Herb Leaf Classification System

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1 Problem Statement

The problem we are trying to solve is to accurately label different herbs in a herb garden when a photo is taken. Specifically, we aim to identify the herbs parsley, thyme, chives, and oregano, while labeling all other herbs as unclassified herb. The goal of this project is to develop a computer vision model that can recognize these specific herbs in an image with high accuracy and efficiency.

It might be out of curiosity for someone to figure out what kind of herbs they have in their garden or forest. Accurate classification of herb leaves is critical for quality control, authentication, and conservation of medicinal plants. Therefore, the proposed project aims to develop a herb leaf classification system that can identify individual plants within a garden and differentiate between different herb species based on their leaf images.

2 Importance and Motivation

The problem we are trying to solve is important for several reasons. Firstly, it can satisfy the curiosity of people who want to know what kind of herbs they have in their garden or environment. This can be time-consuming and challenging for those without extensive herb knowledge. Secondly, this tool can also be helpful for the food industry, as it can assist with quality control in the production of herb-infused products and reduce the risk of misidentification, which can be dangerous if a misidentified herb is consumed.

Lastly, accurate identification of herb leaves is crucial for quality control, authentication, and conservation of medicinal plants. The development of a herb leaf classification system that can identify different herb species based on their leaf images can aid in the production of medicines, as well as the identification and preservation of endangered plant species. Additionally, the accurate labeling of herbs in natural environments can provide valuable data for ecological studies, aiding in the conservation and management of natural habitats. Therefore, it is crucial to develop a computer vision model that can accurately and efficiently identify different herb species in images, as it has practical applications for the food industry, herb enthusiasts, medicinal purposes, and environmental research.

3 Dataset

For this project, we were unable to find an already existing dataset. Therefore, we will be creating our own dataset for the training & testing of model from Google Images. To create the training & testing set we will pull 500-1000 images from Google Images for each of our four herb types: parsley, thyme, chives, and oregano, and split the set into 90% and 10% to train & test.

For the final test set we will be pulling 20-30 images of herb gardens. We will manually label these images to test the prediction of our trained model in presence of multiple herbs in a single image. Our main goal is to segment these herb garden images to segment into different herb-leaves region and then predict their type in the image and label them.

4 Current State-of-the-Art

In recent years, herb classification using leaf images has gained significant attention due to its potential applications in the fields of medicine, agriculture, and food industry. The ability to accurately identify different herb species can help in quality control of herbal products, detection of adulteration, and conservation of rare and endangered plant species.

Most of the existing studies in this area have focused on the extraction of features from images that represent a singular leaf from an herb and their classification using various machine learning algorithms. Texture features, color histograms, and shape descriptors are some of the commonly used features for herb classification[3]. However, with the recent advancements in deep learning, several studies have started exploring the use of convolution neural networks (CNNs) for herb recognition based on leaf images [1]. Leaf identification normally use images that taken in the laboratory with sophisticated equipment and a white background. The accuracy of these models have been high.

Current research has shifted the focus from high-quality plant images to identifying leaves in natural environments. Leaf segmentation in natural environments has different approaches and accuracy levels. There have been many studies that aim to identify leaves based on images taken in their natural environment [2]. These studies all focused on the identification of a singular leaf taken in nature. The accuracy of the models was lower than the models discussed in the prior paragraph that used images taken with sophisticated equipment and a white background, but the models were still considered successful, with high accuracy.

5 Our Approach

Our project intends to expand on the current state-of-the-art. The research for identifying an individual leaf from nature has already been conducted, and our project expands on it. However, we have not found any studies that take an image of numerous plants and segment the image to locate each individual plant. Each segmented plant would then be fed into an identification model, similar to the pre-existing ones.

For plant segmentation, we have developed our own approach. Firstly, we will identify the center of each individual plant and annotate it on the original image. To do this, we will convert the herb garden image to grayscale, compute the edges/boundaries, perform some noise removal, and then identify each individual plant and the coordinates of its center.

We plan to use the center coordinates of each plant to segment the image into sub-images that will then be fed into our identification model. Currently, the approach we plan to use to extract the sub-images is to take the plant center, create a box around it, and extract the pixels in the surrounding box as a new image. Finally, these segmented image for identified plants would be sent to the classification model to predict the type of plant. Each image will then be labelled as one of the possible plants as discussed previously, or unidentifiable herb if the confidence score for the prediction is lower than a pre-determined threshold.

6 Evaluation Plan

Most of the herb classifiers and leaf detection apps that exist take the picture of only one leaf segment and then produce their results. We aim to take an image of a herb garden and segment each herb from one-another and then classify them. However, it might be difficult to identify if leaves are mixed together, but we will plan to test such mixed herb scenarios as well where identification is tough even by human eyes at a quick glance. It is however an ambitious goal, and we plan to work on it after a working baseline implementation is completed.

For the end result we want to take the original test image of a herb garden, identify the center of each individual plant herb, annotate it and include the predicted label from the model as well as the confidence level for the predicted label. Labels will be ”Chives”, ”Parsley”, ”Oregano”, ”Thyme” or ”Unidentifiable Herb” if the herb does not match a certain threshold for confidence level in our model predicted output.

Figure 1: Example test image input to be segmented and feed into model.

Figure 2: Example test image output.

Beyond the scope of this class, we would hope to expand the algorithm to an expansive list of herbs and not just 4 herbs. This brings on a whole new challenge as there are many herbs whose leafs look rather similar. For example, parsley and cilantro look similar, as well as rosemary and thyme. This would likely require the development of a new model that is more complex.

7 Timeline

Week 1	Create dataset for train and test, and label the data
Week 2	Create model using train data. The model should be able to detect one herb based on its leafs.
Week 3	Image processing and noise removal of test images.
Week 4	Leaf Region Segmentation
Week 5	Dissect objects and feed into model, producing labels.
Week 6	Take output from model and add labels to original test image.
Week 7	Conclude findings, finalize report.

8 Current Progress

Since starting the project we have stayed on schedule with our timeline of events. We programmed a script that extracted 240 images from google for each of the four classes, parsley, thyme, chives, and oregano. The images were preprocessed to 224 by 224 and split into train/test sets. The train set was then used to train a *MobileNet* model with a custom output layer. The model has a 95% accuracy on the test set.

The caveat with this approach is that we have not manually inspected the dataset of images, therefore our model may have some misrepresented images. For example, when looking at the labeled images for parsley you will find some that are an image of prepackages dried parsley including the text ”Parsley”. We believe this error in our dataset might be causing our model to overfit, potentially affecting negatively on the ability to correctly identify the plant after segmentation in the future. This is something we will have to revisit once we start feeding the segmented image into the model.

22 images were then extracted from Instagram to use as the test set for the image segmentation. Instagram was used as it was a reliable method to get test images that best resemble being taken from a natural environment with a normal phone camera. For labeling purposes we choose images that included the gardener labeling the plants, this eliminated the need for the three of us, who are not herb experts from misidentifying the plants. This once again leads to the caveat that we don’t want the herb names in our test images as we believe it has potential for our model to incorrectly learn the name of the plants instead of the leafs identifying feature. The major goal of our project is to take an herb garden where you don’t know what is what and label it, therefore in the pre-processing of the test images we will be blurring out any identifying labels of the herbs in the image. To do this we are using the keras_ocr and cv2 API. This was the stage-1 and has been completed.

The image is then annotated with the center of each herb. This feature implementation is currently in progress, broken down into several stages. Stage two has been completed, converting the images to black and white, the connected components are labeled and lastly the center of each component is computed. When annotating these centers on the images we find that there tends to be clusters of ”centers” around each plant.

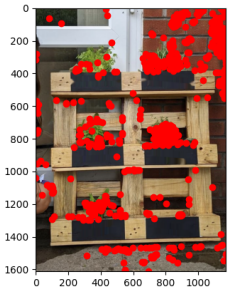

Figure 3: Example output after stage 2.

This leads to stage 3 which is currently under execution. Stage-3 will encompass the major task of locating the approximate true center of each plant using the points found in stage-2. A filter needs to be applied for the removal of outlier points in the image and then we will tentatively use k-means for locating the true center for each of the cluster of points which represents a plant.

9 Project Improvements If Time Permitted

One of the main limitation of our current set up is that we only train our model on four herbs, when in reality there are thousands of different herbs. At minimum it would be great to expand the model to at least cover all of the commonly used spices and herbs used world wide in cooking. This would make the application in the food industry much more useful.

In an ideal world, we would also use completely different images in training our model. Ideally we would have enough pre-labeled images of herb gardens that would allow us to segment the image and use the sub-images as the train and test set in our model as the model currently uses high quality images of the herbs usually against a white background, this doesn't match the segmented images we are feeding into the model for labeling.

Another challenge that we aim to tackle if time permits is to successfully segment the mixed leaf scenario and identify the plants. In reality, the image of a garden could contain the interleaved leaves into each other if plants are nearby. Current approach might find it difficult to segment this scenario into two or multiple separate images. Hence, it would be a challenging task to develop a model for identification of leaves in such a case.

References

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