



Understanding the ecosystem of datasets in AI/Computer vision



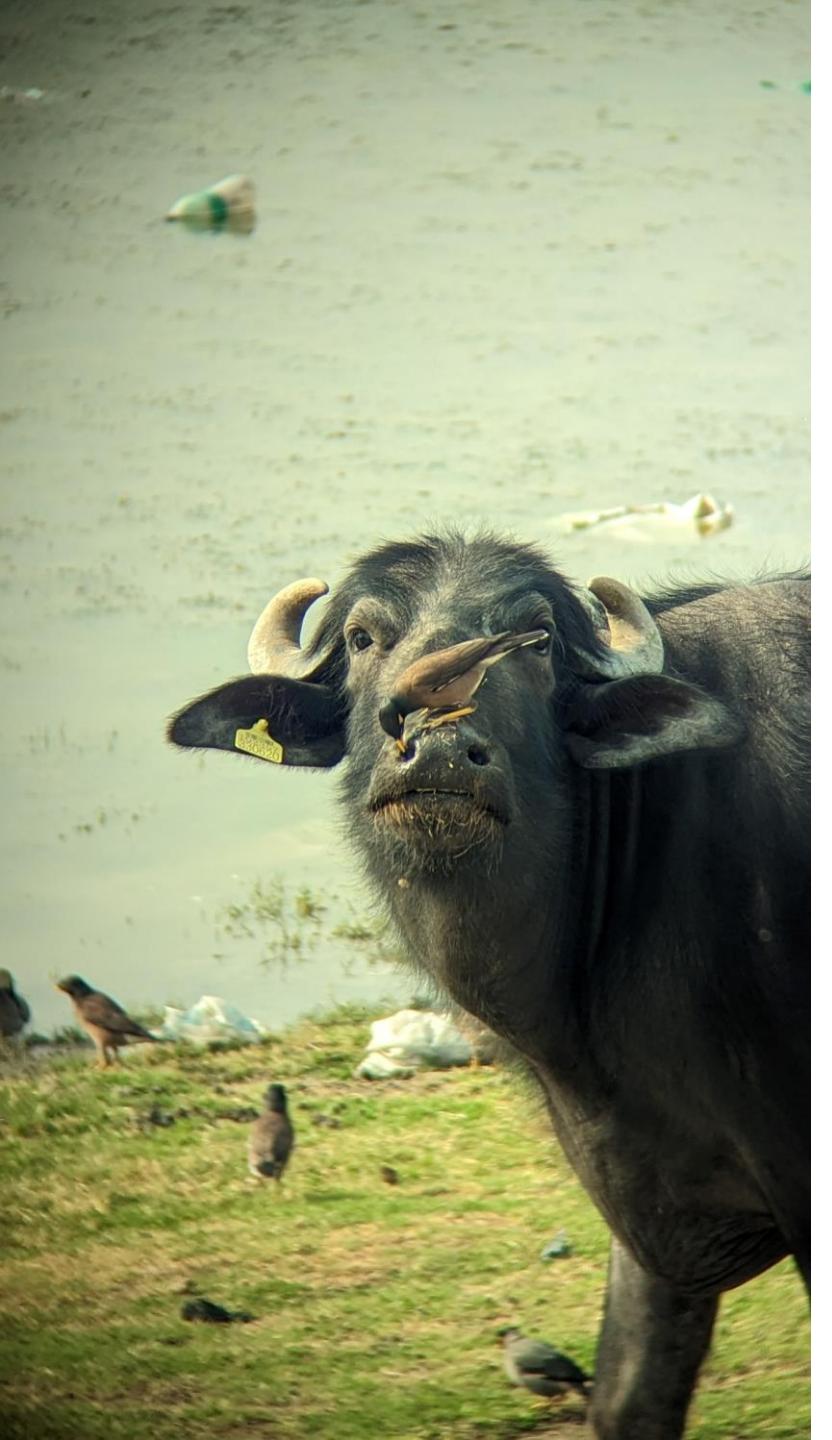
Hemal Naik, PhD

www.hemalnaik.com hnaik@ab.mpg.de

Center of the Advanced Studies of Collective Behavior (CASCB),
University of Konstanz.

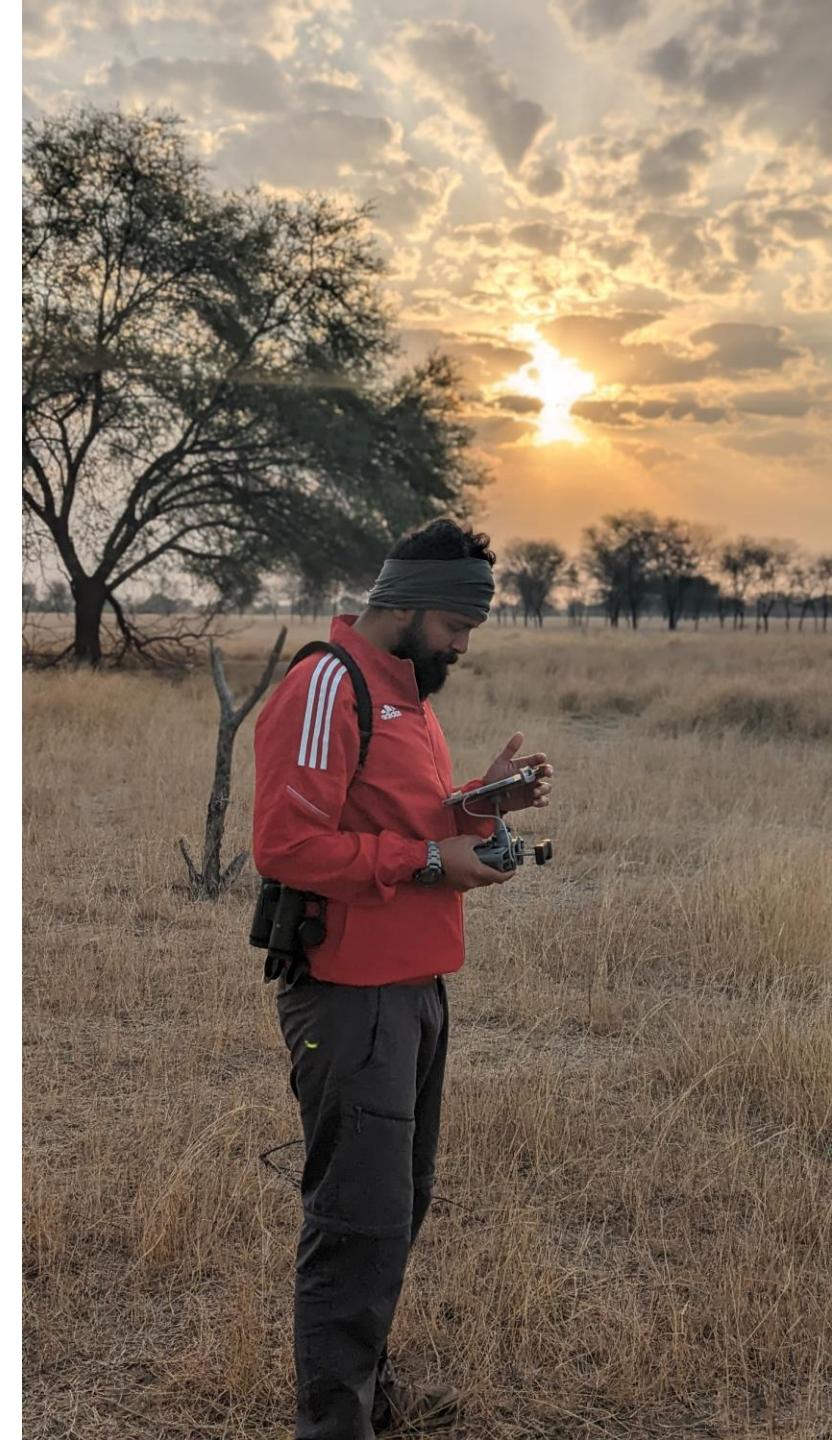
Dept. of Ecology of Animal Societies,
Max Planck Institute of Animal Behavior (MPI-AB).





Introduction

Biomedical Engineering
Biomedical computing
Bird watching
Animal Behaviour
Art

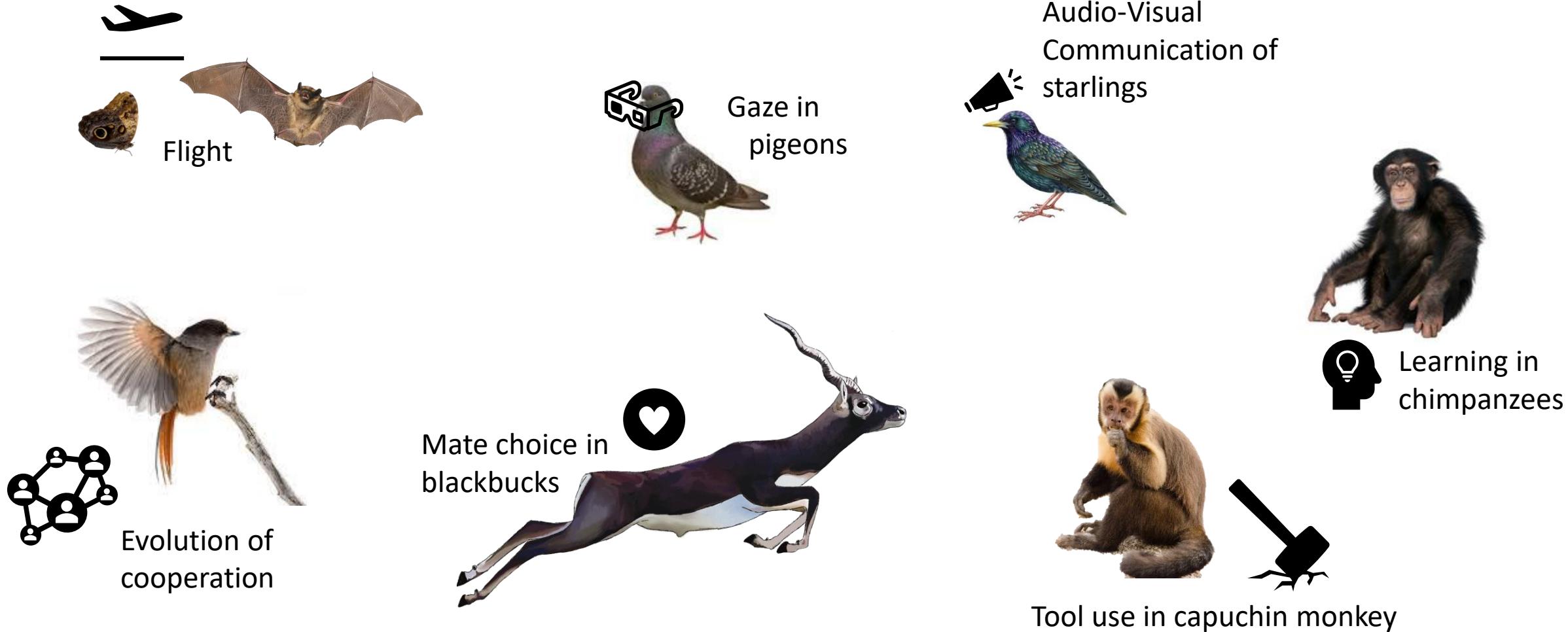


Today's discussion points

- The vocabulary of computer vision and AI
- Introduction to the dataset ecosystem
- Why is this relevant for your research?
- How to be part of this ecosystem?
- Is there a starting kit?

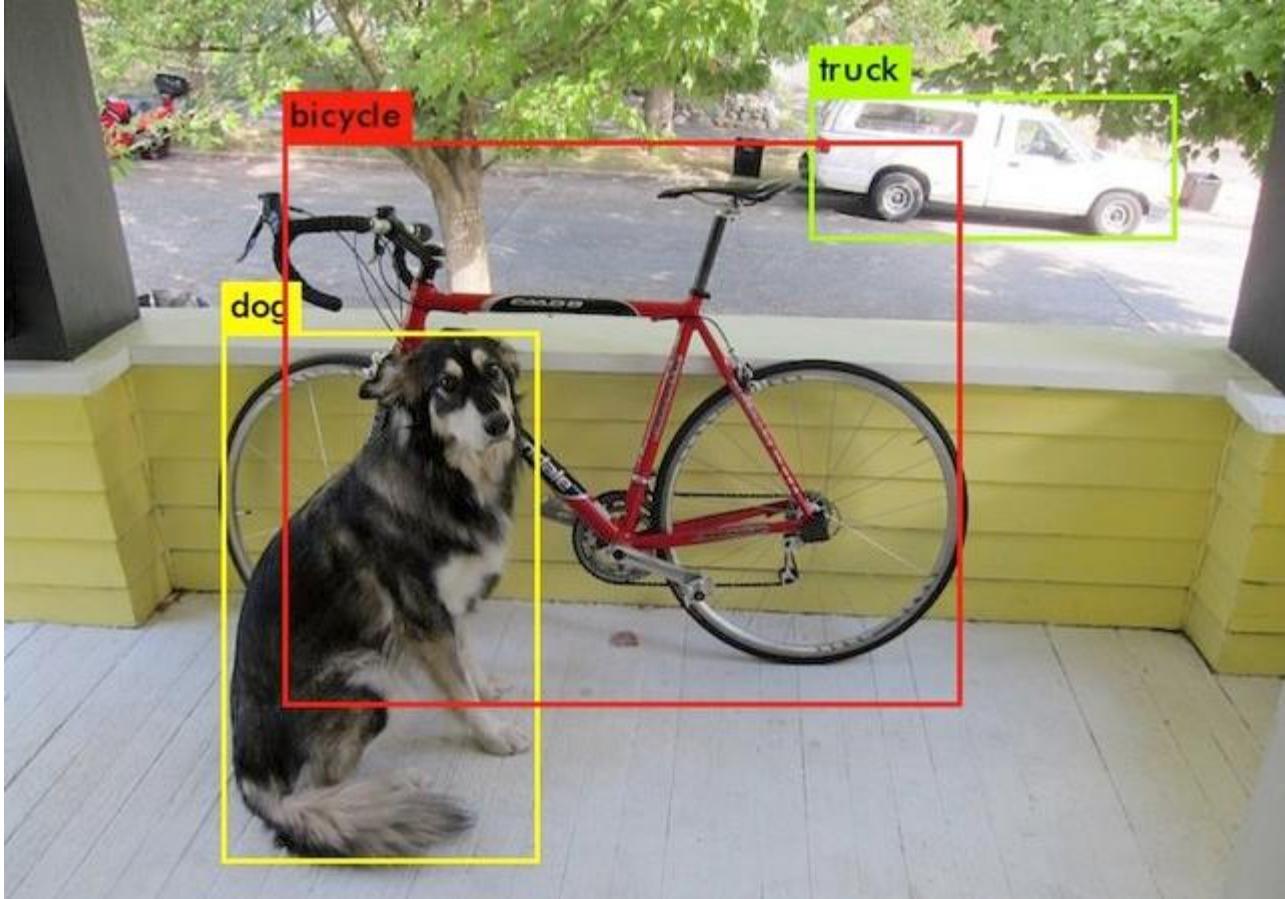


Studying behaviour with AI



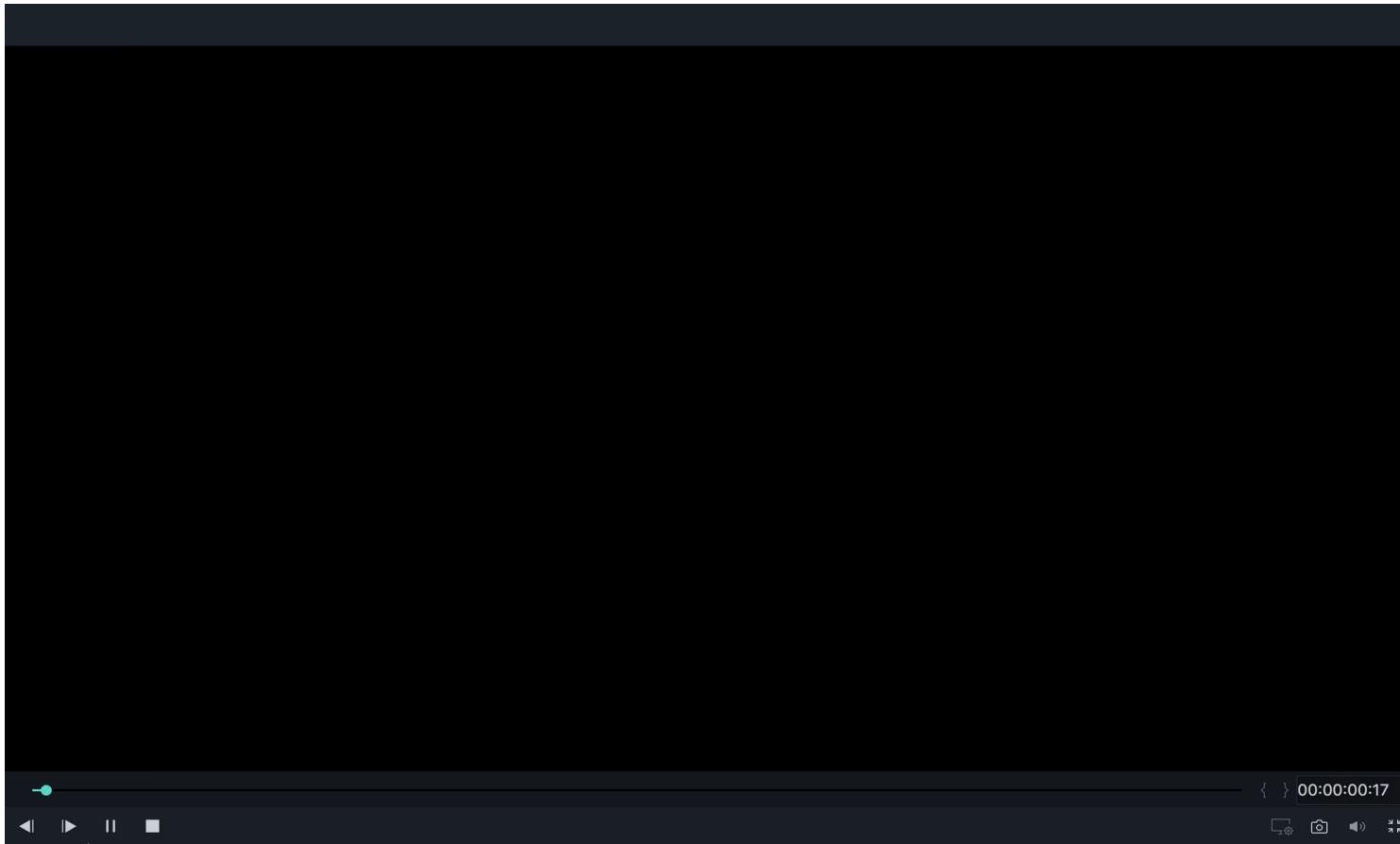
What about the vocabulary?

It is important to know your problem



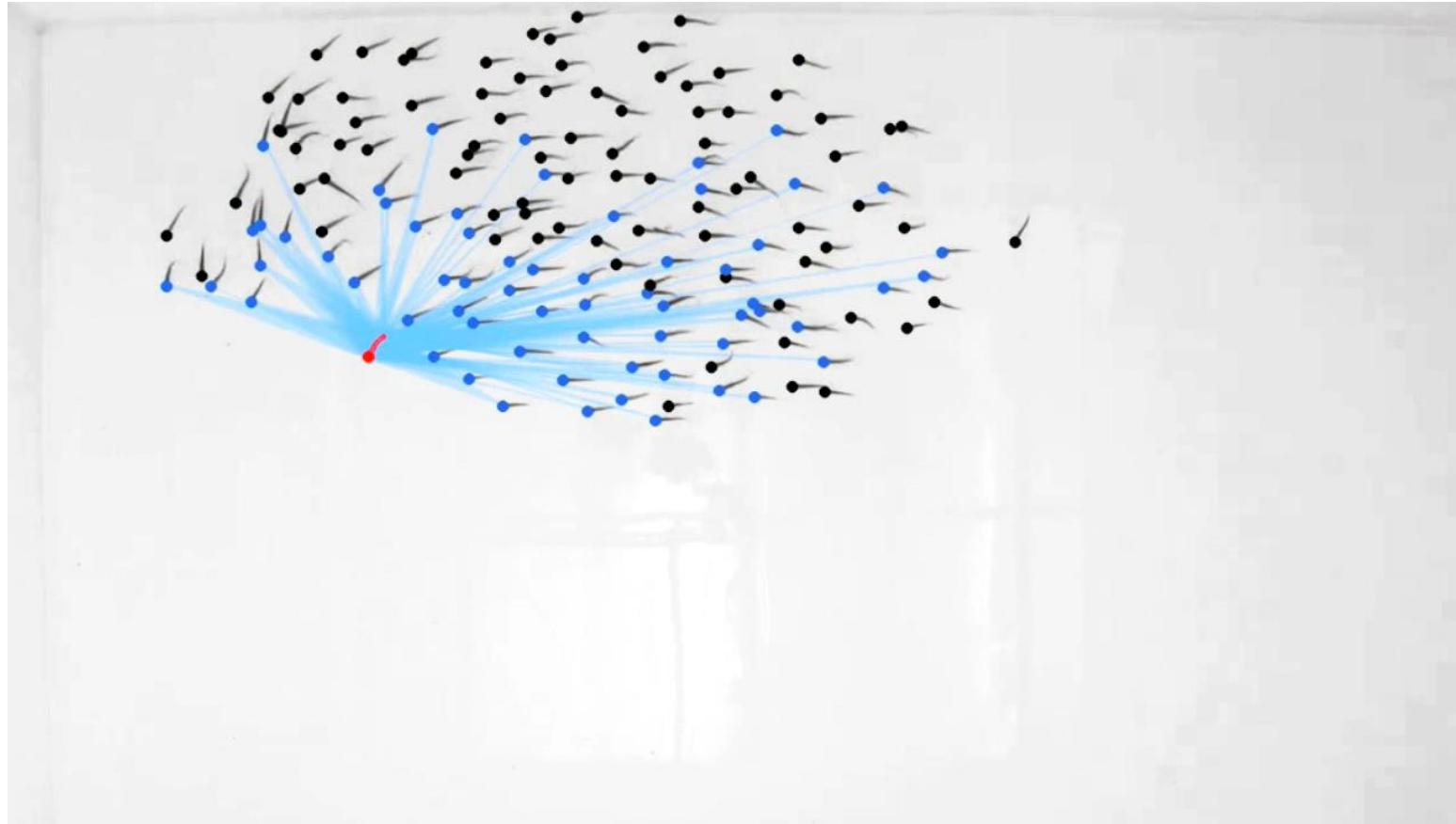
Detection &
Classification

Understanding specifications of the problem



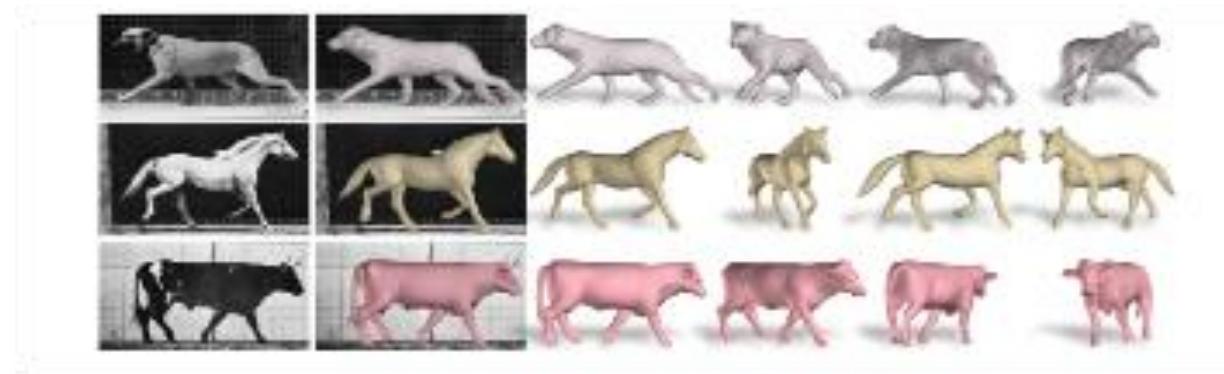
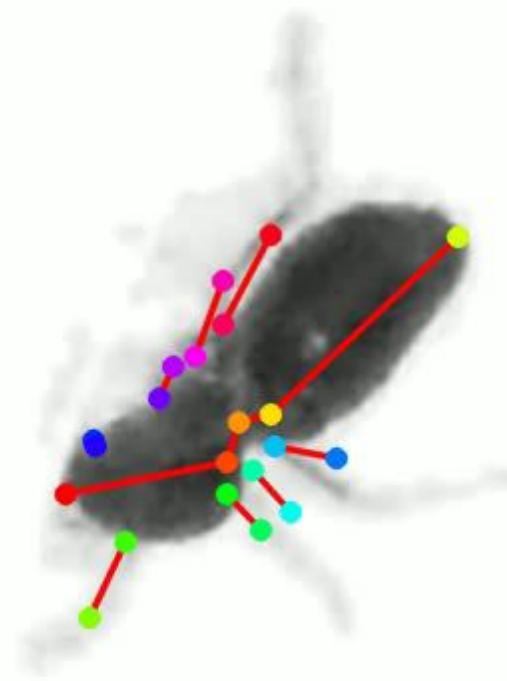
Tracking

Devil is often in the details



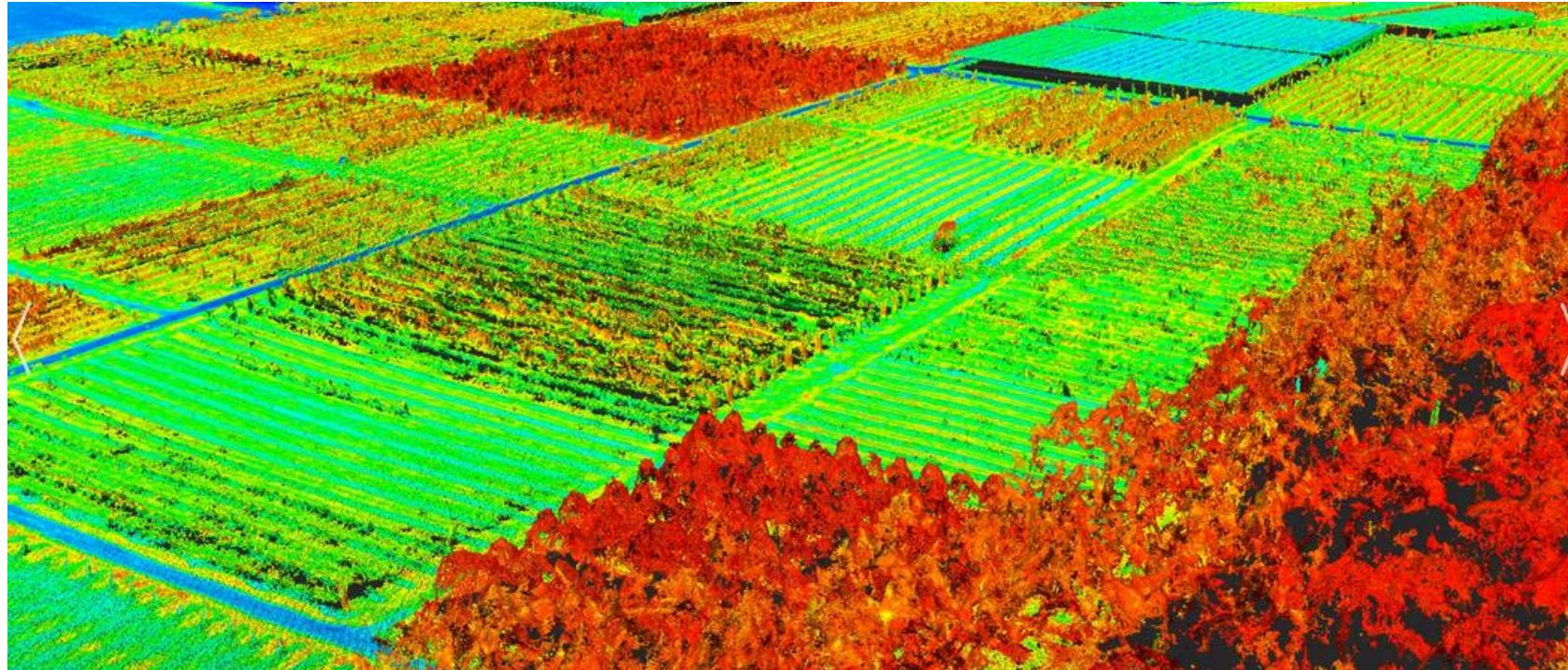
Identification

Some details are painful to extract



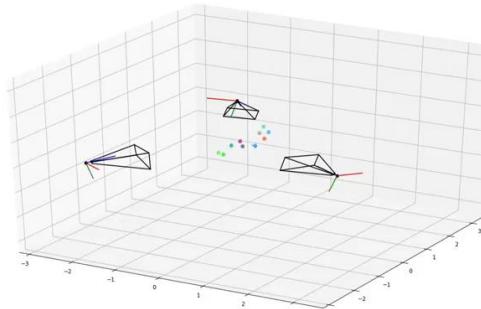
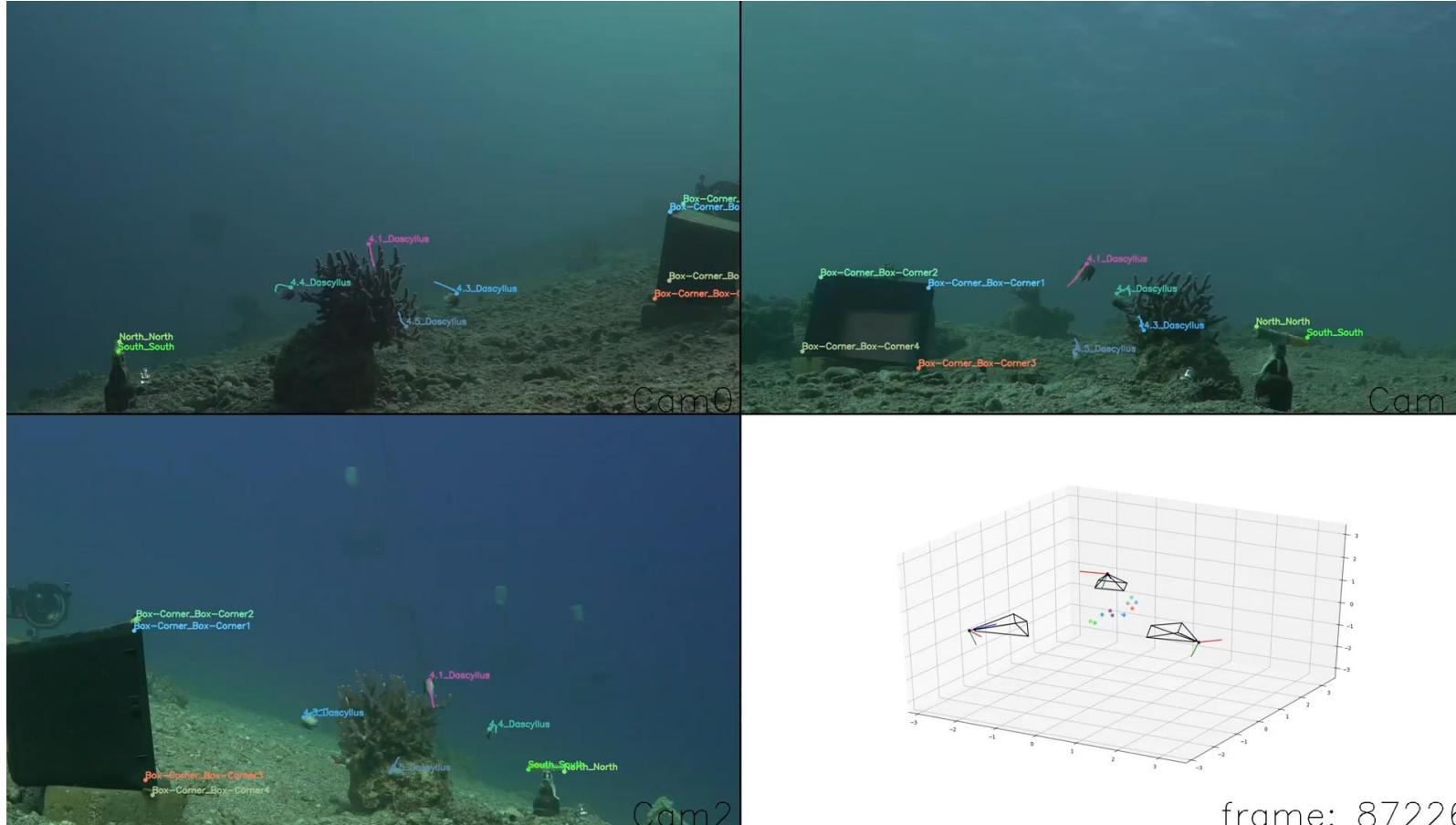
2D/3D Pose or posture
reconstruction

Some problems are tedious



Segmentation

But thinking things thorough pays off



frame: 87226

3D reconstruction
& tracking

Dataset is one of these crucial details



What is the ecosystem of dataset?

Computer science

- Research is problem specific
- Challenging & generic solutions
- Novelty is approach for solutions
- Deployment is not priority

Biology

- Research is question oriented
- Solutions are application specific
- Novelty is findings not method
- Deployment of method is crucial

Datasets for computer vision/AI

- A collection of images or videos curated for solving one or more problems
- Dataset gives a systematic approach for solving problems
- Often constrained with a set of conditions
- Allows measurement of accuracy in problem solving
- Benchmarking with relevant metrics offers means for method selection

Dataset are the currency of AI research

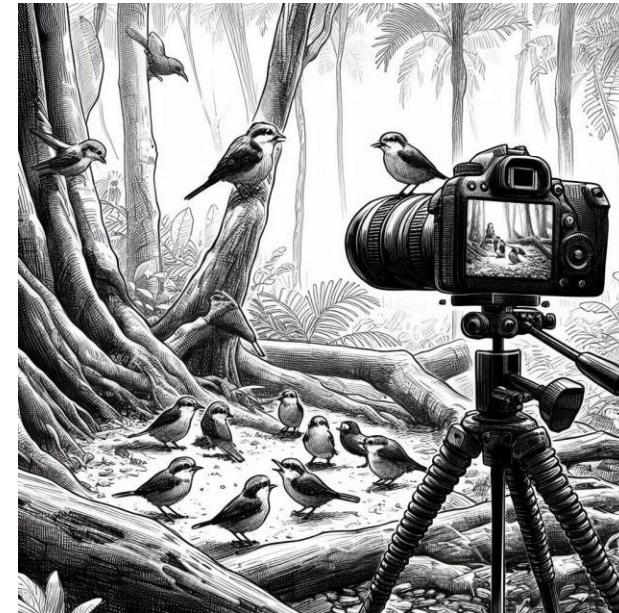
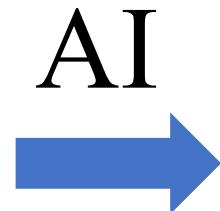
- Introduces new problems in domain
- Enhances engagement within community
- Catapults development of novel solutions
- Encourages collaborations

Case study: Bird behaviour in 3D



Indoor

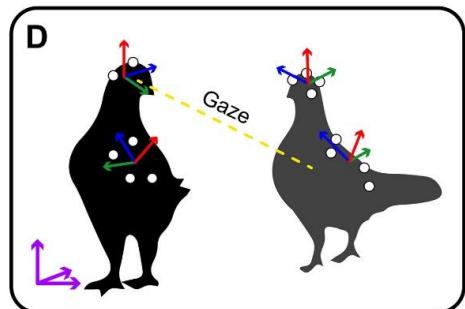
Highly accurate measurements,
large scale data collection but
expensive.



Outdoor

Maintain the same accuracy, with
limited conditions and complex
scenario.

Collective behaviour using 3D tracking

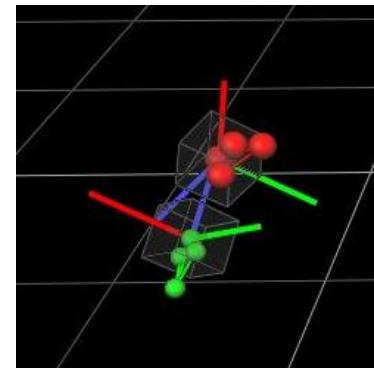
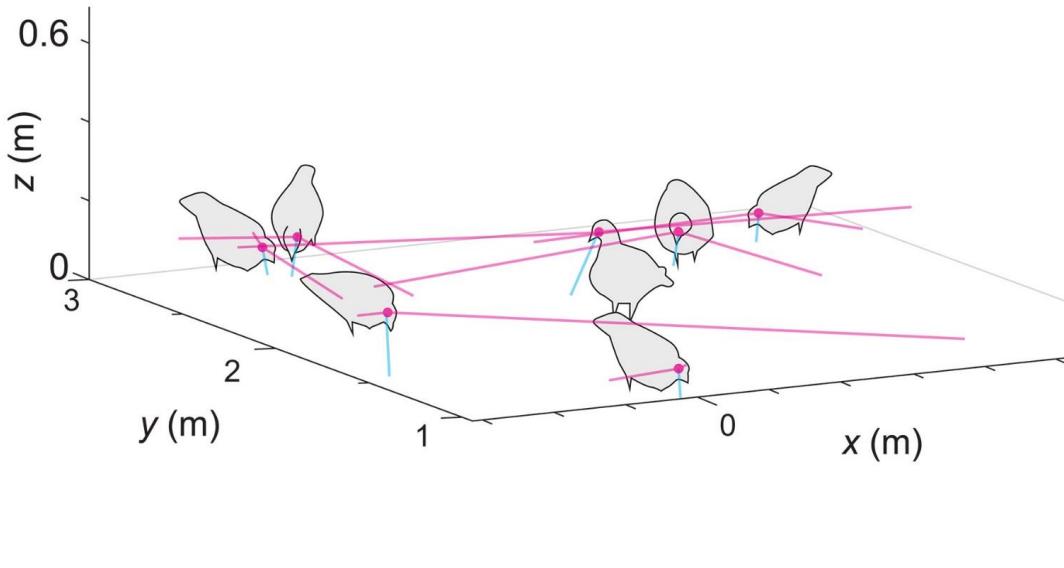
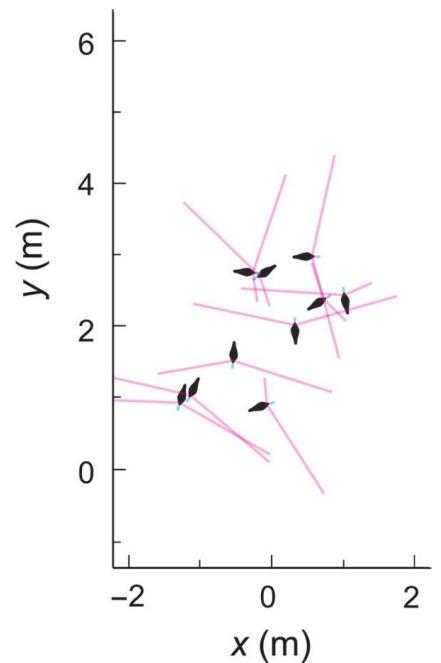
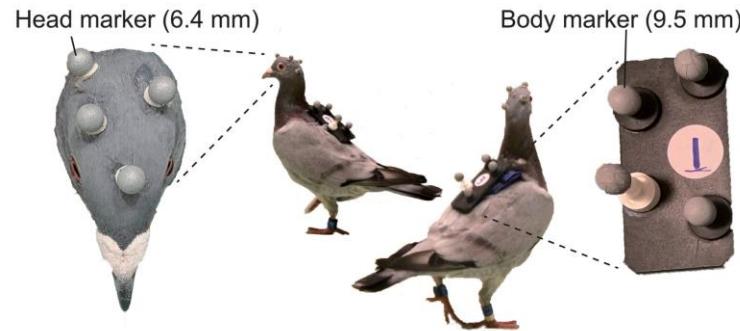
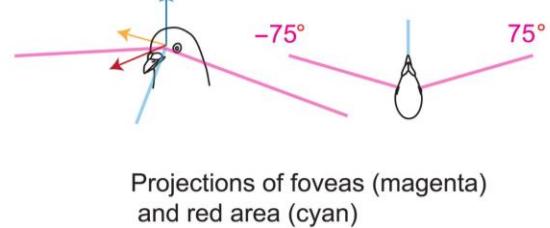
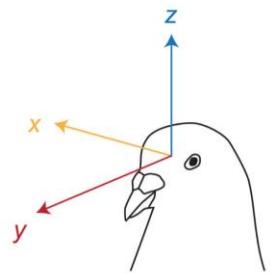


Identity

Posture

Case study B
Gaze tracking in multiple birds

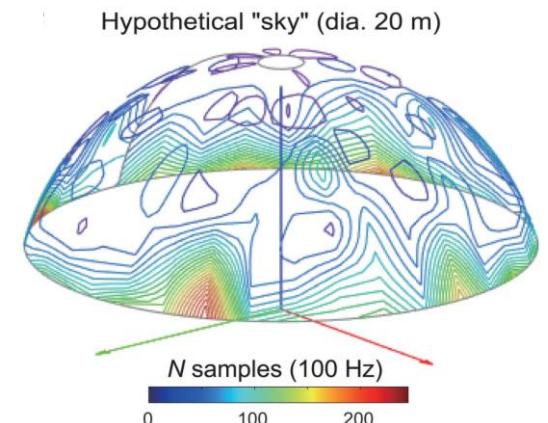
Gaze and attention



Vicon

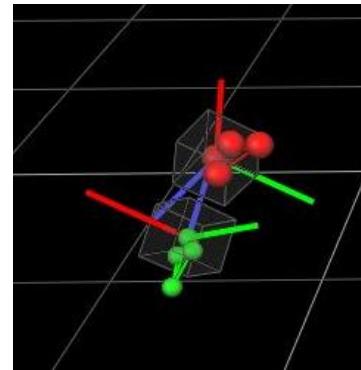


Video

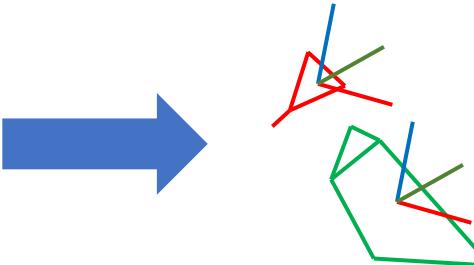


From markers to marker-less

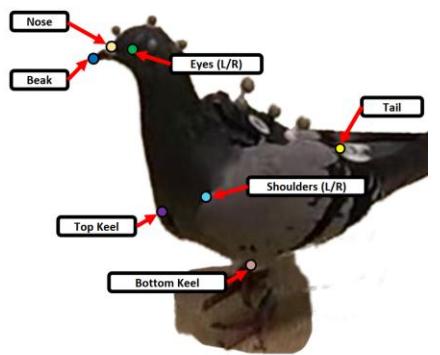
6DOF Pose



Stereo
Triangulation

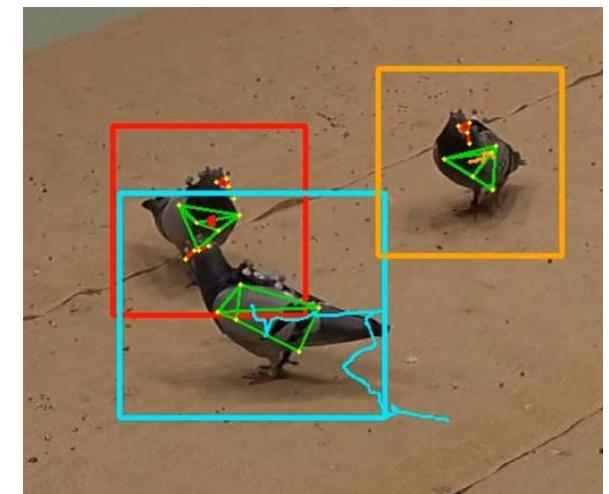
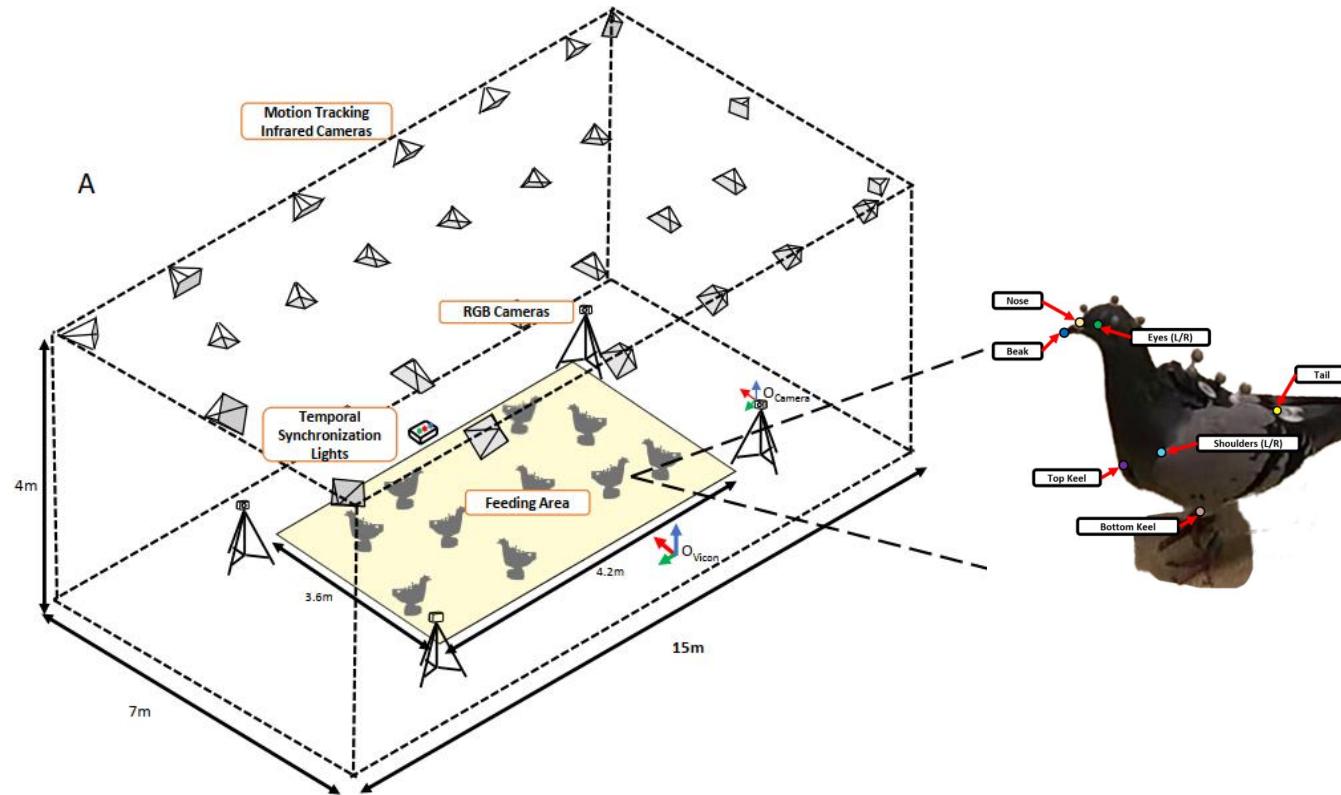


Manual annotation in 1st frame



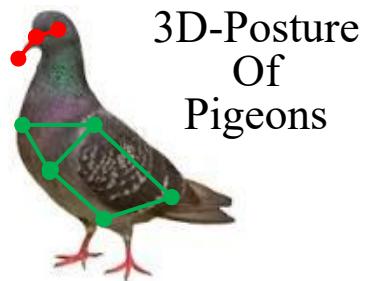
3D feature
registration

Automated annotations for machine learning



Projection

Ground truth: 3D movement and posture



3D-Posture
Of
Pigeons



GitHub

3D-POP
3D-POPAP

400+
downloads



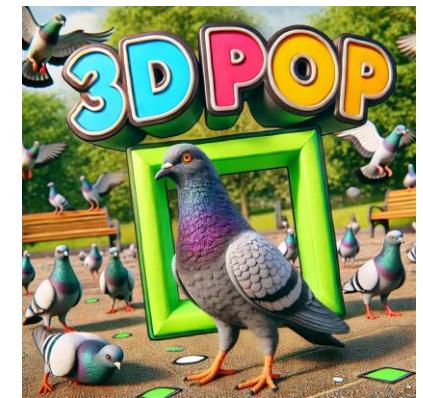
Large scale dataset for freely moving birds based on automated annotation using mocap for 2D-3D markerless posture tracking

3D-POP : Posture of pigeons

- Manual validation for automated method for annotating complex datasets
- First large-scale dataset
 - Time : 350 mins (markers), 60 mins (markerless)
 - Tracking position : 300k annotations over 4 million instances
 - 3D/2D Posture : 1.8 million **unique** 3D postures
 - Identity : 18 pigeons
- Multiple problem configurations
 - Single vs multiple camera tracking
 - Single vs multiple individual ID
 - Marker vs markerless tracking
 - Position vs posture tracking

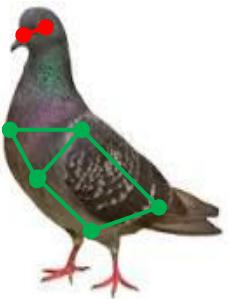


3D-POP
3D-POPAP



479+
downloads

Markerless tracking of flocks

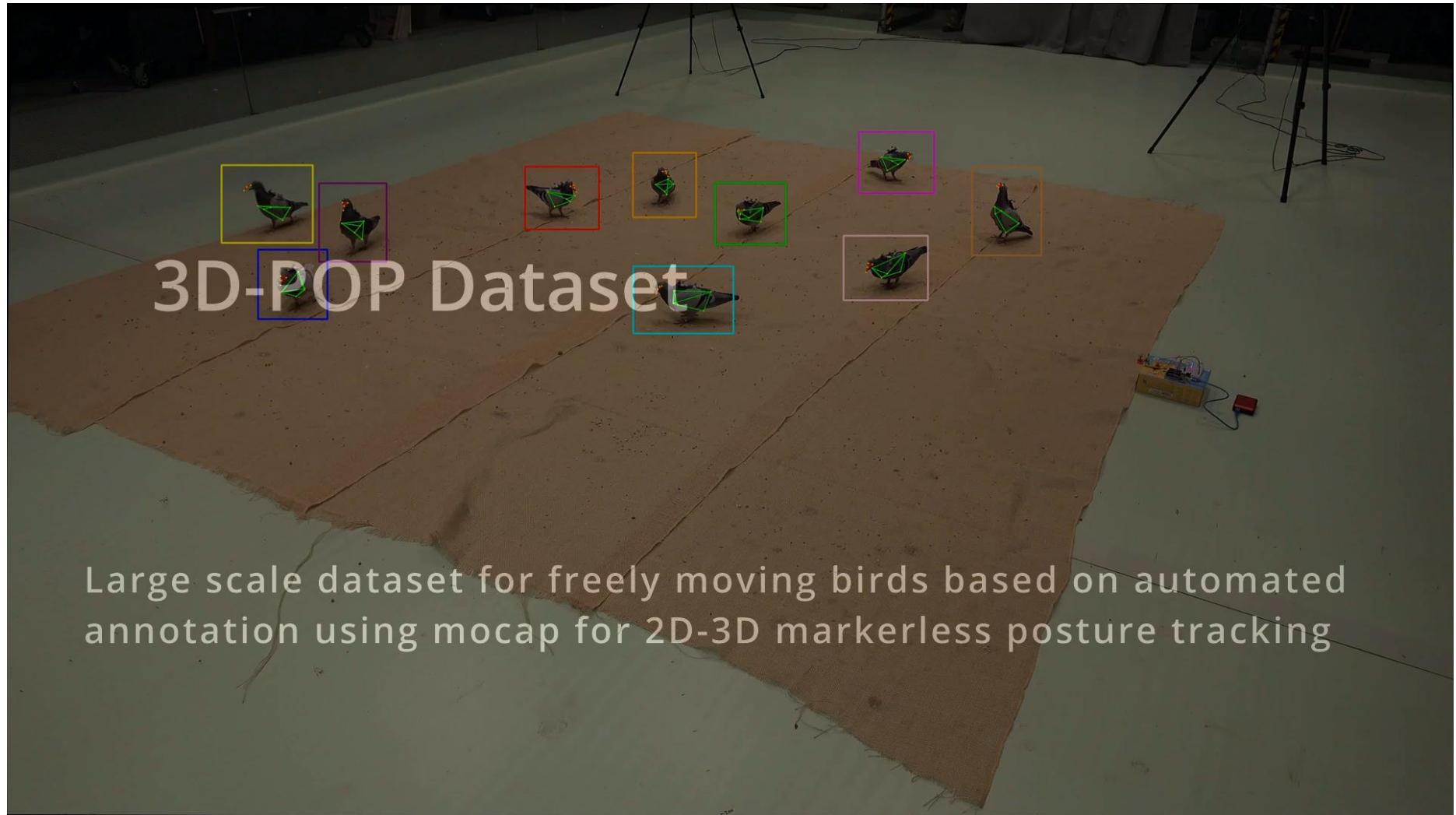


Case studies

2D Tracking

3D Hybrid

3D Markerless



Monitoring behaviour in the wild



3D-MuPPET, U Waldmann, Chan, Naik et al. International Journal For Computer Vision (IJCV) 2024.

Benchmarking for pose estimation

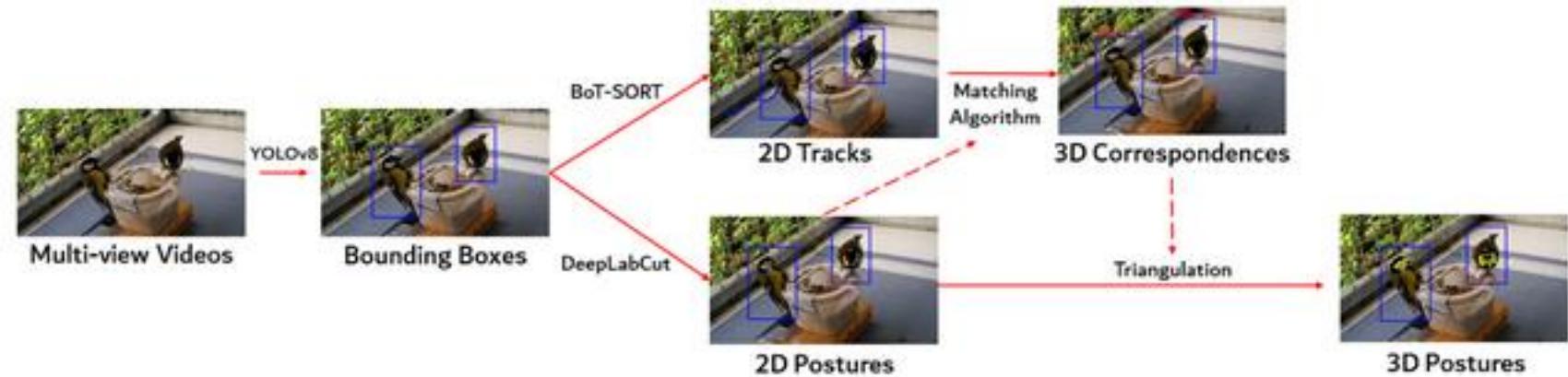
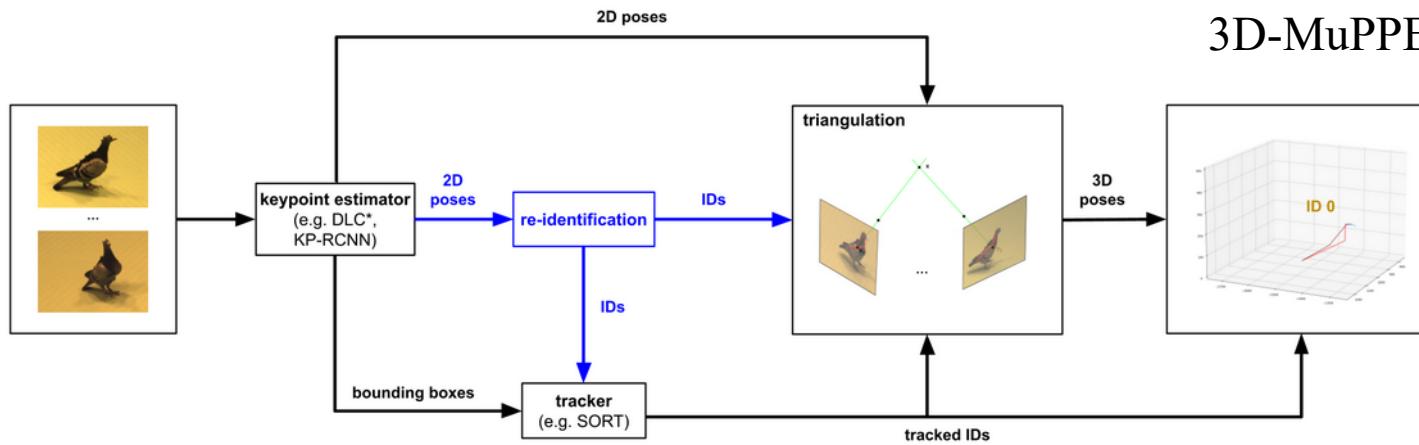
Metric/Method	3D-KP-RCNN	3D-DLC*	3D-ViTPose*	LToHP (Iskakov et al., 2019)
RMSE (mm) ↓	25.0	25.0	24.0	14.8
Median (mm) ↓	9.4	7.5	7.0	5.8
PCK05 (%) ↑	53.2	66.1	71.0	76.7
PCK10 (%) ↑	85.4	90.9	92.5	94.3
Mean Speed (fps) ↑	1.76	0.72	0.51	0.38

Metric/Num. of Ind	1	2	5	10
2D				
RMSE (px) ↓	8.6	20.1	57.2	272.5
Median (px) ↓	4.3	6.0	7.7	17.9
PCK05 (%) ↑	90.5	76.9	66.7	42.9
PCK10 (%) ↑	98.7	93.4	83.6	53.9

Metric/Num. of Ind	1	2	5	10
3D				
RMSE (mm) ↓	11.1	26.9	93.2	434.3
Median (mm) ↓	6.9	6.0	15.4	246.7
PCK05 (%) ↑	70.4	54.1	30.2	11.4
PCK10 (%) ↑	94.9	82.4	60.3	19.7

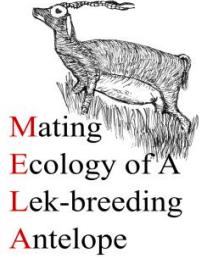
Promoting scalable, affordable and practical

3D-MuPPET, U Waldmann, Chan, Naik et al. IJCV 2024.



3D-SOCS , Chimento & Chan et al. MEE 2024.

Case study 2: Mating ecology using UAVs



Behaviour



Mate choice

Method



Tracking large herds
using a fleet of UAV



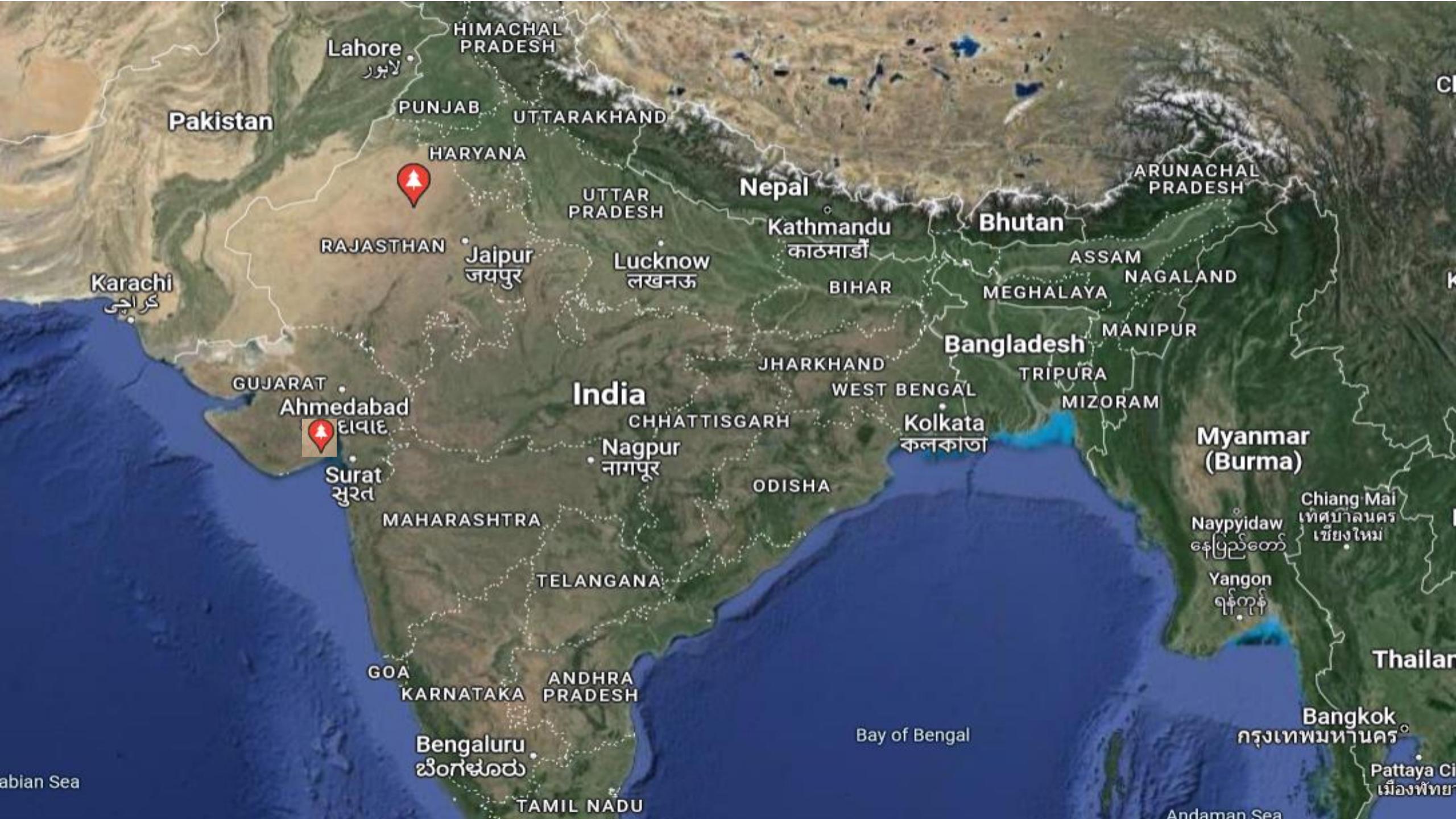
What is lekking?

Rare strategy

Elaborate displays

Mating specific

Open questions





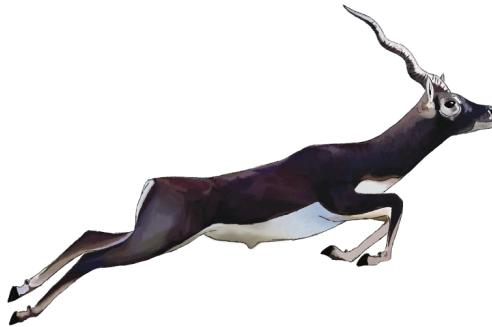
Traditional study approach – focal observation



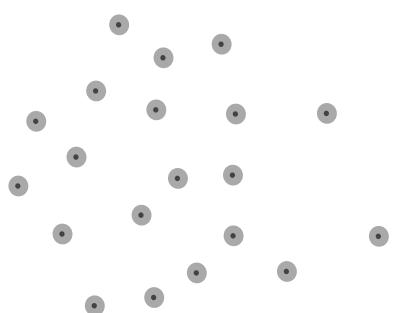
Lekking Blackbucks (*Antilope cervicapra*)



Measuring behaviour pattern of individuals



Social



Spatial



Lekking notes

- Traditional lekking ground
- Lekking area : 200 meters x 300 meters
- Adults, subadults, females
- No of individuals : up to 200
- 15-20 days with peak activity at sunrise-sunset

Females



Males



Sub-adult males





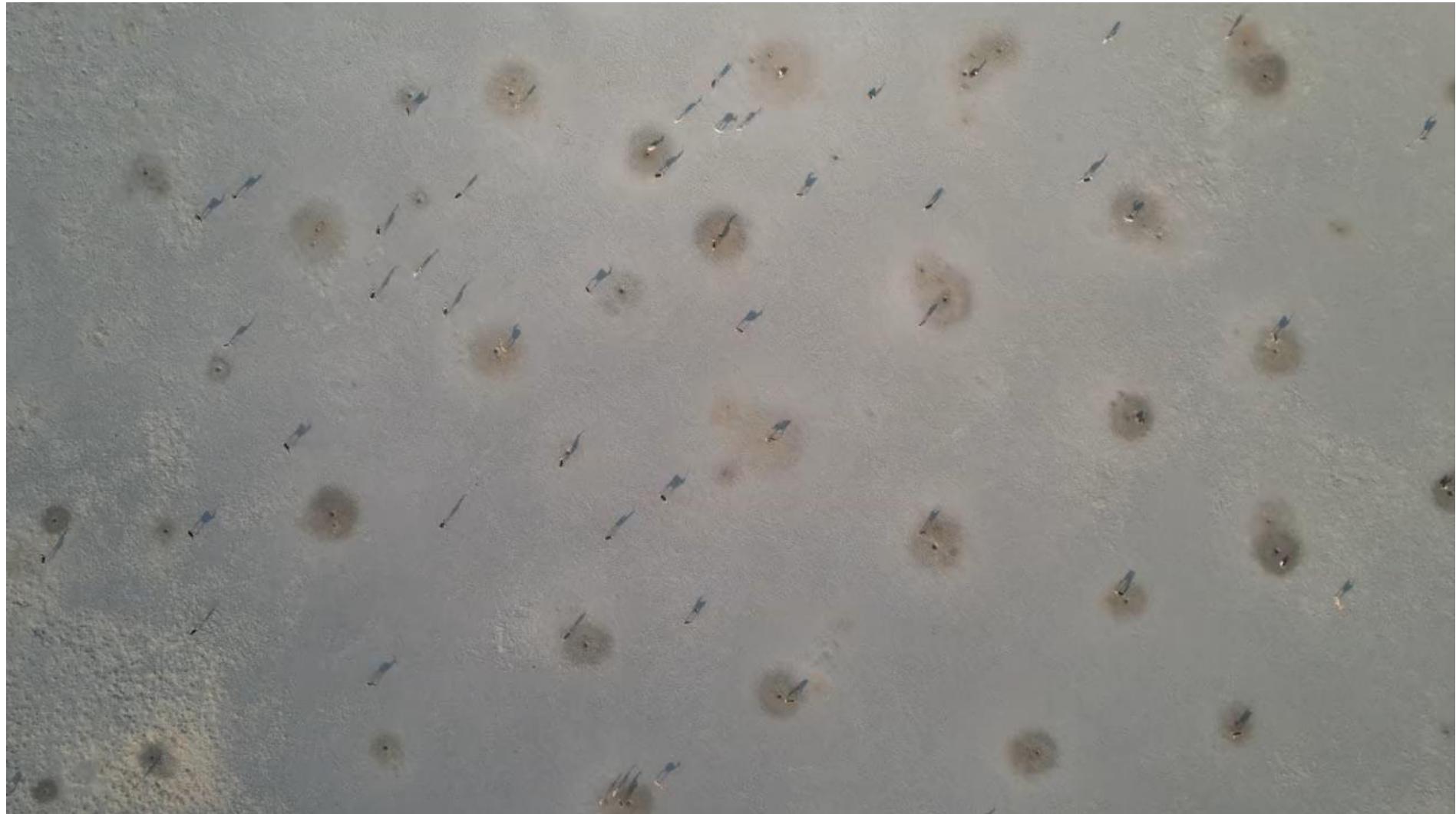
The problem of MOT and Re-ID



Females



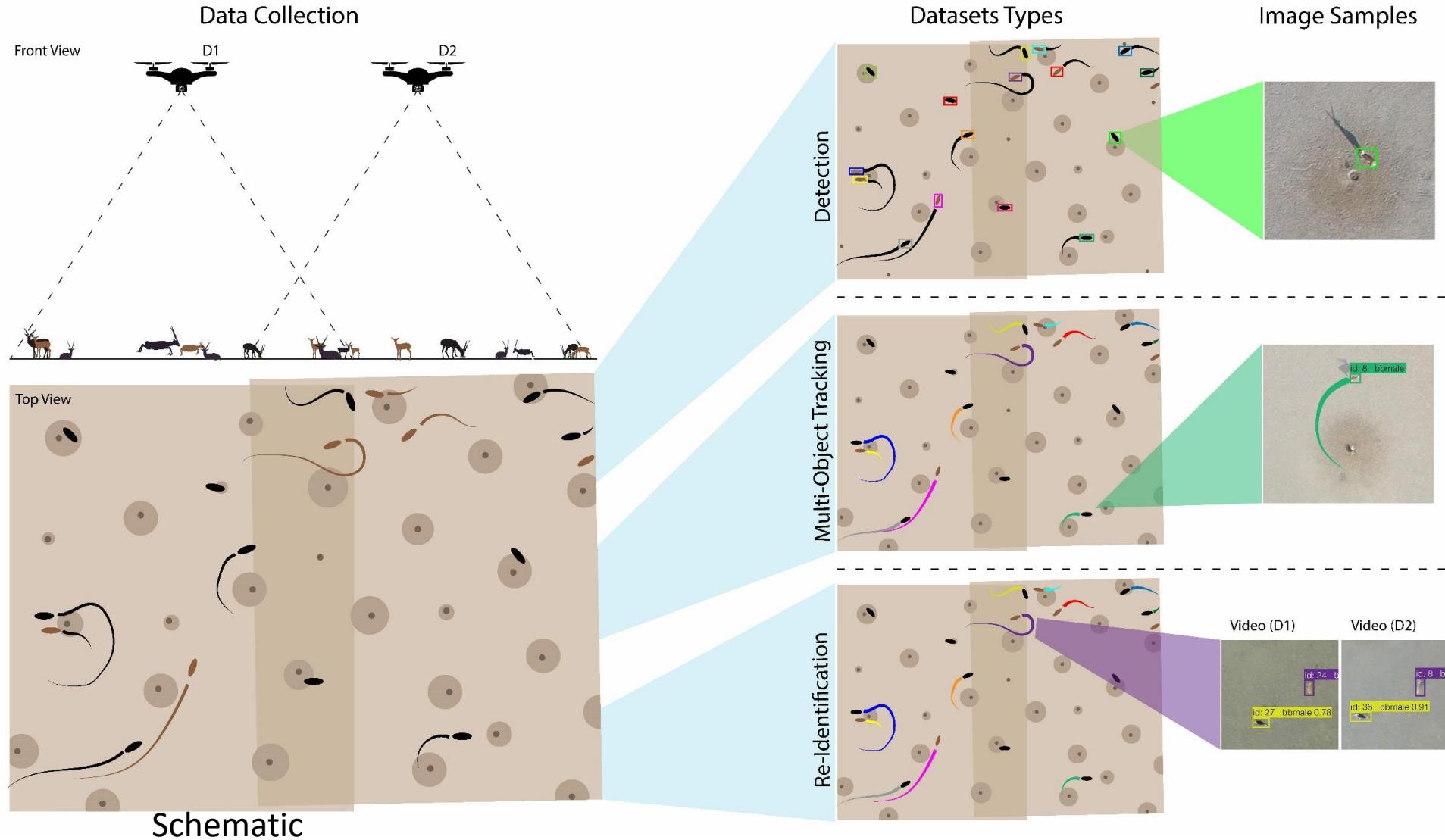
Males



Speed x4



Dataset preparation and execution



Detection dataset



Key statistics

Total images : 320
Categories : 2 – 6
Variation : light, density, time
Annotations : 18.4 K



MOT dataset



Manual annotation using Dark Label

Key statistics

Total time : 12 videos (21K frames)

Longest video : 5800 Frames

Individuals : 30 – 130

Total tracks : 680

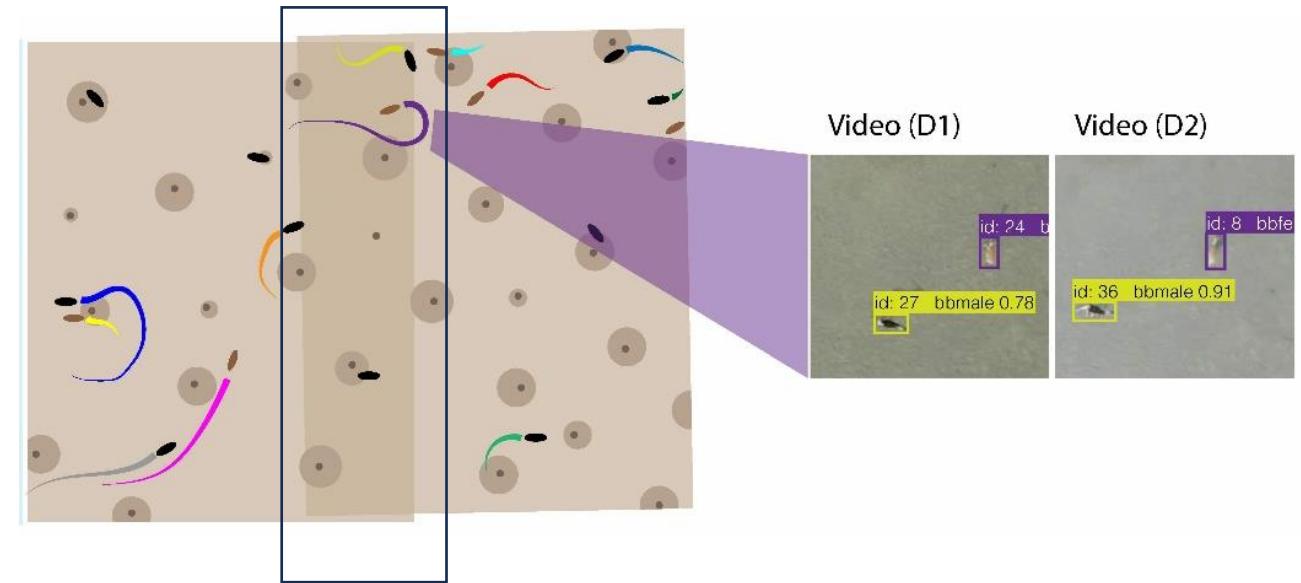
Annotations : 1.2 Million

Resolution : 5.4K

Tutorial available
with dataset



Re-ID - dataset

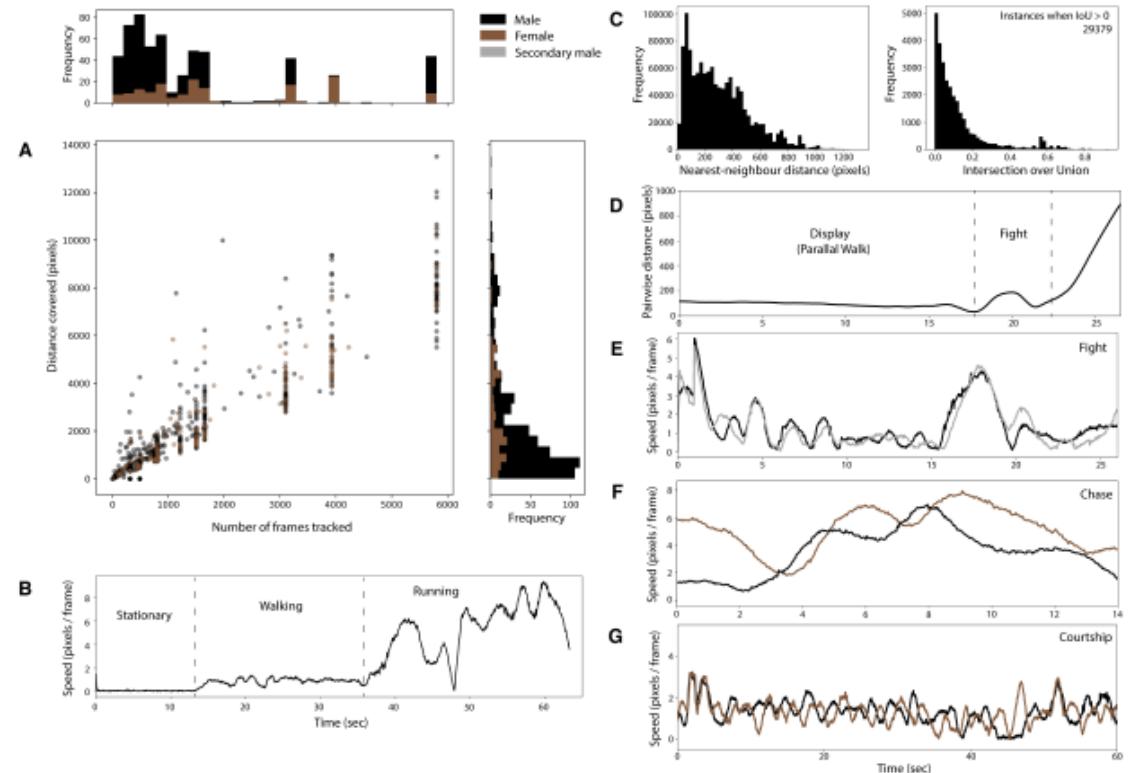


Key statistics

Video pairs : 11
Video length : 600-1100 Frames
Individuals : 730
Resolution : 5.4K

How good is the data?

- Ground truth for Multi-object tracking with 130+ animals
- First dataset to offer reidentification
- Max - 3 Min (5800 frames) total 12 minutes
- Real behaviour movements



Dataset 200+ downloads



Benchmarking of tracking methods

Method	Re-ID	HOTA [†]	DetA [†]	AssA [†]	MOTA [†]	MOTP [†]	IDF1 [†]	IDsw [↓]
ByteTrack	-	0.4950	0.5124	0.4868	0.9347	0.5932	0.8335	777
OC-SORT	-	0.4203	0.4880	0.3726	0.8699	0.5928	0.6421	8736
BoT-SORT	-	0.5286	0.5165	0.5495	0.9429	0.5933	0.9214	171
	osnet_x0_25	0.5365	0.5159	0.5665	0.9430	0.5930	0.9418	158
	osnet_x1_0	0.5378	0.5160	0.5690	0.9429	0.5931	0.9451	153
	osnet_ain_x1_0	0.5369	0.5160	0.5671	0.9430	0.5931	0.9435	150
	lmbn_n	0.5355	0.5159	0.5644	0.9427	0.5929	0.9400	169

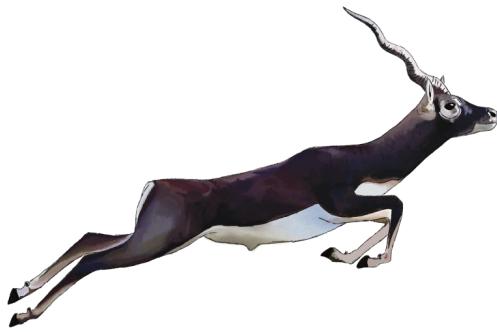


YOLOv8 + BoT SORT (Re-ID)

- ID switching is big problem
- MOTA metric is not sufficient
- Tracking with Re-ID is good but extremely slow
- HOTA metric is good but does not consider categories



Behaviour from movement tracking



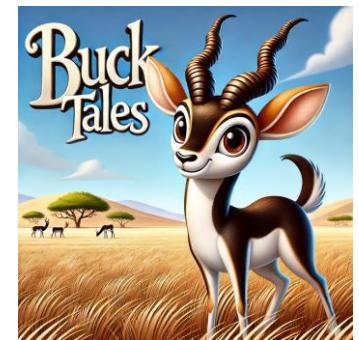
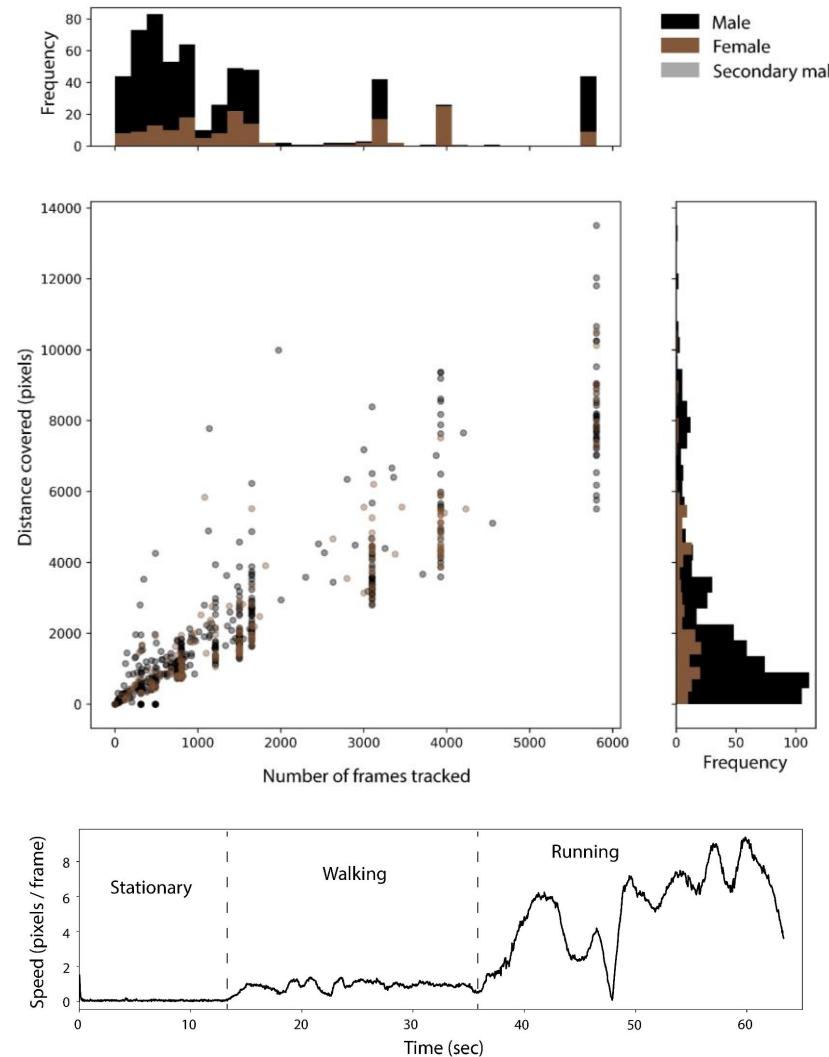
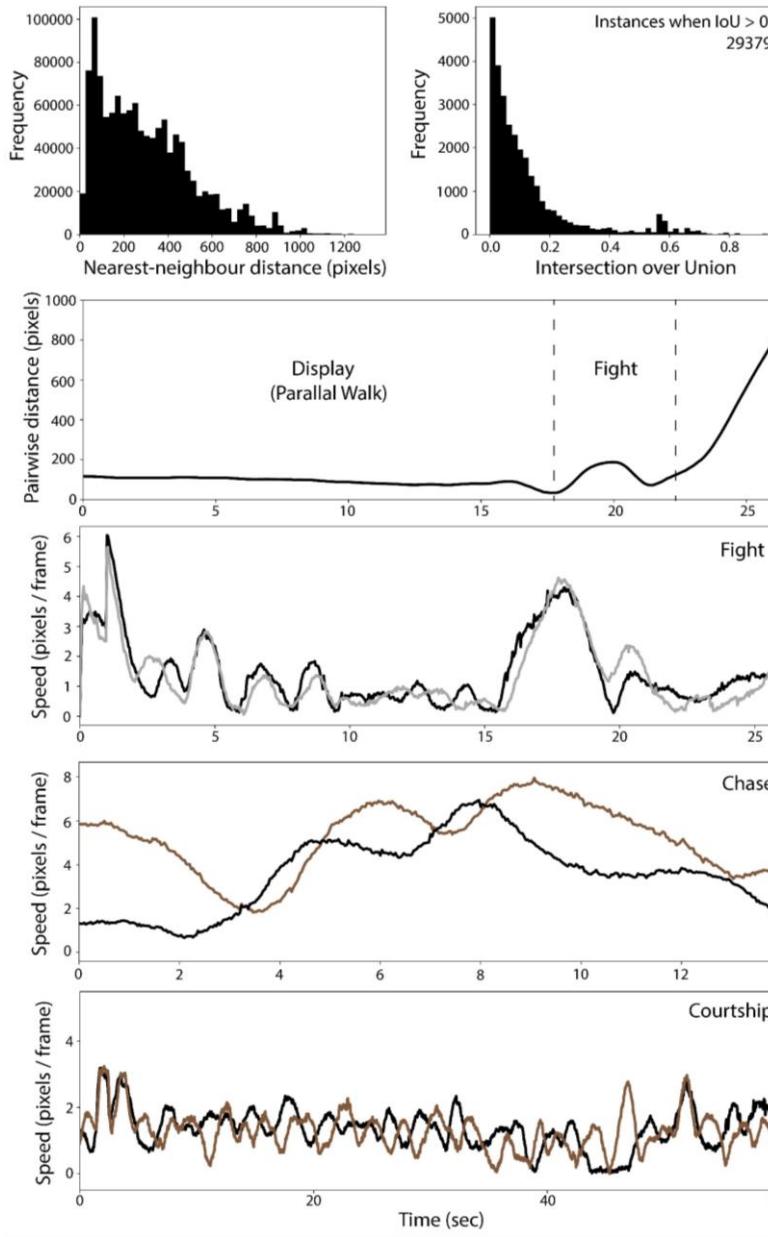
Detection

Tracking

Identification



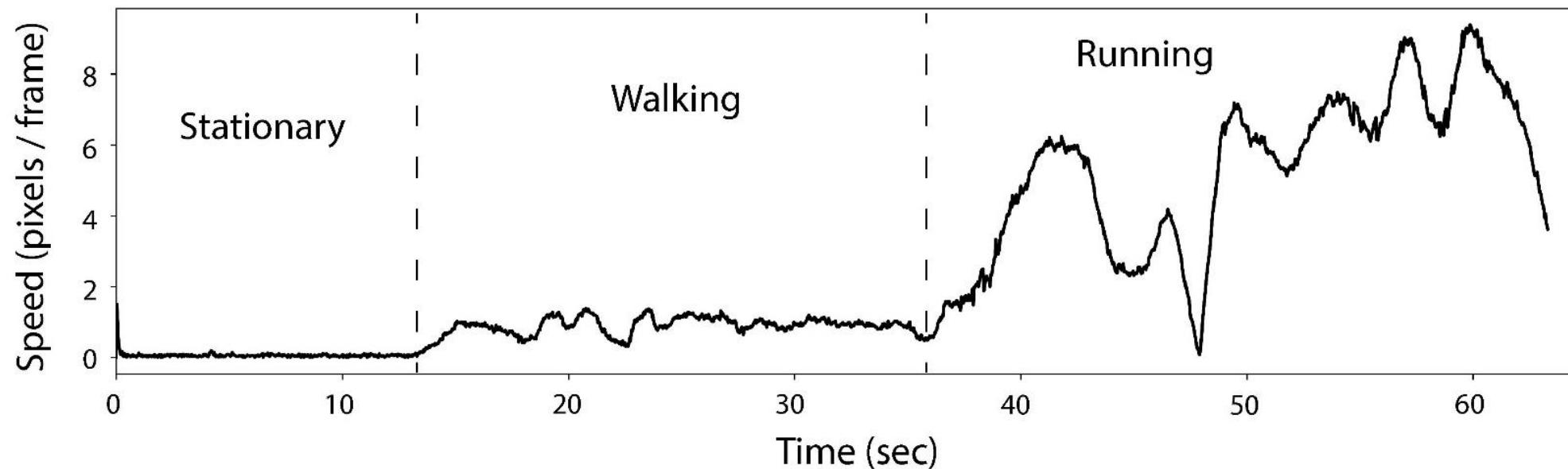
Demonstrating dataset quality



Dataset 200+ downloads



Behaviour patterns from movement

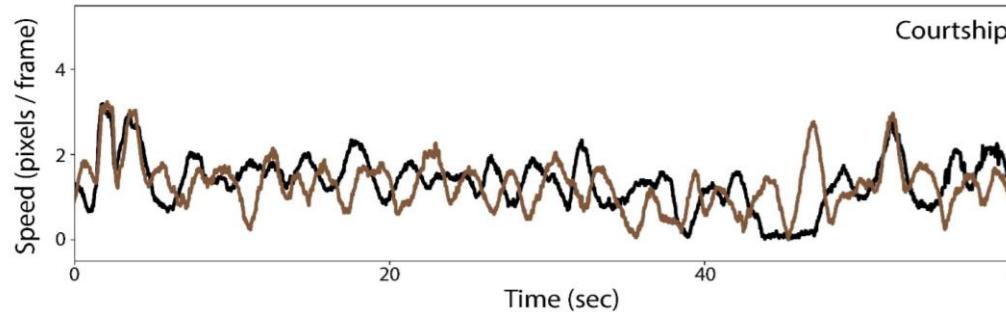
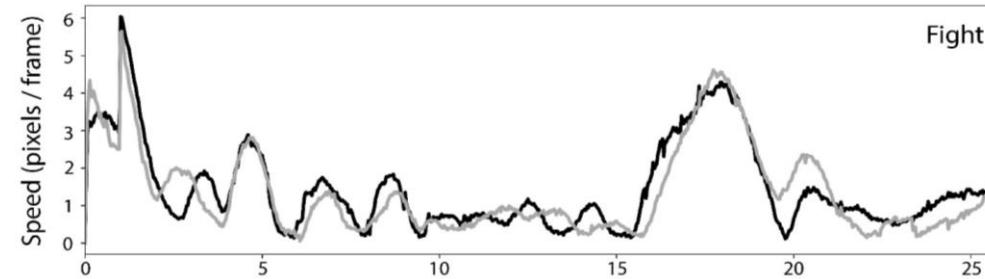


Behaviour states of animals from movement





Quantifying interactions



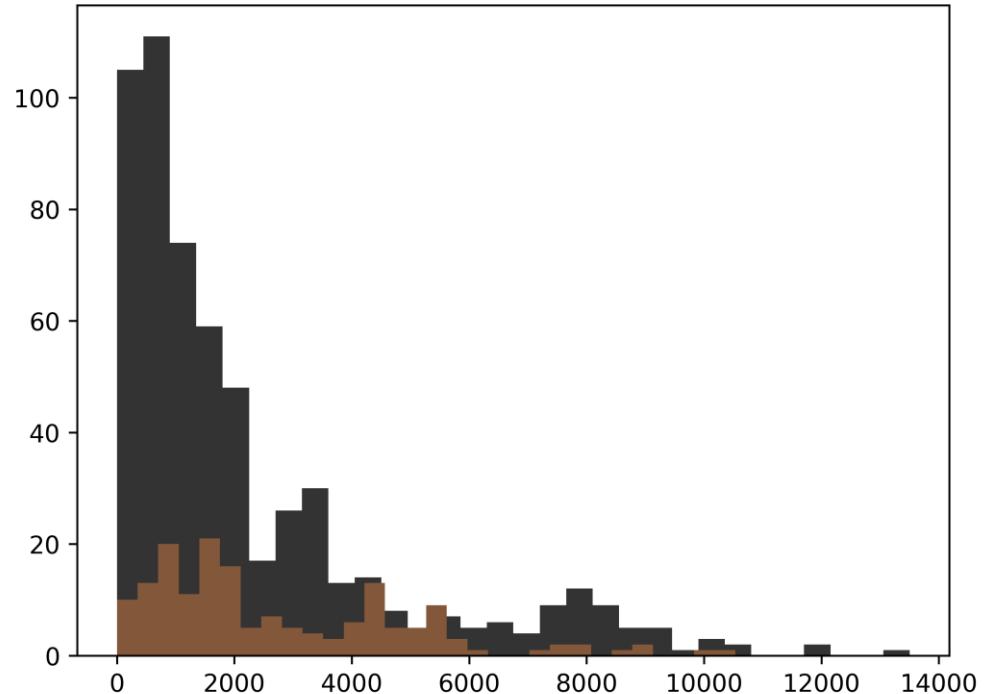
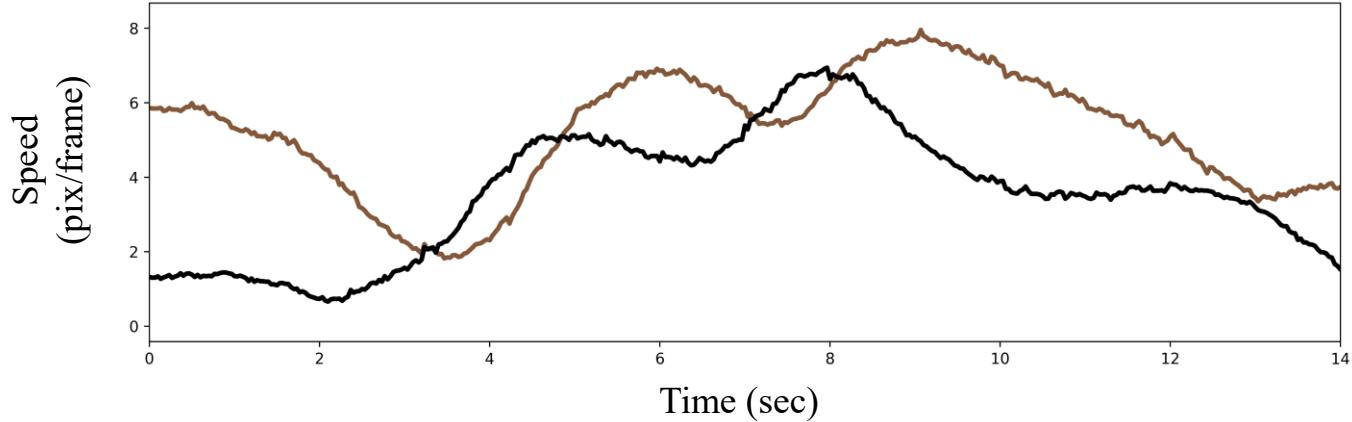
Currently processing whole dataset of 150Hrs.





Other analysis

Chase



Distance covered

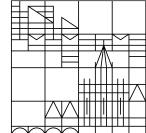
Other analysis : speed variation, proximity variation etc.



BuckTales: A multi-UAV dataset for multi-object tracking and re-identification of wild antelopes

Hemal Naik, Junran Yang, Dipin Das, Margaret Crofoot,
Akanksha Rathore, Vivek Hari Sridhar

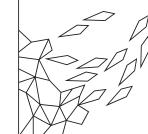
Universität
Konstanz



Max Planck Institute
of Animal Behavior



Centre for the Advanced Study
of Collective Behaviour



Summary

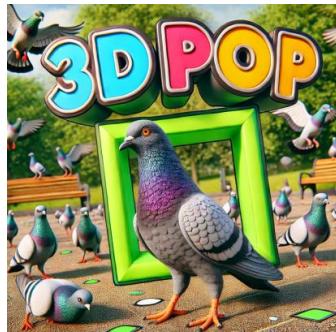
- First dataset for **tracking** wild animals with UAVs
- Long trajectories for multi-object tracking task
- Unique ground truth for Re-ID task
- Dataset to benchmark algorithms for wildlife studies



Mating
Ecology of A
Lek-breeding
Antelope

Datasets build bridges

Computer Vision
measurement techniques



Largest collection of AI datasets
with wild animals

Animal Behaviour
biological application



Imaging Hangar



Smartbarn-mocap
3D-POP
3D-MuPPET

Is there a starting kit?

- Use existing platforms which have dataset

kaggle



- Check out challenges organized for tasks

ZOONIVERSE

- Citizen science offer means to create dataset

Hugging Face

- Do not forget benchmarking with useful metrics

iNaturalist



 122,613,201
Observations to Date

[SIGN UP](#)  [EXPLORE](#) 



BJ Stacey ~ Shark Eye Snail from Essex County, Massachusetts, USA

Pl@ntNet



ONE PLANT

With the **Pl@ntNet** app, identify one plant from a picture, and be part of a citizen science project on plant biodiversity

Bird identification

Merlin®

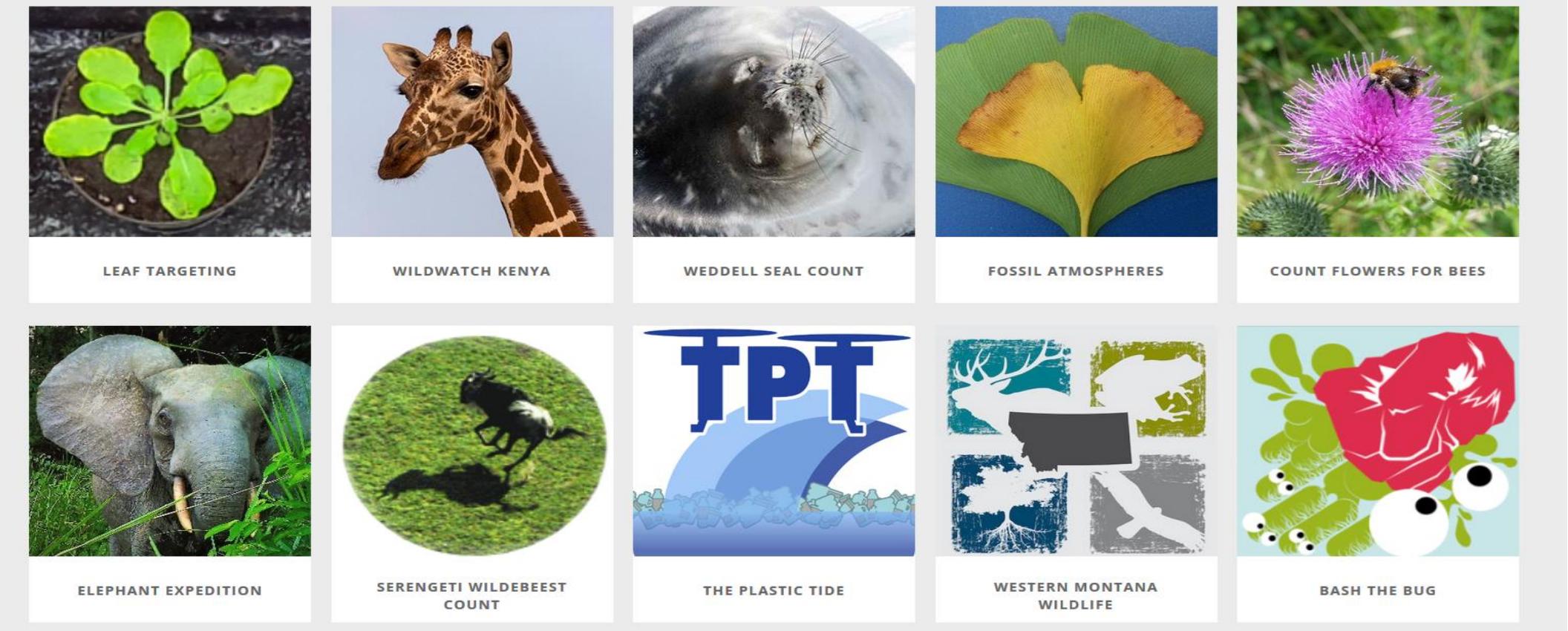
[Home](#) [The Story](#) [Bird Packs](#) [Help](#) [Download](#)

Identify the birds you see or
hear with Merlin Bird ID

Free global bird guide with photos,
sounds, maps, and more.



Zooniverse – Dataset using citizen science



Source : <https://www.zooniverse.org>

Take home message

- Plan on making datasets (and publish with CVPR, NeurIPS etc.)
- Follow a stepwise approach for making one
- Benchmark your methods with existing datasets
- Use task specific metrics that make sense for the task

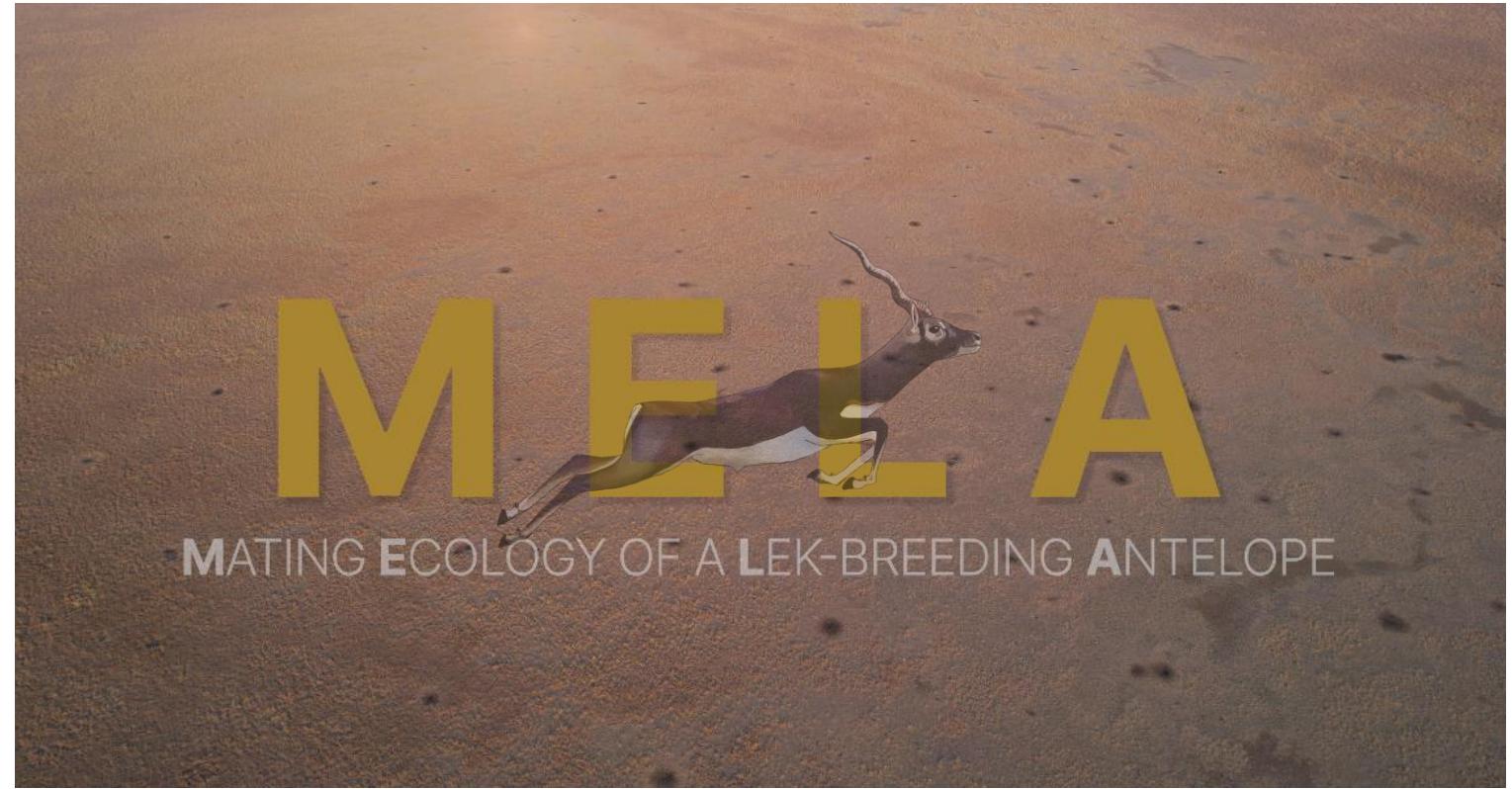
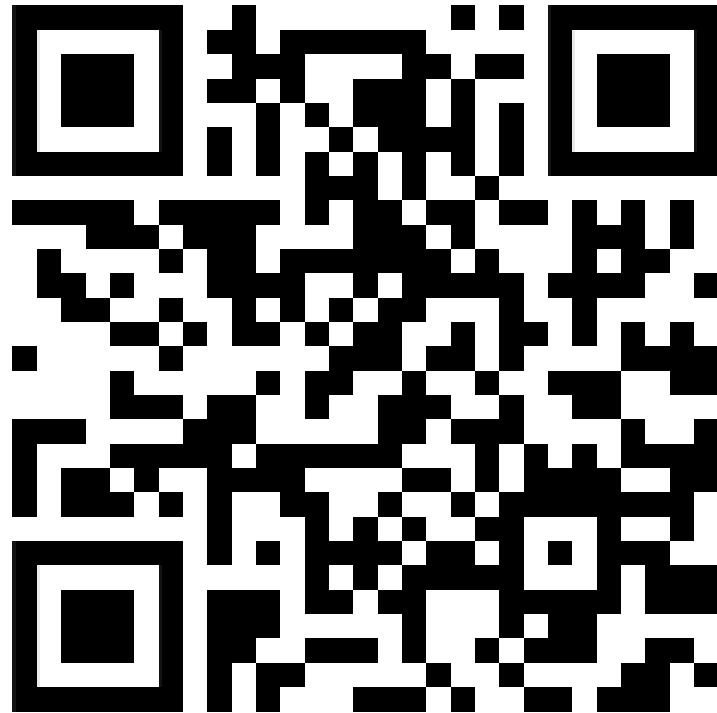


Mating
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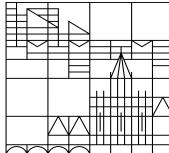


AVAILABLE NOW

A short documentary about project MELA.

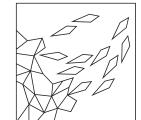


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of Collective Behaviour



AKADEMIE
SCHLOSS
SOLITUDE