

Hydroponic System

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Project summary :

This design creates a hydroponic system that can gather and analyze data on plant growth automatically. This project could record and analyze plant growth by taking images and videos of the plants growing within the system. This system counts the number of leaves, the area covered by green leaves, and the height and width of the plant growth. It can also identify different plant species and determine whether the plant is diseased.

Research Plan :

1. Purpose statement:

Our project aims to design and develop an innovative hydroponic system integrated with advanced image and video analysis technology. This system is engineered to offer a more efficient, accessible, and sustainable method of plant cultivation, particularly useful in urban environments where space and resources are limited.

2. Problem description and background

In recent years, the world has witnessed unprecedented urban growth. This urbanization, while beneficial in many aspects, has led to significant challenges, particularly in the realm of agriculture and food production. Traditional farming practices, while effective in the past, are no longer sufficient to meet the growing demands of urban populations. These practices require vast tracts of land, ample water resources, and intensive labor – resources increasingly scarce in urban settings.

The necessity to devise innovative agricultural methods is more pressing than ever. This is where our hydroponic system project enters the picture. Hydroponics, the method of growing plants without soil, using mineral nutrient solutions in an aqueous solvent, presents an efficient alternative to traditional farming. This soilless agriculture method is not only space-efficient but also conserves water and nutrients, making it a sustainable solution for urban environments.

Our project is motivated by the urgent need to address food security in densely populated urban areas. As cities expand, the availability of arable land diminishes. Hydroponics offers a way to grow food in limited spaces, such as urban apartments, rooftops, and balconies. This method enables city dwellers to cultivate fresh produce in their homes, contributing to their household food supply and reducing their reliance on store-bought, potentially less fresh options.

Another driving factor behind our project is the environmental impact of traditional agriculture. Conventional farming methods are often associated with various ecological issues, including soil degradation, water pollution from fertilizers and pesticides, and high carbon emissions due to the transportation of crops. By adopting hydroponics, we can significantly reduce these environmental impacts. Our system is designed to be eco-friendly, using less water and no soil, thereby minimizing pollution and the carbon footprint associated with food transport.

2.1 Benefits to People

The integration of hydroponic systems in urban settings significantly benefits city residents. Firstly, it offers a practical solution to the issue of limited space. In crowded urban environments where traditional gardening is not feasible, hydroponics allows individuals to grow plants in small, controlled environments. This accessibility encourages more people to participate in growing their food, fostering a connection with their food sources and promoting healthier eating habits.

Hydroponics is also a boon for those with busy lifestyles. Our automated system, equipped with sensors and cameras, reduces the time and effort required for plant care. Users can monitor their plants remotely, receiving updates on plant growth and environmental conditions. This convenience makes gardening more appealing and manageable, even for those with little spare time.

Furthermore, our project has educational value. By engaging with the hydroponic system, individuals, especially the younger generation, gain hands-on experience with advanced agricultural technologies. They learn about sustainable practices, the science behind plant growth, and the importance of environmental conservation. This education is crucial in raising awareness about sustainable living and inspiring future innovations in agriculture.

2.2 Contribution to Prosperity

The implementation of hydroponic systems in urban areas holds significant economic potential. First and foremost, it introduces an innovative sector in the urban economy – urban farming technology. This sector not only creates new business opportunities but also generates jobs in areas such as system design, manufacturing, maintenance, and sales.

Our hydroponic system, with its advanced technological features, has the potential to attract investors and entrepreneurs interested in sustainable urban development. As the demand for local and fresh produce grows, urban hydroponic farming can become a profitable venture, supplying local markets and restaurants with high-quality produce. This local production reduces transportation costs and associated carbon emissions, contributing to a more sustainable and resilient local economy.

Additionally, the adoption of hydroponic systems can stimulate research and development in related fields. Universities, research institutions, and private companies may invest in further improving hydroponic technologies, exploring areas like nutrient optimization, energy efficiency, and automation. This research not only enhances the efficiency and effectiveness of hydroponic systems but also contributes to the broader field of sustainable agriculture.

2.3 Impact on the Planet

Our hydroponic system project is fundamentally aligned with environmental sustainability. By circumventing the need for soil, the system conserves land resources, an important consideration as natural landscapes and agricultural lands are increasingly converted for urban use. This conservation is crucial in maintaining biodiversity and ecosystem services.

Water conservation is another significant environmental benefit. Hydroponic systems use substantially less water than traditional soil-based farming, as water in hydroponics is

recirculated and reused. This efficiency is particularly vital in urban areas, where water resources can be scarce and expensive. Additionally, by minimizing water runoff, hydroponics reduces the risk of water pollution from agricultural runoff, which is often laden with fertilizers and pesticides.

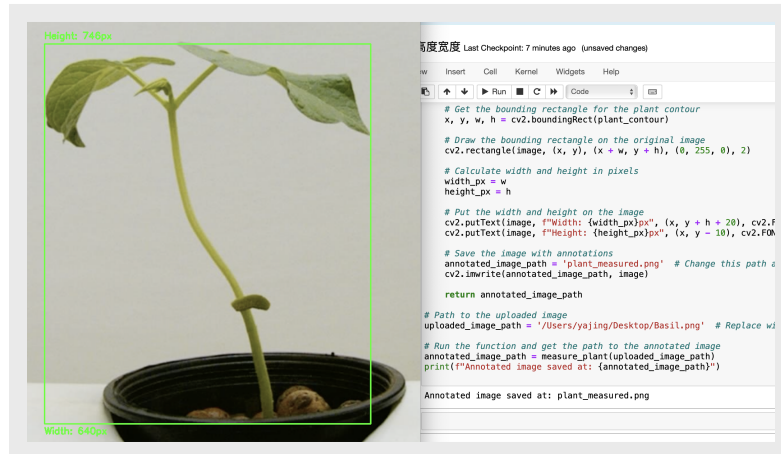
Moreover, our system contributes to the reduction of greenhouse gas emissions.

Traditional agriculture is a significant source of carbon emissions, mainly due to the use of fossil fuels in farming machinery and transportation of produce. In contrast, hydroponic systems require minimal mechanical intervention and enable local production, drastically cutting down transportation distances and emissions.

Lastly, hydroponic farming presents a viable solution to farming in areas with poor soil quality or harsh climatic conditions. By controlling the growing environment, including nutrients, light, and temperature, hydroponics allows for plant cultivation in places previously unsuitable for agriculture. This adaptability is particularly important in the context of climate change, as it offers a resilient agricultural method that can withstand environmental fluctuations.

3. Scope of the project

3.1 Measure the height and width



This code uses bounding rectangles to calculate the height and width of plants in pixels. This feature is essential for tracking growth rates and identifying any abnormalities in plant development.

3.2 Green Area Calculation:

```
# Convert to HSV
hsv = cv2.cvtColor(image, cv2.COLOR_BGR2HSV)

# Define range of green color
lower_green = np.array([35, 50, 50])
upper_green = np.array([85, 255, 255])

mask = cv2.inRange(hsv, lower_green, upper_green)

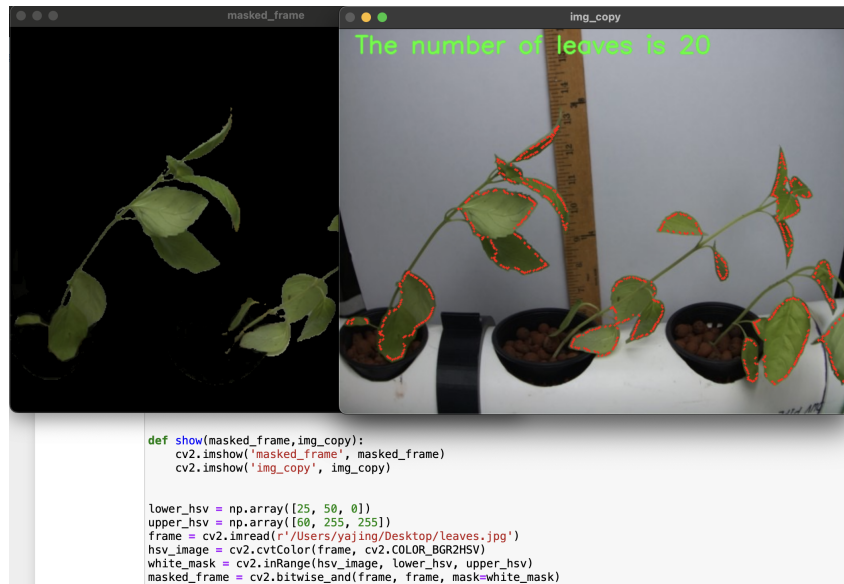
# Draw contours
contours, _ = cv2.findContours(mask, cv2.RETR_TREE, cv2.CHAIN_APPROX_SIMPLE)
cv2.drawContours(image, contours, -1, (0, 255, 0), 3)

# Calculate the green area
green_area = np.sum(mask > 0)
```

The code uses OpenCV to read and process images of plants. It converts images to the HSV color space to accurately identify green areas, which are crucial for assessing plant health and growth. A mask is created to isolate the green areas, and contours are drawn

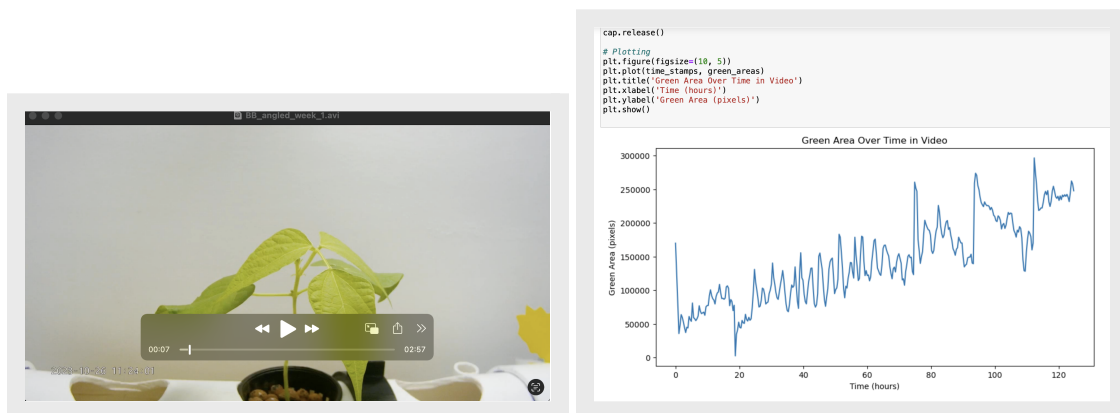
around these areas. The total green area is calculated by summing the pixels within the mask, providing a quantitative measure of plant growth.

3.3 Leaf Counting:



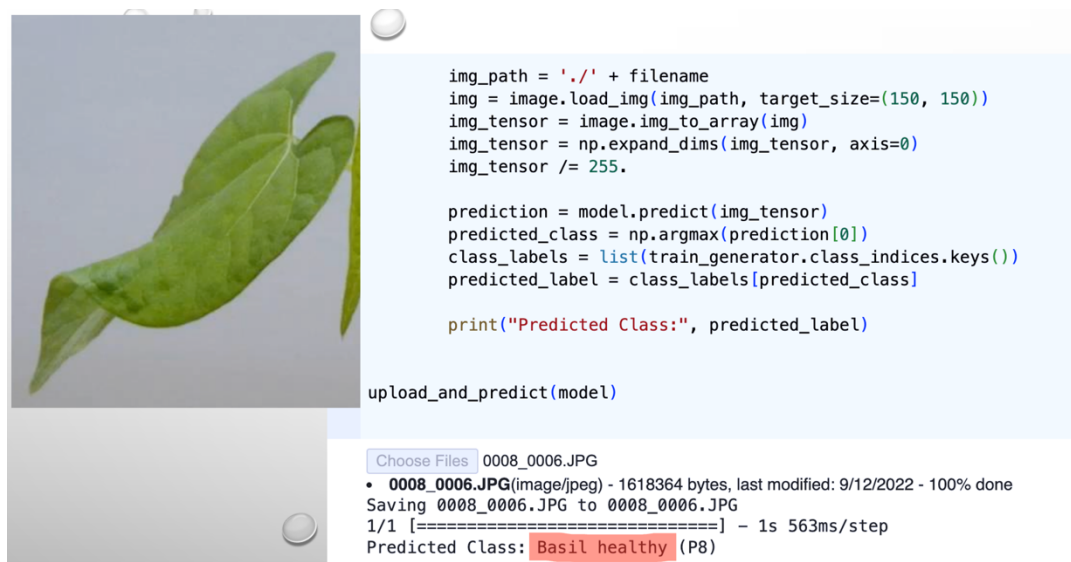
The leaf counting process involves converting images to grayscale and applying thresholding techniques to separate leaves from the background. Contours are detected for each leaf, and their areas are calculated. Based on the area, leaves are counted, allowing for monitoring of new leaf growth, a key indicator of plant health.

3.4 Video Analysis for Time-Lapse Growth Tracking:



The code also processes video files to track plant growth over time. Frames from the video are analyzed similar to still images, calculating the green area for each frame. These values are then plotted over time, providing a visual representation of plant growth.

3.5 Machine Learning for Disease Detection and Leaf Classification:



The code includes a machine learning model using TensorFlow and Keras. A convolutional neural network (CNN) is built and trained to classify plant leaves and detect diseases.

The model is a Sequential model from Keras, indicating a linear stack of layers. It includes multiple Conv2D layers with increasing filter sizes (32, 64, 128), which are typical in CNNs for extracting features from images. Each convolutional layer is followed by a MaxPooling2D layer, reducing the spatial dimensions of the output and hence the number of parameters. After convolutional layers, the model uses a Flatten layer to convert the 2D features into a 1D vector, followed by Dense layers, including the output layer. The output layer's number of neurons corresponds to the number of plant classes (diseases and leaf types) to be classified. relu activation functions are

used in the convolutional and dense layers, with softmax in the output layer, typical for multi-class classification tasks.

This part of the project is crucial for automated health monitoring of the plants, identifying potential issues early on.

3.6 Future Work

3.6.1 Using a Lego Train for 3D Plant Pictures:

We plan to put a camera on a Lego train that moves around the plants. This way, the camera takes many pictures from all sides. With these pictures, we can make a 3D model of each plant. This is better because it lets us see the plants from every angle, not just the top. It helps us measure how the plants grow in a really detailed way.

Also, these 3D pictures can help the computer learn better about the plants.

3.6.2 Making the Computer Smarter with Transfer Learning:

Transfer learning is when you take a computer program that has learned one thing and use it to help learn something else. It's like when you know how to ride a bike, and that helps you learn to ride a scooter faster. We want to use this idea to make our computer program better at finding plant diseases and knowing different kinds of leaves. This way, the computer can learn faster and do a better job. It also means our system could work with many types of plants.

Budget:

Raspberry Pi 4 8GB	160 \$

Budget justification: The Raspberry Pi can be used to record stored data. Speak the code put into it and then he can help the system to automatically record the growth of the plant.

References :

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