Final Project proposal (updated)

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The project goal

In the final project, our goal is to develop a computer vision system that given an input image will be able to:

1. Correctly identify five distinct **species of flowers** (*daisy*, *dandelion*, *roses*, *sunflowers*, *tulips*).

   If none of these categories are present in the image, the system should output the label *"no flower/no known flower species in the image"*.

2. Determine whether the flowers appearing in the input image, if any, are **healthy** or not.

In order to carry out this project we will employ **only traditional computer vision techniques** without relying on modern deep learning models and approaches. We plan to compare several of the approaches presented in class, such as SIFT, SURF, template matching, HOG and bag of words, in order to output the results obtained for the input image with each of them, and determine which one performed better.

We should end up with a fully-functional pipeline that takes a single test image, pre-processes it, extracts global and local descriptors, compares against prototypical feature models and outputs the most likely flower species identified along with a similarity score and if a flower has been identified, determine whether it is in a healthy state.

The system will output one of the 6 classes identified in the input image (*daisy*, *dandelion*, *roses*, *sunflowers*, *tulips, no flower/no known flower species in the image)* for the first task and one of the two classes "*healthy*" or "*unhealthy*" for the second classification task, specifying the prediction reliability percentage for both of them.

Key limitations include sensitivity to lighting and viewpoint changes, limited number of flower species due to lack of more representative datasets and difficulty distinguishing species with similar morphology or color patterns.

Possible applications

The system can be deployed across agriculture (for crop monitoring, yield estimation, and disease/weed management), ecological and biodiversity monitoring (to quantify floral abundance and invasive species detection), consumer mobile apps (for instance plant identification apps and gardening assistance apps), floriculture retail and supply-chain (for automated quality control and classification of cut flowers), education and research tools.

Performance metrics

To evaluate the robustness of the flower recognition system, we will use the following metrics:

- **Accuracy**, which is the percentage of correctly classified images compared to the total number of images tested. Specifically, we are going to indicate:
  - ***total accuracy***, which is calculated on the entire test set to quantify the overall robustness of the system:

    $$A_{\text{tot}} = \frac{\text{Number of images correctly predicted}}{\text{Number of test images}}$$

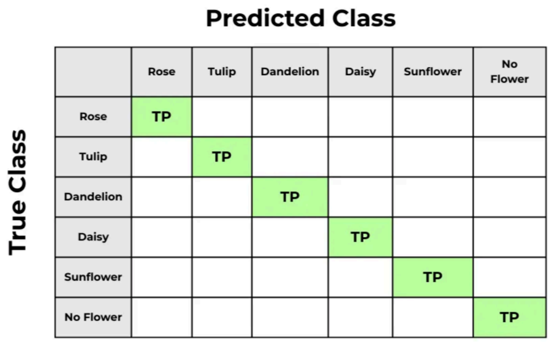
  - ***accuracy per category***, which is the percentage of correct classifications for each of the 5 categories of flowers in the test set, in order to detect any imbalances in some categories. Considering a dataset with n classes:

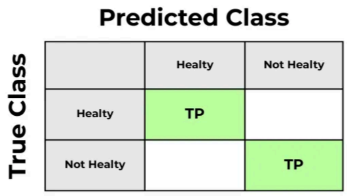
    $$\forall i \in [1, \ldots, n] \qquad A_i = \frac{\text{Number of images of class } i \text{ correctly predicted}}{\text{Number of test images of class } i}$$

- **Confusion matrix**, which complements accuracy by category in trying to detect imbalances between categories in the classification made by the system, and deepens the topic by identifying which classes the model confuses the most.

  In the confusion matrix, actual classes are compared with those predicted by the model: each row represents an actual class, and each column a predicted class. Each cell contains the number of instances that belong to the actual class indicated by the row but were classified as the class indicated by the column. The diagonal shows the correct predictions.

Therefore, the more numbers on the diagonal, the more robust the system is.





- **Mean processing time,** that indicates the average time required to classify an input image, with the goal of determining whether the system can also be used in real-world situations without excessive delay in output.

Sample images

As the main source of images for the train set we intend to use the **Kaggle Flowers Dataset** that can be visualized at the following page: https://www.kaggle.com/datasets/rahmasleam/flowers-dataset.

This dataset consists of images from five distinct flower species, ideal for tasks like image classification and computer vision projects. It provides a diverse range of floral images, enabling models to learn the subtle differences between species.

1. **Daisy**: known for its simple, classic white petals and yellow center.
2. **Dandelion**: bright yellow flowers that are common in fields and gardens.
3. **Roses**: the quintessential symbol of love and beauty, varying in shades of red, pink, and other colors.
4. **Sunflowers**: large, sun-like blooms, recognized for their vibrant yellow petals and central brown disc.
5. **Tulips**: elegant and colorful blooms, popular in gardens and floral arrangements.

The dataset just mentioned will be mainly used for the flower species recognition task.

Concerning the flower health status recognition task, we put together ourselves a dataset containing 15 unhealthy/infested flower images for each species considered by surfing the web. This dataset will be part of the “training set” used for the task, and will be integrated with other 15 healthy flower images for each species taken from the Kaggle Flowers Dataset.

Please note: Due to the inherent fragility of the dandelion, pictures of the diseased flower could not be found, as the species in question does not bloom unless it is in perfect health. In order to maintain symmetry with other species, we have chosen to consider as “unhealthy” the flower images where the characteristic foliage is not complete, but damaged by wind or external agents.

Test dataset

We put together a test dataset which consists of 64 garden and flower images in order to evaluate the system performance.

The dataset features images with different lighting conditions, different viewpoints and different settings in order to measure the accuracy of our system in dealing with varying conditions.

The images were collected by browsing the internet or from already existing datasets.