Improving Greenhouse Robot Autonomy Using Machine Learning

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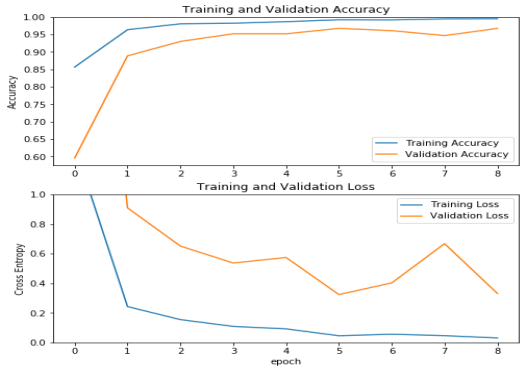
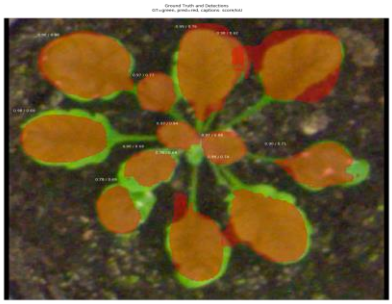
Plant growth in extreme conditions has been a challenge for a long time, mainly because of the efficiency and autonomy of the systems where the plants are seeded. The objective of the plant growth systems is to provide "perfect" conditions to maximize the growth with minimal human involvement. GrowBotHub, an interdisciplinary team at EPFL, tries to tackle the issue and, in that context, the objective of this project is to analyse plant growth using machine learning techniques. Primary, the project has to provide algorithms capable of determining if a plant is ready for harvesting and to optimise the algorithms to run on embedded Linux device in ROS environment. In addition to it, we want to segment leaves of the plants to get a better insight into the plant growth progress.

The first step was to prepare datasets for the training of machine learning models. The dataset for classification is obtained at EPFL in a custom-created environment by putting the camera on top of the plants and capturing the images in the fixed interval. The dataset is later manually classified in two classes, “read” and “not-ready”. Leaves segmentation dataset is based on dataset from Plant Phenotyping organisation.



Optimization results using MobileNetV2

For the plant growth classification, the different architecture of CNN (Convolutional Neural Network) are evaluated to find a compromise between accuracy and complexity of the network, so it can fit the limited computational performance of the embedded Linux board. For that purpose, MobileNetV2 is used to achieve the goal. A few techniques are applied to increase the accuracy of the classification including data augmentation and transfer learning. The network has achieved a good result RMSprop optimizer and binary entropy as a loss function.



Example of the leaves segmentation

The leaves segmentation is achieved using Mask R-CNN, an architecture based on Faster R-CNN, popular Convolutional Neural Network for object detection. As before, data augmentation and transfer learning are applied to increase the performance of the network. Here, ResNet-50 is used as a backbone of the Mask R-CNN which means that ResNet-50 is utilised for classification of the proposed regions. Unfortunatelly, this architecture was too complex to fit it in an embedded Linux device such as Raspberry Pi. Also, even though the leaves detection results were satisfying, segmentation results were not accurate enough for calculating the volume of the leaves. This could be probably solved using a different loss function that emphasis segmentation more and by using more data.

The classification based on the MobileNetV2 model is integrated into a ROS node. The ROS node is capable of reading an image from a filesystem and publishing results of classification on the predefined topic.

Overall, two solutions are presented to plant growth stage analysis using machine learning techniques. CNN used for classification is successfully ported on Raspberry Pi and integrated into ROS.