Detection and classification of insects on stick-traps in a tomato crop using Faster R-CNN

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Background

Insects detection and classification on stick-traps in tomato crops is of relevance for proper pest management and reduced use of inputs. Counting and classification of insects is however time consuming and error prone. Typically, the counting of insects on the traps is done manually. More recently, methods have become available to partly automate the counting. Specific hardware records the so called yellow sticky traps and counts and identifies insects. However more accurate numbers of insects are required for population models and other cameras like smart phone cameras would increase the uptake of this technology by farmers more easily. Therefore the idea was launched that trained operators provide labelled training data for use in a deep learning convolutional network to detect multiple types of insects. In addition to labelling and training on images recorded under controlled conditions, also images were fed to the trained network that were recorded under uncontrolled conditions recorded with smartphone cameras.

Methodology

Images were recorded with a Scoutbox, under controlled conditions with a resolution of 5184 x 3456 pixels. These images were recorded on two greenhouse locations in Belgium. From the 6900 recorded images a subset of 225 images was randomly chosen to represent variability in insect populations to be expected. Each image was split into six section of 1720 x 1220 pixels to fit to an image size being accepted by the CNN for training and classification.

Figure 1. Three insects: macrolophus (mr), whitefly (wf) and nesidiocoris (nc) from left to right respectively

In addition to the Scoutbox images, also a dataset was available being recorded with smartphone camera. The dataset consisted of 90 images recorded with resolution of 4608 x 3456 pixels. The images were also split into six sections each to be accepted in the deep learning and classification pipeline.

The Faster RCNN network was applied in Tensorflow version 1.5 with the object detection module. When training the network, transfer learning was used. The starting point for the training was the trained network on the MS-COCO dataset. The endpoints, or classes for continuing the training were adjusted to three classes. Training of the network was stopped after maximum of 200.000 epochs, or when the total loss was converged at 0.15. The training took about 50 hours on a single Nvidia 1080Ti Gpu. At that point the network was saved as a frozen inference to do classification on the validation dataset.

Results

An example image of insects detected on a yellow sticky trap is shown here. The whiteflies and beneficial insects are identified and counted based on the outcomes of the classification.

Figure 2. Example results for insect detection on complete yellow sticky trap.

The classification shows that 86.7% of whitefly is correctly classified. The weighted accuracy was 87.4%. The trained network was used to classify smartphone images as well. The number of detected whiteflies and macrolophus correlate well ($R^2>0.8$) with the human counted number of insects on the sticky traps.

Table 1. Results of classification given as numbers and percentages of whitefly (wf), macrolophus (mr) and nesidiocoris (nc).

instances		Predicted				
		wf	mr	nc	none	total
labelled	wf	548	0	0	84	632
	mr	0	70	0	3	73
	nc	0	1	6	2	9
	none	26	4	0	0	30
	total	574	75	6	89	

percentage		predicted				
		wf	mr	nc	none	total
labelled	wf	86.7	0.0	0.0	13.3	100.0
	mr	0.0	95.9	0.0	4.1	100.0
	nc	0.0	11.1	66.7	22.2	100.0
					Weighted:	87.4

Next steps

Future counting tasks can now be sped up by pre labelling images to be checked by human operators. Furthermore the detection and counting of insects will be automated and presented to commercial greenhouse growers as a web service to empower their decision making in integrated pest management.

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