ElSa: A Novel Real-time Wildlife Poacher Detection Solution Leveraging Machine Learning Driven Spatio-temporal Analysis of Nighttime UAV Thermal Infrared Videos

EAEV066

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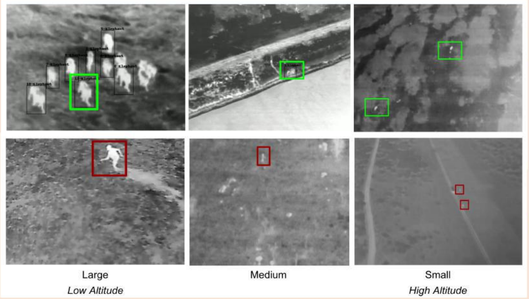
WWF Says African Elephants Will Be Extinct by 2040 If We Don't Act Right Away

To survey a wider area within flying time constraints, UAVs must fly at **heights ~500 ft** (high altitudes)
→ small animal/human sizes



https://sites.google.com/view/elizabethbondi/dataset

Current Solutions

Recent methods leverage computer vision methods:
only study the object's shape in **static images** frames when tested on real-life data:
→ **only 20%** human recognition accuracy
→ **fail to mitigate** high-resolution cameras ($10,000)

Objectives

Software: Develop **a high accuracy** automated computer-vision method for detection of **potential poaching activity**

Hardware Engineering: *Design &* implement **a low-cost engineering design**, built with commodity hardware, for nighttime thermal infrared video capture

Scientific Basis of Research

The **movement patterns** of elephants **differ significantly** from those of humans with respect to speed, turning patterns etc.

→ Previous research fails to leverage this important spatio-temporal nature of *video* data

Methodology/Project Design

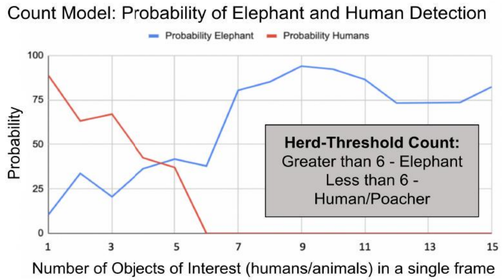
1) **Studied BIRDSAI Dataset:** first large real-life dataset of 172 thermal drone videos collected from 4 national parks in Kenya, South Africa and Uganda
2) **Extracting Spatiotemporal Data:** Measure movement of a moving object (ex. Elephant/human) with respect to a fixed object (ex. Bush, tree)
3) **Outlier Removal and Time Series Smoothing** (Hampel filter & ewm weighted functions)

Training Dataset: 516 total spatiotemporal times series

Machine Learning Model Training: K-Nearest Neighbor (KNN) with Dynamic Time Warping Metric to measure similarity

Herd Count Model Results

of objects of interest can be used **to further improve accuracy**



Results of KNN Spatiotemporal Model

Test Set: 144 spatio-temporal time series

- **36 human patterns**
- **108 elephant patterns**

Method 1: Spatiotemporal Model - Dynamic Time Warping	
Accuracy: 74%	

Method 2: Spatiotemporal Model - Feature Extraction With Herd Count Feature	
Accuracy: 90.9%	

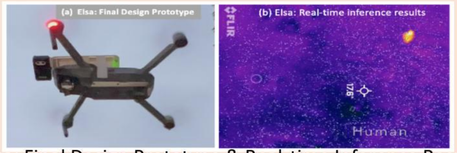
	Actual: Human	Actual: Elephant
Predicted: Human	True Positive 34	False Positive 36
Predicted: Elephant	False Negative 2	True Negative 72

Sensitivity 94.4% Specificity 67%

ElSa is able to detect poachers in nighttime, infrared videos from >500 feet off the ground with a **4X higher accuracy** than the current standard benchmark.

Interpretation & Conclusion

- **First-ever machine learning model** to utilize multi-modal data with **spatio temporal movement patterns** for wildlife conservation.
- When tested using a thermal infrared video dataset collected from four national parks in Africa, my research was able to use movement patterns to detect humans with **over 90% accuracy - a 4X improvement over the existing state-of-the-art methods.**
- Furthermore, my low-cost ($300) engineering design ElSa built with commodity components **mitigates the need for costly high-resolution thermal cameras** ($10,000), **easing the burden** on resource-constrained Parks in Africa and Asia.



Elsa: Final Design Prototype & Real-time Inference Results

Future: Apply this novel methodology to the conservation of other endangered animals