# BambooFolio: Enhancing Bamboo Species Classification Through Image Processing

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***Abstract*— Bamboo is a highly adaptable and environmentally significant plant species essential to many economic sectors, including building, furniture manufacturing, and environmental preservation. Nonetheless, bamboo species are difficult to identify and categorize because of their immense diversity and subtle variances. The tools and technologies were not invented or discovered, even though the concept of applying digital image processing to identify bamboo species that significantly exploited the methodological approach has been accomplished previously. Our model is an effective Graphical User Interface (GUI) created to increase the accessibility and user-friendliness of the suggested Ideas for the consumers. Because BambooFolio can quickly and accurately identify bamboo species, it is a valuable tool for ecological research, reforestation initiatives, and industrial bamboo uses. The project's evolution demonstrates how cutting-edge image processing methods combined with approachable user interfaces may be able to close the gap between technology advancement and biodiversity protection. To correctly identify the species from its photos, we have extracted the important and relevant characteristics using various image processing techniques. BambooFolio uses computer vision and image processing to identify the variety of bamboo species efficiently and precisely for botanists, academics, and laypeople alike. It offers a stimulating and useful platform that boosts the efficiency of the classifying procedure.**

***Keywords—Graphical User Interface, environmental preservation, reforestation.***

## I. INTRODUCTION

Bamboo is the fastest-growing evergreen plant that belongs to the family of grasses. After China, India has the second-largest bamboo reserve in Asia. It has 125 indigenous species and 11 exotic species from 23 genera of its family. Out of 125 native species, 40 have been raised by the Maharashtra Bamboo Development Board, of which 7–8 is currently in use. There are a total of 1600 applications of Bamboo. Bamboo is globally of great interest due to its rapid growth, and renewable, recyclable, and environmentally friendly properties. Bamboos are traditionally categorized visually using exterior anatomical traits. Species are often identified by their anatomical features, including stems, internode distances, leaves, culm sheaths, flowers, etc.

In the 1960s, researchers from the Jet Propulsion Laboratory, Massachusetts Institute of Technology, Bell Laboratories, and the University of Maryland developed digital image processing techniques. Despite high costs, affordable computers, and technology in the 1970s led to rapid expansion, enabling real-time processing. Digital image processing has become a popular method since the 200s due to its affordability and adaptability, making it the least expensive and most cost-effective approach. The fast-developing science of image processing makes it possible to digitally detect and identify plant species, including Indian bamboo species. The ability to analyze photos and extract information on plant species, growth, and health makes this technology essential to botany and agriculture. Image processing is an interdisciplinary area that brings together computer vision, botany, and machine learning. It offers vital data for conservation efforts, environmental monitoring, and crop management. This procedure offers uniformity and efficiency in the field, which makes it a vital instrument for agricultural and ecological preservation.

Conventional techniques for identifying bamboo depend on morphological traits, which can be difficult to evaluate and require a lot of effort. Furthermore, it's possible that these techniques won't work well for differentiating between closely related species. The identification of bamboo species by digital image processing and machine learning approaches has gained popularity in recent years. These methods may be used to train machine learning algorithms to classify bamboo species with high accuracy since they can objectively extract and evaluate a wide variety of information from photos of bamboo. Bamboo species have been effectively classified using machine learning methods, with a classification accuracy of more than 90%. These algorithms may be used to create smartphone apps for identifying bamboo, keep an eye out for changes in the species composition of bamboo forests, and create new bamboo-based goods. The image processing feature of MATLAB is among the methods that are essential for differentiating between different species of bamboo because of its accuracy, flexibility, and versatility. Algorithms offer an automated and impartial method for identifying bamboo species, doing away with the subjective and laborious aspects of conventional techniques. This technology reduces prejudice and human error while ensuring consistent and dependable outcomes. As a result, MATLAB offers a full range of image-processing techniques that are useful for differentiating between different species of bamboo.

The Bamboofolio model shows potential for classifying different kinds of bamboo using image-processing methods in MATLAB. Its capacity to adapt to real-world settings and the precision of species classification in a variety of contexts, however, remain major research gaps. As things are right now, the model's actual use may be hindered by its incapacity to manage illumination, angle, and backdrop alterations during image capture. Furthermore, the accuracy with which the model can discern minute changes across closely related species of bamboo is yet unknown, which further diminishes its dependability for precise species identification. Moreover, the model's capacity to generalize across various kinds is hindered by the lack of uniform and extensive datasets covering a broad range of bamboo species. Closing these gaps by strengthening the model's adaptability to a variety of environments and raising its accuracy in species identification

The project aims to classify different bamboo species by analyzing the shape, size, and other factors of bamboo leaves, culms, and branches. BambooFolio software helps reduce fraud by enabling customers to accurately identify bamboo species used in products. Existing studies rarely integrate multiple feature variables and quantify key classification-influencing aspects. Automated recognition of bamboo has not been thoroughly established due to the lack of studies, databases, and difficulties in manual collection. The proposed work uses a central moment classifier to automate the classification of bamboo species, resulting in considerable recognition accuracy. The project also presents a novel approach for the automatic identification of bamboo based on cross-sectional images through computer vision, with 100% accuracy on the training dataset and 98.7% accuracy on the testing dataset.

To ensure consistency and standards, bamboo images are preprocessed and collected. Texture analysis, edge identification, color histograms, and other feature extraction techniques are used to determine leaves' form, texture, and internode features. Image segmentation techniques are used to evaluate different parts of split bamboo plants. The technique of identification is connected to a database containing information on various bamboo species. A user-friendly internet interface is provided for easy involvement. Field testing confirms accuracy in real-world scenarios, and updates and data maintenance are planned for further photographs. Working with specialists ensures accurate species identification and continuous system development. It is now possible to expand the system to include other species.

### A. *Introduction to Bamboo species considered for the dataset*

We carefully took sample photos of every bamboo species from different viewpoints and angles in cooperation with MBDB. This method accounted for the differences in bamboo morphology since various species have distinct physical characteristics and traits. We made sure to collect three to five photographs of each species from various perspectives, resulting in a comprehensive dataset that provides details about each species. Two particular bamboo species of interest that were selected as the center of attention for the BambooFolio project underwent an especially extensive data collection process. Our goal was to create a precise and trustworthy classification algorithm that could differentiate between these closely related bamboo kinds by acquiring a solid dataset for these two species.

*1) Bambusa tulda:* Bambusatulda is a medium-sized tropical clumping that is also known as Jati banh or Mritinga. It is frequently called Indian Timber bamboo or Bengal bamboo. It is used extensively in India's paper pulp industry in addition to being a great and robust timber for scaffolding and building due to its nearly solid culms. Bambusatulda lacks nodal roots and possesses woody culms. Most of the agile branches are dispersing. The culm sheaths of jati banh are triangular and chordate.

It reaches a height of 6–23 meters and an internodal spacing of 30–60 cm. In addition, the leaf sheaths seem smooth and the leaf hairs are pale. The leaf blades are linear, measuring 150–250 mm in length and 17–37 mm in width. There are fifteen to twenty secondary veins in each leaf blade.

*2) Bambusa bambos:* Bambusa bambos, a tropical thick clumping bamboo species endemic to Southeast Asia, is sometimes referred to as Kotoha or Behor Bans. The robust, rapidly expanding woody culms of Bambusa bambos range in height from 10 to 35 meters and have an average diameter of 10 to 20 cm. The internodes are spaced 15–46 cm apart and have very thick walls that are dark green. Some lower nodes generate small aerial roots, and the nodes exhibit minor swelling. Nodes are frequently spine-like structures that have a core dominant branch and one or two lateral branches. The long, wiry, and typically twisted lower branches of thorny plants are directed downward. The highest leafy branches have tiny spines and form a plume-like fan. The tips of the lance-shaped leaves are long and pointy. They are 8–15 cm long and 15–30 cm wide.

| Sr no. | Bamboo species considered for the dataset | | |
|---|---|---|---|
| | Categories | *Bambusa tulda* | *Bambusa bambos* |
| 1. | Length(leaf) | 150-250 mm | 8-15 cm |
| 2. | Width(leaf) | 17-37 mm | 15-30 cm |
| 3. | Texture(leaf) | Smooth | Slightly rough |
| 4. | Margin(leaf) | Smooth | Occasional serration |

Table No. 1: Comparison Between Bamboo Species Considered for Dataset

## II. LITERATURE SURVEY

The survey was based on a study article, and after reviewing relevant information, decisions were made. The effectiveness of the investigation and outcomes were heavily influenced by the research report.

Bamboo plants are categorized using digital image processing and the central moment algorithm as reported in paper [1] by K sing et al. Using the central moment, they were able to derive the morphology of the bamboo culm sheath. They presented a brand-new method that takes image borders into account alone when classifying bamboo using Fourier moments. They assert that this approach will improve classification accuracy since the borders of the bamboo sheaths vary among species.

P.Sarma and J.K. Talukdar's study[2] provides an overview of research in image processing, deep learning, and various algorithms like CNN, SVM, rule-based, and greedy. They also explore various bamboo species and criteria for effective bamboo species recognition.

E. P. Purwandari et al journal .'s work [4] described an Android rule-based expert system that was able to differentiate between many bamboo species. They use a rule-based, greedy algorithm that can identify between several types of bamboo.

A deep learning algorithm was used by Lee S. H. et al. [5] to identify plant species based on leaf veining. Their study on plant classification involves four steps: preprocessing images, feature extraction, sampling, and classification. By utilizing the Sobel edge detector and the CNN feature extractor, they fared better than the SVM classifier.

Numerous leaf traits were used in a study by Singh Krishna et al. [6] to identify the kind of plant. In their study, they used an image moment-based classifier—which is purportedly a unique idea in this field—to compute the moments of the leaf morphology.

The conversation guided how to proceed with our work and suggested several technologies for obtaining a trustworthy tool. The authors discussed the benefits and drawbacks of each strategy, providing direction for our work and identifying suitable technologies for obtaining a reliable tool..

## III. METHODOLOGY

The project uses traditional computer vision and machine learning algorithms for bamboo species detection. Image segmentation techniques, like thresholding and contour detection, are used to isolate and extract bamboo leaves and stems. Supervised machine learning algorithms, such as decision trees, support vector machines (SVMs), and convolutional neural networks (CNNs), are used for classification. Decision trees reveal essential features for species differentiation, SVMs handle complex feature spaces, and CNNs automatically learn hierarchical features from images, making them suitable for extensive datasets with numerous bamboo species.

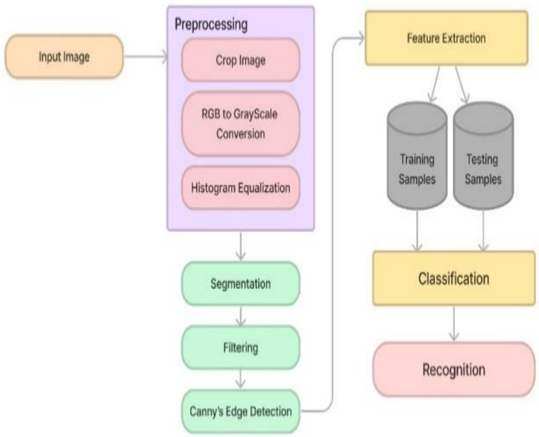
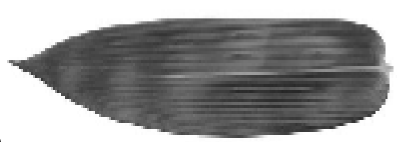


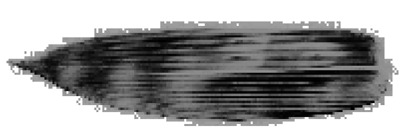

Fig 1: Algorithm Approach for Image Processing

The process of analyzing bamboo leaves and stems involves several stages. The first stage involves collecting digital images for analysis, which are then subjected to preprocessing operations to standardize the data and improve the quality of the input images. The second stage involves image segmentation, where the leaves and stems are separated from the background using techniques to isolate the regions of interest. The third stage involves feature extraction, where the features defining bamboo species are extracted from the segmented regions. The fourth stage involves training and classification using supervised machine learning algorithms, which can classify new images into the appropriate species category based on the extracted features. The final stage involves presenting the results, including generating reports, displaying classification accuracy, and highlighting the species detected in each image.

*(a)*



*(b)*



*(c)*

*(d)*

*(e)*

Fig 2 : (a) original image (b) grayscale image (c) histogram equalization image (d) segmentation image (e) canny edge detection image

### A. *Data Gathering:*

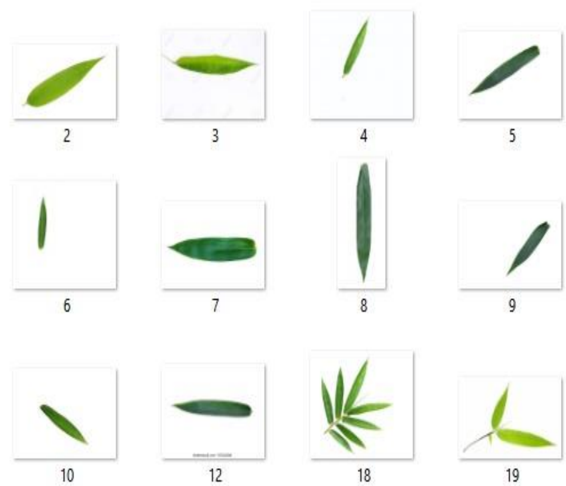



Fig 3: Dataset of Bamboo Leaves

We carefully took sample photos of every bamboo species from different viewpoints and angles in cooperation with MBDB. This method was used to account for the differences in the morphology of bamboo since various species have distinct physical characteristics. We made sure to collect three to five photographs of each species from various perspectives, resulting in a comprehensive dataset that provides details about each species. Two particular bamboo species of interest that were selected as the center of attention for the BambooFolio project underwent an especially extensive data collection process. Our goal was to create an accurate and trustworthy classification model that could differentiate between these closely related bamboo species by acquiring a solid dataset for these two species.

*B. Architecture Design:*

The use case diagram illustrates the operation of a graphical user interface or system, which involves several steps. After uploading an image, preprocessing is performed, including cropping, histogram equalization, segmentation, filtering, and feature extraction. Cropping captures only the necessary portion of the image, while histogram equalization enhances contrast and creates a more detailed histogram. Thresholding isolates objects from the background, while filtering fills gaps and eliminates white spaces. Edge detection finds specific features and edges, which are used to compute aspect ratios and extract features.

Feature extraction is crucial for accurately classifying bamboo species. These features are used as input data by classification algorithms, like machine learning models. Support vector machines train the data, and the output displays information on individual bamboo species, including their common name, scientific names, applications, and other features.

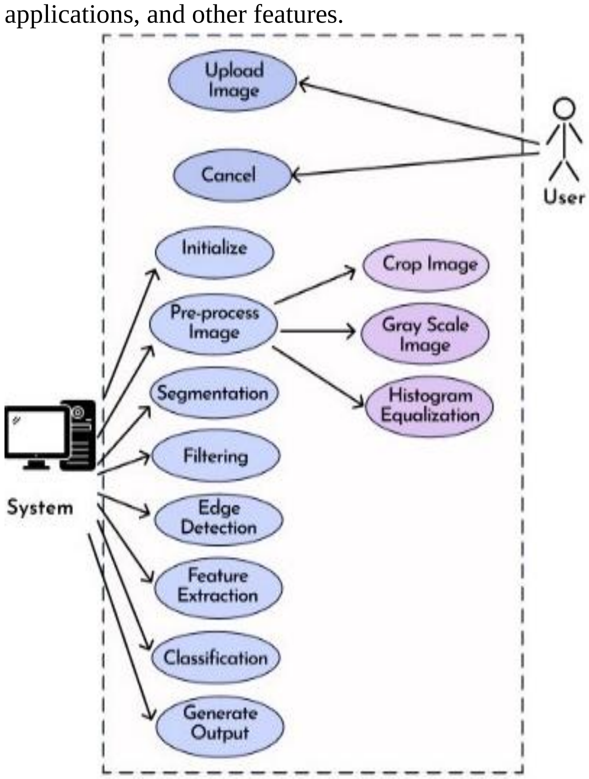



Fig 4: User Case Diagram

## IV. RESULTS

The excellent potential of picture technology for the preservation of plants and the environment is demonstrated by BambooFolio. By combining image capture, processing, feature extraction, and classification, we have developed a system that can recognize and categorize several bamboo species based on their leaf features. The study that is being presented looks at the two most prevalent species, and it has produced an algorithm that will eventually be used to get rid of some of the uncertainties that came up throughout the investigation. Our study shows how image processing may be used to accurately identify and categorize several kinds of bamboo. This study report focuses mostly on the procedure and a few pre-processing techniques applied to our image dataset. Several features are collected from pre-processed photos of stems and leaves.

Our understanding of biodiversity and bamboo preservation can be greatly improved by ecological studies. Because bamboo is an essential component of many ecosystems and has both ecological and commercial importance, botanists, environmentalists, and policymakers will find this method helpful in the future. Making educated decisions for ecological conservation and sustainable resource management is made easier when bamboo species can be reliably identified and categorized. The ecological and economic significance of bamboo in many habitats means that the system has an impact on climate research and conservation as a whole.

## V. FUTURE SCOPE

The future of bamboo species detection through image processing is promising, with potential applications in various industries. As technology advances, the integration of machine learning and deep learning approaches will improve the accuracy of species detection. Neural networks can learn complex features from images, recognizing subtle differences between species. Mobile applications for bamboo species identification will become more user-friendly, making it easier for researchers and nature enthusiasts to identify bamboo species in the field. Image processing can also support the bamboo forestry industry by identifying optimal species for construction, furniture, and paper production.

As technology advances, the ability to monitor and protect bamboo species and their habitats will grow, positively impacting bamboo ecosystems and sustainable resource management.

## VI. CONCLUSION

The enormous potential of image processing methods in botany and environmental protection is shown by the BambooFolio. With the integration of picture capture, preprocessing, feature extraction, and classification, we have created a system that can reliably identify and categorize several bamboo species according to the characteristics of their leaves. We show in our research's conclusion how effective image processing is in identifying and categorizing different species of bamboo. It might drastically change how we do ecological studies, biodiversity assessments, and bamboo conservation. Because bamboo is an important component of many ecosystems and has both ecological and economic significance, botanists, environmentalists, and legislators who are working toward a sustainable future can find great assistance in this strategy.

The area of digital image processing-based bamboo species identification has advanced significantly. We have successfully closed the gap between biodiversity and technology by using advanced image processing techniques, preprocessing, feature extraction, and picture acquisition. This project was significant since bamboo has an economic value in some places.

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