
LiveStalk:

Augmented Ranching with Drones, Deep Learning and Data-Centric Thinking
Team: Whit Blodgett, Jeff Day, Omar Kapur, Ricardo Jenez, Justin Jeng

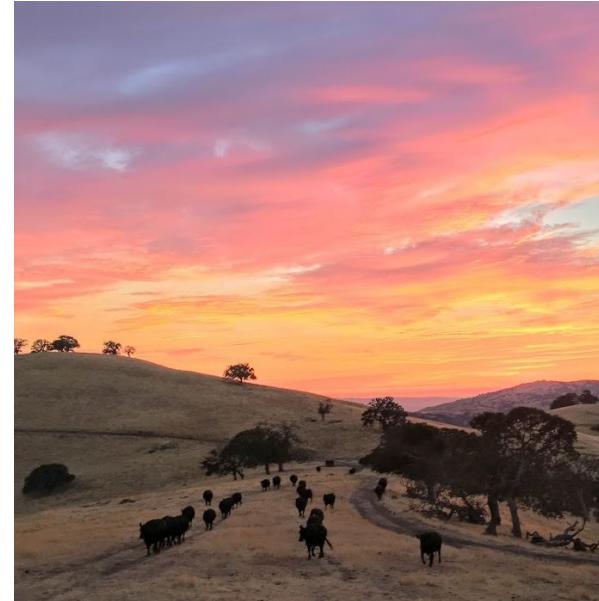


Problem we're solving



Count

"Counting cows can be difficult since they sometimes hide in ravines, especially when giving birth"



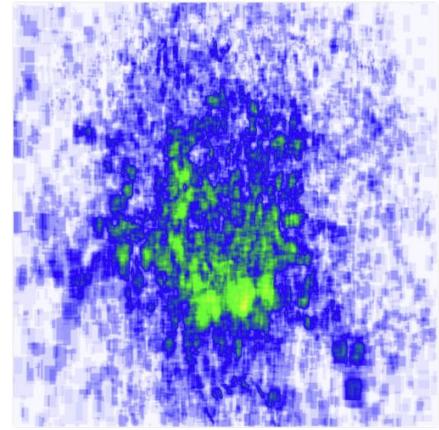
Location

"Ranches can span hundreds of square miles, while we have a general sense - we're never 100% certain where the herd is"

Data

Connolly Ranch, CA

- 1 hour filming window
- Variable image capture (height, pitch, shutter speed)

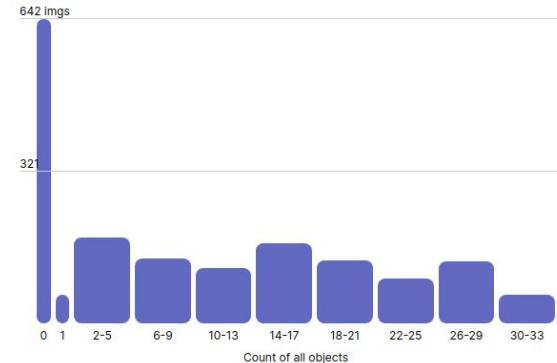


Images	1,723
0 missing annotations	
642 null examples	

Annotations	15,860
9.2 per image (average)	
across 1 classes	

Average Image Size	4.16 mp
from 4.16 mp	
to 4.18 mp	

Median Image Ratio	2720×1530
wide	



Data Collection

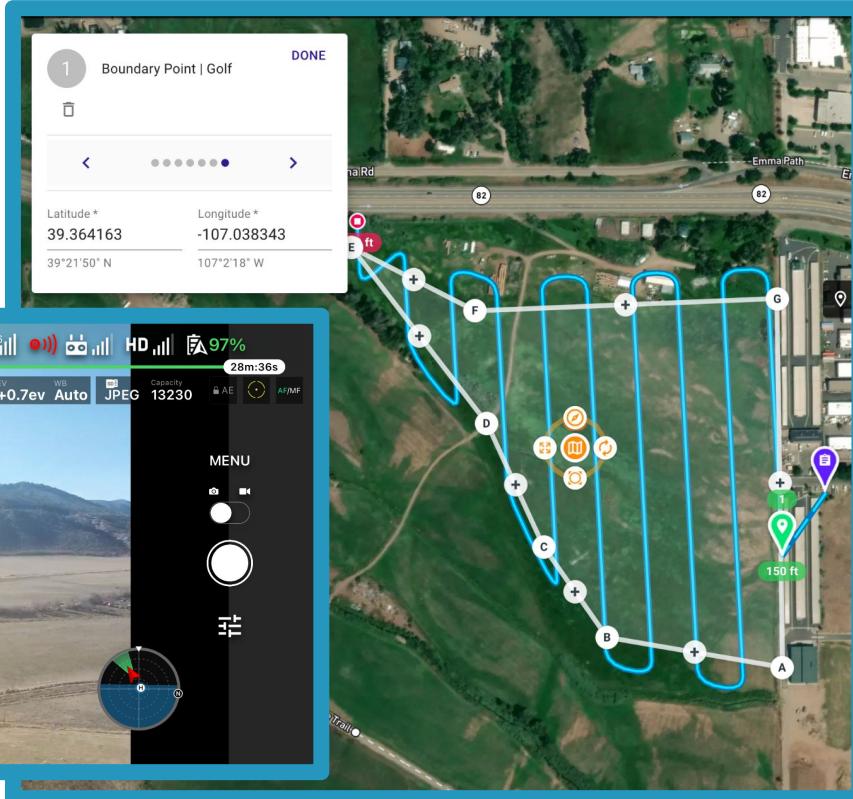
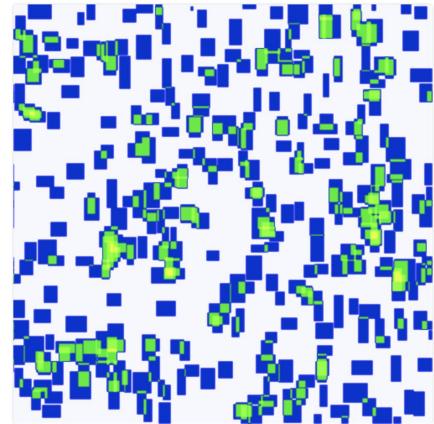


Image Annotation - Small Dataset

Carbondale, CO assorted ranches,

- 15 individual photo sessions across 5 days in 7 locations
- Consistent image capture
- No overlap images

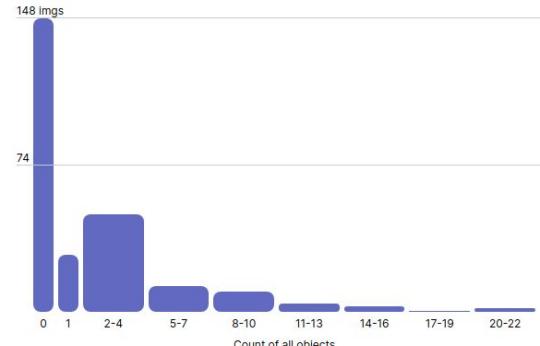


Images
258
0 missing annotations
148 null examples

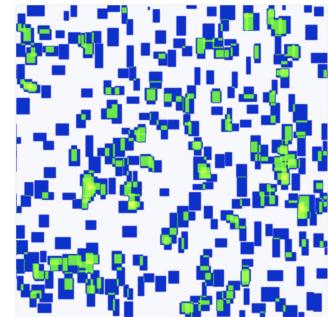
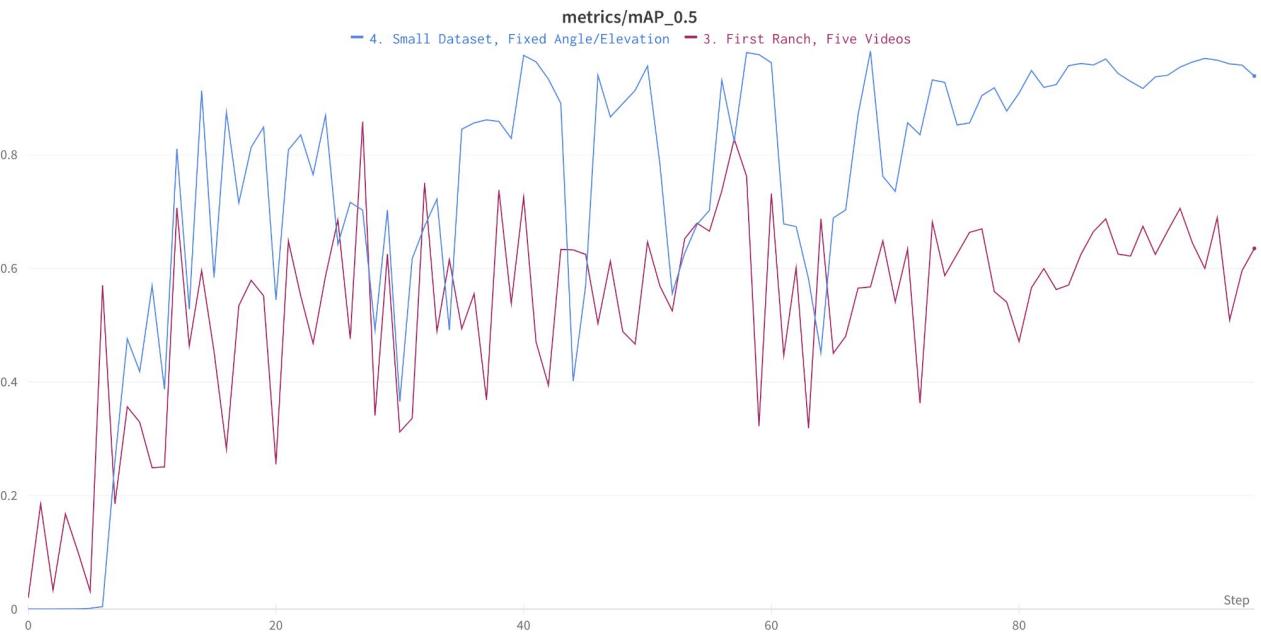
Annotations
464
1.8 per image (average)
across 1 classes

Average Image Size
12.00 mp
from 12.00 mp
to 12.00 mp

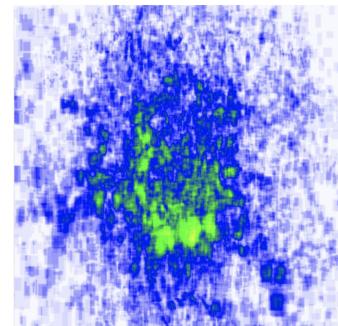
Median Image Ratio
4000×3000
wide



Data Centric



Carbondale
(464 cows)



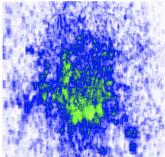
Connelly
(15,860 cows)

Experimentation

- Four experiments, each using **YOLOv5s** trained on a different dataset
 - #1-3 trained on initial run (increasing size)
 - #4 trained on a small dataset with fixed angle and elevation
- All experiments tested against a holdout test set of 59 images

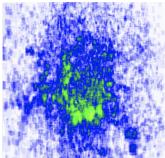
Experiment	mAP (IoU of 0.5)
1) First Ranch, One Run	0.3629
2) First Ranch, Two Runs	0.4429
3) First Ranch, All Runs	0.6351
4) Small Dataset (fixed angle/elevation)	0.9388

Experiment 1:
First Ranch, One Run



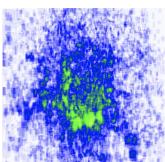
Training images: 439

Experiment 2:
First Ranch, Two Runs



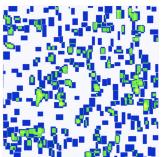
Training Images: 701

Experiment 3:
First Ranch, All Runs



Training Images: 1137

Experiment 4:
Fixed Angle / Elevation
(Small Dataset)

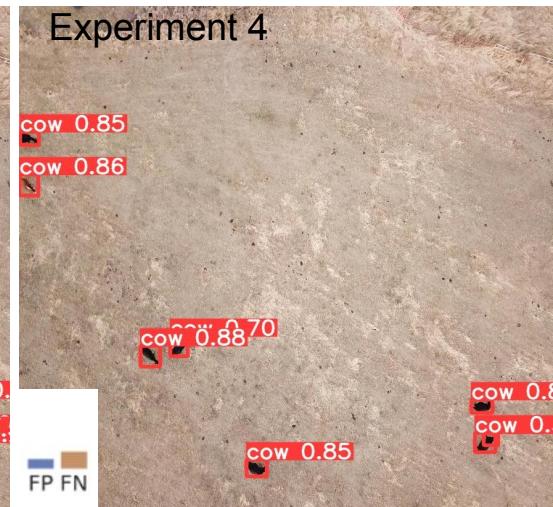
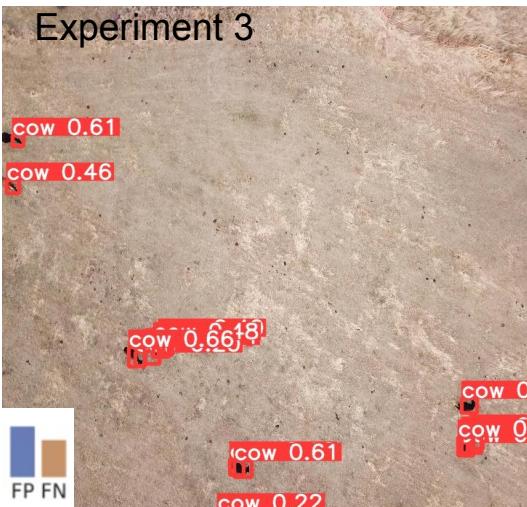
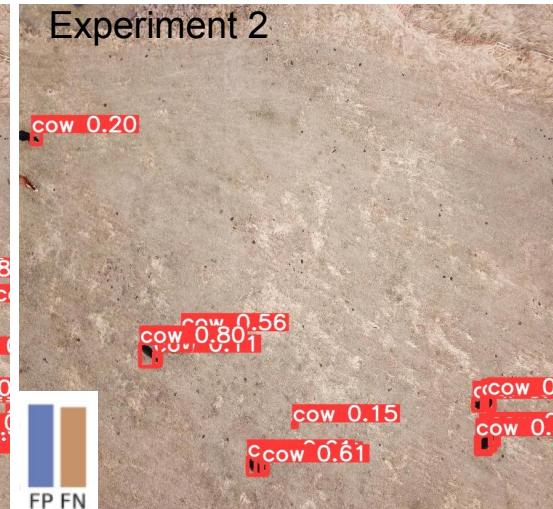
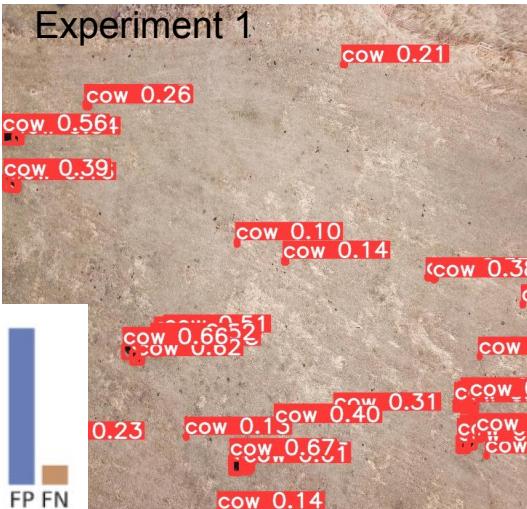


Training Images: 258

Error Analysis

The same test image, with detection results from each experiment (there are 7 cows labeled in the image)

All detections with confidence > 0.1 shown for comparison purposes



Model Training Pipeline

Roboflow

- Import videos from drone
- Sample at ~1 frame each 2 seconds
- Perform annotations
- Export Raw images (full size)
- Some experimentation with training a model for label assist as data size grew

Resplit

- Split into train/valid/test to avoid data leakage
- Due to small datasets, valid and test were the same for final experiments
- Holdout test set only used at end of project
- `resplit-data.ipynb`

Augmentation

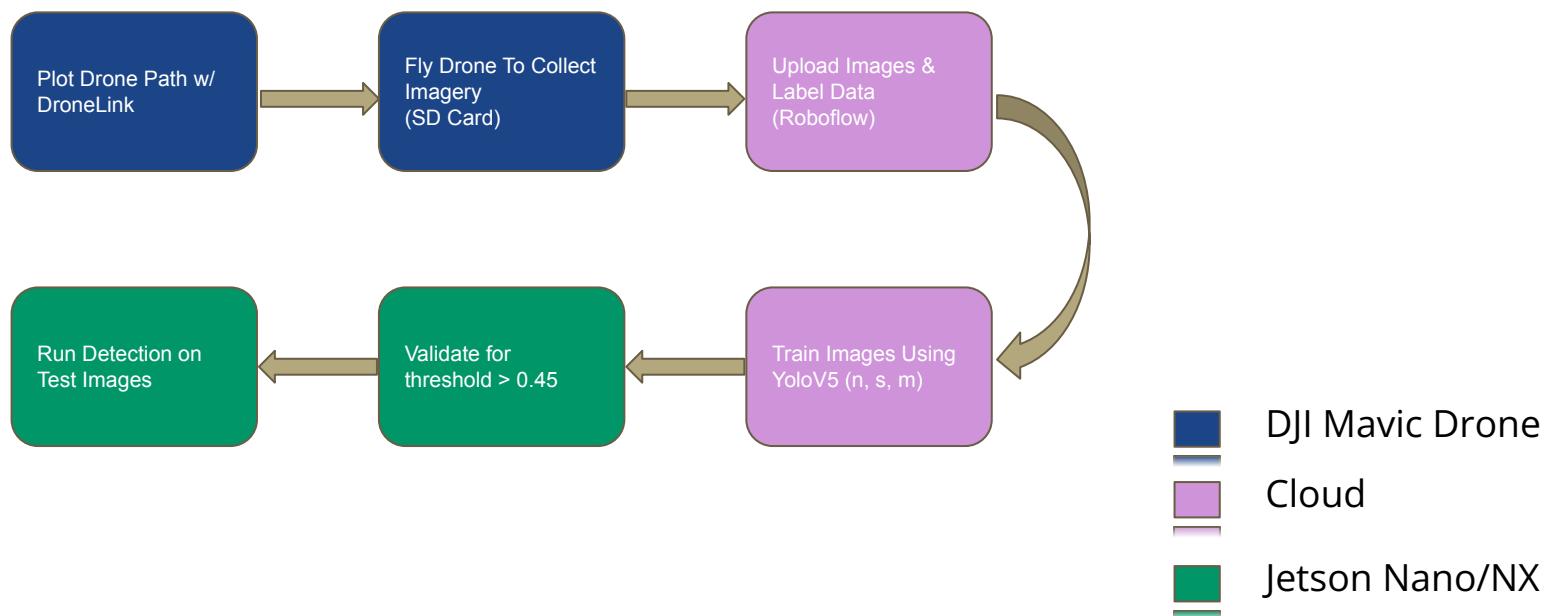
- Pull in train, valid, and test resplit data
- Apply transforms
 - Resize to **736 x 736** (all)
 - Minor experimentation with training transforms (monochrome, flipping, etc.)
- `augmentation.ipynb`

Train and Evaluate YOLOv5

- Use yolov5s to train on training set
- Evaluate performance on validation/test data
- Use wandb to log results
- Use Tide to categorize errors
- `yolov5-train-val.ipynb`

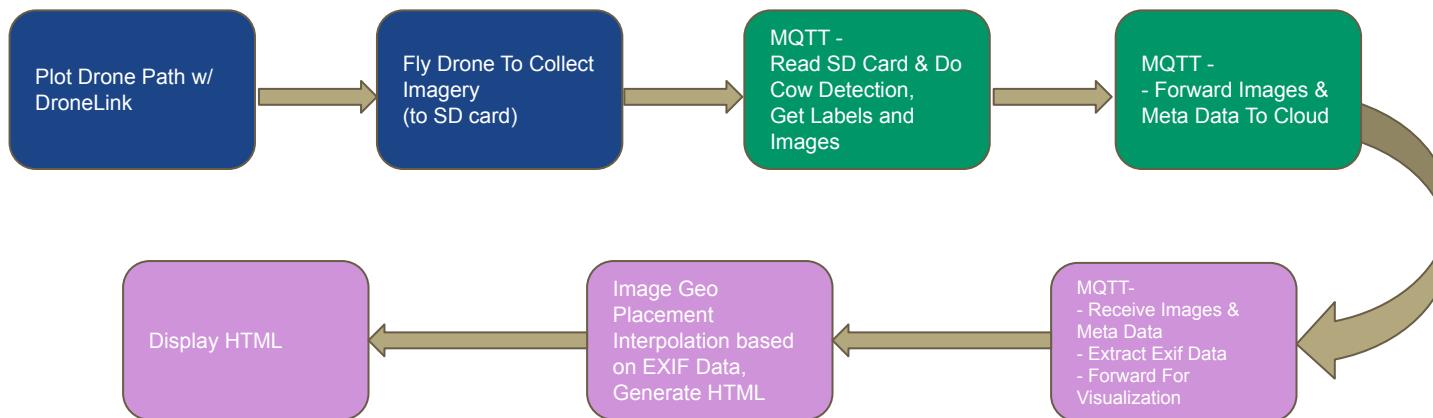
LiveStalk Flow: Image Capture And Analysis

Training Pipeline And Model Setup



LiveStalk Flow: Production Pipeline

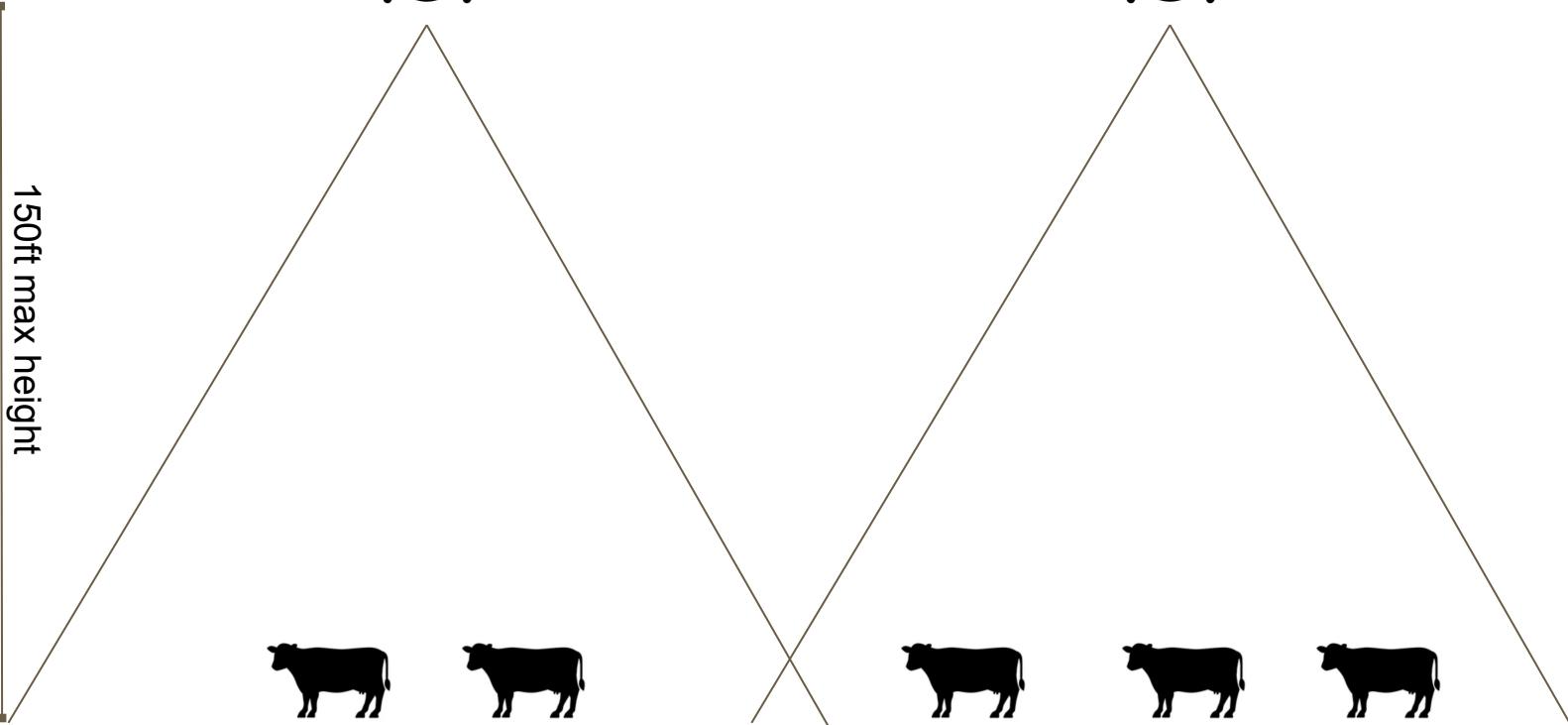
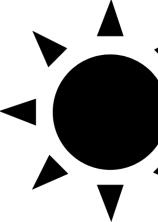
Current Deployment Approach



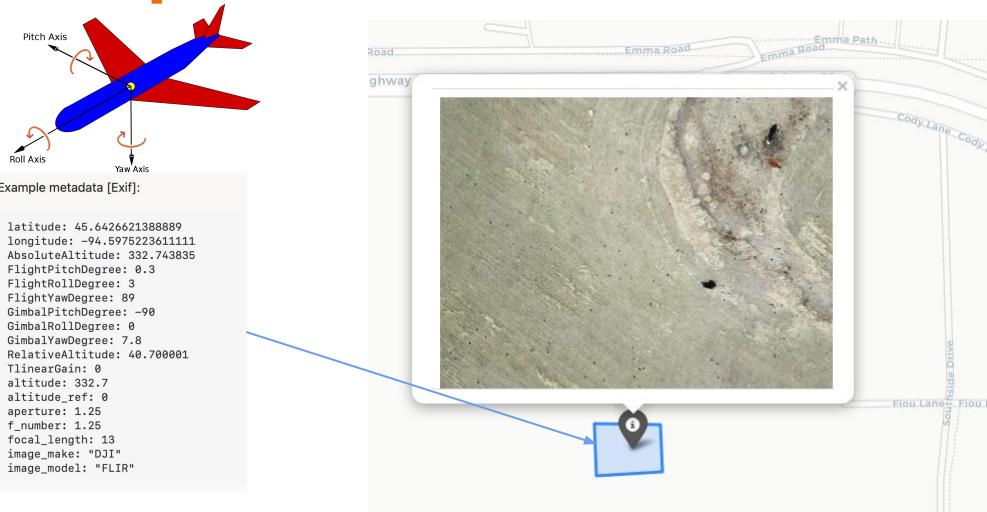
Next Step Will be To Eliminate the SD Card and Send Live Images For Detection To The Nano/NX w/ Potential For Changing Drone Path

- DJI Mavic Drone
- Cloud (AWS)
- Jetson Nano/NX

Counting Methodology

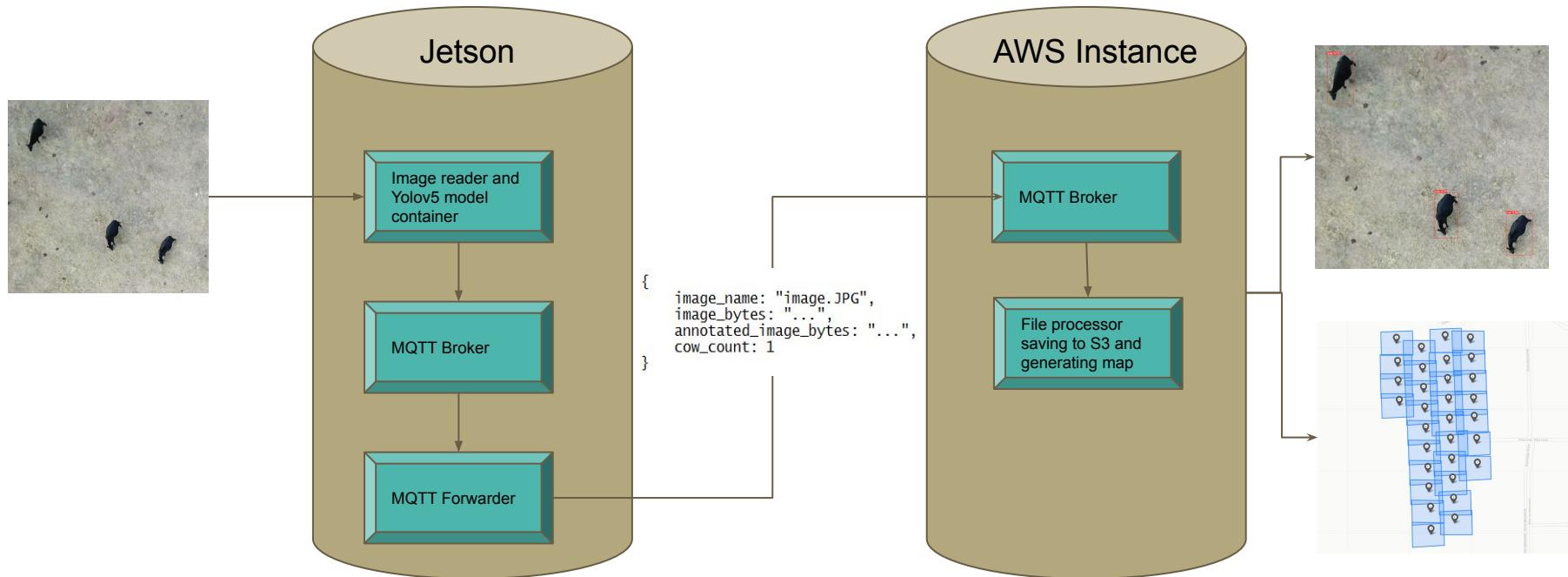


Georeferencing & Map Visualization

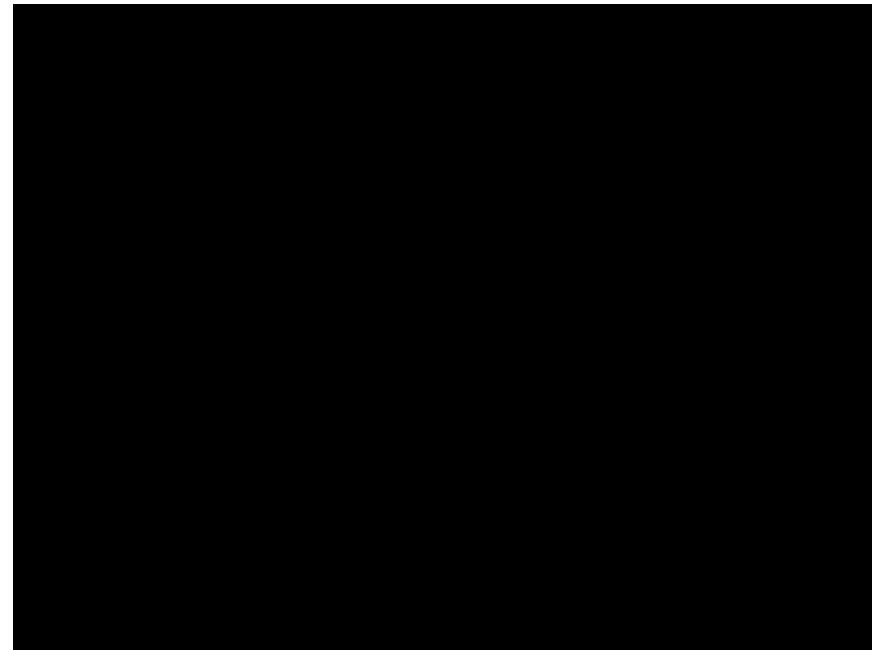
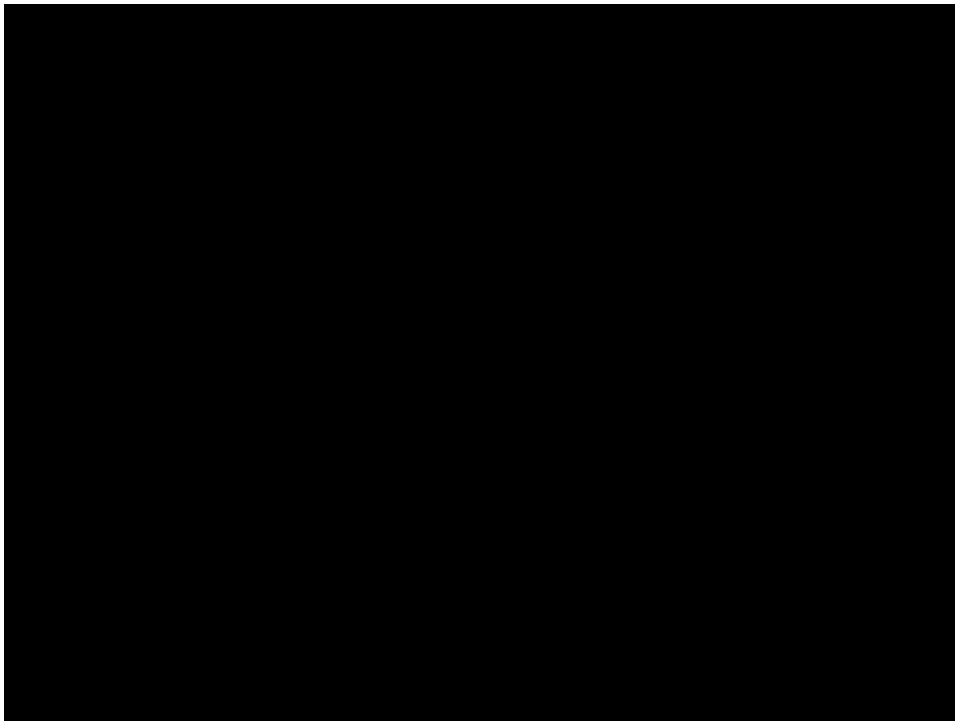


- Image field of view to bounding box conversion
 - Georeferenced_fov = f(fov_h, fov_v, cam_pitch, cam_yaw, cam_roll, rel_altitude, cam_lat, cam_long)
 - Further discussion [here](#)
- Final UI: map of cow counts and bounding boxes
 - Geospatial stack: folium, shapely, geopandas, pyproj

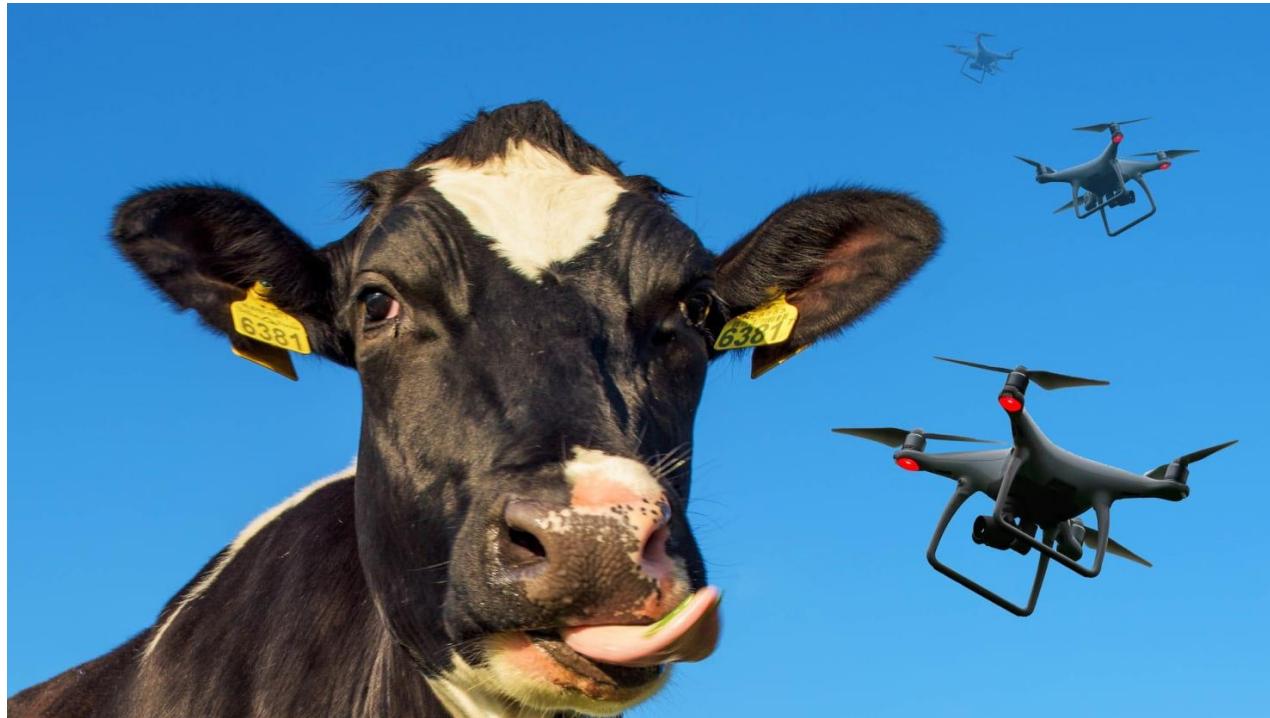
Technical Infrastructure



Solution Demo



Conclusion - Drones With Smarts At The Edge Is Real



We Demonstrated A Practical Application Of Image Detection At The Edge Using All the Techniques From This Class.

This The Beginning Of Operational Automation Of Drones For Everyday Use With Smarts On The Drone.

Thank You

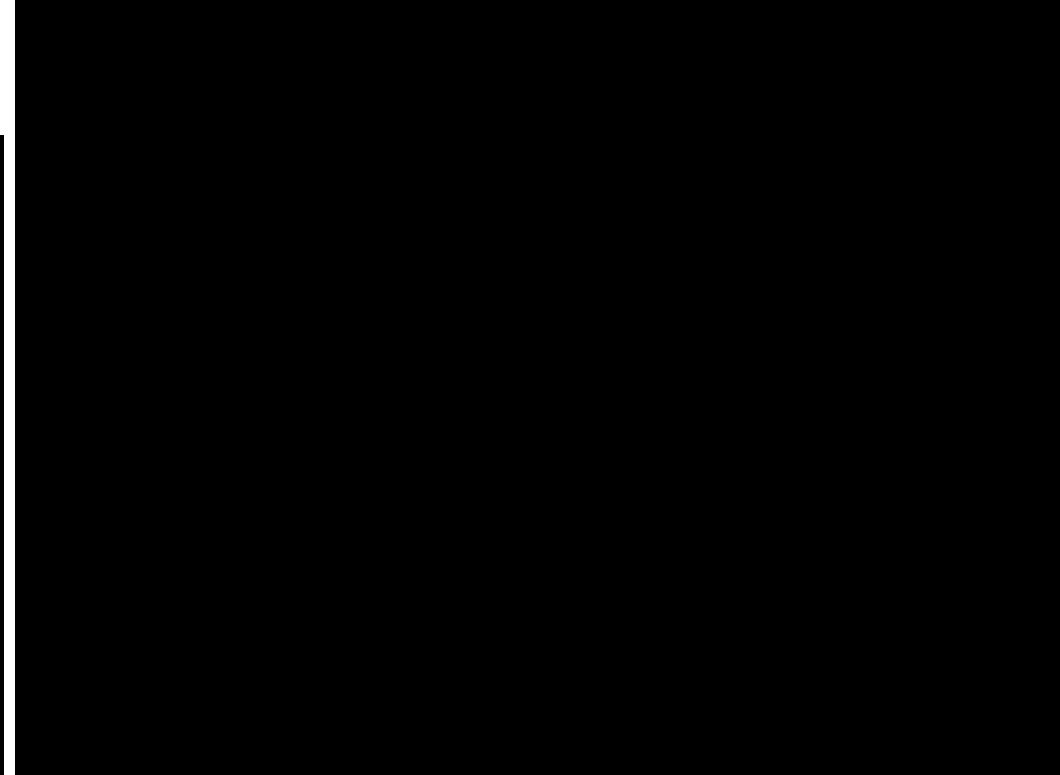
Any Questions?

Unused Slides

Technical Infrastructure

- Container based approach to development
 - Jetson Nano/Xavier NX container with MQTT & Yolov5
 - AWS EC2 containers with MQTT Broker and MQTT Client w/ PIL Imaging, EXIF tools, Geo library'
- Reliable delivery mechanisms using MQTT
- Image detection using trained model from Yolov5s on Nano/NX
- HTML generation using XXX Geo Library

Solution Demo



Deployment

- Telemetry we have: (?) Heading, speed, Lat/Long

Where is the inference run? How do we send model to drone?

Error analysis

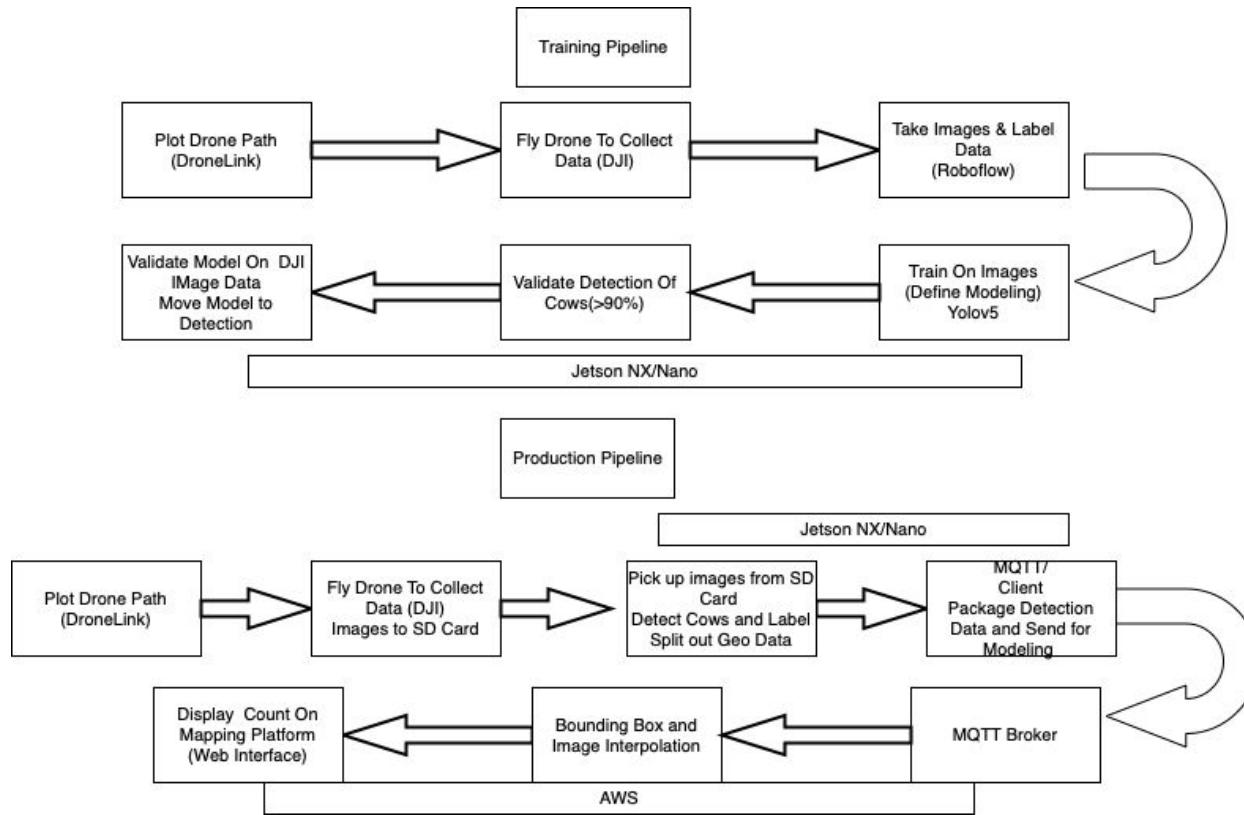
Monitoring Model Drift/Change for anomalies

Data Feedback Loop

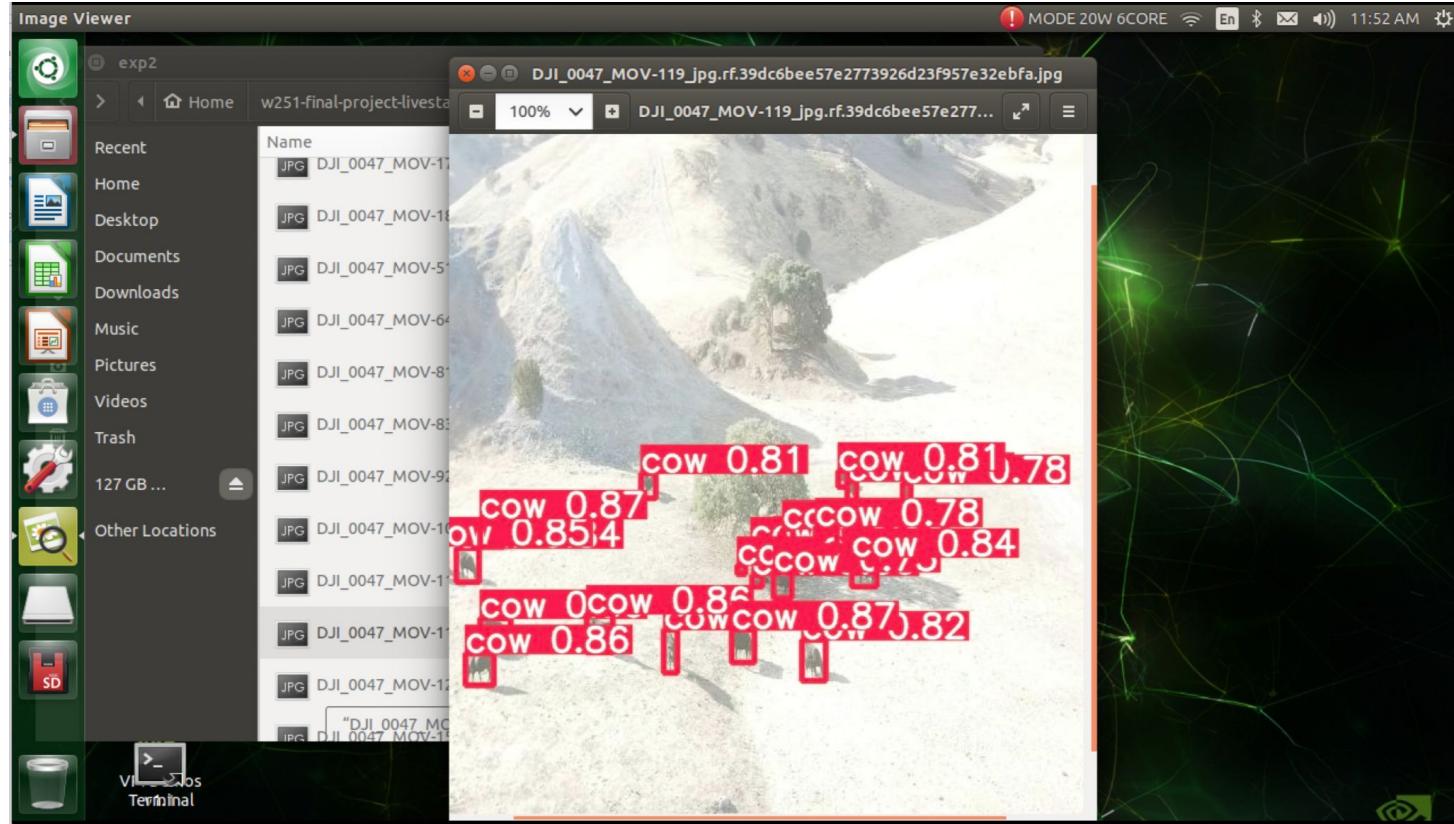
Drone Mission Planning: DroneLink



LiveStalk Flow:



Training And Detection on NX



Error Analysis

Sample images from Experiment 4
(best results)

Blue boxes - actual

Red boxes/text - predicted



Image Annotation - Test Holdout Set

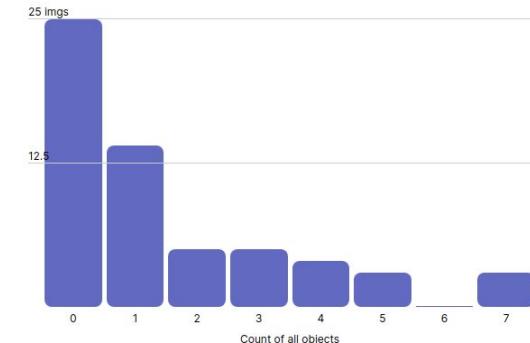
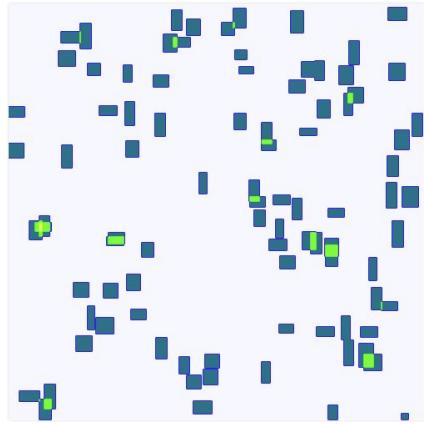
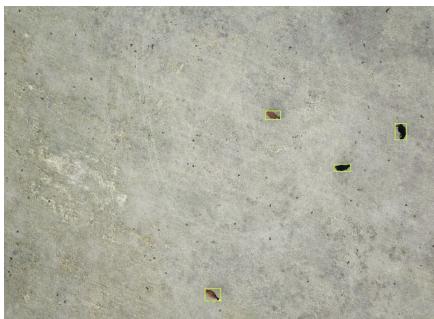
- Images taken from a single pass over a pasture
- Consistent elevation (~45m above ground) and camera angle (90° down)
- Dataset size:

Images
59
0 missing annotations
25 null examples

Annotations
91
1.5 per image (average)
across 1 classes

Average Image Size
12.00 mp
from 12.00 mp
to 12.00 mp

Median Image Ratio
4000×3000
wide



Goals

	Teams		
Milestones	DATA	MODEL	DEPLOYMENT
Count Cows	Bounding Box Labeling of Cows	Accurately count cows Stretch goal: Trajectories of moving cows	Host counting model onboard / connection to edge device
Navigate Field	Ensure drone only looks within the ranch for cows & doesn't double count	Autonomous Navigation	Using Nav inference, navigate field to ensure full coverage

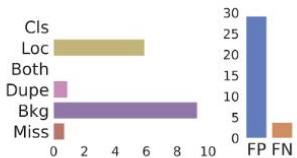
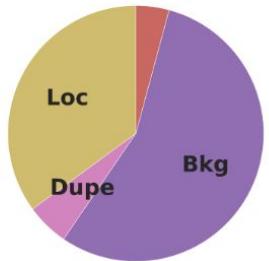
Error Analysis

Analysis using TideCV
(<https://github.com/dbolya/tide>)

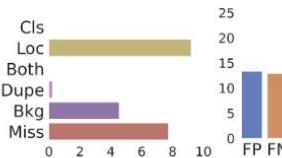
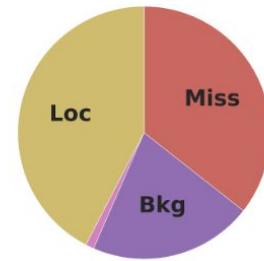
Key:

- Loc: Localization
- Dupe: Duplicate Detection
- Bkg: Background Error
- Miss: Missed Error
- FP: False Positive
- FN: False Negative

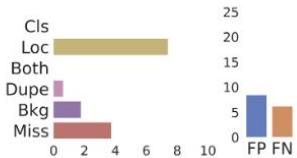
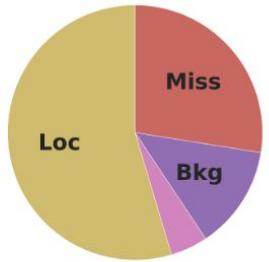
1. First Ranch, One Run



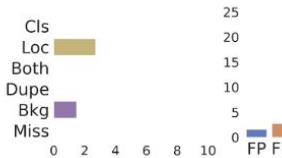
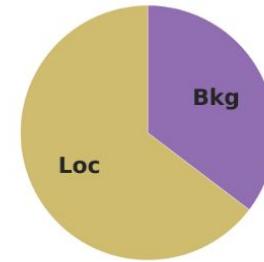
2. First Ranch, Two Runs



3. First Ranch, All Runs



4. Fixed Angle/Elevation



Results

Experiment	mAP (IoU of 0.5)
1) First Ranch, One Run	0.3629
2) First Ranch, Two Runs	0.4429
3) First Ranch, All Runs	0.6351
4) Small Dataset (fixed angle/elevation)	0.9388

Experiment #4
(small dataset with
fixed angle and
elevation, **blue line**) is
the clear winner!

