David Little Livestock
Range Management Endowment
AT THE UNIVERSITY OF IDAHO

2023 Project Progress Report:

Technology to Manage Livestock Location Within RANGE and REALITY

(By Dev Shrestha)

RESULTS for 2023:

TITLE: Technology to Manage Livestock Location Within RANGE and REALITY.

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BACKGROUND: Over 150 years ago barbed wire transformed livestock grazing and management in the western U.S. Despite technological advances, barbed-wire fencing is still the dominant means of managing livestock worldwide. Though wire fencing is effective, it can fragment landscapes, harm wildlife, and is a major cost to ranchers. Virtual fence systems offer exceptional management flexibility, reduce yearly maintenance, and eliminate obstructions for wildlife. Wireless virtual fencing was proposed several decades ago coupling location-based communication technology with an aversive stimulus delivered to the animal when it crosses a virtual boundary. The first functional electronic approach to fencing was proposed to keep dogs inside a designated area which became the Invisible Fence© system. Several virtual fence systems recently became available to manage livestock. However, these virtual fencing are unsuitable for typical rangeland livestock operations because they are bulky, power-hungry, and expensive.

Preliminary research was conducted on animal response to electrical stimuli when paired with audio or visual cues. A communication system was developed using time-of-flight technology combined with trilateration to locate cattle in a virtual pasture and deliver aversive stimuli at the boundary. An initial prototype has been designed and is ready to develop and refine into a fully functional, scalable virtual fencing system and deploy it in field trials on working ranches. Design and development will follow a powerful interdisciplinary and iterative approach with device designs being tested by animal response leading to subsequent improved devices which are detailed for energy use, reliability, and effectiveness. The project will rely on evaluation and guidance from livestock producers and land managers to suggest design features, operational parameters, and potential use cases. This approach will result in a system highly relevant to western ranchers. This simple yet robust virtual fencing technology could, like barbed wire over a century ago, be a catalyst that transforms livestock operations and improves economic and environmental sustainability for ranchers across the globe.

HYPOTHESIS or OBJECTIVES: Since 2019, we have been honing prototype designs and conducting research in animal behavior related to the development of a non-collar virtual fence system. We know including associative (audio and/or visual) cues are important for learning and understanding a boundary. Additionally, it has been demonstrated that ear-based electrical stimuli are effective, and we have known parameters like audio cue and shock are reliably aversive. After adding the communication/position component, and firmware to manage animal location and provide a user interface we will be ready to start large scale tests with collaborators.

Goal for this funded research was:

- Explore the impact of different audio and visual cues and their delivery on animal response and compliance in a field setting
- Simulate harsh environmental conditions to test device durability and performance in range conditions
- Finish initial firmware and interface development and launch beta-testing of ear tags for exclusion zone applications, examining effectiveness of exclusion, device longevity, and user interface

PROCEDURES: Animal Behavior Team-Through a series of small scale, short duration experiments, was able to study animal response of audio cues, visual aids, and cue-stimulus parameters. We used the University of Idaho's animal research facility to conduct those experiments and was able to demonstrate the efficacy to the advisor board members.

Engineering Team-Using results from animal behavior research, final firmware development and a user interface was programmed. Devices still need to be tested for long term harsh environmental hardiness and performance of tags and beacons in range scenarios.

ACCOMPLISHMENTS or RESULTS: The engineering team worked with the animal team to build prototypes ready for testing on animals in the field. Several critical steps on the engineering side were accomplished. Students funded by this project wrote code to translate a theoretical mathematical model to computer code that can be downloaded into a micro controller on the prototype.

Circular Exclusion Zone:

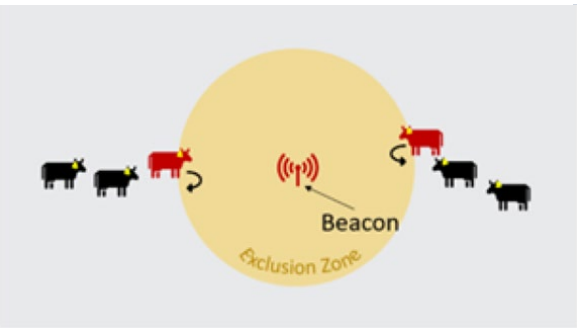

Figure 1: Circular exclusion zone experiment. Animals were trained to listen to audio cues and not to cross into an exclusion zone where a hay bale was placed. The animals stayed away from the bale that they were not supposed to go nearby.

The test of a one beacon exclusion zone was successful. Four animals were outfitted with ear devices. The radio transmitter was placed around a hay bale. When animals came within 10-meter distance of the hay bale, a sound cue followed by an electrical stimulus was delivered. The animals were observed to turn around quickly when they crossed the boundary and were trained within a couple days. Figure 1 shows the concept (left) and actual field testing (right). Four trained cows did not approach the hay bale even when herded toward it and held near it with moderate pressure.

Riparian Exclusion Zone:

Algorithms for more complicated exclusion zone like the irregular shaped riparian zone shown in Figure 2 are now being developed. The student funded by this project developed the code to determine how close the animal is to the exclusion zone boundary.

Figure 2: *Riparian exclusion zone experiment. The algorithm was developed to determine the location of animals using multiple beacons around an irregular shaped riparian zone.*

The algorithm is almost ready for testing. The algorithm to measure distance of an animal from a beacon and locate the cow based on multiple measurements is complete. The estimation of accuracy on how close the animal to the boundary is still being finalized. We expect this system will be ready for testing by spring of 2024.

PUBLICATIONS or OUTPUTS:

One presentation was made from this research and one journal manuscript is being prepared for submission. We expect to submit for journal publication by 2024.

Shryock, M., Launchbaugh, K., De Avila, H., Shrestha, D. 2023. Comparison of location sensing technologies for precision agriculture applications. Presented at the 2023 ASABE Annual International Meeting, St. Joseph, MI. Paper # 2300726.