Scope
Volume 14 Number 03 September 2024

Deep Learning Image Processing in Medicinal Plant Industry Approach

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Abstract

Background/Purpose: The integration of deep learning techniques in image processing has shown significant potential in various fields, including the identification and analysis of medicinal plants. **Methodology/Approach:** The relevant information and specifics for this case study on image processing using deep learning were gathered from a number of research projects that were presented at conferences, reference papers, and websites pertaining to the medicinal plant business. Developing a theoretical notion may be achieved by constructing the model and doing analysis using the ABCD substructure. **Findings/Results:** By enhancing the accuracy and efficacy of plant identification and analysis, the use of deep learning image processing in medicinal plants has the potential to completely transform the sector. **Conclusion:** This research examines the applicability and significance of deep learning and recognition of images in the current context of the medicinal plant sector. **Paper Type:** Analysis of the research based on the case study.

Keywords: Image processing, medicinal plant industry, ABCD analysis, deep learning CNN.

1. Introduction:

Plants play an important role in supporting life and biodiversity on Earth by providing air and water to living organisms. One of the most significant types of plants is medicinal herbs, which are used to treat a variety of disorders. The information regarding medicinal plants passed down through generations must be maintained and conserved [1]. Computer vision, recognition of patterns, and image processing technologies offer promising outcomes for identifying and classifying medicinal plants [2]. Choosing a medical plant with the necessary therapeutic properties is one of the most difficult undertakings. Although herbal therapy has no adverse effects, treatment with an incorrectly recognized medicinal plant could end in the death of a patient [3-5]. As a result, a completely automated method for accurately classifying medicinal plants is unavoidable at this time[6].

Identifying and classifying medicinal plants is critical in the manufacture of traditional medications. Furthermore, appropriate classification of medicinal plants is critical for agronomists, botanists, ayurvedic medicinal practitioners, forestry department officials, and others involved with medicine production. However, a scarcity of skilled taxonomists is a significant challenge in this field. The use of deep learning approaches in image processing has shown great promise in a variety of domains, notably in the recognition and investigation of medicinal plants [7]. Deep learning algorithms can successfully evaluate vast datasets of plant photos, identifying subtle patterns and attributes required for plant identification. This technique not only improves the accuracy and efficiency of medicinal plant identification, but it also contributes to scientific study into the therapeutic properties and uses of these plants.

2. Focus of the research:

- The purpose of this study is to analyze the significance and use of deep learning image processing in the medicinal plantindustry.
- To analyze the functions and significance of CNN, SVM, KNN techniques in this industry.
- To assess the impact and challenges of deep learning on the medicinal plant industry.
- To explore the future prospects of deep learning image processing in this sector.

3. Strategy:

As indicated below, the material acquired from both primary and secondary sources serves as the study's foundation.

Supplemental gathering techniques involve consulting papers, websites, and literature studies on deep learning, image processing, and the medicinal plant sector.

4. Literature review:

Using computer vision, Kayhan, G., Ergün, E., et al. [1] described a method for automatically classifying the leaves of aromatic and medicinal plants based on their colour and shape. A novel feature extraction method that made use of the leaf's fractal, form, and gray characteristics was used for this classification. A few well-known feature sets were combined to create the feature set that was used. Furthermore, they used the application of NBC, which was more accurate than classifiers like KNN, CART, and PNN. It has been demonstrated that by integrating complementary traits, a system for leaf identification can be built. The characteristics that improve plant recognition accuracy were integrated in this study. The findings showed that the average percentage of correctly classified plant species was successfully identified. NBC proved to be a more effective classifier among the employed techniques.

In order to extract features for plant classification and identify medicinal plants from leaf images, Akter, R., Hosen, M.I., et al. [2] introducedattention based CNN architecture. Using a deep learning technique, they categorized the plant species after gathering and pre-processing a dataset of medicinal plants from Bangladesh. Following that, the high-level features for the classification learnt using the data augmentation technique was extracted using a three-layer convolutional neural network. The training process was conducted on 34123 image sand the testing results on an additional 3570 images demonstrated that this strategy is quite viable and effective, yielding a better performance. Even though it has better performance, but it only achieves 71.2 % accuracy, which is considerably low when compared to other methods.

A machine learning (ML) approach for classifying medical plant leaves using multispectral and texture datasets was presented by Naeem, S. et al. [3].In order to gather a standardized dataset, this study performed fused features extraction, edge/line detection, optimum extracted feature selection, along with efficient ML classifier selection. The 14 most valuable features that were helpful in achieving improved classification outcomes were found using the chi-square feature selection method. Five AI-based classifiers in all—the multi-layer perceptron (MLP), Bagging (B), LogitBoost (LB), Simple Logistic (SL) and Random Forest (RF)were taken into consideration. The MLP classifier performed better than other AI-based classifiers that were used, according to the results. There are millions of different kinds of medical plants and herbs in the globe, but this study just looks at the leaves of six different plants.

A system based on intelligent vision that uses an artificial Convolutional Neural Network (CNN) to recognize herb plants was presented by Azadnia, R. et al. [4]. In this Deep Learning (DL) model, a CNN block was utilized towards extraction of features, and a classifier block was used to categorize the extracted features. The classifier block had layers for dropout, dense, softmax, and global average pooling (GAP). The solution for recognizing the leaves of five different medicinal plants was tested using three sets of picture criteria. As a result, the vision-based system achieved an improved level of accuracy in each picture definition. As a result, this method may effectively identify therapeutic plants in real-time and displace conventional techniques. However, one limitation of this vision-based system is its reliance on high-resolution images. The system may struggle to accurately recognize herb plants if the images provided are of low quality or low resolution.

Begue, A. et al. [5] used computer vision algorithms to gather different shape-based features from the leaves of medicinal plants. First, a median blur filter with a window size of 25 was applied to the final image in order to minimize noise in it. Subsequently, a thresholding procedure was carried out, resulting in the image becoming a binary image consisting of only two values: black and white pixels. Otsu thresholding was utilized to accomplish this. Machine learning techniques were then used to classify the leaves of 24 different plant species into the relevant groupings. When compared with different machine learning methods like naïve Bayes, k-nearest neighbor, support vector machines, and neural networks, the random forest classifier produced the best accuracy.

Roopashree, S and Anitha, J [6] developed a vision-based system that can identify medicinal plants automatically using neural networks in computer vision. In this paper, a new set of medicinal leaf data is presented called Deep Herb. A total of 2515 leaf images of 40 Indian herb species are included. SVM and Artificial Neural Networks (ANN) are used to identify and extract features from pre-trained models that have undergone transfer learning. The SVM hyper-parameters are optimized by the application of Bayesian optimization. In addition to two CNN models, Xception-SVM and Xception-SVM-BO with SVM as the classifier, four CNN models were used: VGG16, InceptionV3, VGG19, and Xception with ANN as the classifier. The accuracy rate of the Deep Herb model is average when compared to the other six models.

Using large and diverse pharmacological and natural chemical datasets, Yoo et al. [7] proposed a deep learning-based technique to identify the therapeutic uses of natural compounds. This method addressed the problem of missing information by leveraging deep learning's capacity to combine disparate characteristics. The research produced 686-dimensional feature vectors for 2,882 authorized and experimental medications as well as 4,507 natural substances using hidden knowledge, molecular connections, and chemical property characteristics. These produced characteristics were used in conjunction with validated pharmacological indication data to train the deep learning model. The trained model correctly predicted prospective efficacies with high sensitivity, specificity, and accuracy when features of natural substances were input.

Plant in vitro culture in conjunction with neurofuzzy logic was first presented by García-Pérez et al. [8] to maximize phenolic chemical synthesis in Bryophyllum species under nutritional stress. They created prediction models to describe the total amount of phenolic compounds, flavonoids content, and radical-scavenging ability by utilizing machine learning. The results of the study showed that employing aerial portions of Bryophyllum cultivated in 1/2 MS medium produced the highest phenolic output. One important dietary component regulating phenolic biosynthesis was found to be ammonium concentration. Irrespective of the composition of the culture medium, the maximum antioxidant activity was achieved with aqueous methanol (55–85%), whereas flavonoids were best extracted with >85% methanol. This study emphasizes how artificial intelligence and plant cultivation methods may be used to investigate the phytochemical characteristics of therapeutic plants.

Dahigaonkar and Kalyane [9] introduced a method for preprocessing and segmenting leaf images as the initial steps in training data for classification. The preprocessing aimed to enhance visual appearance and improve dataset manipulation by removing noise and enhancing image quality. The RGB images were sharpened using unsharp masking to improve their appearance and sharpen edge or boundary points. Segmentation divided the image into multiple parts to extract relevant information, involving binarization and morphological operations (erosion and dilation) to remove imperfections. The largest component of the binary image was selected to determine morphological features such as geometric features, shape, color, and texture analysis. Classification of leaf samples using SVM was based on this unique feature set, enabling accurate identification of plant species from leaf images.

Rao et al. [10] introduced a novel method for identifying medicinal plants based on images of leaves captured from different angles, including front and back views. Their approach utilized a database of medicinal plant leaf images and identified unique texture and shape combinations to enhance the accuracy of plant identification. When presented with an image of a plant leaf, the system determined whether it belonged to a medicinal plant, providing information such as the local name, scientific name, leaf properties, diseases it can treat, and displaying the leaf image. The authors opted for DenseNet, a type of Convolutional Neural Network (CNN), due to its advantages in feature propagation and reuse, which improve efficiency and reduce evaluation loss. However, this method may not be suitable for plants with tiny leaves or those lacking a well-defined leaf structure.

5. Industry overview

The medicinal plant industry involves the identification, analysis, and utilization of plants for medicinal purposes. The integration of image processing technology in the medical plant industry represents a significant advancement in how medicinal plants are cultivated, monitored, and processed. Here's an overview of the key applications and notable example industries of how image processing is transforming this field:

Phylos Bioscience

Phylos Bioscience is a pioneering company that integrates high-resolution imaging with genomic analysis to enhance the cultivation and quality of cannabis plants.. In order to provide development and research solutions, the organization provides a variety of tools based on contemporary molecular genetics as well as Report Phrase computational biology. These tools help cannabis growers and cultivators assess the development of new varieties, comprehend the genetic diversity in their product line, and expand their businesses.

Greenhouse Technology

Greenhouse Technology focuses on optimizing growing conditions for medical plants through AI-integrated image processing. Their systems use cameras and sensors to capture real-time images of plants, which are analyzed to automatically adjust light, temperature, and humidity levels. This ensures optimal growth conditions, promoting healthier plant growth and higher yields. Greenhouse Technology's solutions help streamline the cultivation process, making it more efficient and effective

Ceres Imaging

Ceres Imaging is a venture-backed firm that uses aerial imaging and spectral image processing to track key crop factors such as plant nutritional and water contents (fertilizer/irrigation deficits), the existence of diseases/parasites/weeds, and yield of crops. They give farmers with data and insights that assist them enhance crop management, such as application of fertilizer, irrigation plans, stress/problem identification, and additional applications.

Hummingbird Technologies

Hummingbird Technologies utilizes drones equipped with high-resolution cameras to capture images of medicinal plant fields. These images are processed to detect areas of the field that may require attention, such as those affected by pests or diseases. By facilitating targeted interventions, Hummingbird Technologies helps ensure that only the highest quality plants are harvested. Their technology enhances field management and contributes to better crop health and yield.

Front Range Biosciences

Front Range Biosciences employs continuous image monitoring and machine learning to analyze images of hemp and cannabis plants. Their technology identifies signs of disease, nutrient deficiencies, and other stress factors, allowing for real-time plant health management. This proactive approach improves overall crop quality and yield. Front Range Biosciences is dedicated to advancing agricultural practices through innovative technologies and comprehensive plant health monitoring.

Table 1: Industries and their Functions

S.No	Industries	Technology	Function	Benefits
1	**Phylos Bioscience**	High-resolution imaging and genomic analysis	Detects early signs of disease and plant stress	Timely interventions, preventing widespread crop loss
2	**Greenhouse Technology**	AI-integrated image processing	Adjusts light, temperature, and humidity levels	Ensures optimal growing conditions, healthier plant growth
3	**Ceres Imaging**	Aerial imagery with advanced image processing	Monitors plant health and quality	Ensures optimal conditions for high-quality plant

				production
4	**Hummingbird Technologies**	Drone-based high-resolution imaging	Detects pest infestations and diseases	Facilitates targeted interventions for high-quality harvests
5	**Front Range Biosciences**	Continuous image monitoring and machine learning	Identifies signs of disease, nutrient deficiencies, and stress factors	Real-time plant health management, improved overall crop quality

The table 1 gives a detailed description of industries that use advanced technologies to monitor and manage plants. Phylos Bioscience uses high-resolution imaging and genomic analysis to detect early signs of plant disease so that timely interventions can be made to avert widespread crop loss. Greenhouse Technology employs AI-integrated image processing for adjusting light, temperature and humidity levels so that they may be conducive for growth hence healthier plants are realized. Ceres Imaging uses aerial imagery together with advanced image processing to ensure that plants are monitored for their health and quality thereby ensuring optimal conditions for high-quality plant production. Hummingbird Technologies employs drone-based high-resolution imaging to detect pest infestations and diseases, facilitating targeted interventions for high-quality harvests. Front Range Biosciences uses continuous image monitoring and machine learning to identify signs of disease, nutrient deficiencies, and stress factors, enabling real-time plant health management and improved overall crop quality. These technologies collectively enhance efficiency, accuracy, and productivity in plant health monitoring and management.

Table 2: Industries and their Net Income and Employee Count

Industries	**Employee Count**	Net Income
Phylos Bioscience[12]	50	$8.17M
Greenhouse Technology [15]	78	$17.1 M
Ceres Imaging [11]	85	$11.9M
Hummingbird Technologies [13]	51	$10M
Front Range Biosciences [14]	75	$2.2M

The table 2 provides an overview of the industries, detailing their employee numbers and net income. With 50 employees, Phylos Bioscience has revenue of $8.17 million. Greenhouse Technology employs 78 people and has revenue of $17.1 million. Ceres Imaging has 85 employees and revenue of $11.9 million. Hummingbird Technologies employs 51 people and has revenue of $10 million.Front Range Biosciences, with 75 employees, has revenue of $2.2 million. These data also highlight the size of these companies and the economic growth of the Plant Inspection Management industry.

6. ABCD Analysis

ABCD Analysis is a structured method used to evaluate and analyze various aspects of a system or situation. It is particularly useful in understanding the Advantages, Benefits, Constraints, and Disadvantages associated with implementing a particular technology, process, or strategy. This method provides a comprehensive framework for decision-making, allowing stakeholders to weigh the pros and cons of a proposed solution effectively.

Advantages:

Image processing technology offers several advantages across industries.

- ❖ It significantly improves accuracy in identifying and monitoring plant health, pests, and diseases, which is crucial for early intervention and effective management.
- ❖ Moreover, these technologies enhance efficiency by automating processes, reducing manual effort, and optimizing resource allocation.
- ❖ They also enable scalability, allowing for the analysis of large datasets and the expansion of operations as needed to meet growing demands.

Benefits:

The adoption of image processing technology brings numerous benefits to industries.

- ❖ The identification of medicinal herbs using automation is crucial and may eventually supplant the human recognition of numerous plant species by subject matter specialists. This has several advantages, including lower costs and time requirements with respectable classification accuracy.
- ❖ In agriculture and farming, it facilitates enhanced research in plant health and disease management, contributing to scientific advancements and sustainable practices.
- ❖ For pharmaceutical companies and the agricultural sector, these technologies improve productivity by optimizing crop yield and quality, which is essential for developing new drugs and improving agricultural practices.
- ❖ Furthermore, image processing technology supports environmental monitoring by assessing impacts, monitoring biodiversity, and managing natural resources efficiently.

Constraints:

Despite its benefits, implementing image processing technology presents certain constraints.

- ❖ High initial costs are a significant barrier, as it requires investment in advanced imaging equipment, software, and infrastructure.
- ❖ Moreover, the complexity of these technologies demands specialized knowledge and training for operation and maintenance.
- ❖ Integrating new technology with existing systems can also be challenging, potentially disrupting current workflows and processes.

Disadvantages:

There are some disadvantages associated with image processing technology in industries.

- ❖ Dependency on data quality is a critical issue, as the accuracy and reliability of the technology heavily rely on the quality of input data.
- ❖ Technical challenges such as algorithmic complexity and the need for substantial computational resources can also pose barriers to effective implementation.
- ❖ Additionally, regulatory and ethical considerations, intellectual property rights, including data privacy, and regulatory compliance, must be carefully addressed to mitigate risks and ensure responsible use of these technologies.

7. Conclusion

The identification and categorization of medicinal plants has advanced significantly with the incorporation of image processing technology, especially deep learning approaches. Considering the vital role that medicinal plants play in offering natural cures for a range of ailments, as well as the possible hazards that come with misidentification, it is imperative that precise and automated procedures be developed. These technologies support biodiversity preservation and traditional knowledge preservation in addition to improving the accuracy and efficiency of plant identification. Globally enhancing patient outcomes and promoting sustainable healthcare practices will be greatly aided by ongoing study and application of these technologies.

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