

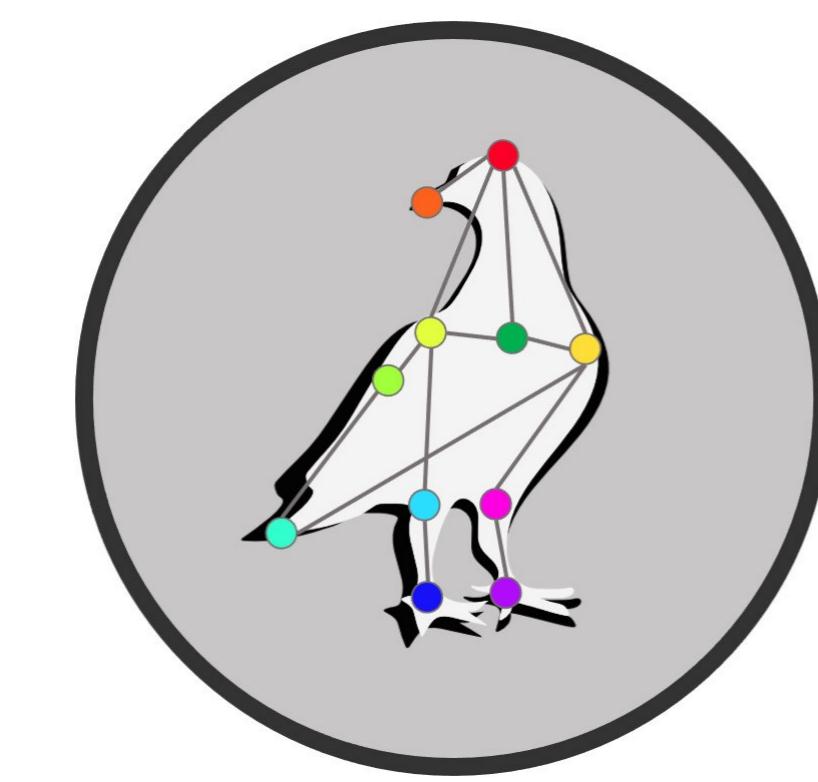
# PigeonPose: An integrated Pipeline for Markerless 3D Tracking of Pigeon Behavior

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## Introduction

Behavioral science, a multidisciplinary field spanning neuroscience, psychology, and ecology, aims to understand individual, collective, and social behaviors along with their neural and genetic correlates. Nevertheless, quantifying naturalistic behaviors remains challenging due to time-consuming manual methods that are prone to errors and inconsistencies.



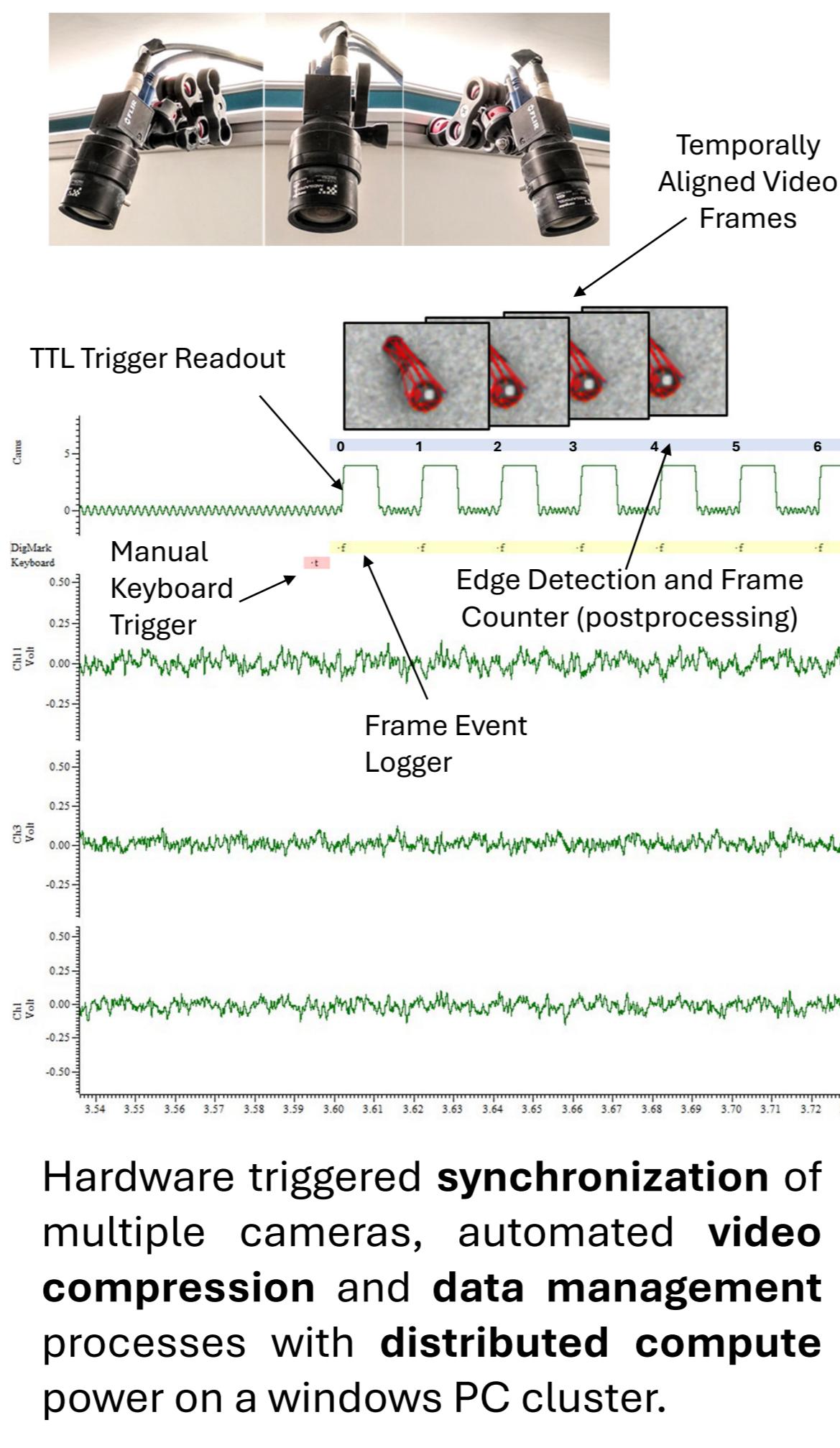
### MOTIONPYPE PYTHON PIPELINE FOR BEHAVIOR ANALYSIS

Integrating techniques from physics, computer science, and mathematics has improved this process, particularly in pose estimation. Several tools for pose estimation exist, but they have been mainly designed for standard animal models such as rodents and their adoption can be technically complex. However, given that birds are increasingly popular in neuroscientific research there is an obvious lack of analysis tools to detect unique avian behaviors such as head bobbing or flying.

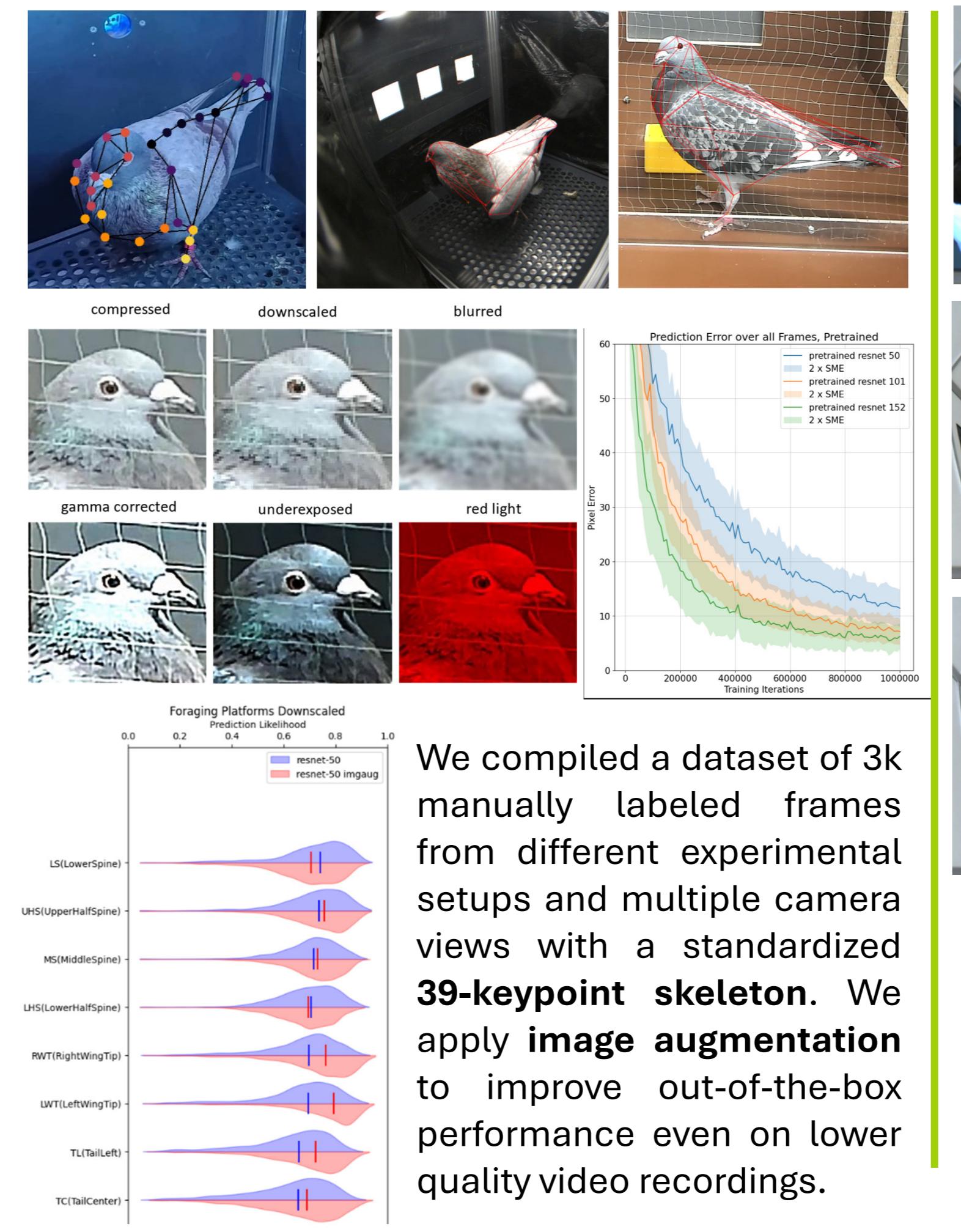
Here we address the above-mentioned challenges and provide a scalable solution for markerless 3D tracking during long recording sessions of up to 2 hours. Finally, we demonstrate the tracking results of single and multiple freely moving pigeons in an open field setup and in a restricted operant chamber. Our pipeline leverages DeepLabCut and Anipose for behavioral tracking and includes:

- a software toolkit for synchronizing multi-camera video capture with external hardware
- a Python module for data compression, analysis, triangulation, and behavior analysis
- a large labeled dataset for pigeon tracking and pre-trained models with robust out-of-the-box performance

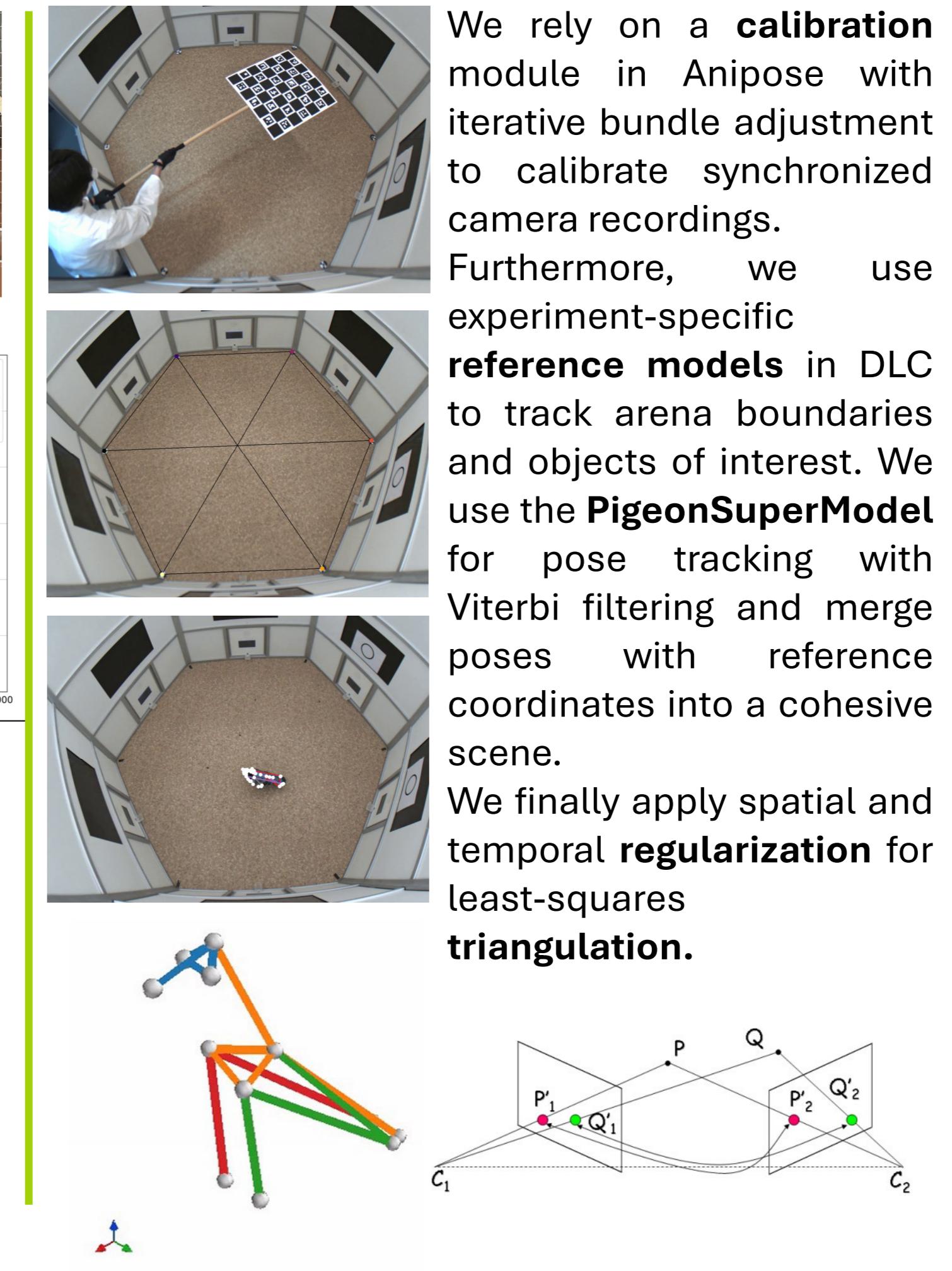
## Synchronized Recording



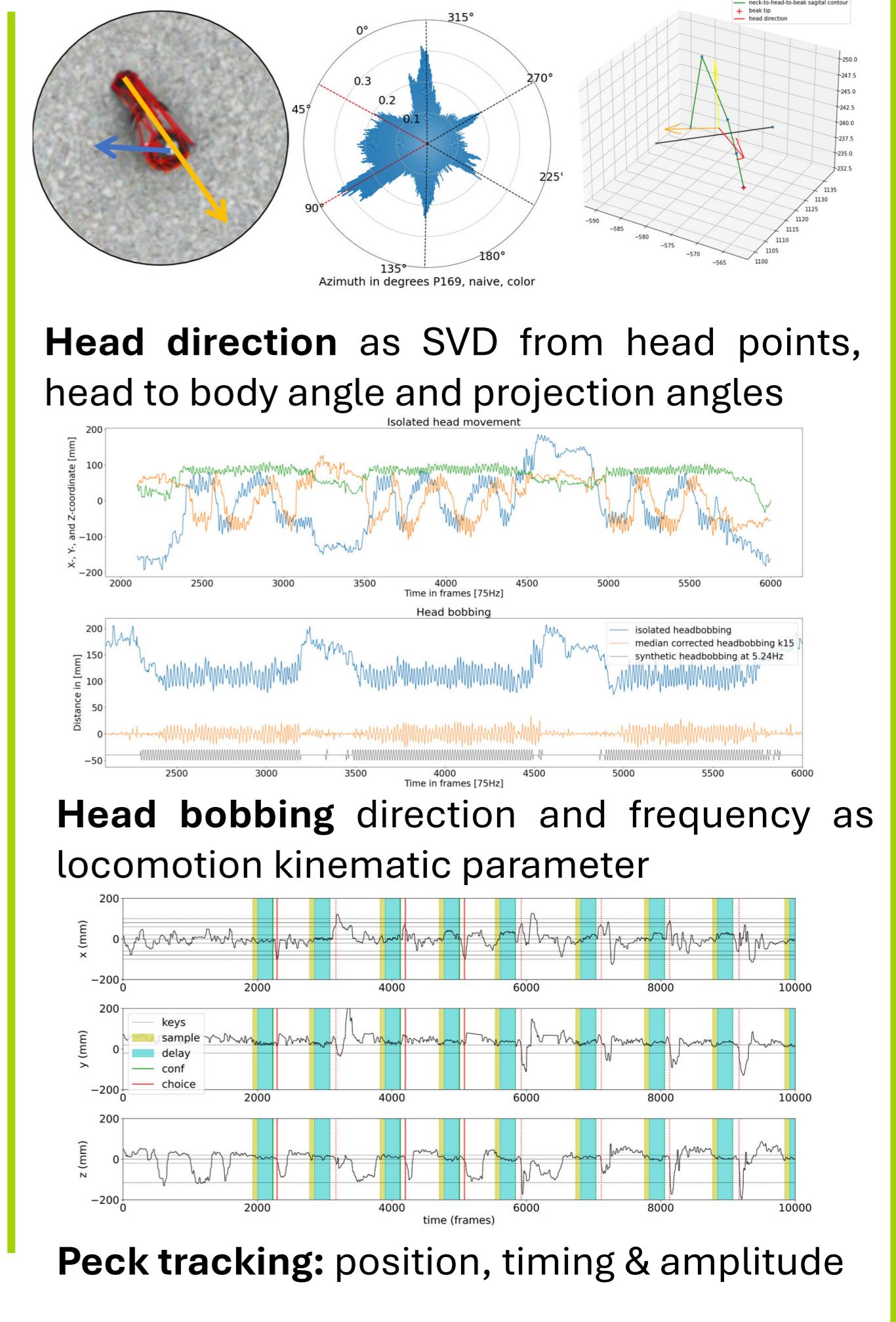
## PigeonSuperModel with DeepLabCut



## Triangulation with Anipose

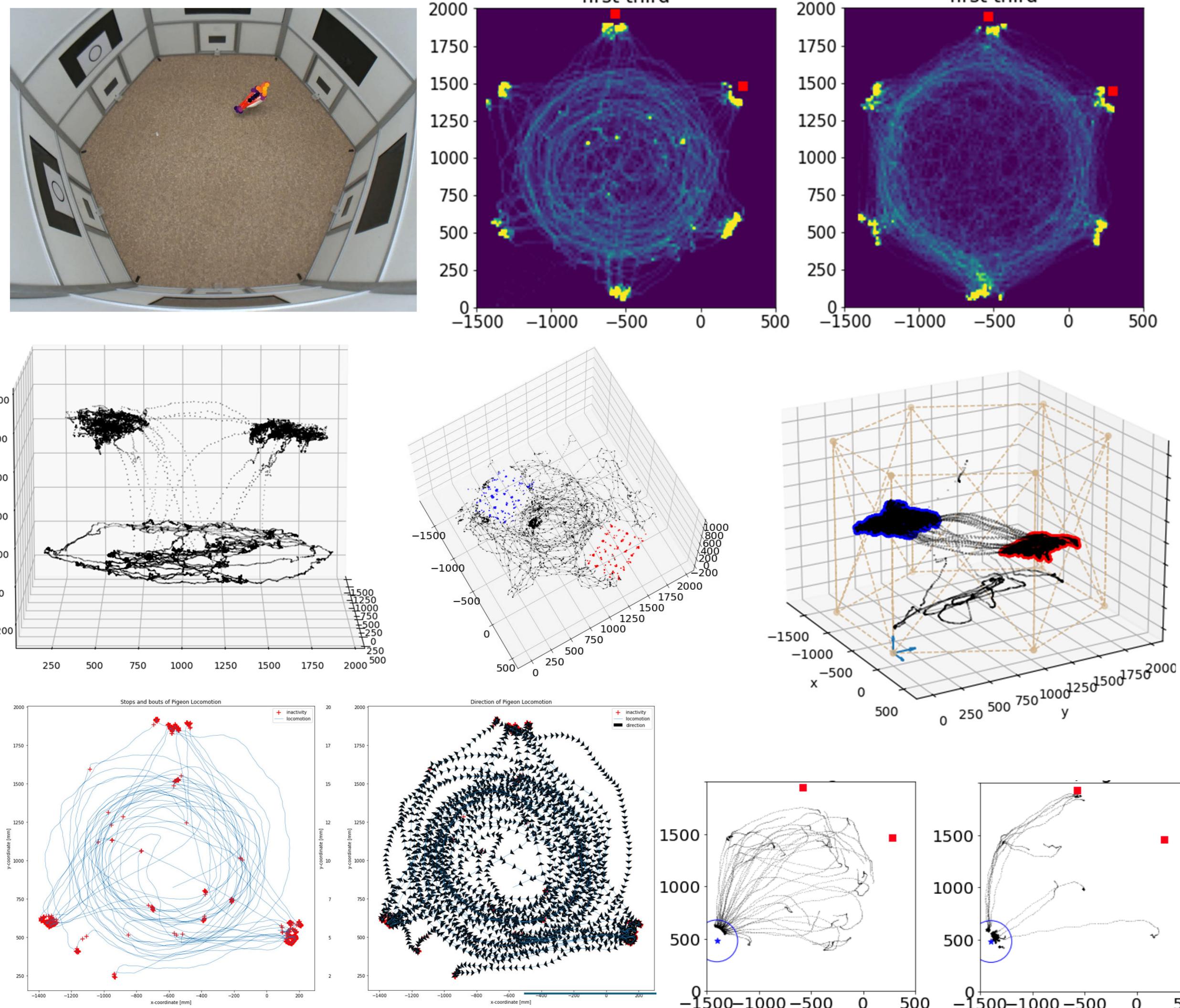


## Behavior Analysis



## Results

### Arena Tracking Setup



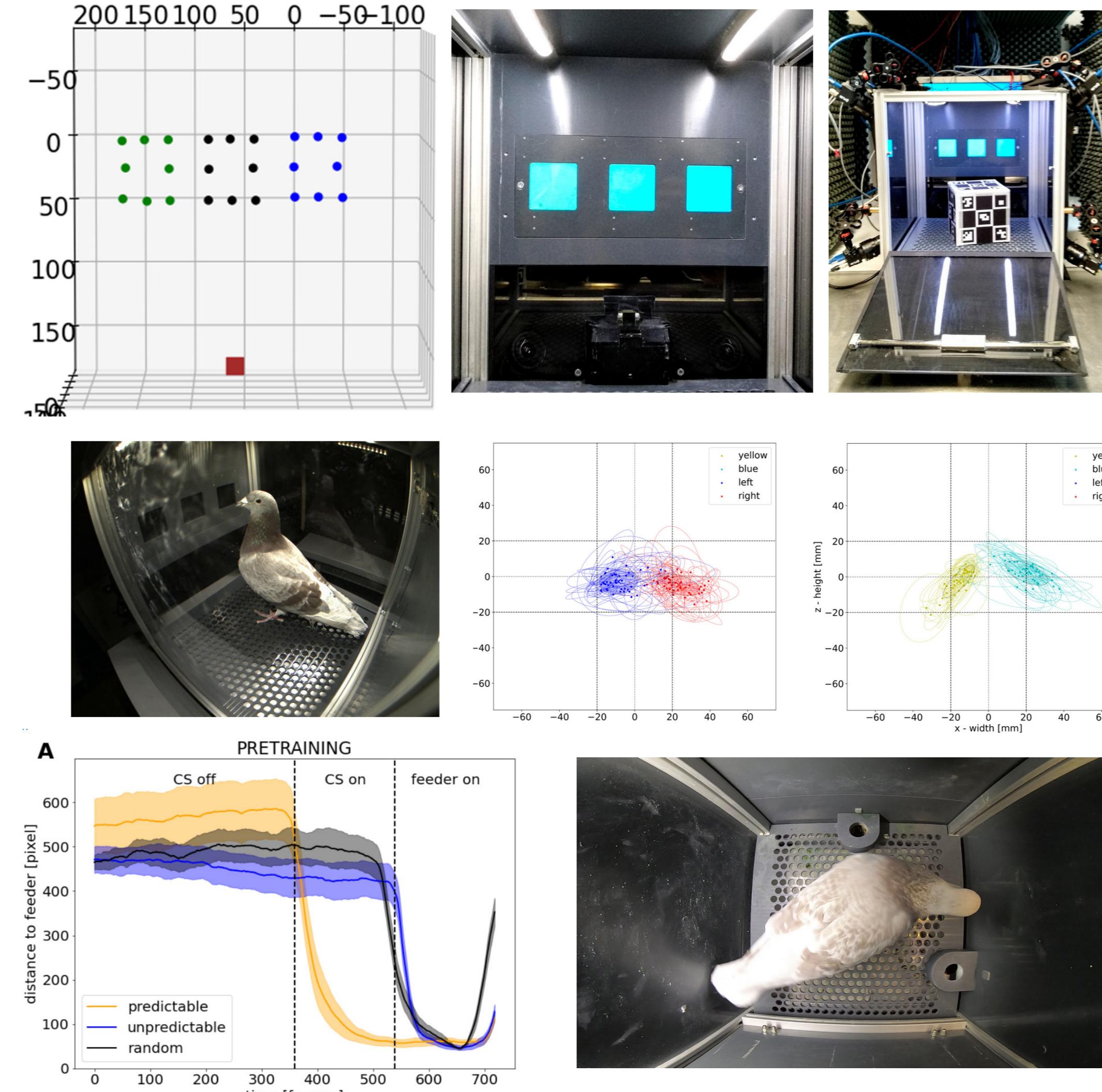
The pipeline was tested in multiple experiments both in large space setups (left) and in operant chambers (right). Video recording with up to 8 cameras resulted in a considerable compute load in compression, analysis and triangulation, but multiple views reduced triangulation error considerably.

We analyze pigeons' walking path and flight trajectory between feeders to investigate spatial memory, as well as optimal foraging decisions between food patches, see left panel.

In smaller spaces, pigeons' pose and pecking behavior is predictive for upcoming choices and anticipatory behavior, both in a working memory task and classical conditioning experiments.

The PigeonSuperModel performed very well across different experiments, animals and viewpoints, as well as on video data from new experiments and other labs.

### Operant Chamber Setup

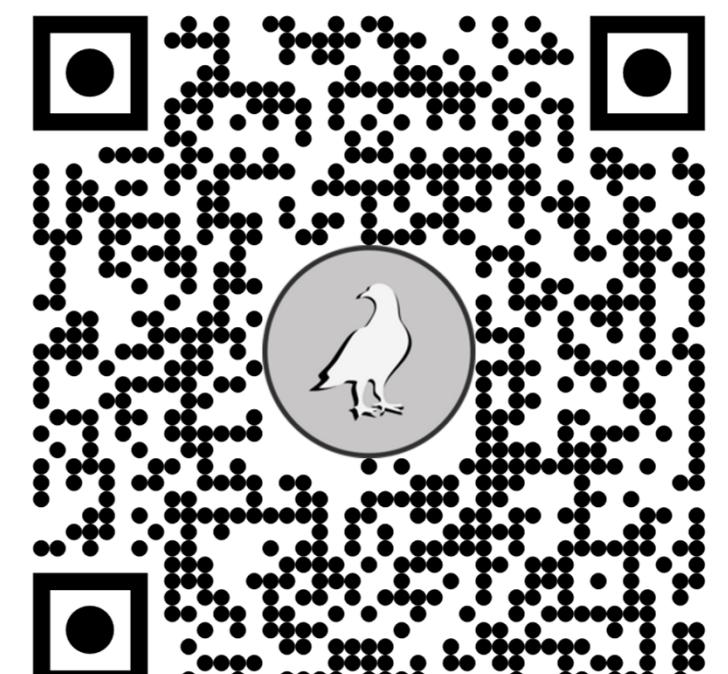


## Data Availability

Check our GitHub Repository or get in touch for details and download instructions:

- start with our **hardware recommendations** on how to set up your own 3D Tracking arena
- use **SyncFlir** for synchronized video recording in C++
- download our **labeled dataset** and **PigeonSuperModel** for single- and multi-pigeon tracking
- check our **MotionPype** library in Python as wrapper for 3D video tracking using DLC and Anipose
- go through our commented **Python Notebooks** for step-by-step guides

## GitHub



## References

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