# Comparative Analysis of Real-Time Object Detection Algorithms for Digital Dermatitis in Dairy Cattle

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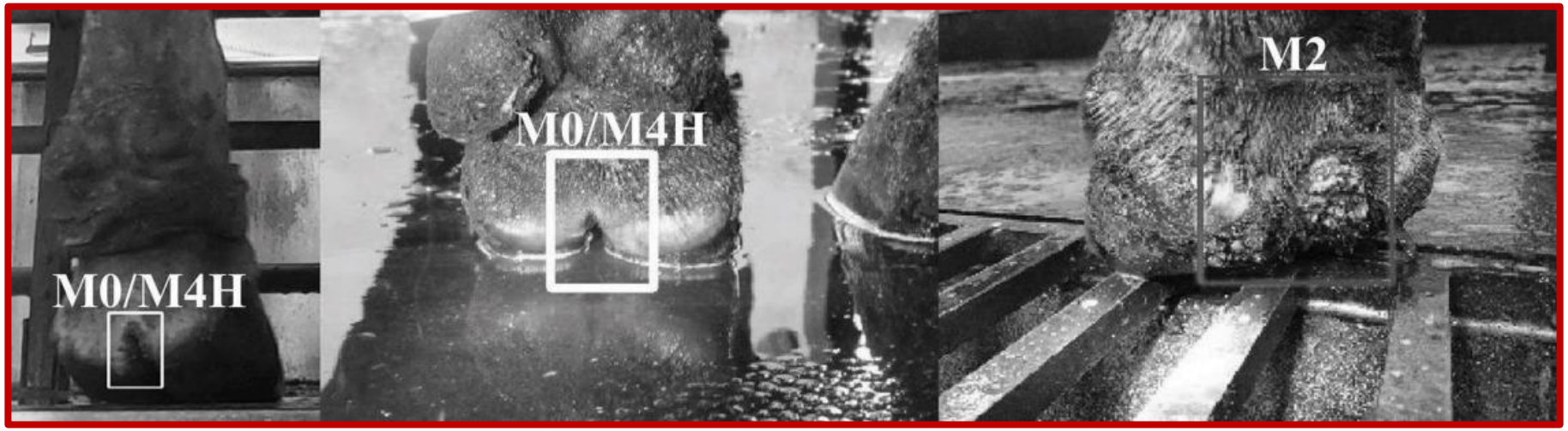
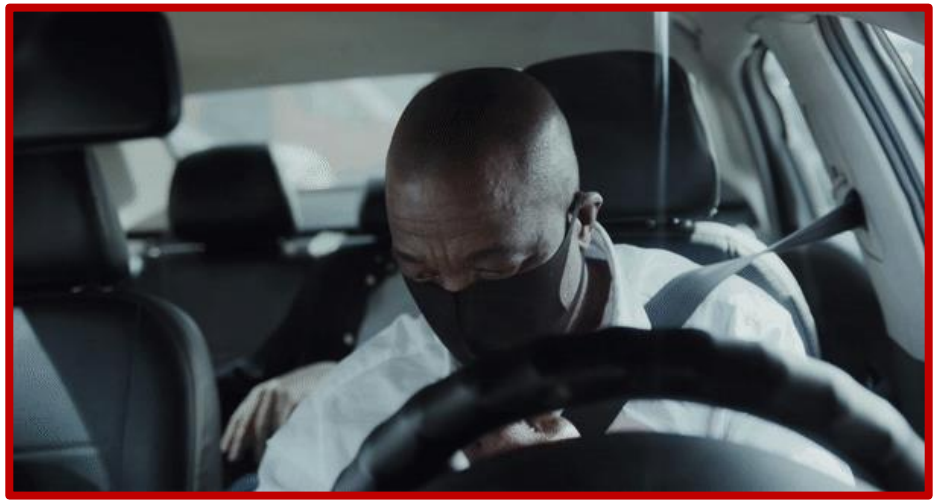
# Digital dermatitis

- **Digital dermatitis** (**DD**) is the most prevalent bovine infectious claw disease in North American and global cattle industries.
  - **Painful lesions** on the skin-horn border of the hoof
  - **Severe lameness**, decreased milk production, increased infertility rate
- Visual inspection is traditionally used to detect DD.
  - Requiring extensive training, time, and labor



# Computer Vision

- Computer vision (CV) can be used to perform **object detection** and calculate the associated **class probabilities**.
  - Unique opportunity to improve early detection, prevention, and optimized treatment plans
  - Detection and classification of health events are still rare in veterinary medicine



# Computer Vision

# Object Detection

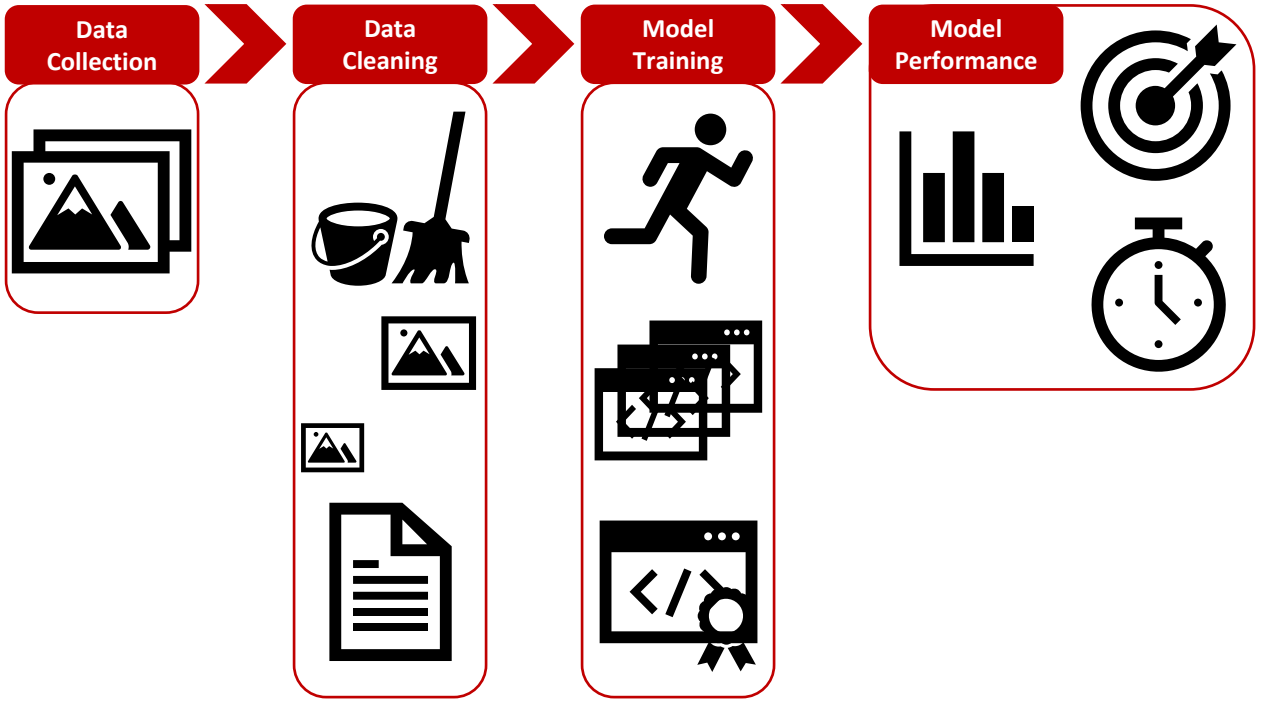
- Object detection locates the presence of objects with a **bounding box** and **class labels** of the located objects in an image.
  - Two-stage object detectors
    - Region-Based Convolutional Neural Networks (R-CNNs)
  - One-stage object detectors
    - Single-Shot Detectors (SSD)
    - You Only Look Once (YOLO)

# Motivation

- The purpose of this project is to implement a CV model for the **real-time detection of DD** in dairy and beef cattle.
- The motivation is to **minimize the effects of DD-associated lameness** in all cattle by means of early detection, prevention, and prompt treatments.

# Approach

1. Data Collection
2. Data Cleaning
3. Model Training
4. Model Performance
5. Model Comparison



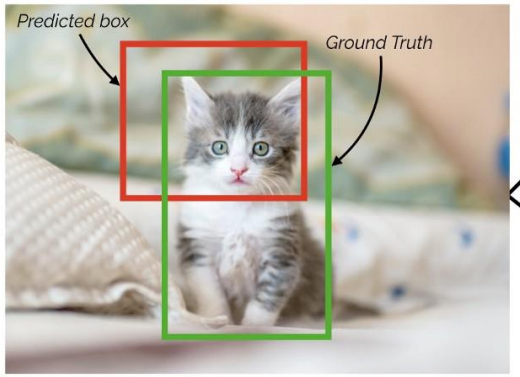
# Data Collection

- Camera facing the backside of the hind foot with a clear view of the interdigital space of the hoof
- Two sets of images
  - 2,227 JPEG images of **single lesion** for Dataset 1
  - 409 JPEG images of **multiple lesions** for Dataset 2
- Scored for M-stages of DD by a trained investigator
  - **M0/M4 and M2** for Dataset 1
  - **M0, M2, M2P, M4H, and M4P** for Dataset 2

# Model Training

- 90% images for training and 10% images for testing
- 8 object detection models (TensorFlow 1.X)
  - Faster R-CNN & Cascade R-CNN
  - SSD & SSD Lite
  - YOLOv3 & YOLOv3-Tiny
  - YOLOv4 & YOLOv4-Tiny

# Model Evaluation




IoU threshold = 0.5 = *False Positive (FP)*

IoU threshold = 0.2 = *True Positive (TP)*

***IoU for the prediction** = ~0.3*

$$\text{Precision} = \frac{\text{Object} \cap \text{Detected box}}{\text{Detected box}}$$

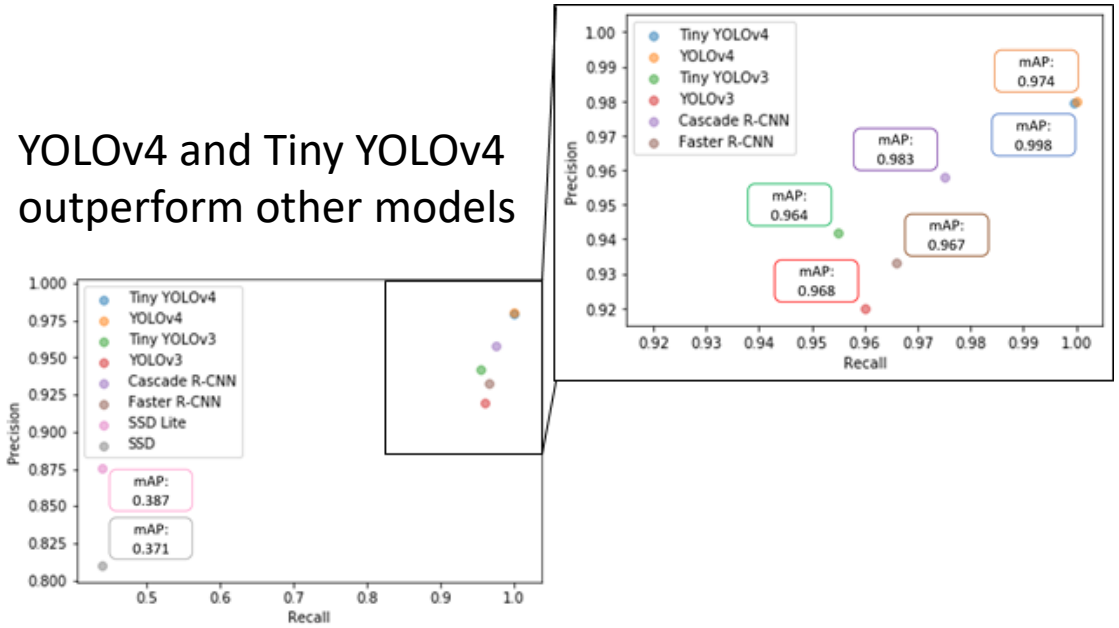
$$\text{Recall} = \frac{\text{Object} \cap \text{Detected box}}{\text{Object}}$$

$$\text{IoU} = \frac{\text{Area of Overlap}}{\text{Area of Union}} = \frac{\text{Object} \cap \text{Detected box}}{\text{Object} \cup \text{Detected box}}$$

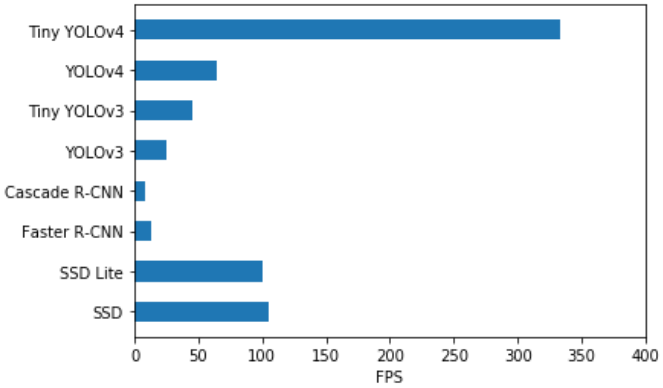
# Model Comparison

Real-world dataset containing single object per image and two class labels for object detection (Dataset 1)

YOLOv4 and Tiny YOLOv4 outperform other models

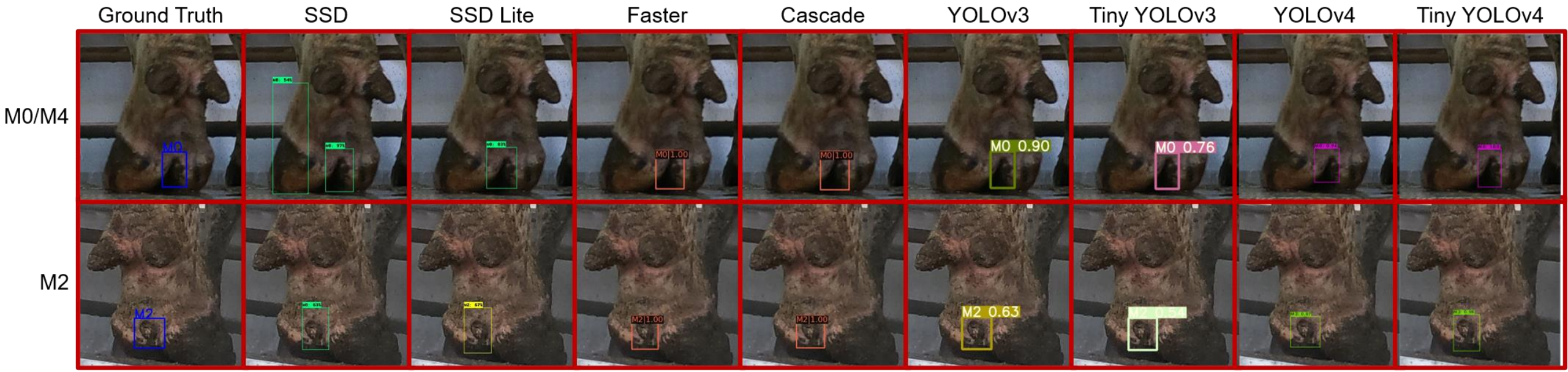



Tiny YOLOv4 is the best model for our use case



# Model Comparison

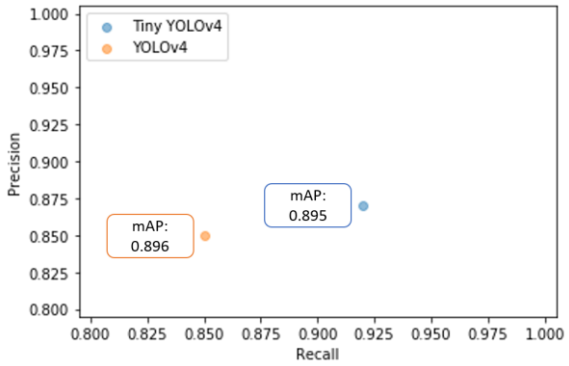
Real-world dataset containing single object per image and two class labels for object detection (Dataset 1)

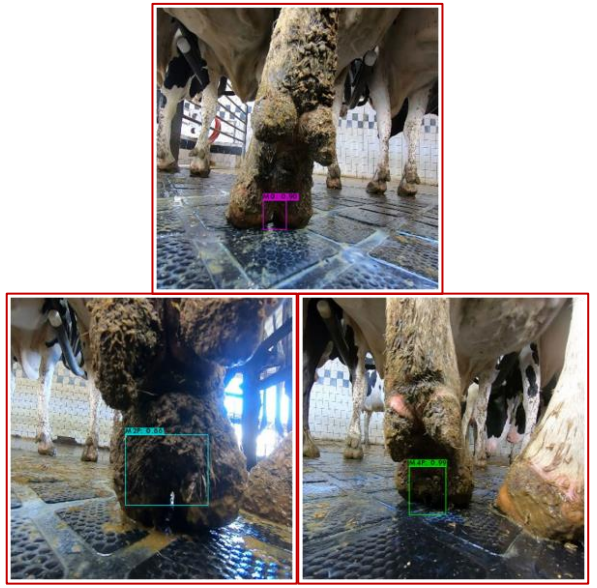


# Model Comparison

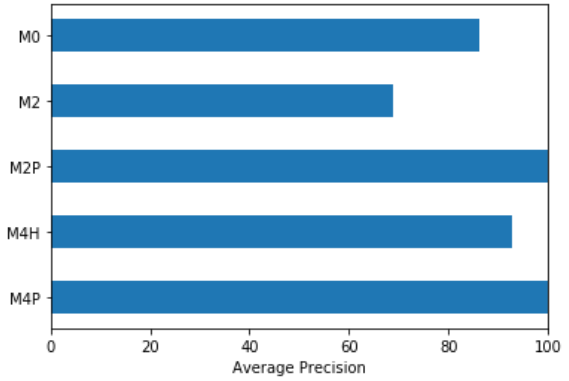
Real-world dataset containing multiple objects per image and more class labels for object detection (Dataset 2)

Similar performance for Tiny YOLOv4 and YOLOv4



Difference in performance between classes for Tiny YOLOv4

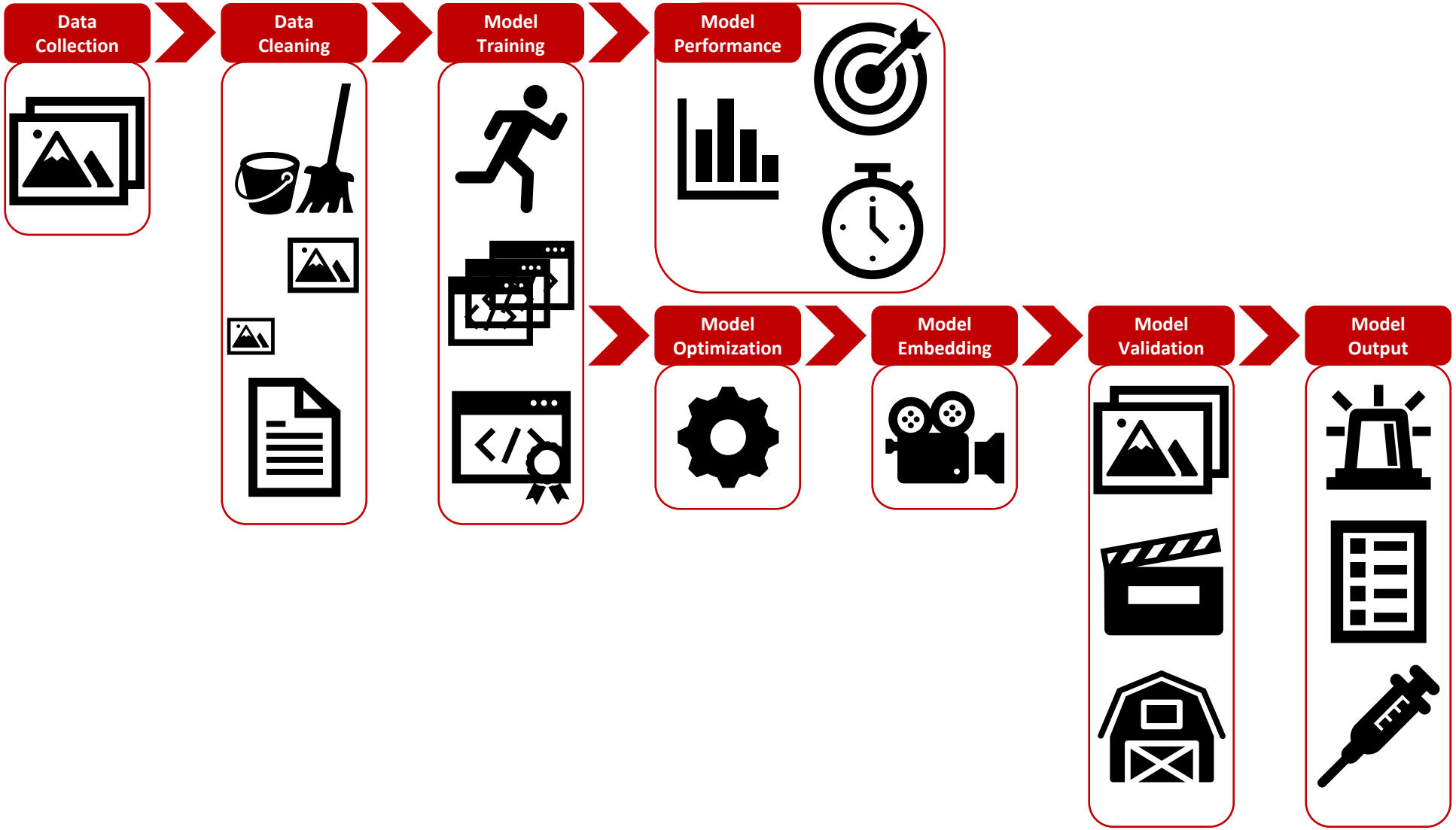


# Model Comparison

# Summary and Future Directions

- YOLOv4 and Tiny YOLOv4 outperformed all other models
- Tiny YOLOv4 was the best model for our use case
- Computer vision for veterinary medicine

# Summary and Future Directions



# Summary and Future Directions

- Application using video and real-time detection
  - Device-Based Implementation
  - Cloud-Based Implementation
- Extend to beef cattle
- Other object detection algorithms
- Other programming frameworks

# Acknowledgements


- Döpfer Lab (former and current)
  - Claiborn Bronkhorst
  - Montana Linz
  - Allie Hoerth
  - Juan Francisco Mandujano Reyes
  - Nathan Bollig
- Thesis Committee
  - Prof. Guilherme Rosa
  - Prof. João Dórea
  - Prof. Paul Merkatoris
  - Prof. Brian Yandell
- US Department of Agriculture
- National Institute for Food and Agriculture - Animal Health Grant (WIS03082 )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United States Department of Agriculture
National Institute of Food and Agriculture

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# Thank you!