Bachelor Degree Project in Industrial Engineering, 30 ECTS [PR508G] Spring Semester 2020
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In cooperation with Naturbruksförvaltningen Sötåsen
The students can be reached online through Zoom 28th of May 11.00-13.00
See Zoom link: https://us02web.zoom.us/j/8440290515?pwd=bVExQmJONHNnY290bXl4TmYrSEc1dz09

HÖGSKOLAN I SKÖVDE

Crop and weed detection using image processing and deep learning techniques

This project develops a system for the identification of spinachs, cleavers and dandelions as an alternative to the weed detector system on FarmBots company robots. Artificial intelligence and computer vision are combined achieving an accuracy of 78.10% for spinachs, 53.12% for cleavers and 44.76% for dandelions. In addition, the coordinates of cleavers and dandelions are given according to their location on the FarmBot.

INTRODUCTION

The aim of this project is to achieve the recognition of spinachs (*Figure 1 (1)*) and two different weeds: dandelions (*Figure 1 (2)*) and cleavers (*Figure 1 (3)*). This is done in collaboration with Naturbruksförvaltningen Sötåsen that has lend us their FarmBot in order to carry out this thesis by creating an alternative to its built-in weed detector.
A weed detection system is developed by using new techniques such as image processing, object detection and artificial neural networks (ANNs). The development of the system is done programming in three different environments: Matlab, Python and FarmBot.
This project helps individuals to take care of their own orchards while trying to introduce new technologies into agriculture, leaving room for a future growth of technology in this field.

Figure 1. Crop and weeds to detect.

PROBLEM DESCRIPTION

The current FarmBot weed detector works by previously knowing the location of the crops and their colour range; when something is not according to this, it is automatically considered as a weed. If there is a weed too close to a crop it will not be detected. That is the main problem to solve in this thesis; to do so, a neural network is trained to detect those weeds no matter their location or colour. Therefore the correct functioning of the neural network while recognizing those weeds is the main aim of this thesis.
In addition to the main goal, this project also implements the obtention of the identified weed coordinates and a comparison with other detection systems including the FarmBot one.

METHOD

The design and creation methodology has been followed during the development of this project. Firstly, after the problem identification, a literature research into the main topics has been done. Then, a prototype based on this knowledge was developed and implemented, but as the results were not as expected, another prototype was suggested, leading to the final model. When the model was feasible and the results valid, the conclusions were written and the project finished.

APPROACH

The system developed works as follows:

- The FarmBot takes pictures of the whole field, in this case 54 in total, and stores them into its Google cloud storage.
- With python, the FarmBot API is accessed and the pictures are downloaded into the computer storage.
- Matlab retrieves those pictures and works with them accordingly. The pictures are processed, introduced to the network in order to train and test it and, finally, the proper pictures of a whole FarmBot field are introduced to the trained network where the weeds are detected and located.

DEVELOPMENT

This system is programmed in three different environments, therefore, three different programmes are developed.

- The FarmBot is programmed on its web-based programming environment. The objective of this programming is taking pictures of the full FarmBot bed. The robot will move as follows: it starts from a safe position on the upper left corner, takes a picture and moves one position to the right, repeating this sequence until it reaches the end of the row. Then it takes a picture and moves to the begging of the next row. This is repeated until the robot reaches the final position on the lower right corner of the FarmBot bed and moves back to its safe position, ready to start again.
- The Python code is executed from Matlab in order to download the pictures. It uses the company credentials to access the cloud storage and, before downloading the images to the computer, it empties the folder where they will be stored. Once the folder is empty, the pictures are downloaded.
- Matlab retrieves those pictures to work with them. First of all, it applies two processing techniques to them: sharpening and glare removal, in order to improve the images for the posterior network training. Next step the images are randomly separated in train and test sets and manually labelled in order to know the exact position of every element inside of them as object detection is being applied. After this, the last layers of the AlexNet network are modified as transfer learning is the method used to work with in this project. Then, the network is trained first recognizing the proposed regions, learning from them and finally reviewing what has been learnt. Lastly, a test is done by introducing the test set of images in order to know if training more is needed.

RESULTS & CONCLUSION

Once the trained network is obtained, it is time to finally detect what is inside the FarmBot. This is done by introducing the 54 pictures that conform the FarmBot bed into the network. The elements are detected and those with more than a 75% of confidence are shown as the detected weeds and crops as it can be seen in *Figure 3*.

Weed type	X	Y
Cleaver	1424.8	838.92
Dandelion	1513.2	596.41
Dandelion	1412.2	168.09
Cleaver	1286.4	1263.3
Dandelion	1316.9	338.59
Cleaver	1191.6	1166.9
Cleaver	1151.2	982.27

Figure 2. Weed coordinates table.

As seen in *Figure 2* the network also gives out a table with the type of the detected weeds as well as their coordinates, in millimetres, inside of the FarmBot bed.
The accuracy obtained through the project is a 78.10 % for spinachs, 53.12% for cleavers and 44.76% for dandelions.
To end the results, two comparisons are made, one with the FarmBot built-in detector and another one with a network developed by Córdova-Cruzatty taken from the literature research.
Once the project is finished, the images are correctly processed, the network correctly trained and the results obtained, it can be said that the development has been successfully done and the weeds correctly located and identified. Through the comparison with FarmBot current detector, it can be concluded that our system is more intelligent and advanced. Also, comparing it with Córdova-Cruzatty network, this project shows a satisfactory accuracy despite the small dataset it has.

DISCUSSION

First, we need to highlight that this project explores a new research field for FarmBot company since it develops a new weed detection system they have not tried yet.
Even if the results are satisfactory, some problems faced are not totally solved. The camera characteristics make difficult to avoid glare and overexposure, this can be fixed by either changing the camera, the environment or using polarizers. Another problem faced is the small datasets used, which can be easily solved by taking more pictures, which will probably improve the network accuracy.
This thesis leaves room for possible research projects such as developing a weed detector by creating a neural network from scratch in order to get more control over it; augmenting the number of plants the network can recognize so it would be more intelligent, and developing a weed removal system based on the coordinates given out by the weed detector of this project.

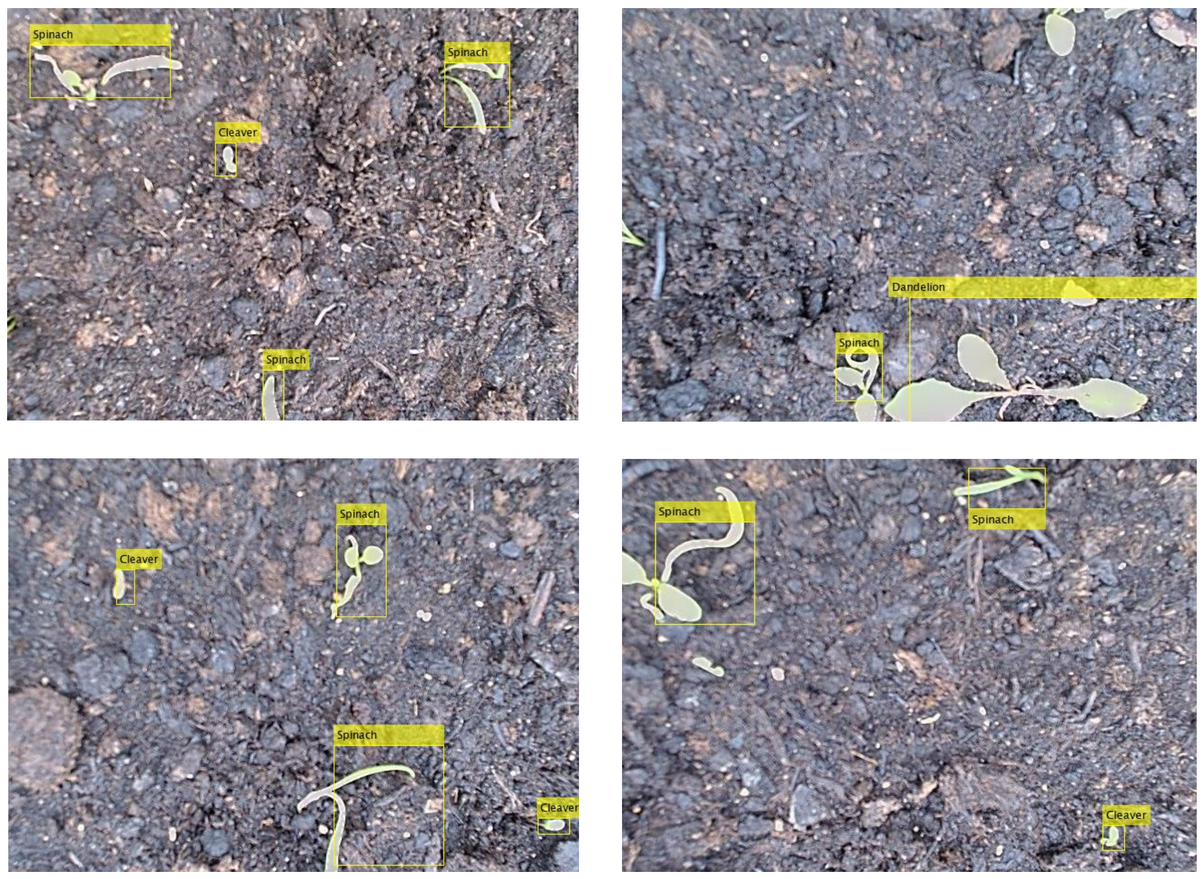

Figure 3. Detected images.