Real-time Wildlife Detection on Embedded Systems

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Final Presentation
Project Description

- Dataset: 200,000 photos taken by 18 fixed camera traps over 10 years
  - Focus on 3 classes that are most important to Jasper Ridge
- Train CNNs on GCP to get best possible performance on task
- Try to deploy on Raspberry PI and get inferences in real-time
- Reduce memory and power footprint by pruning and other sparsity techniques
Experimental Setup

- Filter out dataset to only include classes relevant to this task
- Split up into train/validation/test with equal class balance
- ~50,000 samples in Train, ~8,000 in Valid, ~6,000 in Test
Deliverable

- Pretrained model selection
- Efficient execution framework
- Real-time, on-device, low power inference system
Delivered System

Step 1: Users use model selector, which chooses which model to use, given power/accuracy constraint.

Step 2: Launch our script - it efficiently handles power consumption, preprocesses new images, and outputs predictions with thumbnails.

Motion sensor triggers → Photo creation event → Selected Model (Tensorflow Lite)

"coyote"
Delivered System

Step 1

Model Selection

Selected Model

Tensorflow Lite

Step 2

Raw Camera Image

Motion sensor triggers

Photo creation event

Execution

Selected Model

Tensorflow Lite

"Coyote" thumbnail
Optimizations

- Configurable input tensor size
- < 2% CPU utilization during standard operation via low power sleep state
- < 25% CPU utilization during inference
- ~50x reduction in packaged model size through operator pruning and fusion
- Optional model quantization
## Model Analysis

Accuracies are reported on test set

<table>
<thead>
<tr>
<th>Model (image size)</th>
<th>Human Accuracy</th>
<th>Coyote Accuracy</th>
<th>Lion Accuracy</th>
<th>Mean per-class Accuracy</th>
<th>Execution Time (s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Resnet18 (64x64)</td>
<td>97.9</td>
<td>57.6</td>
<td>62.7</td>
<td>72.7</td>
<td>0.39</td>
</tr>
<tr>
<td>Resnet18 (224x224)</td>
<td>99.3</td>
<td>71.5</td>
<td>81.7</td>
<td>84.2</td>
<td>4.03</td>
</tr>
<tr>
<td>Resnet50 (64x64)</td>
<td>98.2</td>
<td>58.0</td>
<td>62.0</td>
<td>72.7</td>
<td>0.92</td>
</tr>
<tr>
<td>Resnet50 (224x224)</td>
<td>99.2</td>
<td>80.1</td>
<td>83.7</td>
<td>87.6</td>
<td>10.58</td>
</tr>
</tbody>
</table>
Conclusion

Contributions

- Delivered a highly accurate ResNet model for wildlife detection
- Analysis of power vs. accuracy characteristics across model complexities and input resolutions
- Easy to use, optimized system for wildlife detection on the Raspberry Pi

Thanks to our mentors, Professor Paepcke and Professor Ullman, along with Trevor Hebert and Jasper Ridge Wildlife Preserve for amazing support and inspiration!