Leveraging computer vision systems for monitoring animal health and productivity on dairy farms

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My Background

Animal scientist
Focus on animal health and management

CHTC allowed me to accelerate my research and perform analyses that would be impossible otherwise.
Outline

My research

Computational implementation
  • computing requirements
  • deployment
  • throughput/time

Using CHTC/HTCondor

Personal and professional impact
• Research applications of machine learning and computer vision for farm management and genetic selection

**Sensors:**
- Wearable Cameras
- IR Spec.
- RFID
- Sound
- Housing

**Animal-Level Information**
- Animal Identification
- Animal Behavior
- Body Weight
- BCS/Composition
- Milk Components
- Milk Yield
- Estrus Event
- Feed Intake
- Feed Efficiency
- Disease Risks

**Environmental Information**
- Weather
- Crop
- Water
- Soil

*Tullo et al., 2019*
Current methods for monitoring cattle:

- Visual observation
  - Large-scale applications?
  - Subjectivity
- Wearable sensors
- * Computer vision
Benefits of Computer Vision

- Cameras are affordable and easy to install
- Ability to monitor multiple animals at a time
- Images provide a great amount of information
  - Animal location/action
  - Social interaction
  - Weather/season
  - Health/mobility
Research: Cow mouth tracking

- 1,662,417 images
- Cropped for each individual cow (utilizing CHTC)
- 4,008,630 sequential images
- Mask R-CNN

Inferences made on remaining 4,008,245 images
Research: Calf heat stress detection

- 27,704 images
- YOLOv3
- tinyYOLOv3

Training: 297 images
Validation: 128 images

Inferences made on remaining 27,704 images
Research: Calf identification and growth monitoring

- 27 + TB of data
- Current project
- Xception (ongoing analyses)
Implementation

- These analyses utilize complex algorithms
- Large datasets (thousands or millions of images)
- Image data is large (400x600 = 24,000 pixels)
- Image preprocessing
- Computationally demanding to train

- Mask R-CNN
  - 44 million parameters
- YOLOv3
  - 40.5 million parameters
- tinyYOLOv3
  - 8.9 million parameters
- Xception
  - 22.8 million parameters
Neural Network Training

• Multiple neural networks to train independently:

• Different datasets
  • Evaluate which one is the best for training (preprocessing, data collection strategies, etc)
  • Perform multiple experiments (effect of day, lighting, etc)

• Hyperparameter tuning
  • Train using multiple combinations to find the best
 Neural network training: GPUs vs CPUs

Research  Implementation  CHTC  Impact

CPU vs GPU in practice

(CPU performance not well-optimized, a little unfair)

- Intel E5-2620 v3
- Pascal Titan X (no cuDNN)
- Pascal Titan X (cuDNN 5.1)

VGG-16: 66x
VGG-19: 67x
ResNet-18: 71x
ResNet-50: 64x
ResNet-200: 76x

Data from https://github.com/jjohnson/cnn-benchmarks
Using CHTC/HTCondor

• Using since Fall 2021
• > 4,000 computing hours
• Larger projects require dozens of trained neural networks
• Each project contains thousands of images for training, and 100,000s or even millions of images for inference
Using CHTC/HTCondor

- Datasets stored on Staging
- Python environments using Miniconda
  - Compressed environment packs stored on SQUID
- Queue jobs using txt files
- Template folder for each category of project (containing .sub, .sh, python files, etc)
  - Each template expects datasets following a certain format and outputs files/folders following a certain format
Use case: cow mouth detection

Input: Dataset containing images and bounding boxes

- Dataset/
  - Img01.png
  - Img01_bbox.txt
  - Img02.png
  - Img02_bbox.txt
  - Img03.png
  - Img03_bbox.txt

Output: Bounding box predictions on test set

physical measurements
• distance traveled
• acceleration
• velocity

provides insight on feeding behavior, health, and milk production
Use case: calf detection

- Input: Dataset containing images and masks
- Output: Mask predictions on test set
Use case: edge computing

Deploy trained model (trained using CHTC) in edge computing applications to make inferences real-time.
Use case: calf identification

- Collecting images 24/7 following calves the first 2 years of life
- Tracking growth, health, and behavior
- Estimated > 100 TB data to be acquired
CHTC Benefits/Limitations

**Pros:**

- Potential ability to access data directly from our own servers (access point)
- Checking logs to have an idea of how far into the job (which epoch, for example) the 12/24/72hr limits were reached
- Flexibility to submit jobs to CPUs or GPUs depending on availability and size of job
- The option to have emails sent when jobs are done running

**Cons:**

- Large datasets can take very long to transfer, especially when working from home using a VPN
Personal & Professional Impact

• Ability to perform data analysis that would be impossible otherwise
  • Advancing knowledge of animal health and behavior

• Experience accessing a remote Linux server

• Exposure using a high-throughput computing system

• Consider data flow and automation within remote server environments

• Cultivated skills that will help me in my future career, opened opportunities to present my research in multiple conferences, and work with a great team!
Thank you!
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