

THE TULUNADU LEAF PROJECT

Group 8

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BASIC METHODOLOGY

1. GUI Initialization: The interface is created using customtkinter with three main sections: a sidebar(for controls),a main frame(for image display) and a result frame(for feature and classification output).
2. Image Upload and Preprocessing: Users can upload a single leaf image or select a folder for batch processing via file dialogs.
3. Feature Extraction: Features are extracted from the processed image, categorized into: Shape features, Colour features and Texture features.
4. Leaf Classification: A rule-based classifier uses aspect ratio and mean green value to assign a leaf species (e.g., SpiderPlant, PhilodendronRugosum, etc.).

BASIC METHODOLOGY

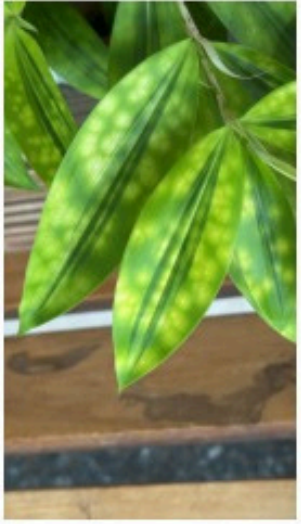
5. Result Display: The original and processed images are displayed in the main frame, resized to 300x300 pixels for consistency. Extracted features shown are grouped by type based on user-selected checkboxes.
6. Batch Processing: For folder processing, the system processes all images in input folder, saves segmented images to processed subfolder, extracts features, saves features and tracks progress.
7. History and Saving: Processing history (file paths, features, predictions) is saved to history.txt.
8. Status and Error Handling: A status label in the sidebar shows real-time updates. Errors during image loading, processing, or classification are caught and displayed in red.

PREPROCESSING TECHNIQUES

1. Resizing
2. Gaussian filter
3. HSV Mask
4. LAB Mask
5. Otsu Mask
6. CLAHE
7. Contour Filtering
8. Sharpening

DRACAENA
SURCULOSA

Original



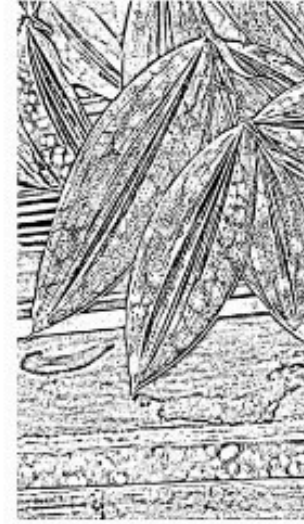
HSV Mask



LAB Mask



Otsu/CLAHE Mask



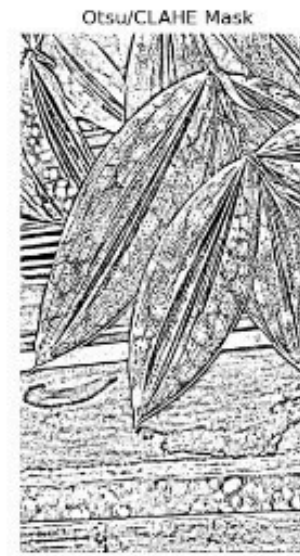
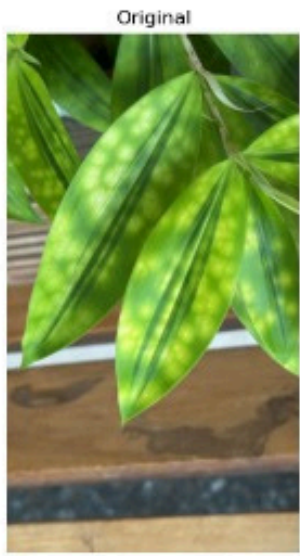
Segmented



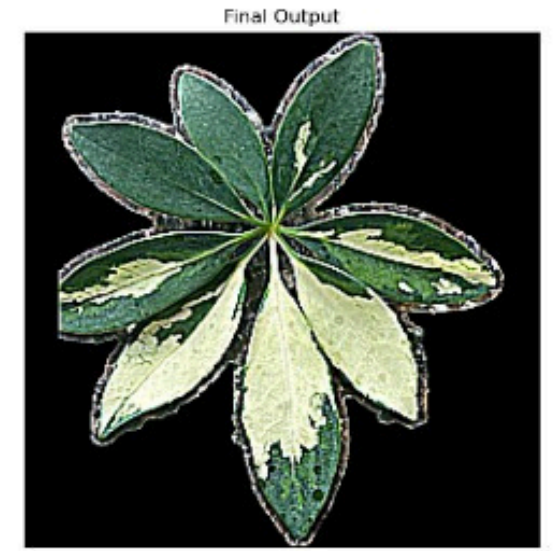
Final Output



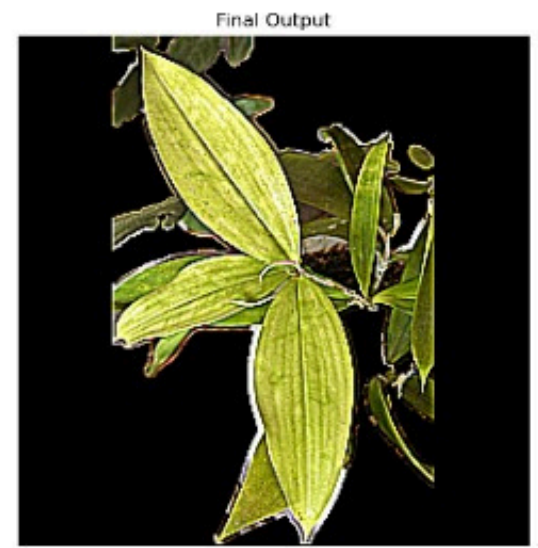
DRACAENA
SURCULOSA



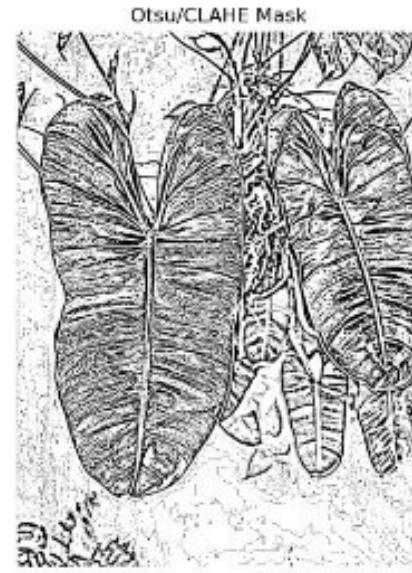
DWARF UMBRELLA
TREE



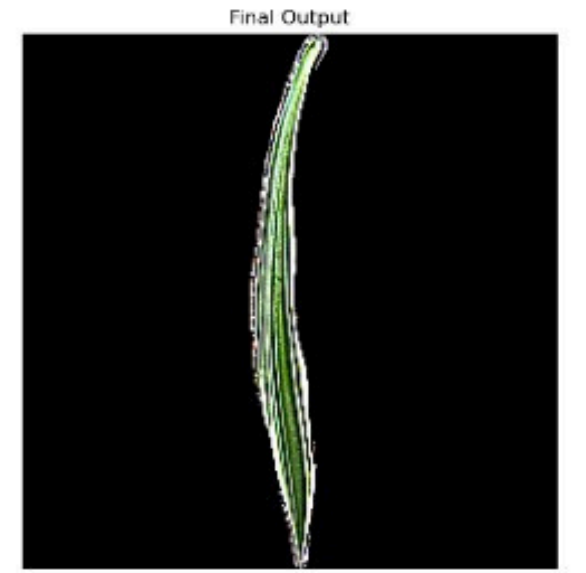
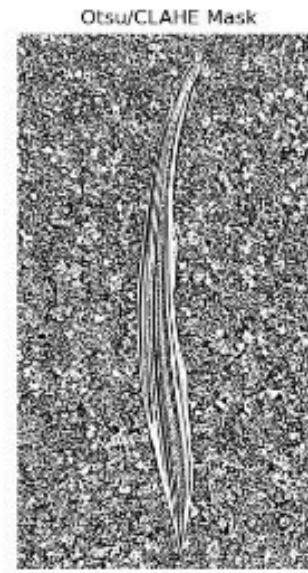
DENDROBIUM
NOBILE



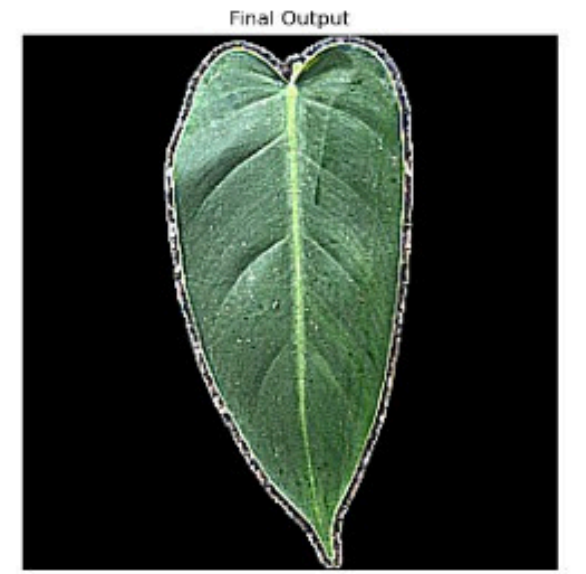
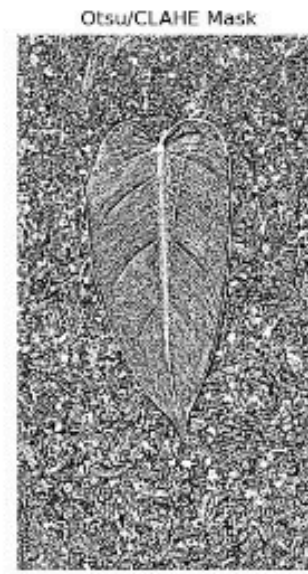
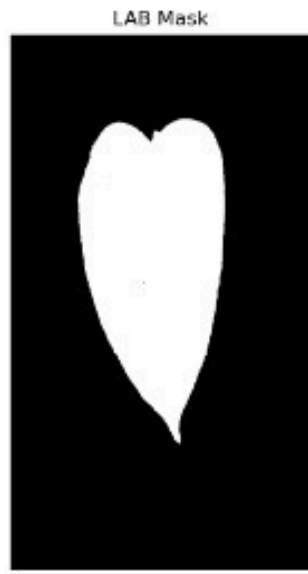
PHILODENDRON



SPIDER
PLANT



PHILODENDRON
RUGOSUM



FEATURE EXTRACTION

1. Shape Features
2. Colour Features
3. Texture Features

SHAPE FEATURES

Shape features capture the geometric properties of the leaf, which are critical for distinguishing species with distinct outlines

1. Aspect Ratio - ratio of width to height of the leaf
2. Compactness - it distinguishes rounded leaves from irregular or elongated ones.
3. Contour Complexity - leaves with serrated edges (e.g., some Philodendrons) have more complex contours than smooth-edged leaves.

COLOUR FEATURES

Color features reflect the leaf's pigmentation, which varies by species and health. This method captures both average color and distribution.

1. Mean RGB Values - exclude background noise, ensuring accurate color statistics. Mean green is particularly emphasized, as it's a strong indicator for leaf type in the classifier.
2. 8-bin Histograms per RGB Channel - normalization is done which prevents bias from leaf size, and the mask ensures only leaf pixels contribute, enhancing accuracy.

TEXTURE FEATURES

Texture features are extracted to capture the surface patterns and structural characteristics of the leaf, which can be distinctive across species.

1. Linear Binary Pattern - focuses on the leaf textures like veins and ridges and it is invariant to light making it best for differentiating leaves with subtle difference.
2. Contrast - it measures the variation in pixel intensities within the leaf region, indicating how much the grayscale values differ across the image

CLASSIFICATION

Leaf Classification System: How It Works

- Image-based system for identifying plant species from leaf images
- Custom GUI application built with CustomTkinter
- Processes leaf images through segmentation, feature extraction, and rule-based classification

HOW CLASSIFICATION WORKS

Species	Aspect Ratio Range	Mean Green Range
SpiderPlant	$ar < 0.5$	$mg > 170$
PhilodendronRugosum	$0.4 \leq ar < 0.5$	$140 \leq mg \leq 150$
DendrobiumNobile	$0.6 \leq ar < 0.7$	$160 \leq mg \leq 165$
DracaenaSurculosa	$0.7 \leq ar < 0.8$	$150 \leq mg \leq 155$
DwarfUmbrellaTree	$0.8 \leq ar < 0.9$	$150 \leq mg \leq 152$
Philodendron	$0.8 \leq ar < 0.9$	$145 \leq mg \leq 150$

- Confidence Calculation: Simple formula showing:
- 0.9 confidence = precise match (narrow range)
- 0.7 confidence = good match (wider range)
- Example: "Spider Plant with 0.9 confidence when AR=0.15, MG=180"

CLASSIFICATION LOGIC

- Method: Rule-based classification in `classify_leaf(features)`.
- Approach: Uses conditional logic based on feature thresholds.
- Key Features for Classification:
 - `aspect_ratio`: Ratio of width to height of the leaf's bounding box.
 - `mean_g`: Average green intensity in the leaf's RGB image.
- Process:
 - Compare `aspect_ratio` and `mean_g` against predefined ranges.
 - Assign a species label and confidence score based on matches.

CLASSIFICATION RULES

- Rule Structure: If-then conditions for each species.
- Examples:
- SpiderPlant: $\text{aspect_ratio} < 0.5$ and $\text{mean_g} > 170$.
- Confidence: 0.9 if $0.1 \leq \text{aspect_ratio} \leq 0.2$ and $175 \leq \text{mean_g} \leq 185$, else 0.7.
- PhilodendronRugosum: $0.4 \leq \text{aspect_ratio} < 0.5$ and $140 \leq \text{mean_g} \leq 150$.
- Confidence: 0.9 if $0.45 \leq \text{aspect_ratio} \leq 0.48$ and $141 \leq \text{mean_g} \leq 145$, else 0.7.
- Default Case: If no rules match, label as “Unknown” with 0.5 confidence.
- Supported Species: SpiderPlant, PhilodendronRugosum, DendrobiumNobile, DracaenaSurculosa, DwarUmbrellaTree, Philodendron.

CONFIDENCE SCORING

- Purpose: Indicates reliability of the predicted species.
- Mechanism:
- High Confidence (0.9): Features fall within a narrow, precise range (e.g., $0.62 \leq \text{aspect_ratio} \leq 0.65$ for *DendrobiumNobile*).
- Moderate Confidence (0.7): Features fall within broader range but still match a species.
- Low Confidence (0.5): No matching rule (Unknown species).
- Example: For *SpiderPlant*, confidence is 0.9 if `aspect_ratio` and `mean_g` are tightly matched, otherwise 0.7.

INTEGRATION WITH GUI

- User uploads an image via the GUI.
- Image is segmented (improved_leaf_segmentation).
- Features are extracted (extract_features).
- Classification is performed (classify_leaf).
- Results (species, confidence) are displayed in the GUI.
- Display:
- Classification results shown in the classification_label widget.
- Updated via update_classification_display.
- History: Results stored in history for later review.

GRAPHICAL USER INTERFACE

- After running the code, two files open : GUI system and Preprocessing pipeline steps.
- File button shows options to Upload Image, Batch Process, Save Results and Export Visualisation.
- View button enables you to choose between light or dark modes.
- Help button gives general steps to follow to run the system.
- Export Vis button saves the output RGB and LBP plots.
- Batch Process button allows you to process all images in input folder, save segmented images to processed subfolder, extract features, save features and track progress.

GRAPHICAL USER INTERFACE

- Resume Batch and Pause Batch button allows you to resume and pause the batch process respectively.
- Tick Boxes to select the features you need to extract.
- Save Results button allows you to save the features obtained.
- Upload the image in the window 'Original Image'.
- Preprocessed image will be shown in the window 'Preprocessed Image'.
- Feature Analysis window shows details about the shape, texture and colour features which were selected based on the preprocessed image. It also has RGB plot for that leaf image and LBP Pattern Preview bar chart.
- Image can be resized by hovering the mouse on the original image.

GRAPHICAL USER INTERFACE

- Status shows the progress and each action of the system.
- Show Steps tick box under the window Processing Options allows you to select or deselect it depending on whether you want the other window ' Preprocessing Pipeline Steps' to show or not.
- Reset View button allows you to get the original dimensions of the input image after zooming in or out.
- Classification Result window shows predicted species and the confidence.
- Preprocessing History window at the bottom of the GUI system.