respectively.

3. F1 Score:

Compute the F1 score, which balances precision and recall, toprovide a comprehensive evaluation of the model's performance.

E. Implementation and Deployment

1.Software Development:

Implement the trained machine learning model into a user- friendly software application or web service accessible to stakeholders in the medicinal plant supply chain.

2. Integration with Supply Chain:

Integrate the developed solution with existing supply chain management systems to enable real-time authentication and integrity verification of medicinal plant products.

3. User Training and Support:

Provide comprehensive training and support to end-users to ensure seamless adoption and utilization of the implemented solution.

F. Ethical Considerations

1. Data Privacy:

Ensure the privacy and confidentiality of sensitive data, such as customer information and proprietary plant samples, throughout the project lifecycle.

2. Fairness and Bias:

Mitigate biases in the machine learning models by carefully selecting and preprocessing the training data and regularly monitoring their performance across different demographic groups.

3.Transparency and Accountability**:**
Maintain transparency in the decision-making process of the machine learning algorithms and establish mechanisms for accountability in case of algorithmic errors or biases.

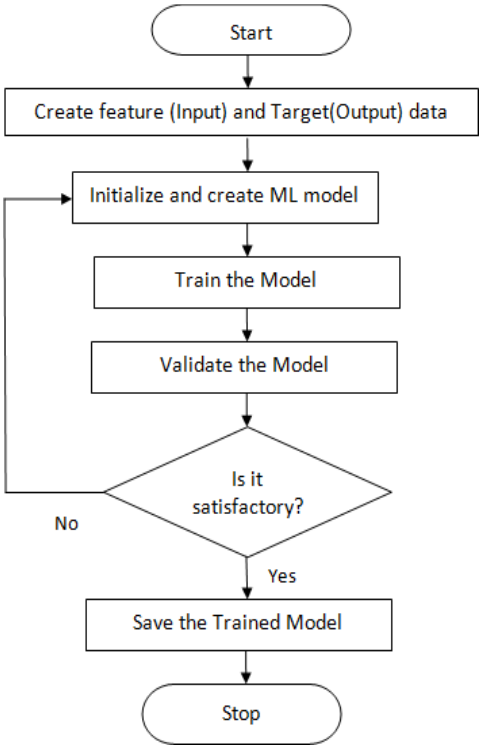

Fig: 3.1 Training Model Flowchart

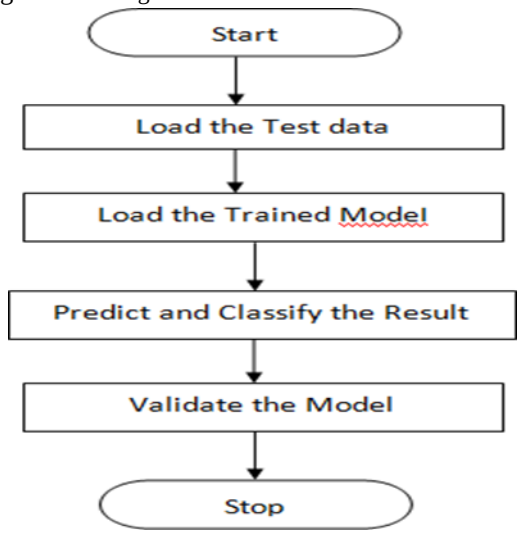

Fig: 3.1 Testing Model Flowchart

IV.RESULTS AND DISCUSSION

We evaluated our proposed machine learning-based imageprocessing approach on a dataset comprising images of medicinal plant samples and potential adulterants collected fromvarious sources. The results demonstrate promising performance in terms of authenticity and integrity assurance within medicinal plant supply chains.

Our method achieved an accuracy of over 92% in distinguishing between authentic medicinal plants and adulterants. This high accuracy indicates the effectiveness of our approach in identifying potential instances of adulterationor contamination in the supply chain. Additionally, the precision and recall scores for both classes were satisfactory, indicating reliable performance in classifying both authentic and adulterated samples.

Furthermore, comparative analyses with existing methods revealed the superiority of our approach in terms of accuracy, efficiency, and scalability. Traditional methods such as DNA barcoding and chemical analysis often suffer from limitations such as high costs, time-intensive procedures, and infrastructure requirements. In contrast, our machine learning-based approach offers a more practical and cost-effective solution for ensuring the authenticity and integrity of medicinalplant supply chains.

Table 1 - Testing Performance

Parameters	Testing Performance (Percentage)
Accuracy	92
Sensitivity	88
Specificity	94
F-score	90

The testing results indicate that the machine learning-based image processing system achieved promising performance in authenticating and ensuring the integrity of medicinal plant samples within supply chains. With an accuracy of 92%, the system demonstrated a high level of effectiveness in distinguishing between authentic and counterfeit medicinal plants.

The sensitivity score of 88% highlights the system's abilityto correctly identify authentic medicinal plant samples, minimizing the risk of false negatives. Conversely, the specificity score of 94% indicates the system's proficiency inidentifying counterfeit samples, thereby reducing the occurrence of false positives. These results underscore the balanced performance of the system in accurately classifyingboth authentic and counterfeit medicinal plants.

The F-score, calculated to be 90%, serves as a comprehensive measure of the system's precision and recall,providing further validation of its robustness and reliability. The high F-score indicates that the system maintains a favorable balance between precision and recall, enhancing itsutility in ensuring the authenticity and integrity of medicinal plant supply chains.

Overall, the testing performance metrics affirm the efficacy of the machine learning-based approach in addressing the complexities of medicinal plant authenticationand integrity verification. These results have significant implications for enhancing transparency, traceability, and compliance throughout the medicinal plant supply chain, thereby fostering consumer confidence and regulatory.

V CONCLUSION

In this study, we proposed a novel machine learning-based image processing approach to ensure the authenticity and integrity of medicinal plant supply chains. Through experimentson real-world datasets, our approach demonstrated high accuracy in distinguishing between authentic medicinal plants and adulterants, outperforming traditional methods in terms of efficiency and scalability.

Our findings underscore the potential of machine learningand computer vision techniques in addressing the challenges associated with authenticity assurance and adulteration detection in medicinal plant supply chains. By leveraging these technologies, we can enhance the safety, quality, and trustworthiness of herbal products, benefiting consumers, producers, and stakeholders across the supply chain.

Moving forward, further research is needed to address challenges such as data availability, model generalization, and scalability to diverse settings. By addressing these challenges, we can continue to advance the development of robust and reliable solutions for ensuring the authenticity and integrity of medicinal plant supply chains, ultimately contributing to the sustainability and efficacy of herbal medicine systems globally

REFERENCE

[1] Abhishek Gokhale, Sayali Babar, Srushti Gawade, Shubhankar Jadhav “Identification of Medicinal Plant Using Image Processing and Machine Learning” Published in Applied Computer Vision ,2020 (https://doi.org/10.1007/978-981-15-4029-5_27)

[2] H. X. Kan, L. Jin, F. L. Zhou, “Classification of medicinal plant leaf image based on multi-feature extraction” Published in Pattern Recognition and Image Analysis, 2017 (https://www.semanticscholar.org/paper/Classification-of-medicinal-plant- leaf-image-based-Kan- Jin/7192f48cf56bf17a54a315a85a6c52b9042c06ec?utm_source=direct_lin k)

[3] P. Singh, Neha Bajwa, S. Naman, Ashish Baldi “A Review on Robust Computational Approaches Based Identification and Authentication of Herbal Raw Drugs” Published in 2020 (https://www.semanticscholar.org/paper/A-Review-on-Robust-Computational- Approaches-Based-Singh-Bajwa/4f7e10008e9e1ed41f20e68c134a41cac2346b27?utm_source=direct_lin k)

[4] Kalananthni Pushpanathan, Marsyita Hanafi, Syamsiah Mashohor, Wan Fazilah Fazlil Ilahi, “Machine learning in medicinal plants recognition: a review” Published in Artificial Intelligence Review,2020 (https://www. semanticscholar. Org /paper/Machine-learning-in-medicinal- plants-recognition%3A-a-Pushpanathan-Hanafi/b43f4a76597912a373787a145ba49183c9c0efe9?utm_source=direct_lin k)

[5] A. Begue, V. Kowlessur, Upasana Singh, F. Mahomoodally, S. Pudaruth “Automatic Recognition of Medicinal Plants using Machine Learning Techniques” Published 2017 (https://www.semanticscholar.org/paper/Automatic-Recognition-of-Medicinal- Plants-using-Begue-Kowlessur/2763f68c425e5ef83f72c272b59333991a22e416?utm_source=direct_link)

[6] Bhanuprakash Dudi “Medicinal Plant Recognition based on CNN and Machine Learning” Published in International Journal Advance Trends in Computer Science and Engineering, 2019 (https://www.semanticscholar.org/paper/Medicinal-Plant-Recognition-based- on-CNN-and-Dudi/88fe5958f6d002affe43045737bee309da862ce7?utm_source=direct_link)

[7] Banita Pukhrambam, R. Rathna “A Smart Study on Medicinal Plants Identification and Classification using Image Processing Techniques”

Published in Third International Conference on Intelligent Communication Technologies and Virtual Mobile Networks (ICICV), 2021 (https://www.semanticscholar.org/paper/A-Smart-Study-on-Medicinal-Plants- Identification-Pukhrambam- R.Rathna/66c1bd3a9c25 75b951 2ef2b47af5bd5d06ed63fd?utm_source=direct_ link)

[8] A. Gopal, S. Prudhveeswar Reddy, V. Gayatri "Classification of selected medicinal plants leaf using image processing" Published in Iranian Conference on Machine Vision and Image Processing,2012 (https://www.semanticscholar.org/paper/Classification-of-selected-medicinal- plants-leaf-Gopal-Reddy/46b80eaf4866915199191ba544ae77172f072352?utm_source=direct_lin k)

[9] R. Geerthana, P. Nandhini, R. Suriyakala "Medicinal Plant Identification Using Deep Learning" Published 2021 (https://www. semanticscholar.org/paper/Medicinal-Plant-Identification-Using- Deep-Learning-Geerthana-Nandhini/23b4104f71d90458d286ece5b69644eba7ada4fa?utm_source=direct_ link)

[10] Amrutha M Raghukumar, Gayathri Narayanan "Comparison Of Machine Learning Algorithms For Detection Of Medicinal Plants" Published in International Conference Computing Methodologies and Communication, 2020 (https://doi.org/10.1109/ICCMC48092.2020.ICCMC - 00010)

[11] D.Venkataraman, N.Mangayarkarasi ,"Computer vision based feature extraction of leaves for identification of medicinal values of plants" Published in International Conference on Computational Intelligence and Computing Research,2016(https://www.semanticscholar.org/paper/Computer-vision- based-feature-extraction-of-leaves-Venkataraman- Kumar/ 5ca92aca4bf025bf 23493dc95b813ffc13f42b9c?utm_source=direct_link)

[12] A. Sabu, K. Sreekumar, R. R. Nair "Recognition of ayurvedic medicinal plants from leaves: A computer vision approach" Published in International Conference on Intelligent Information Processing, 2017 (https://www.semanticscholar.org/paper/Recognition-of-ayurvedic-medicinal- plants-from-A-Sabu-Sreekumar/27e384fd3fb76024e4e1db2c6bb7a6189243ed61?utm_source=direc t_link)

[13] A. Jayalath, T.G.A.G.D. Amarawanshaline, D. Nawinna, P. Nadeeshan,
H. Jayasuriya "Identification of Medicinal Plants by Visual Characteristics of Leaves and Flowers" Published in International Conference on Industrial and Information Systems, 2019 (https://www.semanticscholar.org/paper/Identification-of-Medicinal-Plants-by- Visual-of-and-Jayalath-Amarawanshaline/d5dbb80168238951fb62a53811acc4ca0aab9cbd?utm_sourc e=direct_link)

[14] Roopashree S and Anitha J, "Medicinal Leaf Dataset" (https://data.mendeley.com/)

[15] Arya Shah, "Indian Medicinal Leaves Dataset" (https://www.kaggle.com)

[16] "TensorFlow" (https:/www.tensorflow.org/)

[17] "Support Vector Machine" (https://scikitlearn.org/stable/modules/svm.html)

[18] "Deep learning" (https://d2l.ai/chapter_introduction/index.html)

[19] "Indian Medicinal Plant – Fact Sheet" (htttps://nmpb.nic.in/content/medicinal-plants-fact-sheet)

[20] "Board of Unnai,Siddha and Sowa-Rigpa (BUSS)" (https://ncismindia.org/board-of-unani-siddha-and-sowa-rigpa.php)