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Dendra Remote Animal ID: Scaling Up Biodiversity Monitoring

via in situ animal identification (Camera and Acoustic) using Machine Learning on industrial Edge computing hardware with low power global satellite uplink (SWARM)

Pepperwood dendra
https://dendra.science

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Introduction

Biodiversity monitoring plays a crucial role in conservation biology, acting as an early warning system that can detect potential extinction events or the spread of invasive species.

Conventional monitoring methods like coverboards and transects are labor intensive; they require consistent and repeated manual surveys, often at remote locations.

Although the use of camera traps and acoustic recorders help automate data collection, these tools present new challenges in retrieving and processing the large volumes of data they generate.

Machine Learning (ML) can be used to classify biodiversity monitoring data more efficiently but requires a centralized database for processing and analysis.

Goal

This project aims to develop an integrated platform capable of (1) identifying animals in situ and (2) uploading identification events to a central server via low power satellite uplink. Due to bandwidth constraints, no image or audio files will be uploaded.

Pilot Deployments

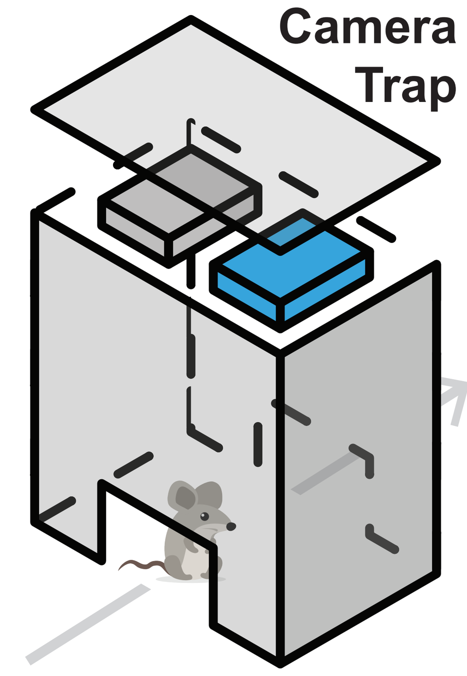
Pilot sites are being developed in at Pepperwood Preserve, Santa Rosa, Sonoma County, CA.

Pepperwood
https://pepperwoodpreserve.org

Camera: Drift fence

Description: A drift fence is a low, fabric barrier that guides small animals through a monitored enclosure with an entry and exit. The enclosure has a ceiling-mounted camera that is triggered when an animal passes through.

Pilot value: This method simplifies image complexity for ML, enhancing recognition rates by providing a consistent field of view and focal distance.



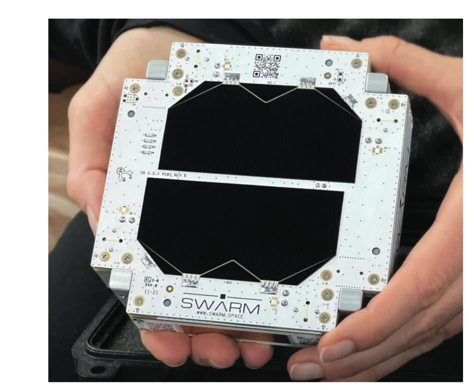
Drift Fence

NVIDIA Jetson

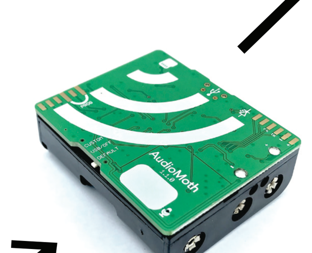
Single-board computer. Industrial edge ML optimized, Low power (5watts)

Dendra

Cloud-based service for managing environmental sensors and time-series data.



SWARM satellite cube sat network



AudioMoth
acoustic recorder

ultralytics YOLOv8

Machine Learning
on-site identification

SWARM satellite modem
Low data rate (600KB /month)

American bullfrog
mating calls

2023-12-12T14:10, Mammalia-Rodentia-Sciuromorpha

Identification event is a single line of text, timestamp & ID

Acoustic: American bullfrog mating calls

Description: Bullfrogs (Lithobates catesbeianus), while native to North American continent, are invasive west of the Rockies and tend to displace at-risk species such as the Foothill yellow-legged frog (Rana boylii). Mating calls are a good measure of encroachment along waterways.

Pilot value: Male bullfrog vocalizations are distinct in frequency from other frogs and toads in our target area, making the signal processing much easier.

Machine Learning

551k images
293k non-blanks

Training Dataset

Deployment: The California Department of Fish and Wildlife (CDFW) used drift fences at 275 locations throughout California from 2019 to 2022, each active for a three-month period.

Identification: CDFW staff manually classified captured images taxonomically from class to species where feasible.

Data Preparation: Taxonomic classifications were consolidated into a singular string format.

<class>-<order>-<family>
Mammalia-Rodentia-Muridae

Scope of Training: The model was initially trained to distinguish taxa at the family level, with birds (Aves) categorized at the class level for this pilot phase.

Manual ID	
class	97%
order	95%
family	93%
genus	28%
species	17%

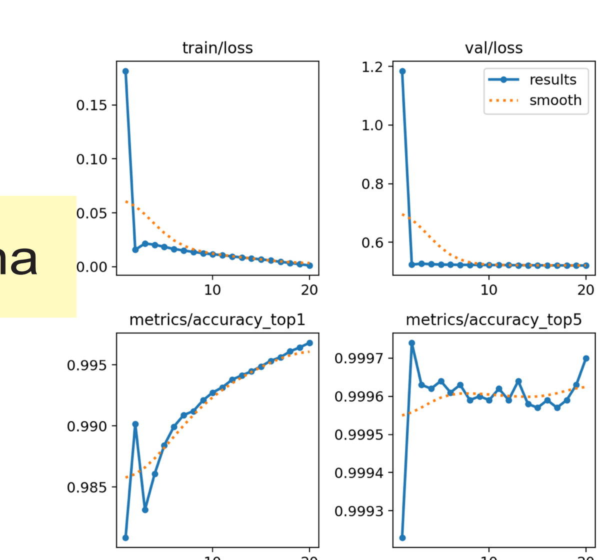
Model Training

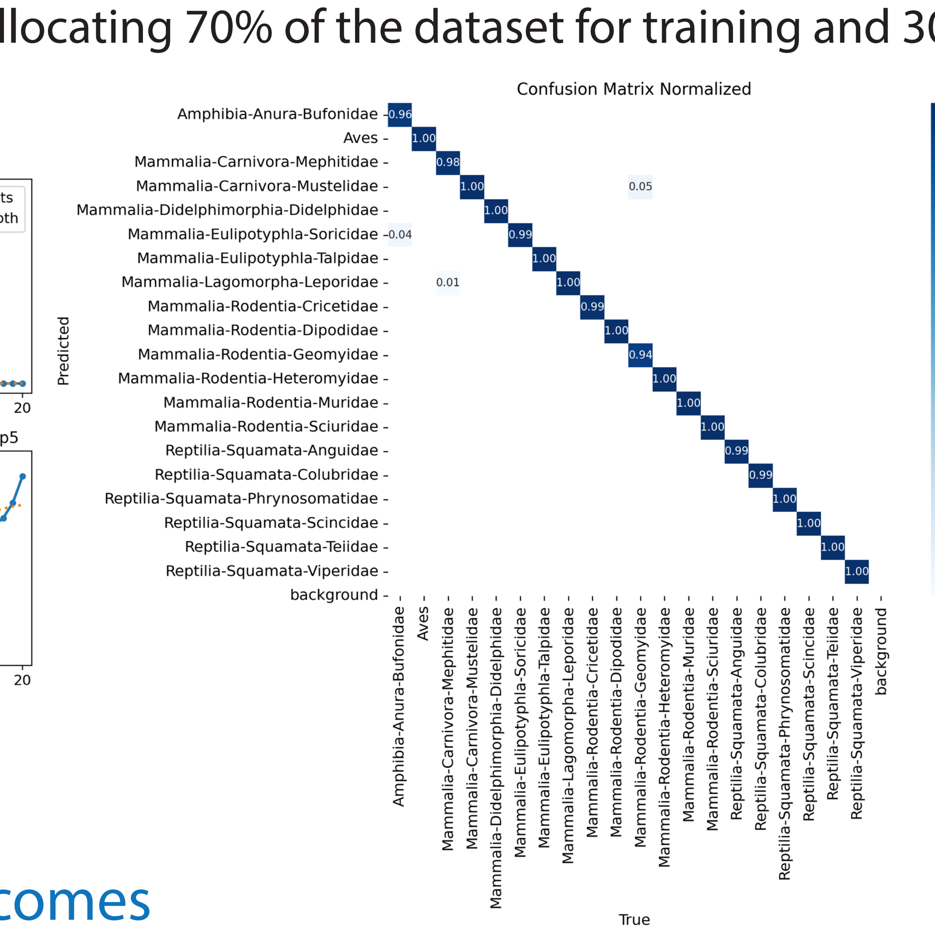
Selected Model: Ultralytics YOLOv8L, a large, preconfigured model with 32 million parameters across 133 layers.

Hardware: standalone workstation with dual GPU cards.

Image Processing: Set image resolution at 832x832 pixels.

Training Regimen: Conducted 20 epochs with a reduced learning rate, allocating 70% of the dataset for training and 30% for validation.





Training Outcomes

Attained an accuracy level >99% after 125 hours of training.

- Learning rate appeared ineffective. Next attempt will use an ADAM optimizer to help with smoother training.
- Frogs and toads: dataset is too limited to distinguish. Will need to supplement training with iNaturalist images.
- Small carnivores: only parts of their bodies fit into enclosure, resulting in less accurate ID.

Acknowledgements

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Natural Reserve System
university of california