The Automation of Camera Trap Distance Sampling with Machine Learning for the Estimation of Population Density and Abundance

Author:
TOM RAYNES

DEPARTMENT OF COMPUTER SCIENCE

UNIVERSITY OF BRISTOL

A thesis submitted to the University of Bristol in accordance with the requirements of the degree of MSc COMPUTER SCIENCE

SEPTEMBER 2025

Abstract

[Abstract]

Acknowledgements

[Acknowledgements]

Author's declaration

I declare that the work in this dissertation was carried out in accordance with the requirements of the University's Regulations and Code of Practice for Research Degree Programmes and that it has not been submitted for any other academic award. Except where indicated by specific reference in the text, the work is the candidate's own work. Work done in collaboration with, or with the assistance of, others, is indicated as such. Any views expressed in the dissertation are those of the author.

SIGNED: ..... DATE: .....

Table of Contents

List of Tables

TABLE **Page**

List of Figures

FIGURE **Page**

1 Introduction

Manual distance sampling bottleneck

Aim to automate distance sampling of a large dataset and use estimated distances to achieve accurate estimates for population activity

WCF dataset

How abundance and density is calculated using distances

2 Background

2.1 WCF Dataset

2.2 Methods and Models

2.2.1 Deep Learning

2.2.2 Mega Detector

2.2.3 Segment Anything

2.2.4 Depth Anything

2.2.5 Dense Prediction Transformers

2.2.6 Calibrating Distances

2.3 Estimating Activity

Distance estimation [1]

3 Experimantal

3.1 Calibration Frame Preparation

3.1.1 Frame Extraction

Python frame extractor

3.1.2 Frame Mask Creation

Mask creation using GIMP, potential use of segment anything

3.2 Detection Frame Extraction

3.2.1 Frame Identification

2.2.1.1 Manual Sample

Converting date/time from csv to a timestamp for each video

2.2.1.2 Automated Sample

Extracting frames from all videos sampled every 2 seconds

3.2.2 Frame Extraction

python script to extract based on timestamps

3.3 Distance Estimation

DPT/BBOX, DPT/SAM, DA/BBOX, DA/SAM

Code adjustments for blue crystal

Variable calibration runs

Depth map diagrams

3.4 Activity Estimation

Refining activity script based on distribution of estimated distances?

4 Analysis

4.1 Analysis of Distance Estimates

4.1.1 Model / Manual Distance Comparison

4.1.2 Error Analysis

4.1.3 Qualitative Analysis

close/far failure cases, sweet spot

4.1.4 Effects of Varying Calibration

4.2 Analysis of Activity Estimates

4.2.1 Manual Sample Activity Analysis

Single chimp frame distances supplemented with manual distances

4.2.2 Automated Sample Activity Analysis

5 Evaluation of Methodology

Improvement over fully manual approach?

Bottlenecks, calibration frame preparation, available compute

Limitations of the environment

Calibration and detection frame image resolution

6 Conclusion

6.1 Further Work

References

[1] T. Haucke, H. S. Kühl, J. Hoyer, and V. Steinhage, "Overcoming the distance estimation bottleneck in estimating animal abundance with camera traps," *Ecological Informatics*, vol. 68, p. 101536, 2022. [Online]. Available: https://www.sciencedirect.com/science/article/pii/S1574954121003277