Performance evaluation of DeepD381v3 for automatic classification of plant leaf diseases

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A timely and accurate diagnosis-based early monitoring system can replace the traditional visual inspection-based diagnosis of plant leaf diseases, which is time-consuming, costly, ineffective in reducing losses and preventing disease spread. In this study, we proposed a DeepD381v3 (Deep disease 381 layers version 3) convolution neural network architecture with swish layers and batch-instance normalization layers. We investigate the transfer learning ability of the proposed network after training DeepD381v3 using 1.2 million ImageNet large scale visual recognition challenge (ILSVRC2012, Russakovsky et al.,2015) dataset with 1000 classes. The pretrained network after training with ILSVRC2012 dataset, we further modified it to classify 14 classes in which 9 classes for tomato and mandarin leaf diseases, 1 class for tomato leaf nutrient deficiency, 1 class from each tomato, mandarin, and grape vine for healthy leaf conditions and 1 for no class conditions. The comparative parameter of the DeepD381 series network is shown in table 1.

Table 1. Comparative parameter of the DeepD381 series network

Network name	Training parameters	Training data	Number of layers	Total number of connections	Network size, Mb
DeepD381v1	2.86×10^7	22,400	381	403x2	104.57
DeepD381v2	2.35×10^7	1,15,010	379	405x2	84.07
DeepD381v3	**2.64×10^7**	**1,99,094**	**381**	**408x2**	**94.70**

This network achieves classification accuracy over 99.18% with training (2,090,550 augmented images), 98.71% with validation (29,862images) and 98.43% with testing dataset (29,862 images). This network also achieves lower training validation loss of 0.0318 and 0.0373 (score 0 is the best value), respectively. The performance metrics of the DeepD381v3 network is shown in Table 2. We simulate real environment conditions to test the Top-1 classification score. DeepD381v3 is capable of diagnosing disease at 60 fps (640x480), with a Top-1 score of 0.90 (with a score of 0 being the best value) and can distinguish diseased and nutrient deficient leaves from

healthy leaves. The research will support farmers in detecting and classifying plant diseases in real-world situations, and by preventing disease spread at an early stage, it will support farmers in developing effective disease prevention measures at an early stage.

Table 2. The performance metrics of the DeepD381v3 network

Input size	Mini batch size	Max epoch	Time, (min:sec)	Tr. Acc., %	Val. Acc.,%	Test Acc., %	Tr. loss	Val. loss
240x240	54	12	1228:56	99.18	98.71	98.43	0.0318	0.0373

Reference

Russakovsky, O., Deng, J., Su, H., Krause, J., Satheesh, S., Ma, S., Huang, Z., Karpathy, A., Khosla, A., Bernstein, M., Berg, A. C., Fei-Fei, L. ImageNet Large Scale Visual Recognition Challenge. IJCV, 2015.