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AI-Based Medicinal Plant Detection System

Sneha Bankar[1], Madhura Raju Wankhade[2], Samruddhi Mahadev Gholap[3], Pranali Vishwanath Ghugarkar[4], Ravindra Pandit Ahire[5]

[1,2,3,4,5]Dept of Artificial Intelligence and Data Science, DYPCOEI, Pune, India

[1]sneha.bankar@dypatilef.com, [2]madhurawankhade04@gmail.com, [3]gholapsamruddhi7@gmail.com , [4]pranalighugarkar673@gmail.com, [5]hackrore@gmail.com

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Abstract

Medicinal plants are really important for our health both in ways of healing and in modern hospitals.. Finding these plants can be very hard and it takes a long time a lot of work and you need to know a lot about plants. To make this easier we made a computer system that uses intelligence to identify medicinal plants by looking at pictures of their leaves. This system uses computer methods like Convolutional Neural Networks to look at the shape, texture, color and patterns on the leaves and sort them correctly. We also use a method called YOLO to find leaves even in complicated places. To make this work we take pictures of leaves clean them up with computer tools like OpenCV and then teach the computer to recognize them. We use a way of teaching the computer called transfer learning, which helps it learn faster with fewer pictures. We made a website where people can upload pictures of leaves and get information about the plant and its healing properties. This system is really good, for doctors, farmers and people who study plants because it is very accurate and works fast. Even though it is very good we still have problems to solve like getting types of pictures and making it work in different environments. In general our system shows how computers can help make finding medicinal plants easier more accurate and faster which can help us have healthcare and protect the environment. Medicinal plants are very important. Our system can help people who work with medicinal plants every day.

Keywords: Artificial Intelligence; CNN; YOLO; Medicinal Plants; Image Processing; Deep Learning.

How to Cite This Article

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Introduction

Medicinal plants have been a part of how we take care of our health for a very long time and they are still used today in things like Ayurveda and Chinese medicine. Even when we make medicine we often get the ingredients from plants.. It is really hard to tell these plants apart because there are so many different kinds and they can look very similar especially when we look at their leaves. Usually we need experts who know a lot about plants to look at things like the shape and color of the leaves to figure out what they are. This takes a time and people can make mistakes. In some places like areas it is hard to find people who know about plants so it is hard for farmers and doctors to know what plants they have. Now that we have things like Artificial Intelligence and Deep Learning we can use computers to look at pictures and figure out what is in them. This is called computer vision. One kind of computer program called Convolutional Neural Networks is really good at looking at pictures and figuring out what is in them. We want to use this kind of program to make a system that can look at pictures of leaves and tell us what kind of plant they come from. We are using a few kinds of programs including one called YOLO to make sure our system is accurate and can work quickly. We also made a website that people can use to access our system. It is easy for anyone to use. Our goal is to make a system that's better than the old way of looking at plants and that can help people who need to know what kind of plants they have. We want our system to be fast, efficient and accurate and to help people who are working with plants like medicinal plants, every day. We are focusing on plant detection and we are using leaf image recognition to do it. Our system is going to use plants and it will be able to look at pictures of leaves and tell us what kind of medicinal plant they come from. This will be very helpful for people who work with plants like farmers and doctors because they will be able to know what kind of medicinal plants they have and they will be able to use them to help people. We are excited about our system. We think it will be very useful, for people who work with medicinal plants like medicinal plants, every day.

Problem Statement

Identifying plants by looking at their leaves is a tough job that needs a lot of expertise in plants. The old ways of doing this are not slow but also often get it wrong because people make mistakes and see things differently. The fact that medic- inal plants are needed more and more in healthcare and farm- ing means we need a way to identify them quickly and cor- rectly. Current computer programs that try to do this job have problems, like not having different examples to learn from, not working well in real life and needing a lot of computer power. So the goal of this project is to make a system that can iden- tify medicinal plants just by looking at pictures of their leaves. This system should be able to deal with lighting, backgrounds and leaf conditions and give answers right away. It should also be something that many people can use, like farmers, scientists and people who work in healthcare including medicinal plants researchers and medicinal plants farmers who need to identify plants

Literature Review

The way we identify plants has changed a lot over time. We used to do it by hand. Now we use computers to do it for us. Some researchers used a method where they would man- ually pick out certain features from pictures of plants like the color and texture. They would then feed these features into a computer program to try to identify the plant. The programs they used were things like Support Vector Machines, Decision Trees and k-Nearest Neighbors. These methods worked okay. They weren't great because the features they used were chosen by people. With the rise of learning things changed. Convolu- tional Neural Networks or CNNs became really good at classi- fying images. CNNs like VGGNet, ResNet and Inception are great at looking at pictures of plants and figuring out what they are. Plant identification using these models is more accurate than the methods. Some recent studies have looked into using trained models and fine-tuning them for plant identification. This approach helps because it doesn't take much time to train the model and it works well even when there isn't a lot of data. There are also models like YOLO that can detect objects in an image in real-time. With all these advancements there are still some challenges. Many plant identification systems are trained on datasets that don't have a lot of variation in things, like light- ing and background. This makes them not work well in real-life situations. Also these systems require a lot of computing power, which makes it hard to use them on devices that don't have a lot of resources. So we need a system that combines learning real- time detection and is easy to use on different devices. Plant identification is a task and plant identification systems need to be robust and scalable to work well. Plant identification using learning models can help address these limitations and provide a better solution. The system should be able to identify plants quickly and it should be easy to deploy on different devices.

Table 1. *Comparison of Existing Work and Proposed System*

Parameter	**Existing System**	**Proposed System**
Approach	Uses CNN for plant classification based on leaf images	Uses CNN for classification and YOLO for real-time detection
System	Focuses mainly on model development and	Complete end-to-end system with backend, frontend, and database

Implementation	evaluation	integration
Real-Time Capability	Supports offline classification only	Provides real-time detection and prediction through a web interface
Dataset Handling	Limited dataset diversity and preprocessing details	Includes a diverse dataset with preprocessing techniques such as segmentation, normalization, and noise removal
Performance	High accuracy in controlled conditions	High accuracy with improved robustness and faster response time
User Interaction	Limited or no user interface	User-friendly web interface using Flask, HTML, CSS, and JavaScript
Application Scope	Mainly for research and academic purposes	Applicable in healthcare, agriculture, education, and real-world applications

Methodology and System Architecture

The proposed system is like a line of steps that work to- gether to identify plants from images.

1. Getting the Image

The system starts with getting the image of a leaf, where people can take a picture or upload one using a camera or the web. These images are used for the steps.

2. Making the Image Better

Making the image better is an important step to make the image clearer and remove things that are not needed. The sys- tem uses things like making the image smaller making all the images the same filtering and separating the leaf from the rest of the image using OpenCV. This helps to get the leaf by itself which makes it easier to tell what kind of plant it is.

3. Finding Things in the Image

The system looks for important things in the image like the shape, how it feels the color and the patterns on the leaf. When using learning the system can find these things by itself using special layers so people do not have to do it manually.

4. Teaching the System

The system uses a kind of computer program called a Con- volutional Neural Network to tell what kind of plant it is. The system is taught using a lot of images of leaves that are labeled. The system also uses things it already knows to make it better and faster. It can detect things in real time so it can find many leaves in one image.

5. Telling What Kind of Plant It Is

The system uses the things it found in the image to tell what kind of plant it is. It can find the leaves in the image. Tell what kind of plant they are.

6. Showing the Results

The system shows the name of the plant how sure it is and what it can be used for in a way that's easy to understand. The system gets this information from a list of plants.

This way of doing things makes sure that the system can identify plants quickly correctly and, in time which is what the plant identification system does.

The proposed system is to visually represent the workflow of the AI-based Medicinal Plant Detection System and explain how data flows from input to output.

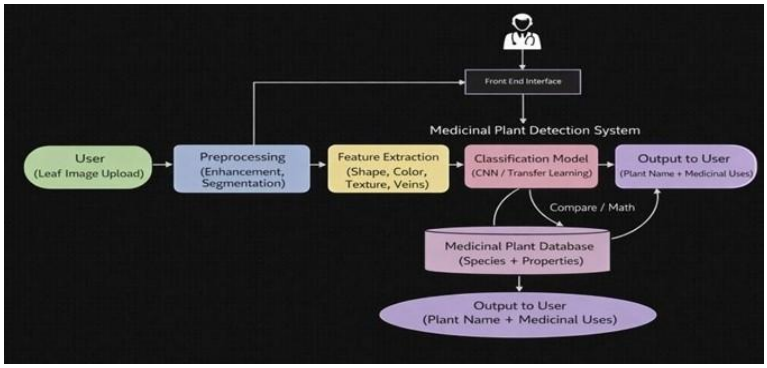

Fig. 1. *Methodology*

System Design

The system is built with parts for the frontend, backend and machine learning.

- Frontend: I made it using HTML, CSS and JavaScript to cre- ate a user- interface.
- Backend: I used Flask to handle the server-side work and con- nect it to the models.
- Database: This is where we store information, about plants and the results of classification.
- Machine Learning Module: It uses CNN and YOLO models to classify and detect things.

The process starts when the user interacts with the system then it processes the image makes a prediction using the model and shows the result. This design makes it easy to fix things add features and make it bigger.

Implementation

1. Dataset Collection

The system starts with collecting images of medicinal plant leaves from sources like public datasets, online botanical web- sites and real-time image capture using cameras or smart- phones. Each image is labeled with its corresponding plant species for learning. We make sure to include images with dif- ferent lighting, background, leaf orientation and image quality. This helps make the model robust and perform better in real- world conditions.

- We collect images from sources.
- Each image is labeled with its plant species.

2. Preprocessing

After collecting data we preprocess the images to improve their quality and make them suitable for model training. Pre- processing includes removing noise resizing images to a size and normalizing pixel values. We also apply segmentation tech- niques to extract the leaf region from the background. These steps help reduce inconsistencies in the dataset and improve the models accuracy.

- Preprocessing improves image quality.
- It helps reduce inconsistencies in the dataset.

3. Model Development

In this phase we develop a learning model using Convo- lutional Neural Networks (CNN) with frameworks like Tensor- Flow and Keras. The CNN model automatically extracts fea- tures from leaf images like shape, texture, color and vein pat- terns. The architecture includes layers pooling layers and fully connected layers. We may also use transfer learning to improve accuracy and reduce training time.

- We use CNN for feature extraction.
- Transfer learning improves accuracy.

4. . Testing

We divide the dataset into training and testing sets to eval- uate the models performance. The training set trains the model while the testing set validates its accuracy. During training the model learns patterns from labeled images using optimization algorithms and loss functions. We evaluate the model using metrics like accuracy, precision and recall.

- Training helps the model learn patterns.
- Testing validates the models accuracy.

5. Integration (Backend Development)

Once the model is trained we integrate it into a backend system using the Flask framework. Flask connects the user in- terface and the machine learning model. It handles tasks like receiving image input preprocessing the image sending it to the model for prediction and returning the result.

- Flask handles image input and prediction.
- It connects the user interface and model.

6. Frontend Development

The frontend is developed using HTML, CSS and JavaScript to provide a user- interface. It allows users to upload leaf images and view results easily. The interface is designed to be simple, responsive and easy to use.

- The interface is user-friendly.
- It allows image upload and result viewing.

7. Deployment

Finally the complete system is deployed on a server or cloud platform for real-time usage. Deployment ensures the system is accessible, scalable and capable of handling users. Cloud deployment options, like AWS or Heroku can be used for accessibility.

- The system is deployed for real-time usage.
- It is accessible and scalable.

Results and Discussion

The system they came up with was tested using pictures of leaves from plants. The results show that it is really good at figuring out what kind of leaf it is and it does this quickly.

Key things we found out:

- The CNN model is very good at learning about the compli- cated parts of leaves.
- YOLO is great for finding leaves in time and it does not take long to do this.
- The system works well even when things are not perfect. Things we measured:
- Accuracy: This shows how often the system gets it right Precision: This shows how often the system is right when it says it found something
- Recall: This shows how good the system is at finding all the things it is supposed to find

The results show that the system they came up with is better than ways of doing things because it is more accurate and faster.. The system only works well if the pictures of leaves are good and the conditions are right. The medicinal plant leaf images are important for the system to work properly. The system is good, at classification of plant leaf images

Performance Analysis

The performance of the proposed AI-based medicinal plant detection system is looked at using classification metrics and real-time system behavior. The evaluation looks at the accuracy of the deep learning model. How well the system works in real life situations.

The dataset is split into two parts, one for training and one for testing. The CNN model is trained many times. When the model is being trained it is seen that the mistakes it makes get fewer and fewer and the accuracy gets better and better which means it is learning the features of leaves like their shape, tex- ture and the patterns of veins. Then the trained model is tested on data to see how well it can be used in different situations.

Evaluation Metrics

The performance of the AI-based medicinal plant detection system model is measured using the following metrics:

- Accuracy: This shows how often the predictions are
- Precision: This shows how many of the predicted plant species are actually correct
- Recall: This shows how good the system is at finding all the actual plants
- F1-Score: This is a balance, between precision and recall and it is used to evaluate the performance of the AI-based medicinal plant detection system model.

Table 2. *Sample Performance Metrics*

Metric	Value (Approx.)
Accuracy	92% – 96%
Precision	91%
Recall	90%
F1-Score	90.5%

Model Performance Observations

The CNN model is really good at finding things in pictures on its own without needing any help from people. When we use something called transfer learning it makes the model bet- ter at telling things which is especially helpful when we do not have a lot of pictures to teach it with. The CNN model is good at recognizing types of plants but it can get confused when the leaves look really similar, to each other. If we prepare the pic- tures properly before giving them to the CNN model it gets even better at identifying the plants.

System Performance

The system is built with a Flask backend. It is ready for people to use right now. We look at how the system works by checking how long it takes to get a response and how easy it is to use. The Flask backend system has some things about it: Fast Prediction Time: The Flask backend system gives us results in just a few seconds Efficient Processing: The Flask backend sys- tem is fast because we worked on making the preprocessing and model loading better User-Friendly Interaction: The web page that the Flask backend system is, on is easy to use because you can upload images and see the results easily

Challenges Affecting Performance

The system works well but some things can affect how it does its job.

These things include:

- Lighting that is not always the different backgrounds
- Pictures that are not very clear or are blurry
- Leaves that look similar on types of plants
- Not having a big enough variety of pictures, in the sys- tem to learn from, which is the limited dataset diversity of the system and the limited dataset diversity that the system has to work with

Advantages and Limitations

Advantages

- High accuracy due to deep learning models
- Fast and real-time detection
- User-friendly interface
- Reduces dependency on experts
- Scalable and adaptable

Limitations

- Requires large and diverse datasets
- High computational requirements
- Difficulty in distinguishing similar species
- Sensitivity to lighting and background variations

Applications

1. Healthcare and Herbal Medicine

The system is really useful in the healthcare sector espe- cially when it comes to herbal medicine practices. It helps peo- ple find plants quickly and learn about their therapeutic prop- erties. This is helpful for practitioners, Ayurvedic experts and even regular people who want to use the plant for treatment. It also means we do not have to rely much on expert botanists and we can avoid using the wrong or harmful plants. In areas where it is hard to get to medical facilities this system can support ba- sic healthcare by promoting the use of safe and effective herbal remedies. Herbal medicine is a part of this and the system is very important for herbal medicine.

2. Agriculture and Farming

The system is also helpful to farmers. It assists them in rec- ognizing plant species and making good decisions about what to grow. It helps them find plants that're valuable for medicine and for selling, which encourages farmers to grow plants that are in high demand. The system can also be used to check the health of plants and find diseases in the future. By identifying plants the system supports sustainable farming and promotes the growth of medicinal plants. This can increase farmers income. Help the agricultural industry. Agriculture and farming are very important. The system is useful for agriculture and farming.

3. Botanical Research and Biodiversity Conservation

The system is very useful for researchers and scientists who study botany and environmental science. It helps them identify and classify plant species quickly which saves time and effort when they are doing field work. Researchers can use this tool to study the variety of plants look at patterns in the environ- ment and document plants. This helps conserve biodiversity by making it easier to monitor and preserve plant resources. The system can also be used to collect and analyze amounts of data for environmental research. Botanical research and biodiversity conservation are areas where the system is helpful.

4. Learning

The system is a tool for students and teachers. It helps stu- dents learn about plant taxonomy and identification in a fun and interactive way. Students can upload pictures of leaves. Learn about different plant species and their uses in medicine. This helps students learn more about biology, botany and environ- mental science. Teachers can also use the system to show stu- dents how artificial intelligence is used in science. Education and learning are very important. The system is useful for edu- cation and learning.

5. Herbal Product Industry

Companies that make products, like oils, medicines and cosmetics can use this system. It helps them check the mate- rials they use. This way they can make sure their products are of quality. They can also prevent using the plant species. This helps them ensure that what they claim their products are made of is actually what they are using. For example if a company says their oil is made from a herb they can use

this system to verify that. It is a tool for companies in the herbal product in- dustry. They can use it to build trust with their customers. Customers want to know that the products they buy are safe and made with quality ingredients. The system can help companies achieve this. It can also help them follow rules and regulations. There are often rules, about what can be put in products. This system can help companies follow those rules. Overall it is a tool. It can help companies make products. It can also help them build trust with their customers.

6. Practical Uses

The system can also help in many other areas.

For example it can help tourists in eco-tourism to find out what plants they see in forests or nature reserves.

- In forest management it can help authorities keep track of plant species.
- It can also help the pharmaceutical industry to research medicines made from plants.
- The system is useful, in areas where people need to identify plants.
- Eco-tourism, forest management and pharmaceutical in- dustry can all benefit from it.

Limitations and Future Work

The system can be improved by adding new features to make it more accurate, easy to use and useful in real life. One important improvement is to make it work on phones so users can take pictures of plants and identify them right away. This will make the system more accessible to farmers, researchers and regular people when they are out in the field. Healthcare and herbal medicine will benefit from this. Another key improvement is to add plant species to the systems database, including different types of lighting, backgrounds and environmental conditions. This will make the system better at identifying plants and increase its accuracy. Putting the system on cloud-based platforms will also make it more scalable allow access and support many users at the same time without slowing down. The system can also be improved by adding support for languages so users from different regions can use the system in their own language. This will make the system more useful and popular. Agriculture and farming will also benefit from these improvements. The system can also be improved by connecting it to devices like cameras and sensors which will allow for automatic plant monitoring and real-time data collection in fields. Additionally the system can be extended to include features for detecting plant diseases, which will allow users to not identify plant species but also diagnose diseases based on the condition of the leaves. This will make the system more useful, in agriculture and healthcare. Herbal medicine and botanical research will also benefit from these improvements.

Output

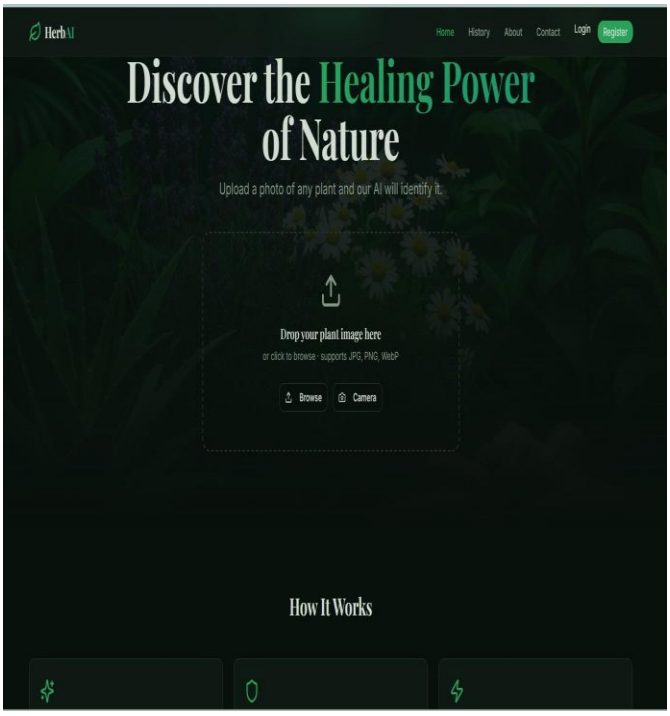

Fig. 2. *User interface*

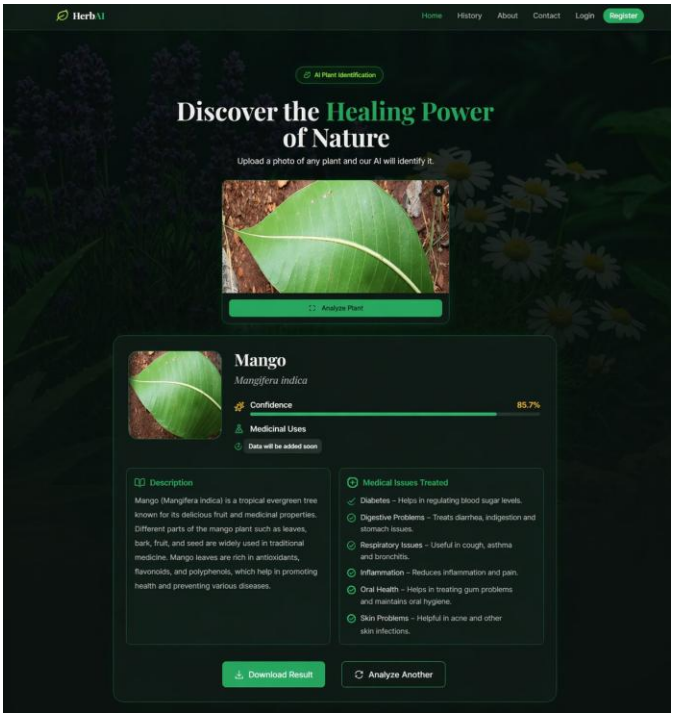

Fig.3. *User interface*

Conclusion

This paper presents a system that uses intelligence to identify medicinal plants from pictures of their leaves. The system uses a type of computer program called a Convolutional Neural Network to classify the plants and another program called YOLO to detect the plants in time. This allows the system to accurately and quickly identify plant species based on what their leaves look like. The system also uses techniques to prepare the images before using them to train the model, which helps the model work better. A website built using Flask makes it easy for users to access the system. The system is designed to make it easier to identify plant species without needing to be an expert. It could be useful in areas like healthcare, farming and scientific research. The system works quickly and reliably which is helpful. There are still some challenges to overcome, like the need for data and dealing with changes in the environment. However the system shows a lot of promise for being used in real-world situations. Could be improved further in the future. The medicinal plant detection system provides a reliable solution. The medicinal plant detection system is easy to use. The system can help in healthcare. The system can help in agriculture.

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