

#### **MAY 17 - 19, 2022** MANDALAY BAY | **LAS VEGAS, NV**

# RFD JOURNAL LIVE!

# Drones on the Farm: Tracking Livestock with RFID Equipped UAVs

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### Agenda

- RFID & Livestock Management
  - **RFID** in Rangeland Cattle Management •
  - Cal Poly Rangeland Cattle Management Practices •

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- UAVs for Livestock Management
- Limitations to Developing a RFID-UAV System •
  - Previous Cal Poly PolyGAIT RFID-UAV Studies
  - UAVs & Animal Behavior •
- Current Cal Poly PolyGAIT RFID-UAV Studies
  - UAV & Cattle Behavior Preliminary Study
  - **RFID-Equipped UAV Testing**
- Future Work

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#### **RFID & Livestock Management**

•RFID tagging widely used in livestock management

•*RFID* tagging of cattle is mandatory is some countries, i.e. Canada [3]

•USDA requiring all beef cattle traveling interstate to be RFID tagged by 2023 [2]

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•Benefits of RFID tagging cattle:

Improves in animal welfare with faster detection of injured animals [14]
Allows for quicker determination and location of stolen animals [12]
Increases disease traceability and reduces fast-spreading disease impact



# **RFID & Livestock Management**

•Ear tags amongst the most common cattle RFID tags methods

> •Ear tags are typically lowfrequency with short reading distance (few inches) •Some ear tag options are UHF •Two types of RFID readers: mounted static readers, *mobile (handheld or wand)* readers





Above: Example of a Static RFID Reader Unit

Left: Ear-tagged cow read with **RFID** reader wand

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# RFID in Rangeland Cattle Management

•Mounted static RFID readers may not provide regular data in rangeland environments

•Cattle movement dependent on a variety of factors

•Cattle are likely to seek out shade spots in high-temperatures

•Genetic makeup may affect livestock grazing patterns [10]

•Cattle return irregularly to water spots [15]

•Hand-held wand readers require cattle to be scanned individually •Cattle must still be herded back to a single location





# Cal Poly Rangeland Cattle Management

•Cal Poly Animal Science uses RFID/GPS data to manage herds for intensive grazing •*RFID/GPS measurements provide insight into where cattle move throughout the day* •Data used to make decisions on pasture rotation and determine animal health

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•Cattle tagged with RFID ear tags and GPS collar units •Tags must be hand-scanning tags with wand-readers to collect data •Time consuming and infrequent process

•Cattle often become separated during herding operations

- •Searches for lost cattle conducted on foot
- •Slow process due to large pasture size



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#### UAVs in Livestock Management

Several studies have been conducted on the use of UAVs for livestock management
UAVs allow for data to be collected in a safer and quicker manner
Multi-UAV systems have been simulated to herd cattle [7]

•Visual data on livestock distribution can help track herd grazing habits [13]

Few studies done on the introduction of RFID to UAV-based livestock management
UAVs have been combined with GNSS [8] and image-based systems
Visual-based UAV systems often use machine-learning for cow detection [5]
RFID combined with UAVs remains a new field of study



# Limitations to Developing a RFID-UAV System

#### •Cost

•Single UAV system minimizes overall expense

#### •Rangeland Size

Active RFID tags capable of transmitting further but require battery-power
Passive RFID tags more suitable for large rangelands due to lack of battery

#### •Time

•Flight time for most commercial UAVs limited to under 30 minutes

•Weight of a payload (RFID reader/system) cuts down on overall flight time

#### •UAV Maneuverability

•RFID tags may not be read instantly, especially at high altitudes and on beef cattle
•Multi-rotor UAVs capable of hovering and flying at low altitudes





### Previous PolyGAIT RFID-UAV Studies

•Previous Cal Poly PolyGAIT work investigated RFID-UAV time limitation [4]

> •10 min to scan a 293-acre pasture •Area divided into hexagons •Assumes instant RFID reads •GPS data can be matched to RFID •Allows for cattle location to be more quickly found •*Replaces searching for lost* cattle on foot



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#### UAVs & Animal Behavior

•UAVs known to disturb wildlife, specifically when flying in target-oriented flight patterns [9]

•Similar distress responses observed in large guanaco herds [11]

•No significant behavioral effect on 2-year-old cattle when flying 9 meters AGL with a single UAV [1]

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Repeated flights over multiple days resulted in acclimation to UAV presence
9m height likely too far to reliably detect passive RFID tags on cattle



# PolyGAIT UAV Cattle Behavioral Study: Setup

•Study conducted with beef cattle heifers from the Cal Poly Ranch

- •Young cattle: 9-months to 1-year old
- •Varying degrees of handling
- Initial screening experiment used individual cows separated from the herd
  - •Quiet, small pasture location
  - •*Cows separated by handlers and placed in pasture environment*
  - •Testing done once cows became static

Above: Example of a single cow in the testing pasture





# PolyGAIT UAV Cattle Behavioral Study: Setup

•UAV used: DJI Phantom 4 Pro V2.0
•Smaller than RFID-equipped UAV
•Average flight time: 30 min
•Visual data collected from onboard camera



- •Two factors tested in a randomized block design
  - Direction of approach (front, back)
    Height above ground (3m & 6m)
    Data blocked by individual cow





Above: DJI Phantom 4 Pro v2.0 UAV used in testing

Left: Visual diagram of initial experiment design, each color denoting a unique run





# PolyGAIT UAV Cattle Behavioral Study: Testing

•Screening experiment showed inconclusive results

> Binary response variable
> Cattle demonstrated a clear "startle" response to UAV approach
> No statistical significance in data

> > Above: Example of binary "startle" response





# PolyGAIT UAV Cattle Behavioral Study: Testing

•Individual cow response differed heavily

Cows had experienced varying degrees of handling prior to UAV testing
Constant movement common
Difficult to conduct flights above static animals

Above: Example of constant cow movement





# PolyGAIT UAV Cattle Behavioral Study: Results

•Isolating cows likely skewed results

•As prey animals, cattle stress increases when they are isolated [6]

•Testing with herds would provide more realistic responses

Experiment adapted to test with a herd
9-month to 1-year old heifers
All cattle equally handled
Experiment repeated twice
Both large pasture environments
Direction factor removed from testing

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*Top: Example of Chorro Ranch testing procedure Bottom: Cal Poly cattle herd in a pasture at Chorro Ranch* 







# PolyGAIT UAV Cattle Behavioral Study: Results

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Herd experiment yielded different results
Cattle herd demonstrated slow drift away from the UAV
Herd drift towards tree cover
Less overall cattle movement
Less cow-to-cow variation
Curious, bold cow responses
Short acclimation period, about 10 min
Little to no cattle response to UAV presence following acclimation period



# PolyGAIT RFID-UAV Cattle Study: Setup

•RFID tags: Avery-Dennison Dogbone •UHF passive tag (950-960 MHz) •Max range: 12m, 8 sec to read •RFID system: MiniStock •Developed by Process Expert •Long-range UHF RFID reader •Wifi equipped for instant data transfer

•UAV used: DJI S900

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(discontinued, comparable to DJI Matrice) •Hexacopter design

•Unburdened flight time: 20 min









# PolyGAIT RFID-UAV Cattle Study: Setup

•Passive UHF RFID tags placed on cattle collars

- •2 tags placed on each collar
- Collars provided insulation from cow bodyTags placed in different orientations to
- maximize likelihood of read



*Left: RFID tags placed on leather cattle collar* 

*Right: Demonstration of cattle collar on heifer* 



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# PolyGAIT RFID-UAV Cattle Study: Setup

•UAV fitted to carry RFID system

Secondary power-bank attached to power RFID system onboard UAV
Cell phone hotspot provided wifi connection for live/in-field RFID data transfer without landing







# PolyGAIT RFID-UAV Cattle Study: Testing

Small four-cattle herd used for testing
Docile cows, all frequently handled
Two 9-month to 1-year old heifers collared with tags
Additional two heifers not tagged

•Quiet, small pasture location

•Two UAVs flown simultaneously at unique altitudes
•DJI S900 for RFID data collection
•DJI Phantom for visual reconnaissance







# PolyGAIT RFID-UAV Cattle Study - Results

•Cattle initially wary of UAV presence

Exhibited nervous behavior (increased vigilance, movement away from the UAV)
No extreme stress behavior (no vocalization, hoof stamping, etc.)





## PolyGAIT RFID-UAV Cattle Study - Results

•RFID data successfully collected from both tagged cattle
•Cattle quickly acclimated to UAV presence (~2 minutes)
•Successful RFID reads 6m AGL





# PolyGAIT RFID-UAV Cattle Study - Results

•RFID data successfully collected from both tagged cattle

- •Successful RFID reads 3m AGL
- •Total flight time: 8 minutes





#### Future Work

Additional replication of RFID-UAV testing required
Larger herds with less frequently handled cattle will better reflect real-world scenarios
Newer batteries and less windy conditions may provide more flight time

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Inclusion of visual data collected directly by RFID-equipped UAV
Visual data can be used for machine-learning
Allows the UAV to make "smart decisions" on where to fly
Negates the need for multiple UAVs



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