AN AUTOMATED SYSTEM FOR WEED DETECTION

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Abstract

An automated system for weed detection is an integrated system that combines the capabilities of a diligent robot with the artistry of nature to detect weeds and invoke a precise acoustic alert mechanism. The proposed system harmonizes cutting-edge technology with ecological principles, serving as a sentinel for botanical purity in diverse landscapes. Through a sophisticated sensor array and refined visual acuity, the robot discerns the subtle differentiations that distinguish weeds from desirable flora, enabling targeted identification. Upon detecting weeds, a meticulously orchestrated process initiates an acoustic alert. This integration of robotics and ecology represents a significant step towards effective weed management and ecological preservation, bridging the gap between technology and environmental stewardship. Through rigorous experimentation and evaluation, the system showcases its ability to foster harmonious coexistence between nature and intelligent automation, inviting further exploration and application in the field of ecological landscaping and environmental conservation.

1. Introduction

Advancements in robotics and artificial intelligence have paved the way for innovative solutions in agricultural practices, particularly in weed management. This research introduces a system that combines the Raspberry Pi 3B+ and the Inception-ResNet V2 deep learning model, trained on a comprehensive plant seedlings dataset. The goal is to accurately classify weeds and crops, enabling efficient weed detection and intervention in agricultural fields.

Conventional methods of weed control often come with increased costs and environmental concerns. The proposed system offers an automated and targeted approach to address this challenge. Through transfer learning, the model is fine-tuned to adapt to specific agricultural environments, enhancing its applicability and accuracy.

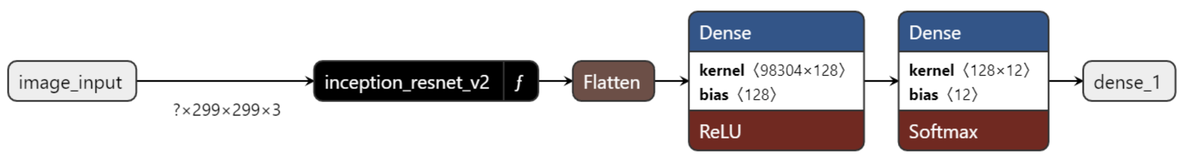
A mobile robotic unit, equipped with the Raspberry Pi 3B+ and the Raspberry Pi Camera V2, operates in the agricultural landscape. Real-time images of plants are captured and processed by the trained Inception-ResNet V2 model. Prompt classification of the images as weeds or crops is based on visual features and characteristics.

Upon weed detection, the system activates a buzzer mechanism, providing an immediate acoustic alert. This alert enables timely intervention to address weed infestations and prevent further crop damage. By automating the process and offering real-time alerts, the proposed system presents a proactive and sustainable approach to weed management. Experimental evaluation of the system's performance and accuracy will contribute to advancing intelligent farming techniques, promoting precision agriculture and sustainable crop production.

2. Proposed Methodology

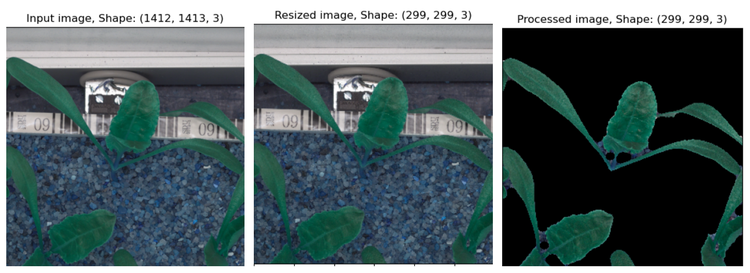
1. A model is trained on a plant seedling dataset using transfer learning and the InceptionResnetV2 architecture, focusing on plant leaves and reducing noise caused by pebbles.
2. The trained model is deployed on a Raspberry Pi module, using a mounted camera to capture live feed.
3. Segmentation techniques are applied to the live feed, creating a bounding box around plant images.
4. The segmented plant images are then classified using the deep learning model.
5. Early weed detection is the primary goal of this system, focusing on seedlings.
6. When a weed is detected, a buzzer is triggered as an alert.
7. This integrated system offers a real-time, automated solution for weed detection and alerting, utilizing deep learning and Raspberry Pi technology.

3. Architecture and Input Images



Transfer Learning Model using InceptionResNetV2

Below are the sample images that we have used as input to the deep learning model.



4. Vegetation Color Analysis Methods

Excess Green Index (ExG)[1]: It is a vegetation index that quantifies the relative abundance of green color in an image.

$$ExG = 2 * G - R - B \tag{1}$$

HSV(Hue, Saturation, Value): The versatile HSV color model captures hue, saturation, and brightness. Extracting green components from vegetation images becomes easier due to distinct green hues in the hue channel, enabling precise analysis and advancements in plant science and ecological research.

$$\begin{aligned} H &= \frac{1}{2}\left(\frac{G-B}{\max(R,G,B)-\min(R,G,B)}\right)\%1 \\ S &= 1-\frac{\min(R,G,B)}{\max(R,G,B)} \\ V &= \max(R,G,B) \end{aligned} \tag{2}$$

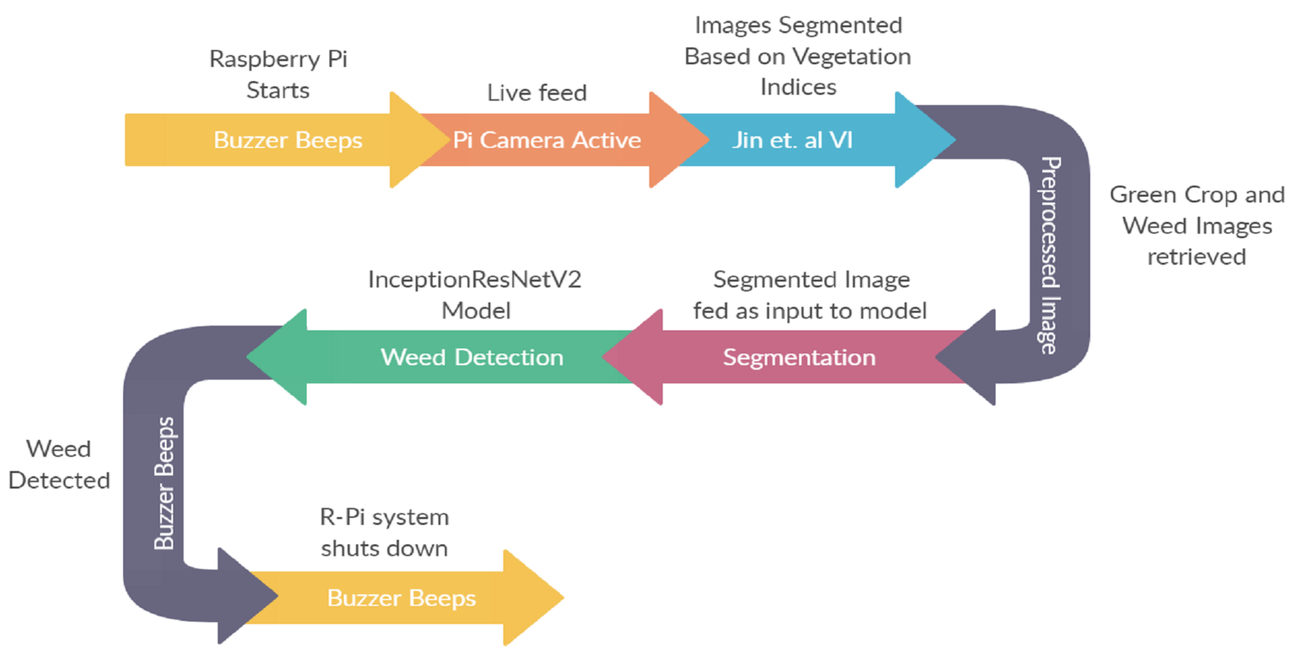
The equation used for segmentation quality by Jin et. al [2] is:

$$-19 * R + 24 * G - 2 * B \geq 862 \tag{3}$$

Jin et. al, proposed the above methodology in [2]. They claim this equation yields high segmentation quality with a much lower computational cost compared to the widely used **ExG** index.

Here R, G, B represents Red, Green and Blue channel intensities of the image respectively.

5. Proposed System



References

[1] David M Woebbecke et al. "Color indices for weed identification under various soil, residue, and lighting conditions". In: *Transactions of the ASAE* 38.1 (1995), pp. 259–269.

[2] Xiaojun Jin, Jun Che, and Yong Chen. "Weed identification using deep learning and image processing in vegetable plantation". In: *IEEE Access* 9 (2021), pp. 10940–10950.