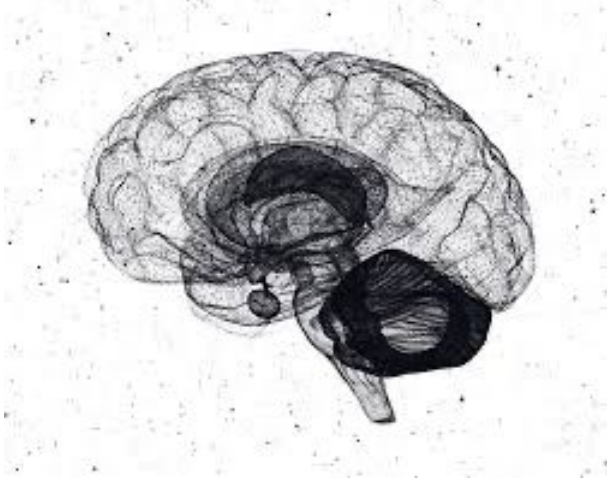
DD2430 Final presentation

Group 10 - Project 14

Introduction

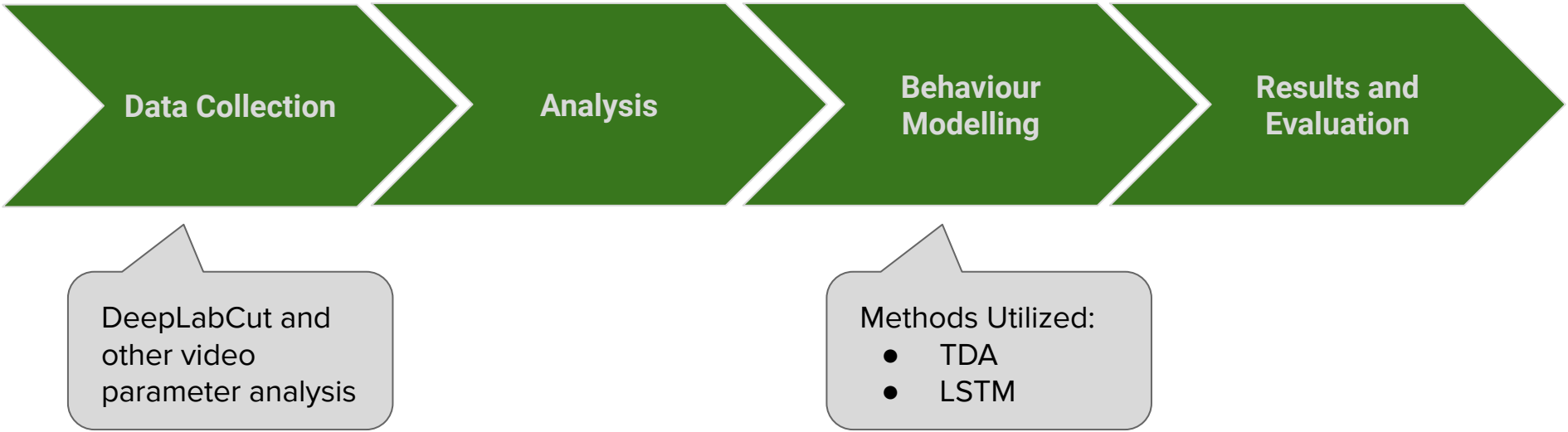
- Self-grooming behavior
- The study of behavior is essential for the understanding of the brain
- Mice serve as models for us humans
- Computer vision framework for behavior analysis
- In collaboration with Fisone laboratory at Karolinska Institutet



Problem Description

- Detection, tracking and quantification of mice self-grooming behavior
- DeepLabCut for pose-estimation extraction given video input
- Model self-grooming behavior through pose-estimates using machine learning/statistical models

Implementation Steps



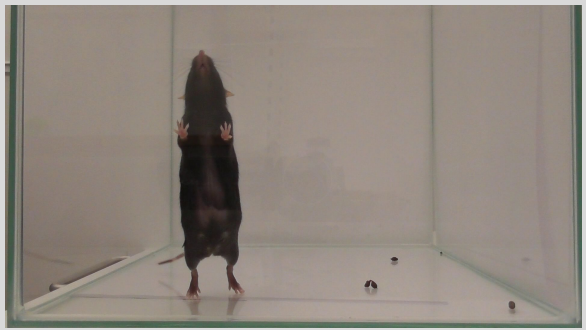
Data Collection Pipeline

Record Raw Videos

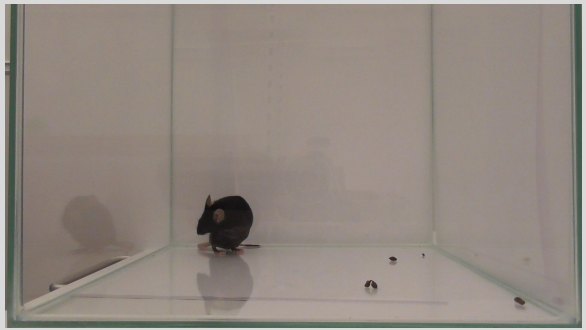
Data Collection Pipeline

Record Raw Videos

Extract General Behaviour Frames



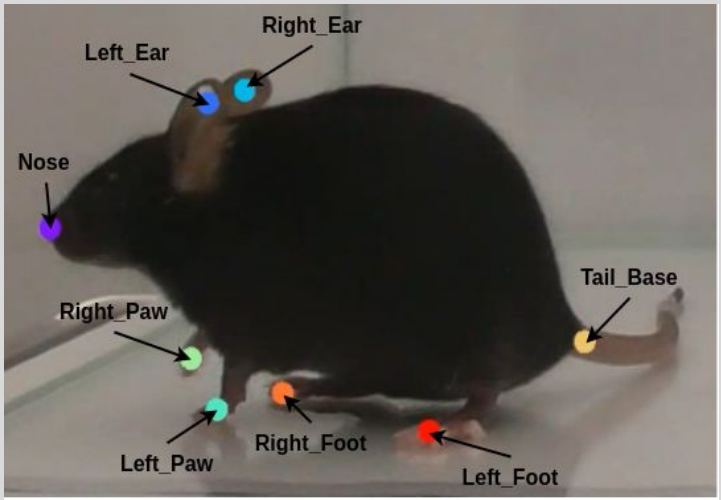
Rearing



Grooming

Data Collection Pipeline

Record Raw Videos



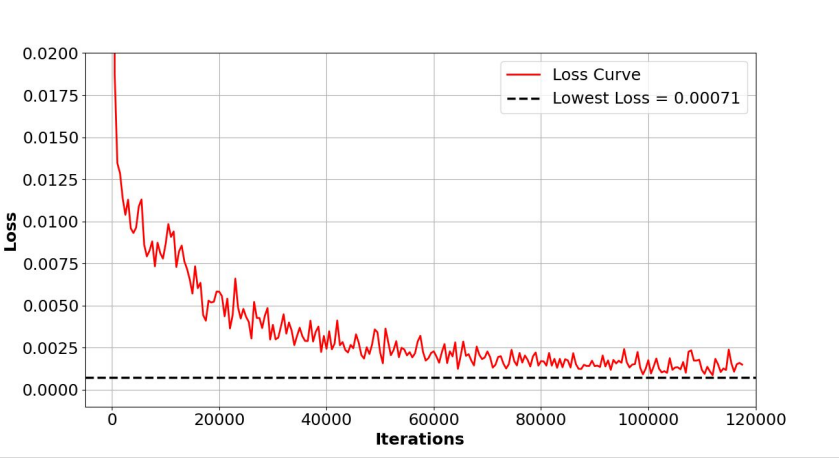
- Dataset with 400 labelled frames in total

Data Collection Pipeline

Record Raw Videos

Extract General Behaviour Frames

Select and Train DLC Model

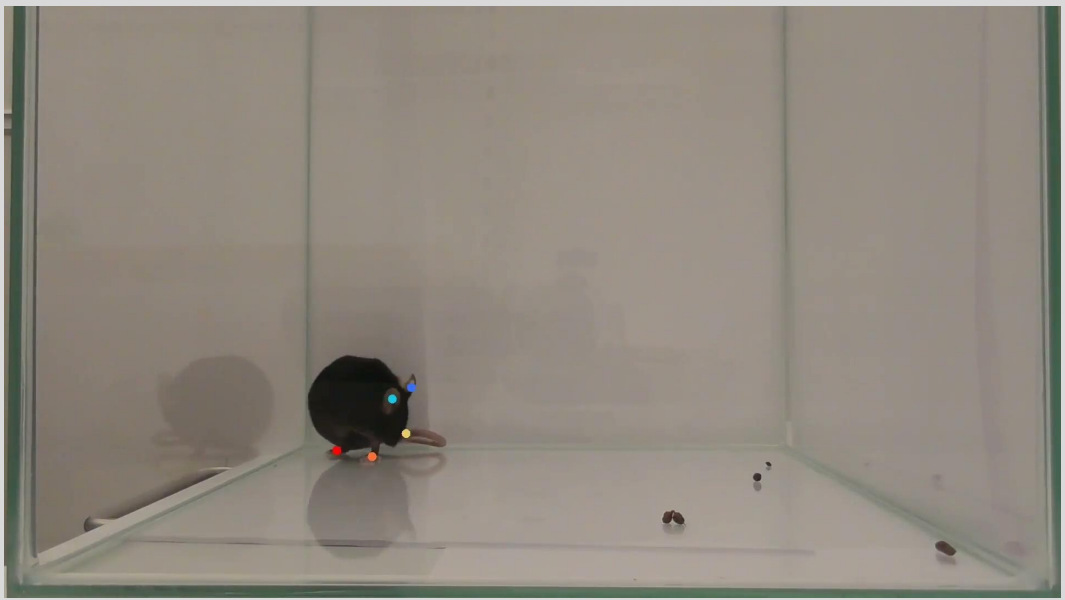


DLC Training

Select Pretrained Network

- ResNet 101
- ResNet 50

Data Collection Pipeline



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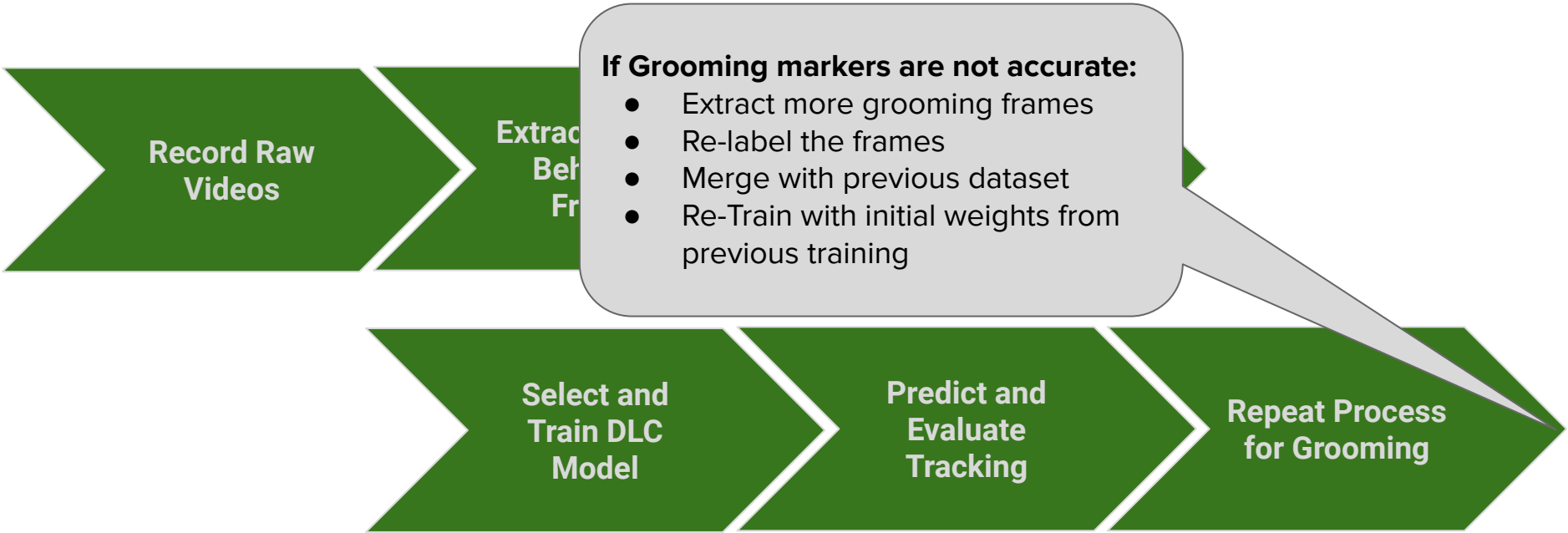
Data Collection Pipeline

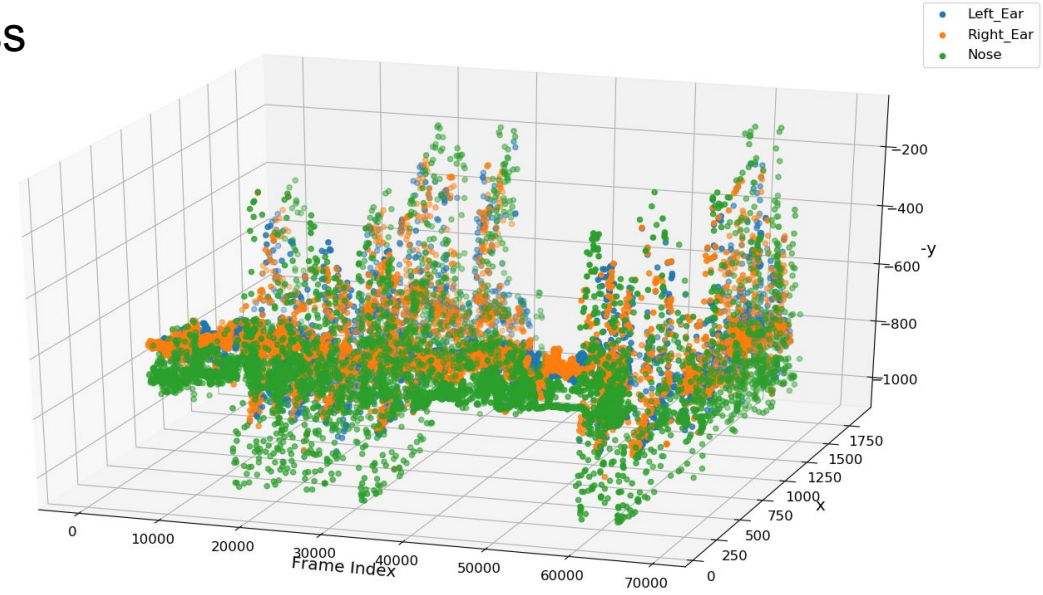


Data

- Video
  - Resolution: 1920 x 1080
  - 50 FPS
  - Recorded for the same Mouse
  - Around 3 hrs of recording, i.e 540,000 frames
  - DLC trained for 120,0000 iterations, which took around 15-16 hours
- Information contained in each predicted marker
  - Bodypart id
  - Frame id
  - Position in frame: *(x,y)*
  - Likelihood of prediction
- For example:
  - For a video with *N* number of frames
  - Given that, 8 body parts are tracked
  - We obtain, *(N x 3) x 8* unique marker points

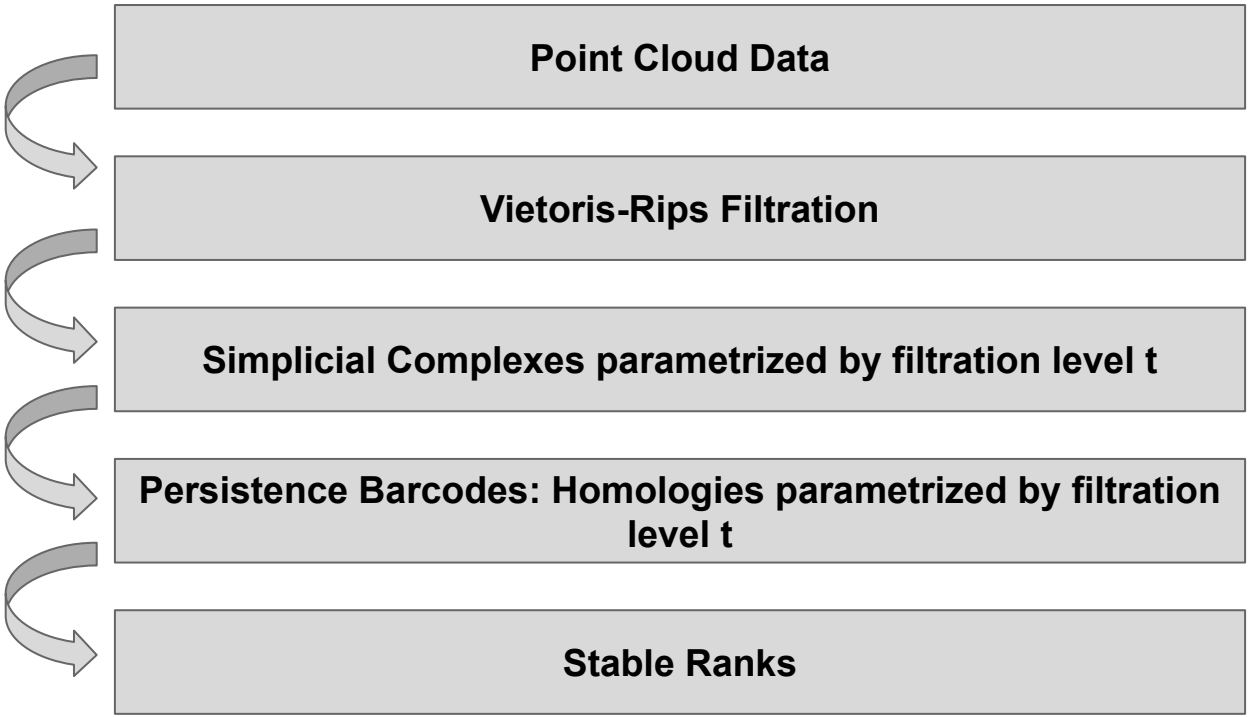
Observed Trends

- Grooming behaviour is much less frequent as compared to other behaviours
- Mouse mostly grooms in one corner of the cage
- Distinct point clusters, corresponding to motion and stationary behaviours

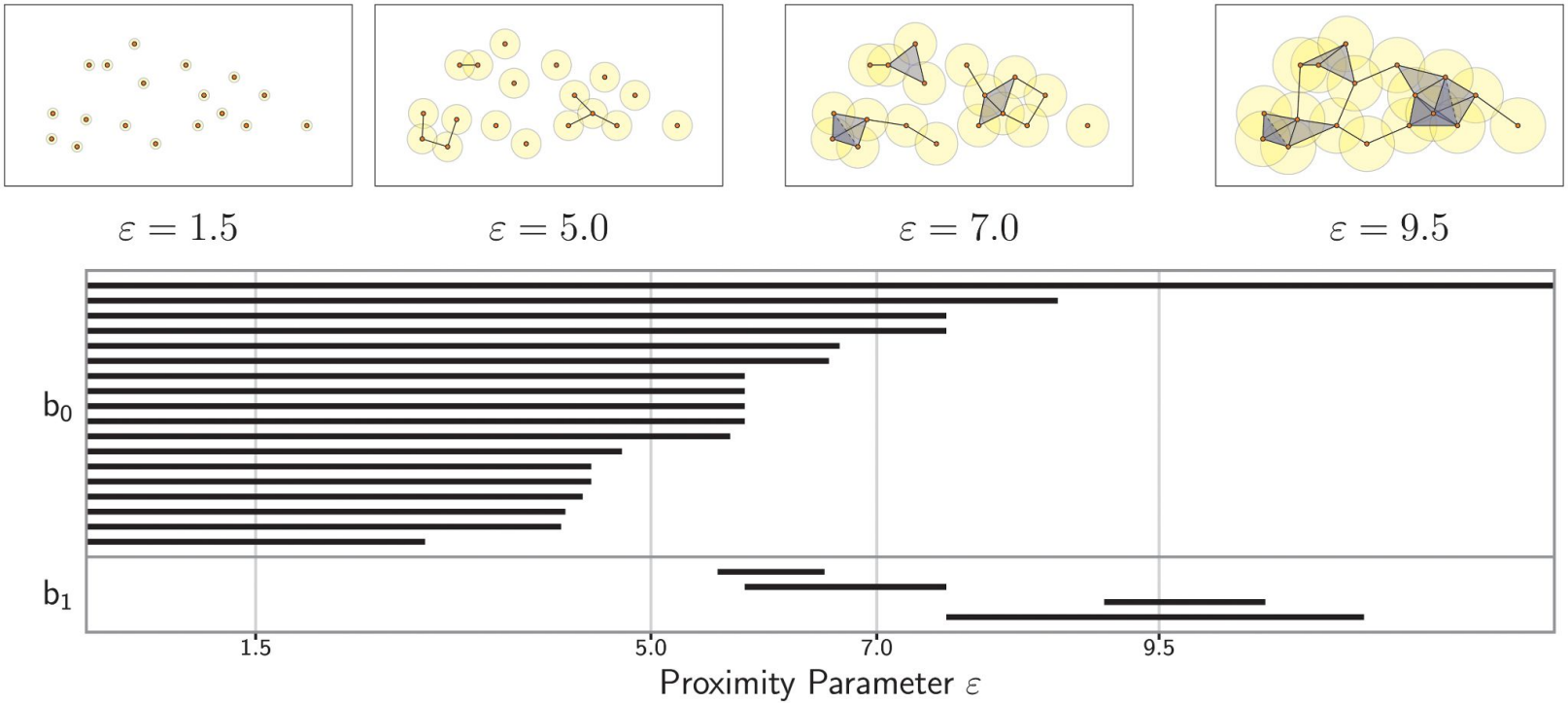


Trajectories

TDA Based Model - Persistent Homology



Persistence Barcodes Illustration



doi: https://doi.org/10.1371/journal.pone.0126383.g004

Model Setting - Stable Ranks Computation

- Sliding window of size 2 seconds (100 frames) with 1 second overlap
- Each sliding window: a point cloud of 16 points in 100 dimensional space
- Pairwise distances measured by correlation metric

$$d(x, y) = 1 - \frac{x_c \cdot y_c}{\|x_c\| \|y_c\|}$$

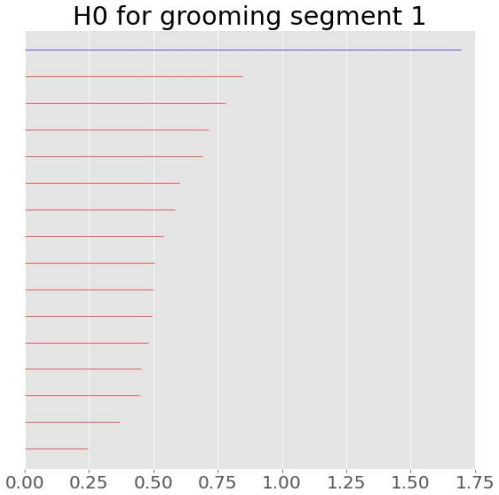
A modified correlation metric with '+' sign to replace '-' is also tested

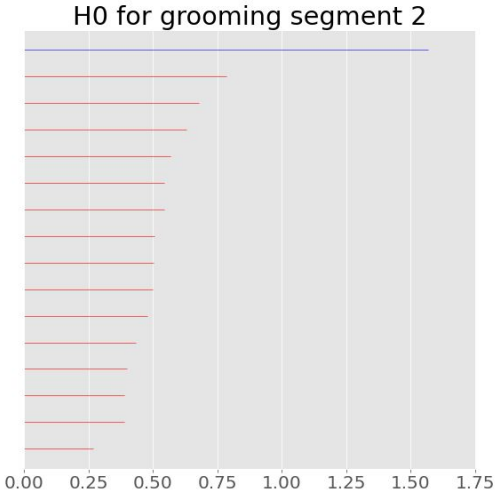
- Stable ranks for barcodes $\{(a_i < b_i) | i = 1, ..., r\}$

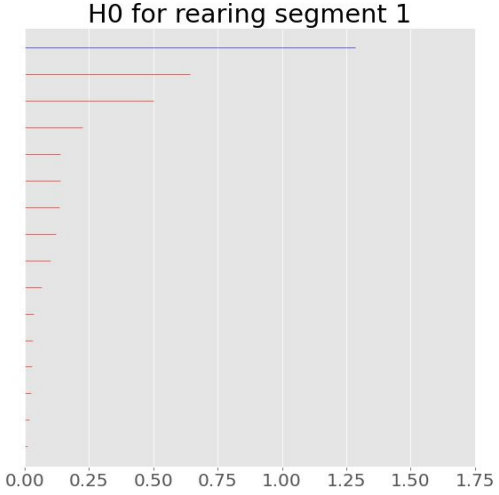
$$\widehat{\text{rank}}(t) = \{\text{number of bars s.t. } b_i - a_i \geq t\}$$

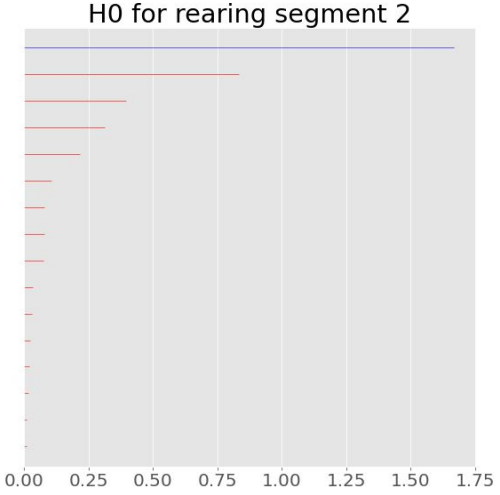
- H0 Homology is considered

Illustration of Behaviour Segment Signature









Model Setting - Classifiers

SVM with homology stable rank kernel, balanced class weights

homology stable rank kernel definition (Frontiers in Applied Mathematics and Statistics, 2021):

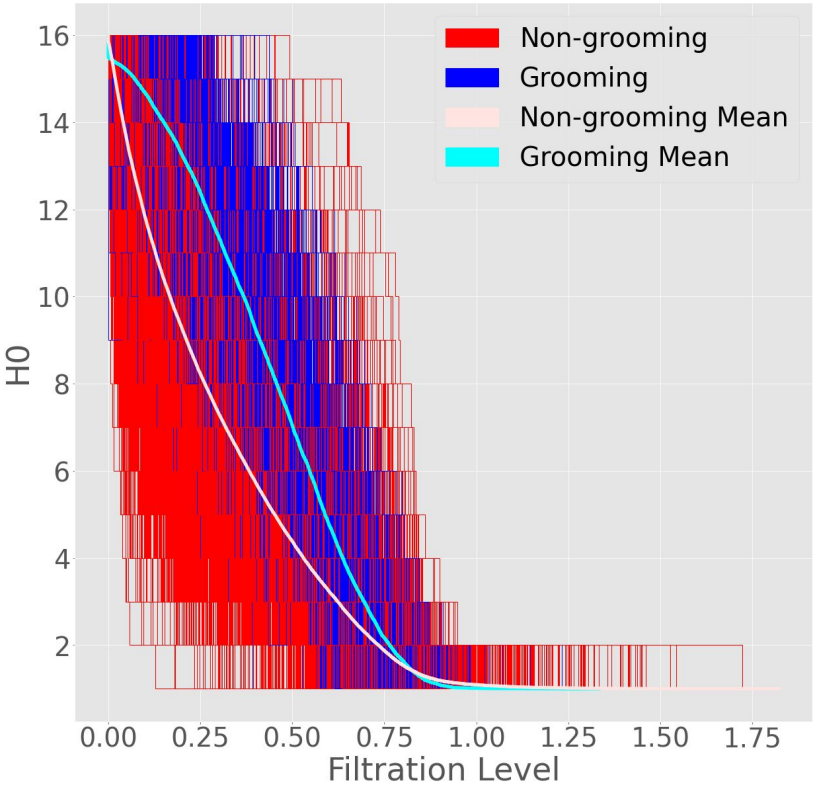
$$K_d(X,Y) = \int_0^\infty \widehat{\mathrm{rank}}_d(X)\widehat{\mathrm{rank}}_d(Y)dt$$

k-Nearest Neighbours with interleaving distances, subsampling equal size of grooming & non-grooming

Interleaving distances definition:

$$d_{\bowtie}(f,g) = \inf\{v | f(x) \geq g(x+v) \text{ and } g(x) \geq f(x+v) \text{ for any } x\}$$

Best Results



9-NN on ARIMA filtered trajectories, default correlation metric

	Train	Validation	Test
f1 Grooming	0.83	0.50	0.48
f1 Non-grooming	0.83	0.79	0.90
Weighted Average Accuracy	0.83	0.73	0.86

Findings, Limitations and Future Work

- Grooming precision is low due to large FP (false positives)
- kNN performs better than SVM
- Pairwise correlations are variant to motion directions
- In future: designing a new coordinate system for mouse which captures angle invariance and reflexivity

LSTM-Based Model

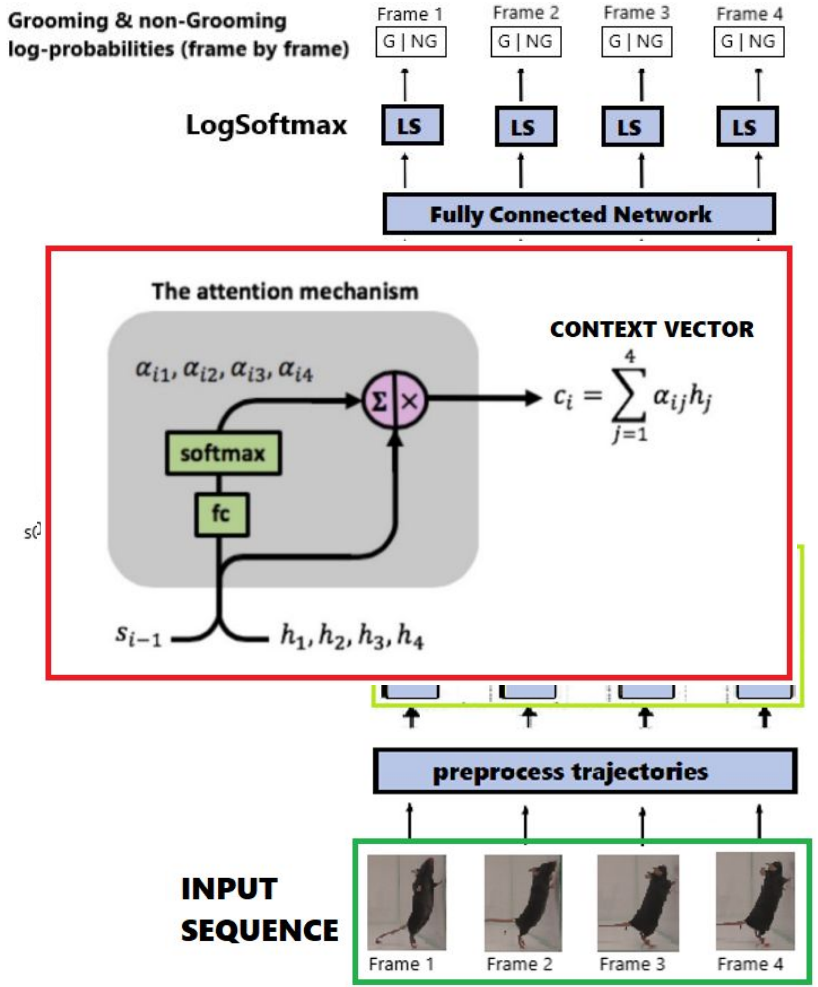
Many to many network.

The network is composed of the following blocks:

1. Pre-processing block;
2. Bidirectional LSTM encoder;
3. Attention mechanism;
4. Unidirectional LSTM decoder;
5. Fully Connected Network + LogSoftmax.

For simplicity, we only tuned the following:

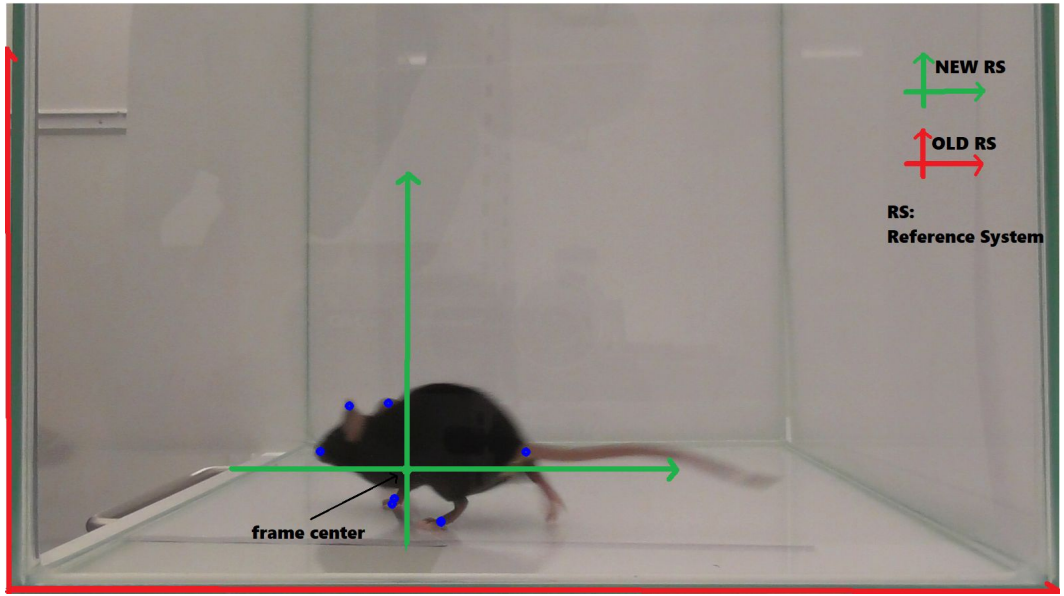
- Pre-processing technique
- Sequence length



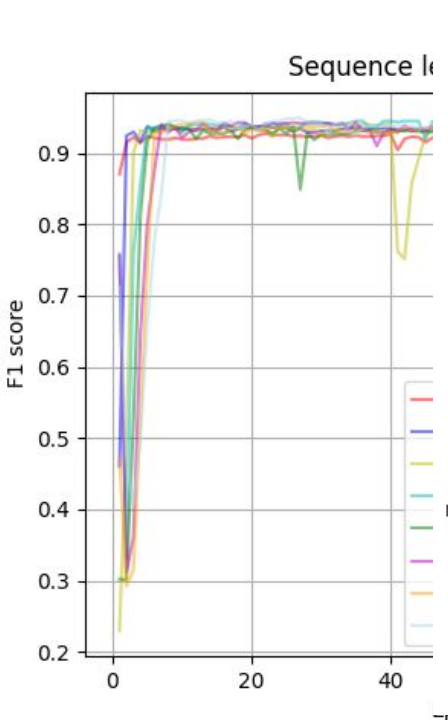
Pre-processing Techniques

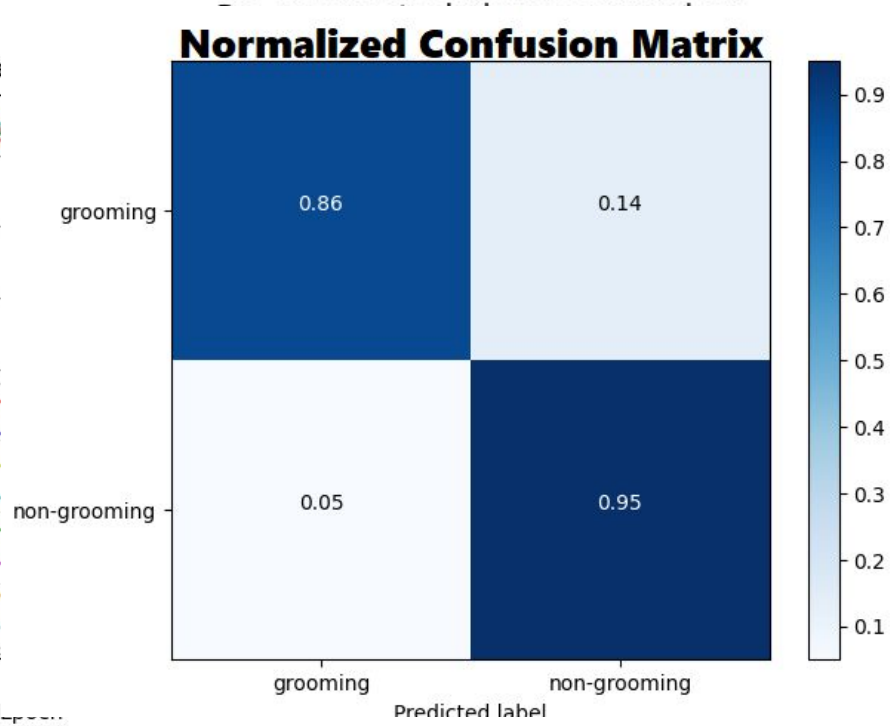
Three distinct techniques have been evaluated:

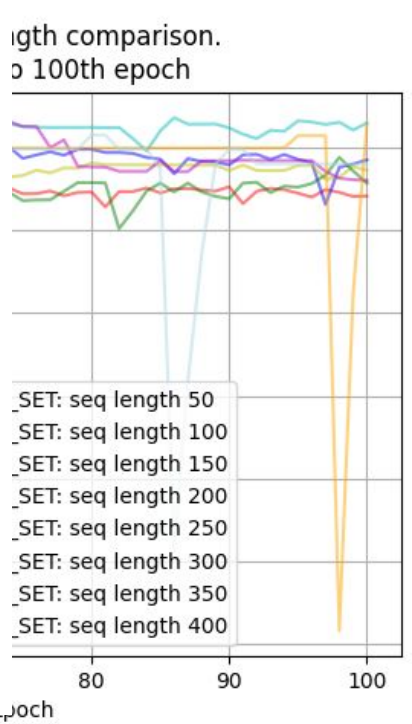
- Recentering with respect to frame center (see image);
- **Recentering with respect to sequence center**;
- Normalization



LSTM - Evaluation and Test







Behaviour Prediction Example

With LSTM

With TDA

Conclusion

Results

- Moderate accuracy in separation of grooming and non-grooming behaviors

Future work

- Robustness and generalizability
- Different experimental settings

Challenges

- Low quality mice recordings