Automated Crop Disease Classification: Examining Lightweight Transfer Learning for the Edge

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Introduction

Motivation & Background:
- Pests and diseases lead to an annual 20-40% loss in food production around the world
  - With climate change, problem worsening
- Automated crop disease identification is more important than ever for farmers
- Little prior work on approach generalized to all crops
- Network of cheap IoT cameras constantly gathering images of plant leaves
  - Need for a lightweight CV approach that can run on edge

Problem Statement:
- Evaluate the effectiveness of a lightweight CNN approach to binary leaf disease classification
  - Effectiveness of transfer learning from low-quality to high-quality dataset
- Details:
  - Input: JPEG crop leaf images of any species
  - Output: Healthy/Diseased Label

Methods

Architecture:
- 2 CONV-POOL
- 2 FC Layers
- Over 74 million params

- 3 CONV-POOL
- 3 FC Layers
- BatchNorm
- LeakyReLU
- Over 24 million params

Experiments & Analysis

Experiments 1 and 2: Compare performance of baseline and custom models; train and test on PlantVillage
- Baseline
  - Test Accuracy (PlantVillage): 78.03%
- Custom
  - Test Accuracy (PlantVillage): 86.21%

- We see that the custom model vastly outperforms the baseline model, by over 8% While being far more lightweight (a third of the size)

Testing on PlantLeaves for Experiment 3, 4 and 5:

Experiment 3:
- Using custom architecture, train and test on PlantLeaves dataset
- We see that no experiment setup performs particularly well on the binary PlantLeaves task, with each of them doing only slightly better than chance.
  - Suggests high degree of difficulty in the underlying task

Experiment 4:
- Using custom architecture, train on PlantVillages and test on PlantLeaves dataset

Experiment 5:
- Using custom architecture, pretrain on PlantVillages; finetune and test on PlantLeaves dataset

Results

Testing on PlantVillages for Experiment 1 and 2:

<table>
<thead>
<tr>
<th>Model</th>
<th>Test Accuracy (PlantVillage)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Baseline</td>
<td>78.03%</td>
</tr>
<tr>
<td>Custom</td>
<td>86.21%</td>
</tr>
</tbody>
</table>

Testing on PlantLeaves for Experiment 3, 4 and 5:

<table>
<thead>
<tr>
<th>Model</th>
<th>Test Accuracy (PlantLeaves)</th>
</tr>
</thead>
<tbody>
<tr>
<td>PlantLeaves Train</td>
<td>53.22%</td>
</tr>
<tr>
<td>Only Pretrain</td>
<td>50.82%</td>
</tr>
<tr>
<td>Pretrain and Finetune</td>
<td>52.77%</td>
</tr>
</tbody>
</table>

Conclusion / Future Work

Successfully constructed a lightweight custom model for low-resolution leaf disease classification
- Beat heavier baseline model
- Transfer learning (from low-quality images to high-quality images) was not effective in this domain space
  - In context, even a model trained directly on the high-quality images did not perform much better
- Future Work: Refine approach with more data, training and complex architectures like ‘squeeze-and-excitation’ networks; can also reframe the problem to separate different species and diseases for ease of classification