Project title: WEED DETECTION AND REDUCED HERBICIDE DOSE

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Introduction

A weed is a plant considered undesirable in a particular situation. One way to control weeds is through the application of herbicides. It is well known that the full-recommended dose of herbicide is appropriate for farming practice to ensure a good level of weed control and prevent yield loss. Previous investigations showed that a good weed control level could also be obtained in case of reduced rate application, which is beneficial to the natural environment and economically profitable [4]

This report is to provide details on the Weed Detection and Reduced Herbicide Dose project. This project makes use of a dataset with over 713 images of common chickweed. The project seeks to propose a solution that uses a model to identify weed plants, make a leaf count of weeds and classify them in groups in anticipation of application of a reduced herbicide dose system, which maintains weed control efficiency.

Problem statement

The general practice of controlling emerged weeds in arable fields consists of the uniform application of a selective herbicide. This ensures a competitive advantage for the crop without severely damaging it. However, the extensive use of herbicides in the last few decades has been challenged by consumers as well as policy makers because of growing concerns regarding their potential environmental impact on drinking water reservoirs, fauna in watercourses, etc.

In 2010, pesticide residues were found in 44% of the drinking water monitoring points in Denmark, and the accepted limit of 0.1 µg/L was exceeded in 15% of the monitoring points [3].

Methodology

The methodological approach followed in this project are as follows:

- Understanding the domain: At this phase, we tried to understand the theory of the reduced herbicide doses and its benefits. We also looked at how the growth stages of weeds are quantified.
- Understanding the data: At this stage, we tried to understand more about the image dataset. We considered at the various modules and libraries that could help us work with the image dataset.
- Image processing: From understanding the data, we tried to remove the noise (gravels) in the images to make way for image processing.
- Analysis and Visualization: At this stage, we sought to churn out key information from the dataset. Analysis was done using systematic methods to recognize a weed, identify weed leaf edges and make a count of them. Data visualization was employed for graphical representation of information and data. Some tools we used for data analysis and visualization are:
  - NumPy: for performing mathematical operations on arrays
  - Pandas: for reading datasets and representing data into dataframe, for data analysis and manipulation
  - Mathplotlib: for plotting diagrams for visual analysis
  - Seaborn: For making visual diagrams for analysis.
  - Skimage is used for image processing
  - OpenCV (Open Source Computer Vision Library) is an open source computer vision and machine learning software library. OpenCV was built to provide a common infrastructure for computer vision applications and to accelerate the use of machine perception in the commercial products. These algorithms can be used to detect and recognize faces, identify objects, classify human actions in videos, track camera movements, track moving objects, extract 3D models of objects, produce 3D point clouds from stereo cameras, stitch images together to produce a high resolution image of an entire scene, find similar images from an image

database, remove red eyes from images taken using flash, follow eye movements, recognize scenery and establish markers to overlay it with augmented reality, etc.

- Python Imaging Library (abbreviated as PIL) (in newer versions known as Pillow) is a free and open-source additional library for the Python programing language that adds support for opening, manipulating, and saving many different image file formats.
- Sklearn library efficient tool for machine learning and statistical modeling

Questions

The following question will be answered by the end of the project:

- At what weed growth stage can reduced herbicide dose be optimal?

Image processing and analysis

For image analysis, image understanding, pattern recognition, and computer vision, we often change an image into a corresponding binary image, where pixels belonging to objects that we want to recognize are transfer to foreground pixels (object pixels) and all other pixels are transfer to background pixels.

Image processing is a method to perform some operations on an image, in order to get an enhanced image or to extract some useful information from it. It is a type of signal processing in which input is an image and output may be image or characteristics/features associated with that image.

Image processing basically includes the following three steps:

- Importing the image via image acquisition tools;
- Analysing and manipulating the image;
- Output in which result can be altered image or report that is based on image analysis

Performing Crop Detection and Leaf Count

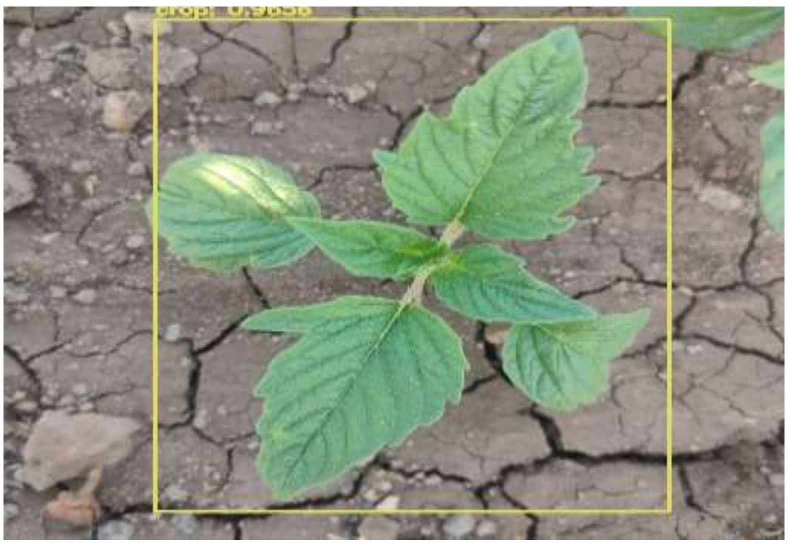
- This is achieved by using YOLO object detection framework, which makes use of Deep Neural Network algorithm to first detect the crop object (weed). A pre-trained YOLO weighted file is used to connect each neuron in the Deep Neural Network to strengthen connections and effect desired output of the network.

- A leaf count of the crop follows using OpenCV library after the images have been pre-processed into a format suitable for the count. To achieve a leaf count we convert colored image into grayscale to obtain a one-channel image, which will reduce edge detection challenges, and to do so Gamma correction method was used which was implemented with OpenCV Library. Then after a suitable image format is obtained, OpenCV method is used to count the number of leaves.

- Based on the leaf count we are able ascertain the growth stage of the weed and a herbicide dosage is recommended using the standard scale which will still achieve the desired results of an efficient weed control regardless of reduction in the full dosage.

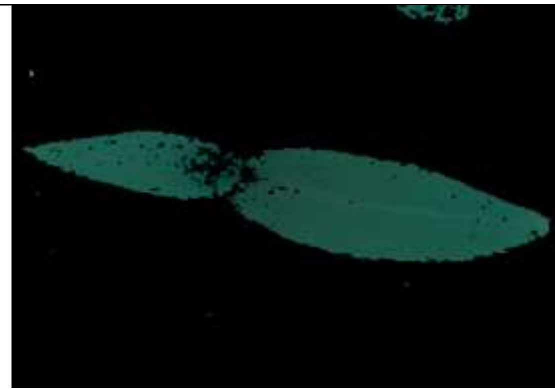
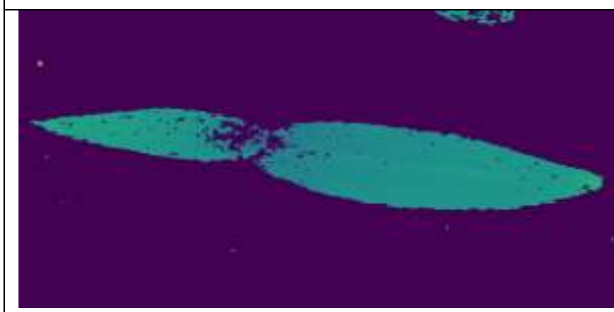
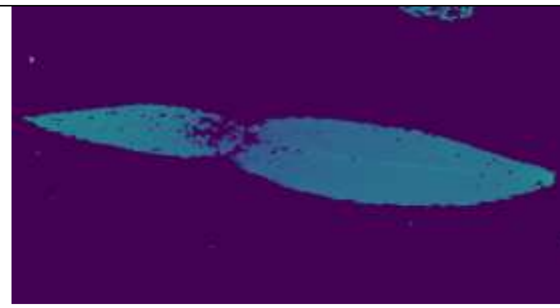
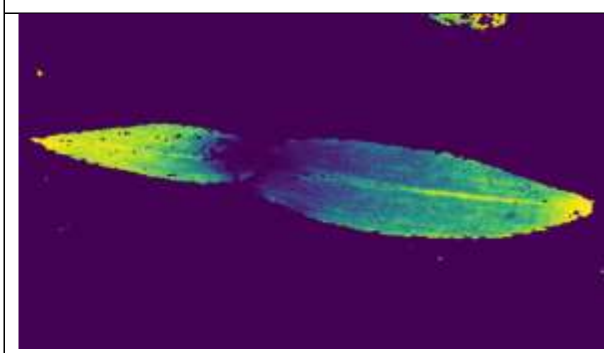
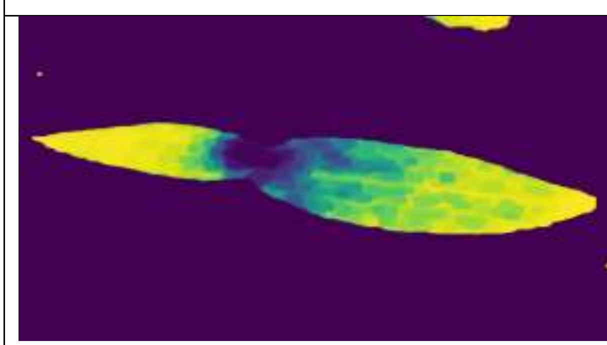
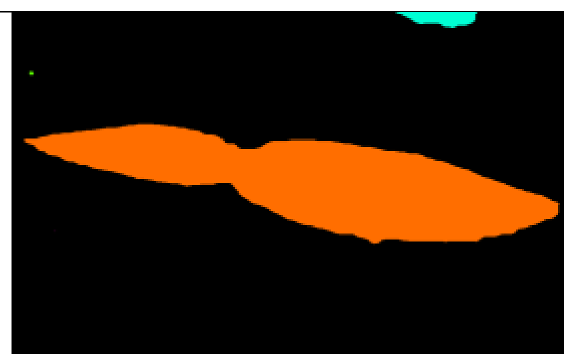
Visualization and insights

1. Bounding box



- In the image above, a bounding box as an image annotation technique is used to show a recognizable weed image.
- the bounding box is an image annotation technique to show a recognizable weed image and in this situation it is drawn on weed plants to indicate detection.

2. Image processing in preparation for leaf count

 a	 b
 c	 d
 e	 f
 g	 h

Keys:

a - represents the sample image being used to test preprocessing.

b - represents image gotten after extracting the background. This section is where we preprocessed the image to be to do the leaf count. We created a method that extract only the green parts in the image helping us to extract the plant from its background.

c - represents image gotten after changing the image **b** to grayscale. Many images have to be in grayscale because of the measuring device used to obtain them. A grayscale (or graylevel) image is simply one in which the only colors are shades of gray. The reason for differentiating such images from any other sort of color image is that less information needs to be provided for each pixel. Grayscale images are sufficient for many tasks and so there is no need to use more complicated and harder-to-process color images.

d - represents image gotten after contrast adjusting grayscale image with gamma correction of y=1.2. Gamma is an important but seldom understood characteristic of virtually all digital imaging systems. It defines the relationship between a pixel's numerical value and its actual luminance. Without gamma, shades captured by digital cameras would not appear as they did to our eyes (on a standard monitor). It's also referred to as gamma correction, gamma encoding or gamma compression, but these all refer to a similar concept. Understanding how gamma works can improve one's exposure technique.

e - represents image gotten after contrast adjusting grayscale image with histogram equalization. Histogram equalization is a method in image processing of contrast adjustment using the images histogram. Histogram equalization is one of the best methods for image enhancement. It provides better quality of images without loss of any information

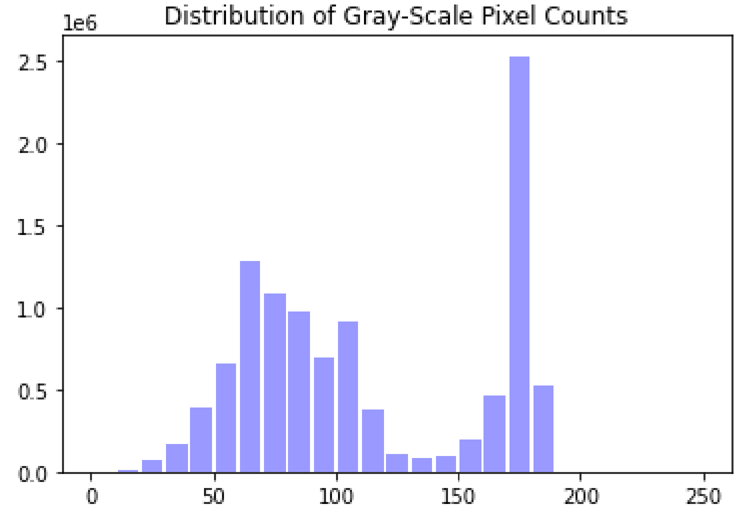
f - represents image gotten after performing dilation and erosion on image **d** and then removing the noise from the image. Dilation and erosion are often used in combination to implement image-processing operations. You can combine dilation and erosion to remove small objects from an image and smooth the border of large objects.

Erosion effects starts eroding white part of image from out to in. This is useful for removing salt nose (white dots) in the image. Dilation is opposite of erosion. It makes objects bigger. .After which we remove the noise from the image.

g - represents image gotten after performing dilation and erosion on image **e** and then removing the noise from the image

h - represents image gotten after using connectComponents method from openCV to do object count using image f and g respectively. Connect-component labeling assigns a unique label to all pixels of each connected component (i.e., each object) in a binary image. Connected-component labeling is indispensable for distinguishing different objects in a binary image, and prerequisite for image analysis and object recognition in the image. Therefore, connected-component labeling is one of the most important processes for image analysis, image understanding, pattern recognition, and computer vision.

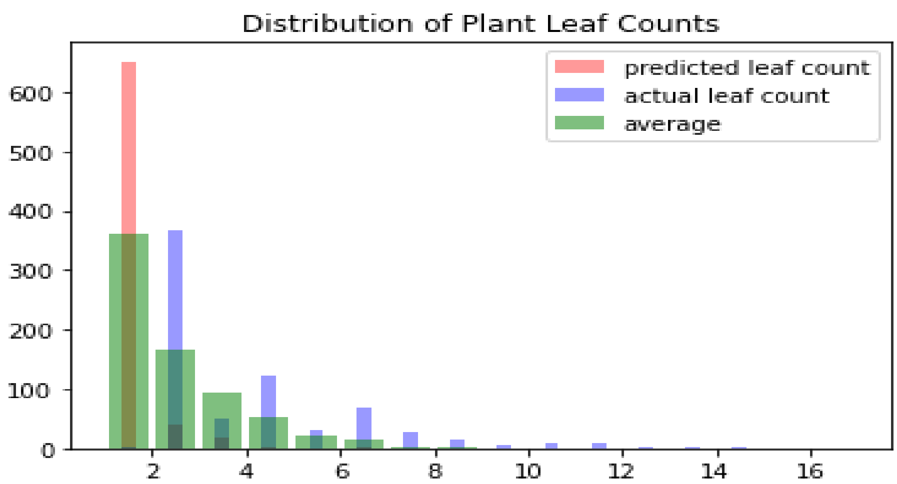
3. Distribution plot



Distribution of Gray-Scale Pixel Counts of image from common chickweed dataset image 297

- The histogram plots the number of pixels in the image (vertical axis) with a particular brightness or tonal value (horizontal axis).

4. Distribution plot



- The diagram above shows a plot for the predicted leaf count, actual leaf count and average count, which is generated by finding the average of the predicted leaf count and actual leaf count.

Impact

With this solution, an economically profitable and environmentally friendly approach to weed control will be achieved:

- Economically profitable means less expenses on herbicides due to an allowable reduction window in dosage by about ¼ of a full recommended dose.
- Environmentally friendly means less amount of chemical release into the soil which can leach into the underground water, eventually finding its way into our waterbodies and poisoning them.

Summary and Recommendations

1. From the leaf count we realized that most weed plants in our dataset had from 1-6 leaves.

2. Investigation on the influence of weed growth stage on the efficacy of herbicides applied at reduced doses under pot experiments at the Institute of Soil Science and Plant Cultivation – State Research Institute in Wroclaw proved high efficacy of the reduced herbicide dose system only when applied to the youngest weed plants, but at later growth stages (6-8 and 10-12 leaves) the effect of the herbicide considerably decreased [4].

   Based on this, we recommend that:

- A reduced herbicide dose of about 75% of the full recommended dose of herbicides can be applied to weeds at early growth stages (2-6 leaves).
- A full-recommended dose should be applied at later growth stages (7-8 and 10-12 leaves) to maintain the efficiency of selected herbicides.

Number of leaves(growth stage)	**Recommended dose(g/ha)**
2-4	0.75N
4-6	0.75N
7 and above	1N

N – recommended dose (15g/ha)

Figures are based on the investigation of the influence of weed growth stage on the efficacy of herbicides applied at reduced doses under pot experiments at the Institute of Soil Science and Plant Cultivation – State Research Institute in Wroclaw

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