ML and Image Analyses for Livestock Data

Joao Dorea
Assistant Professor
Department of Animal and Dairy Sciences
Department of Biological Systems Engineering
High-Throughput Phenotyping: animal-level

• Animal-level information for optimized decision and genetic selection

**Sensors:**
- Animal Identification
- Animal Behavior
- Body Weight
- BCS/Composition
- Milk Components
- Milk Yield
- Estrus Event
- Feed Intake
- Feed Efficiency
- GGE

➢ **Cheap + Precise + Real-Time**
Why Computer Vision Systems?

Can I use other sensing technologies?

A single image can be extremely informative!
...it can go beyond your primary interest!
Computer Vision Systems: Image Analyses

- Complex dataset to analyze
- Variety of tasks: Deep Learning context

**2D Image Classification**
- No calf
- Calf

**3D Image Classification**

**Object Detection**

**Semantic Segmentation**

**Instance Segmentation**

**Image Synthesis**
Monitoring Animal Behavior

Early detection of diseases, social interaction, welfare, feed efficiency, estrus, locomotion, etc.
Monitoring Animal Behavior
Monitoring Feeding Behavior

Hand Motion
Predicting body weight in dairy calves through 3D images

Cominote et al., 2020  Dorea et al., 2019  Fernandes et al., 2019
First Step: **Animal identification** using 2D images

- 59 lactating dairy cows
- Training set: 13,222 images
automatically acquired at UW-Madison
- Testing set: 617 images test
- *Avg accuracy: ~94% to identify individual animals*
Animal identification using 2D images

• It will not work for similar color patterns

Ferreira et al., 2020 - ADSA
Animal identification using 3D images

Using 3D: Voxels Point Cloud

3D CNN VoxNet/PointNet

38 animals - Overall Accuracy = 87%

Ferreira et al., 2020 - ADSA
Using HTCondor: **Animal Identification + Body Condition Score**

- **Camera**
- **Infrared**
- **Depth**

Rafael Ferreira (PhD Student)
Using HTCondor: Animal Identification + Body Condition Score

1st Step: Image Classification

Good

If good: 2nd Step: Image Segmentation (Mask)

Bad

Xception
2D CNN
23M params

U-Net
2D CNN
31M params

3rd Step: Image Classification

(Body Condition Score: 1-5)

Xception
2D CNN
23M params

4th Step: Image Identification

(Animal Identification)

Xception
2D CNN
23M params

Rafael Ferreira
(PhD Student)

1 student
60 cows
4 Cameras
2 phenotypes
Training only

Jobs
127
Number of images/Job
218,355
Training time
1,872 hours
Disk usage
1072 GB
GPU
1
GPU Memory used
754 GB
RAM
739 GB
What about inference? – Azure

- Total processed images: 104,494 (52,247 png, 52,247 tiff)
- Good images (segmented, identified, BCS calculated): 19,163
- Total execution time: 6,441 hours (total time: from image upload to final SQL insert, not only inference!):
  - Several tasks (transfer time, SQL insert, image storage: masks, cropped, ident, BCS);
- Azure logs shows memory allocated but not memory used and the max memory allocated per instance is 1.5GB
- Max parallel instances count: 200

*We would love to use HTCondor for automated inference (real-time?)*
Using HTCondor: Animal Identification + Body Condition Score

**DONE!**

Deep Neural Networks are trained!

1st Step: Image Classification

- Good
  - Xception 2D CNN 23M params
- Bad
  - U-Net 2D CNN 38M params

3rd Step: Image Classification (Body Condition Score: 1-5)

- Good
  - Xception 2D CNN 23M params
- Bad
  - Xception 2D CNN 23M params

4th Step: Image Identification (Animal Identification)

Need to retrain daily (weekly?)

Open-Set problem!
New cows every day

Not Here!
We would need to retrain **daily** (60 cows only):

- **Number of images**: ~13,000
- **Training time**: 10 hours
- **Disk usage**: 10.7 GB
- **GPU**: 1
- **GPU Memory used**: 38 GB
- **RAM**: 5.7 GB

A farm with 6,000 cows would require significant computational resources!

Need to retrain daily (weekly?)

Open-Set problem!
New cows every day

Not Here!

4th Step: Image Identification (Animal Identification)

Xception
2D CNN
23M params

Using HTCondor: **Animal Identification + Body Condition Score**
Our Camera System at UW-Madison

**We have:**
- 40 RGB Cameras collecting data every 5 seconds;
- Depth cameras collecting 3D images and infrared twice a day of every single cow;

**We generate:**
- 1.38 TB of RGB per day
- 10 GB of 3D and Infrared images (500 cows)

**Our Vision:**
*Create state-of-the-art computer vision systems and the largest public database for livestock (image, audio, sensor)*
Our Challenges:

• Frequent transfer of large databases for each new training process;
• Number of GPUs for concurrent jobs;
• User-Friendly interface for general public usage (e.g. Animal Science, Agronomy, BSE, Vet students) – Graphical Interface (commands), teaching?
• Example: Azure Lab Services (Deployment of VMs for each student with Linux or Windows interface – GPU labs);
Opportunities:

• Development of state-of-the-art computer vision systems for livestock operations;
• Training and implementation of complex deep learning algorithms for image analyses;
• Analyses of large imaging datasets (100+ concurrent jobs);
• Collaborations to develop automated training and inference strategies using HTCondor infrastructure;
• Publications of high-impact (realistic research) research in the field of Digital Agriculture
Our Research Group

Digital Livestock Lab

Research Group:

Dr. Luiz Gustavo Pereira (Visiting Scientist)
Dr. Tiago Bresolin (Research Associate)
Dr. Dario Oliveira (Research Associate)
Rafael Ferreira (PhD Student)
Ariana Negreiro (PhD Student)
Caleb LaCount (Undergraduate Student)
Thank you!

joao.dorea@wisc.edu