LAD-Net: A Novel Light Weight Model for Early Apple Leaf Pests and Diseases Classification

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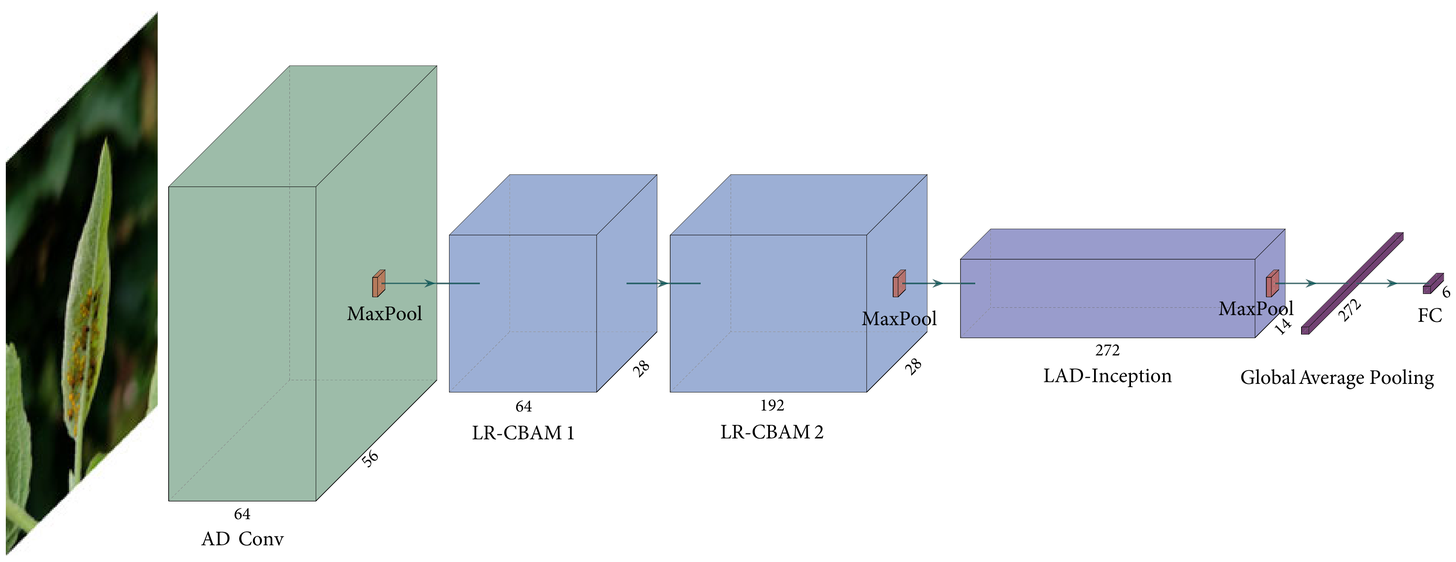
1. Abstract

Aphids, brown spots, mosaics, rusts, powdery mildew and Alternaria blotches are common types of early apple leaf pests and diseases that severely affect the yield and quality of apples. Recently, deep learning has been regarded as the best classification model for apple leaf pests and diseases. However, these models with large parameters have difficulty providing an accurate and fast diagnosis of apple leaf pests and diseases on mobile terminals. This paper proposes a novel and real-time early apple leaf disease recognition model. AD Convolution is firstly utilized to replace standard convolution to make smaller number of parameters and calculations. Meanwhile, a LAD-Inception is built to enhance the ability of extracting multiscale features of different sizes of disease spots. Finally, the LAD-Net model is built by the LR-CBAM and the LAD-Inception modules, replacing a full connection with global average pooling to further reduce parameters. The results show that the LAD-Net, with a size of only 1.25MB, can achieve a recognition performance of 98.58%. Additionally, it is only delayed by 15.2ms on HUAWEI P40 and by 100.1ms on Jetson Nano, illustrating that the LAD-Net can accurately recognize early apple leaf pests and diseases on mobile devices in real-time, providing portable technical support.

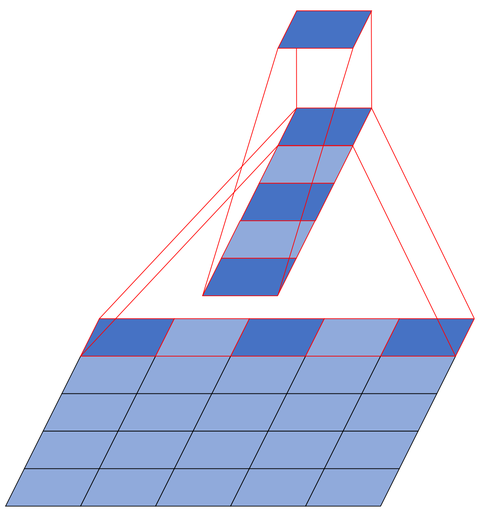


2. Contributions

1. A novel light weight model, the LAD-Net, is pro-posed to achieve real-time diagnose on early apple leaf pets and diseases. Most of existing studies are performed on simple diseased images or taken by professionals for the academic purpose, and the existing classic CNN models with large parameters have difficulty providing a real-time diagnosis on mobile terminals, while the existing light weight models with low accuracy still needs further improvement for the complex disease images. There-fore, a novel light weight model is proposed and deployed to mobile terminals for real-time recogni-tion of early apple leaf pests and diseases, providing a higher recognition accuracy under the natural environment.
2. AD Convolution is presented to make parameters and calculations smaller for real-time inference of LAD-Net. To recognize apple leaf pests and diseases quickly, the parameters and calculations of LAD-Net deployed on resource-constrained devices must be reduced. Therefore, AD Convolution (Asymmetric and Dilated Convolution) is proposed to replace the standard convolution. It combines the advantage of asymmetric convolution and dilated convolution by adding the dilation rate to asymmetric convolution. Consequently, the number of parameters in AD Con- volution is $\frac{6}{25}$ of that in standard 5×5 convolution.
3. LAD-Inception (Inception module using Leaky-ReLU and AD Convolution) is established to improve recognition accuracy of LAD-Net. For apple leaf pests and diseases varying in size, the LAD-Inception is built by adding an extra branch and residual connection to improve the ability to extract multiscale features of disease spots. Meanwhile, channel attention is also utilized to allocate the importance of each branch reasonably, as well as to strengthen the capacity to extract more global infor-mation, which makes the accuracy of the model higher.
4. The lightweight model LAD-Net is deployed and eval-uated on mobile terminals in the natural environment for requirement of agricultural actual production, which achieves fast and accurate recognition for early apple leaf pests and diseases. The experimental results show that LAD-Net only has a delay of 15.2ms on HUAWEI P40 and 100.1ms on Jetson Nano, respec-tively, illustrating that the LAD-Net can reach real-time inference and providing portable technical support.

3. Core Module

To decrease the parameters and calculations, the AD convolution is proposed to replace the standard convolution, which combines the advantages of asymmetric convolution and dilated convolution. Using AD convolution can make the size of the model smaller to be easily transplanted to the device with a limited memory. In addition, less parameters aid the generation of the model.



4. Mobile Terminal and Embedded Device Application

The lightweight model LAD-Net is deployed and evaluated on mobile terminals in the natural environment for requirement of agricultural actual production, which achieves fast and accurate recognition for early apple leaf pests and diseases. The experimental results show that LAD-Net only has a delay of 15.2ms on HUAWEI P40 and 100.1ms on Jetson Nano, respectively.
Detailedly, the PaddleLite tool is used to package the model into an app. First, the PyTorch model is converted to the ONNX format. Then, the ONNX format is converted to pdparams supported by Paddle with X2Paddle. Finally, the PaddleLite tool is used to generate an apks file based on Android Studio and deploy it on the mobile terminal.
Besides, the model is transplanted to the embedded device, Jetson Nano, which is assembled into a small robot. The robot can automatically move in a simulated orchard environment and recognize leaf pests and diseases. The robot follows the planned line around the apple tree while capturing an early apple leaf disease image via its camera. At the same time, the LAD-Net recognizes the image in real-time, and the result is shown in the terminal.