Defining behaviour mathematically: Using DeepLabCut to create an automated scoring system for the study of complex social behaviours

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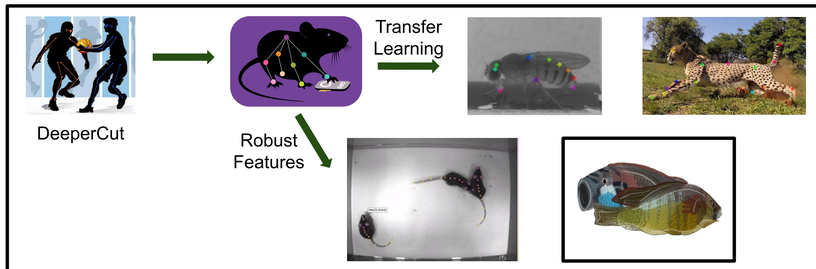
My Automated Scoring Roadmap

Videos → ***DeepLabCut*** → ***Data*** → ***Vectors*** → **YOU ARE HERE** ***Vector Calculations*** → ***Define Behaviour*** → ***Analyze Behaviours***

Why Automate?

- Behaviour scoring is a very time-intensive process, particularly when making repeated observations
- Machine learning has made automated scoring easier and more common, but scoring complex social behaviours remains difficult[1]
  - Number of individuals, obscure behavioural cues complicate the process
- **Here, we detail the construction of an automated scoring protocol using DeepLabCut - a machine learning algorithm - as a first step in the pipeline**

DeepLabCut Overview



- DeepLabCut has not been used for the animal model *A. burtoni*
- Most fish behaviour research using DeepLabCut has focused on shoaling
  - ***No automated scoring system has been constructed to estimate complex social behaviours in fish***

A. burtoni: A Model Organism for Social Behaviour



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References: **1.** Insafutdinov, E. et al. *European Conference on Computer Vision* (2016). **2.** Nath, T. et al. *Nature Protocols* (2019). **3.** Lauer, J. et al. *Nature Methods* (2022). **4.** Munley & Alward, *Molecular Psychology* (2025).



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Automated Scoring Progress

Videos to Point-Estimation

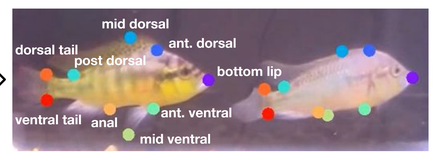
Step 1: Video tape your behavioural trial



Step 2: Feed video to DeepLabCut



Step 3: Label frames of interest

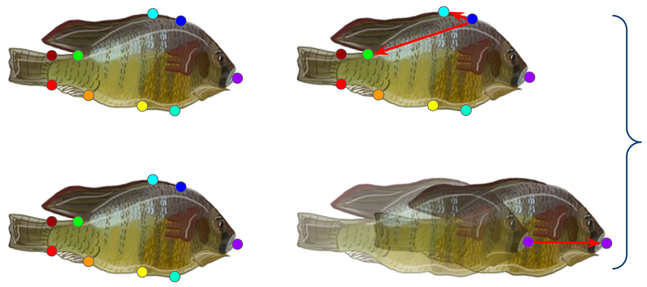


Point-estimate dataset!

Fish1	Fish1	Fish1	Fish1	Fish1	Fish1
antdorsal	antdorsal	antdorsal	middorsal	middorsal	middorsal
x	y	likelihood	x	y	likelihood
772.503	849.949	0.659	791.559	835.767	0.991
772.508	849.949	0.7	791.804	835.771	0.992
772.528	849.989	0.7	791.811	835.771	0.992

Step 4: Labeled frames used for algorithm training (iterate until error levels out)

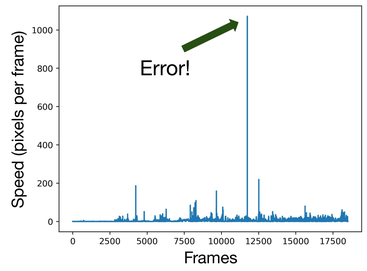
Working with Vectors



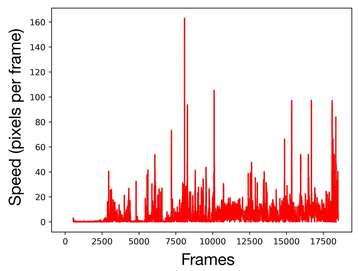
Calculations

- Direction fish is facing
- Velocity and acceleration
- Angle between vectors

Fish 1 (Suppressor)



Fish 2 (Focal)



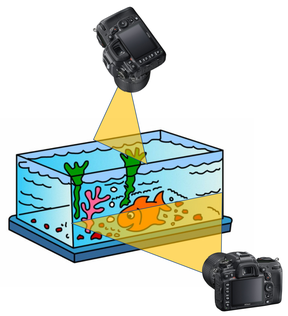
Next Steps

Troubleshooting

- Completing *and validating* vector calculations
- Clean and extrapolate output
  - Dealing with low confidence and missing data

Improve the model

- Pilot study very soon!
  - Longer videos (10 minutes vs. 30 minutes)
  - Improved camera
  - 3D point estimation!



Neuroendocrine mechanisms of individuality in subordinate behaviour

- Male *A. burtoni* will be housed the same tank, separated by a divider
- Focal dominant males will undergo repeated social defeat once daily for up to 7 days in a row
- **Each focal male will have seven 30-minute videos to be scored, resulting in around 180 hours of scoring!**
  - ***It would be a lifesaver if we could automate this step!***

