



# DeepLabCut:

a software package for  
animal pose estimation



Mackenzie Mathis, PhD  
Assistant Professor, EPFL



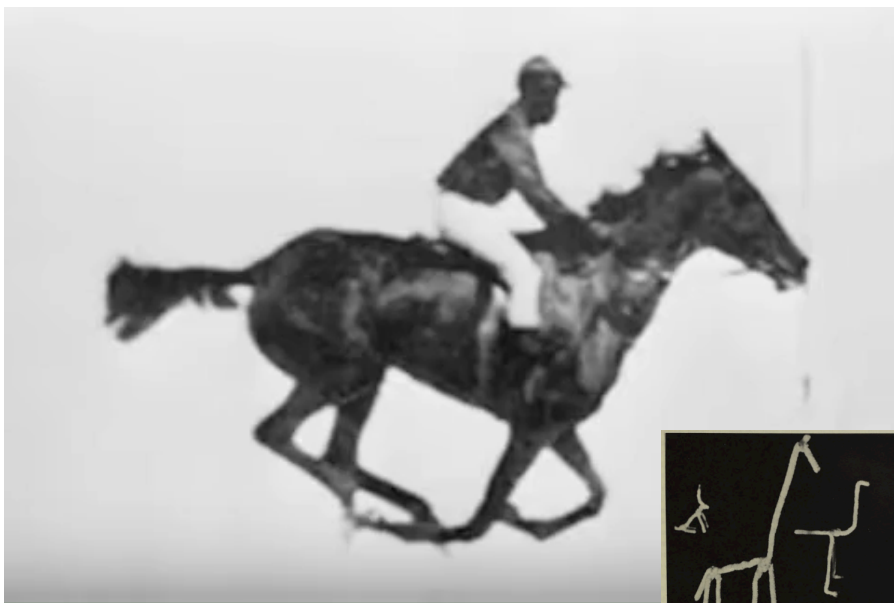
Alexander Mathis, PhD  
Assistant Professor, EPFL



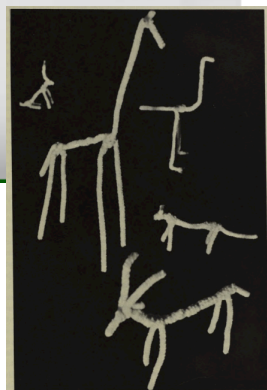
Jessy Lauer, PhD  
CZI DLC Fellow

measuring movement with deep learning

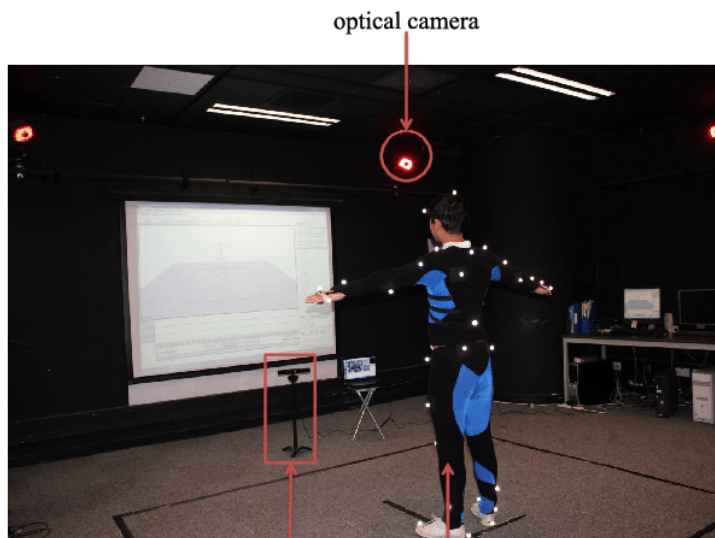
# Measuring movement



E. Muybridge, 1887 (zoopraxiscope)

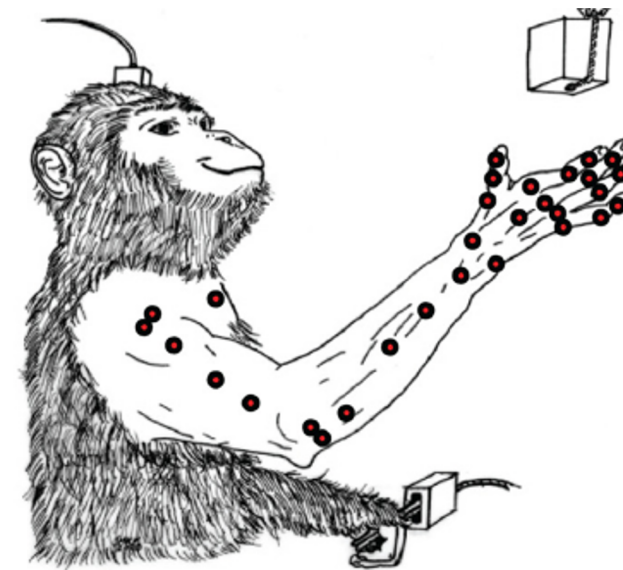


Marr, 1976



optical camera  
Kinect  
tight suit with reflective markers

Liu et al, 2015



Vargas-Irwin et al. 2010

# Deep learning for human pose estimation



MoDeep – *starting 2014*

DeepPose

Conv. PoseMachines

...

**DeeperCut**

**OpenPose**

...

*> 6,000 papers on human pose estimation with Deep Learning*

deep neural networks

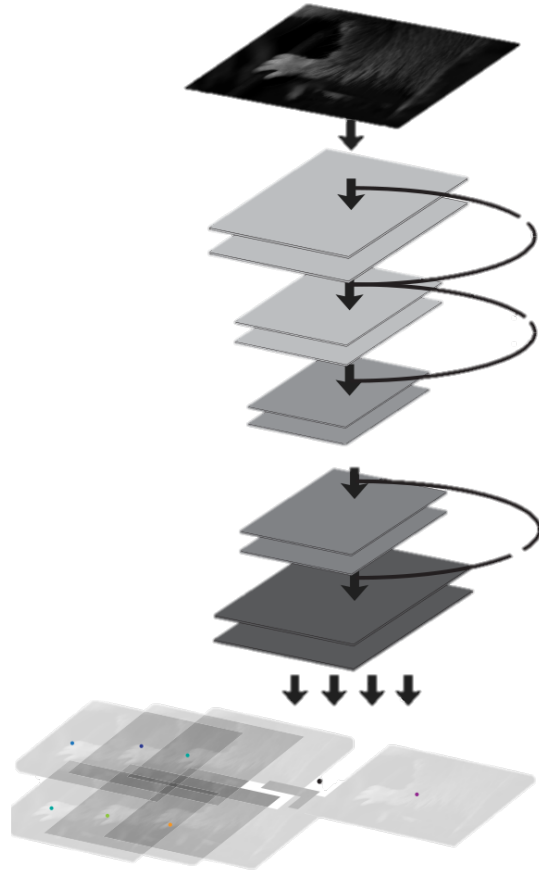
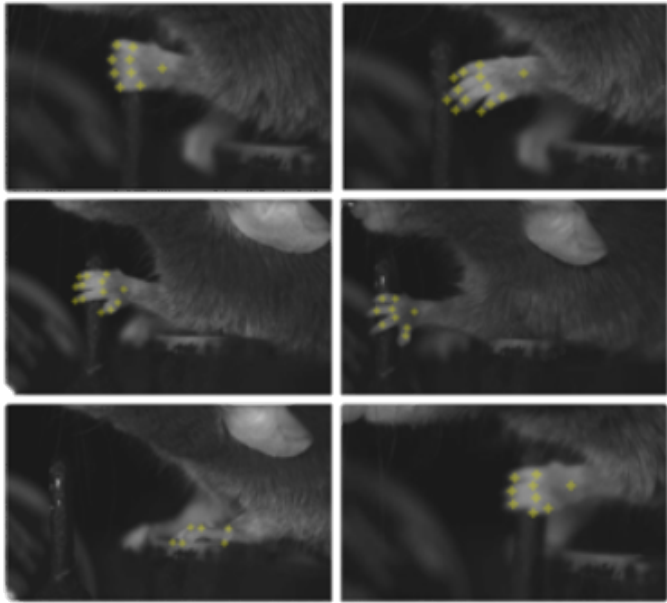
image → **Predictor** → pose

**train**

**A lot of labeled images (>10<sup>6</sup> joints!)**

# DeepLabCut: a toolbox for efficient markerless pose estimation

Labeled training data



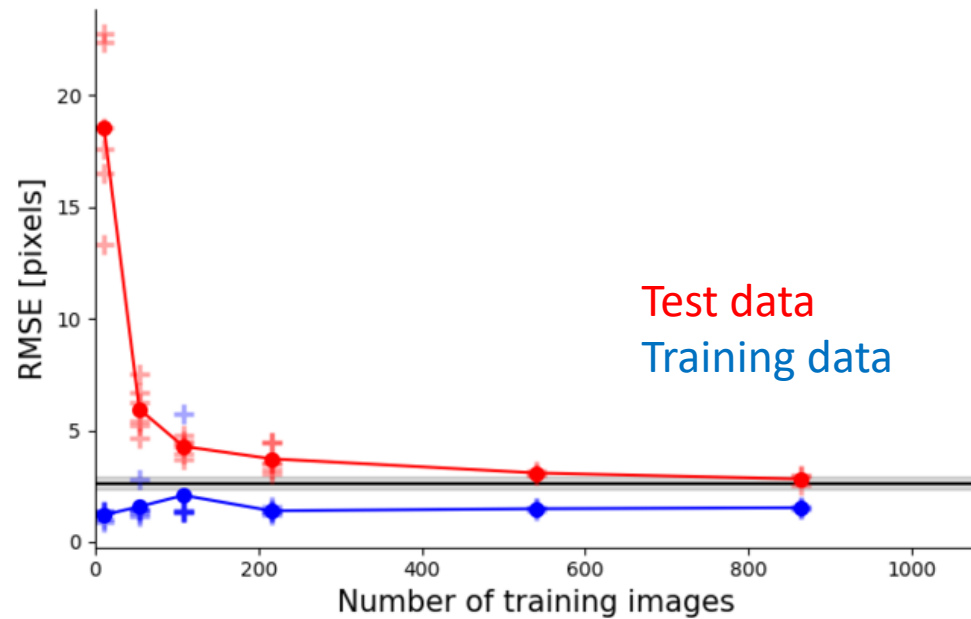
141 training images used (other mice)



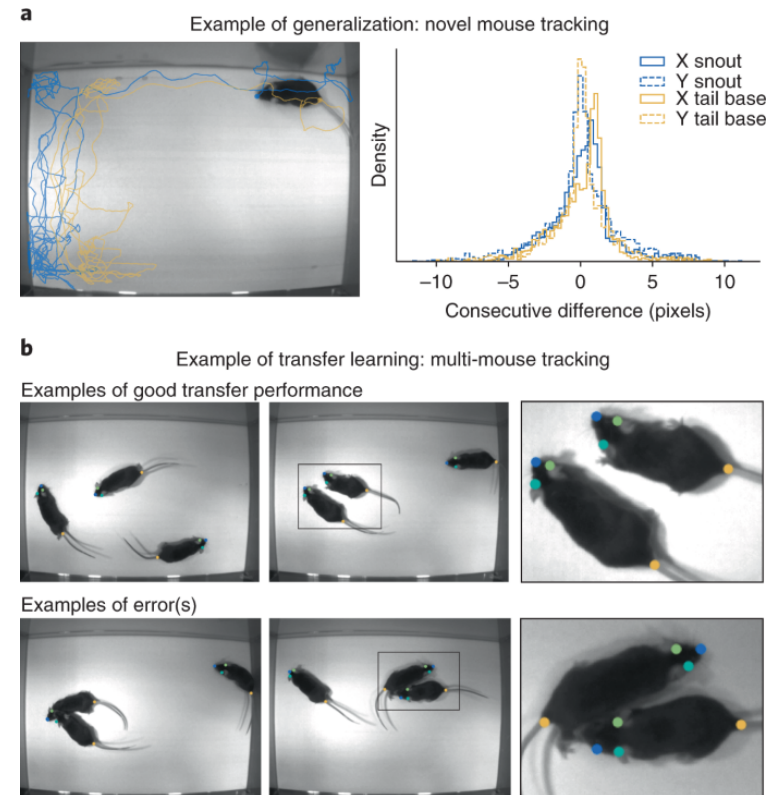
A. Mathis .... M.W. Mathis\* and Bethge\*  
Nature Neurosci, 2018  
Inspired by: Insafutdinov et al, DeeperCut 2016

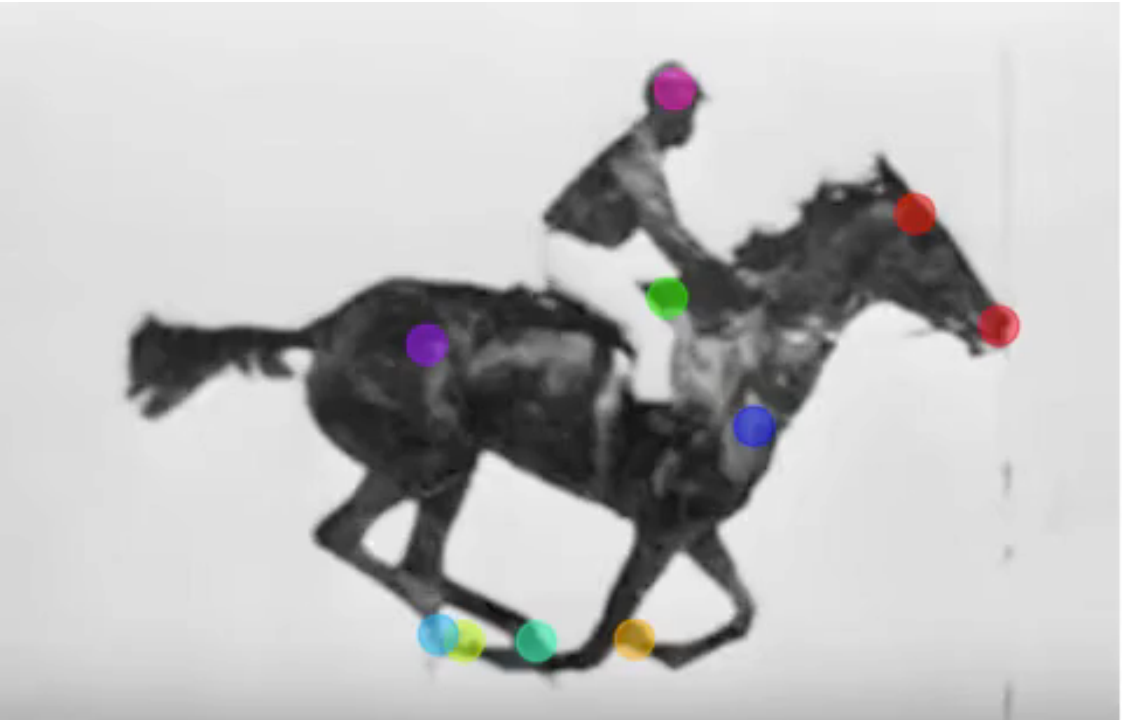
# DeepLabCut: a toolbox for efficient markerless pose estimation

A small amount of training data is required to match human-level performance

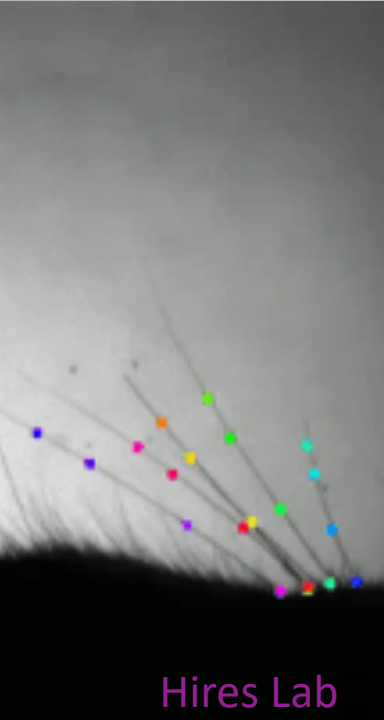


This trained network can generalize to new animals

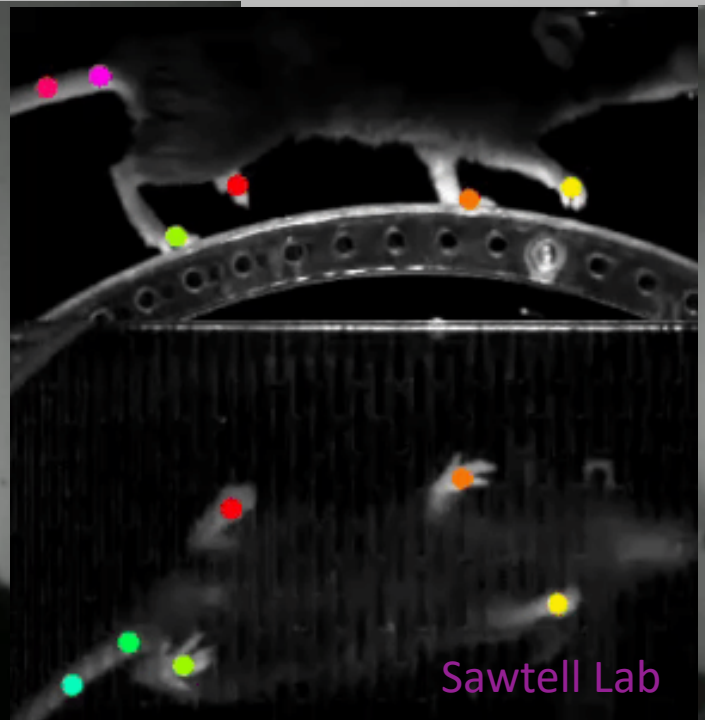




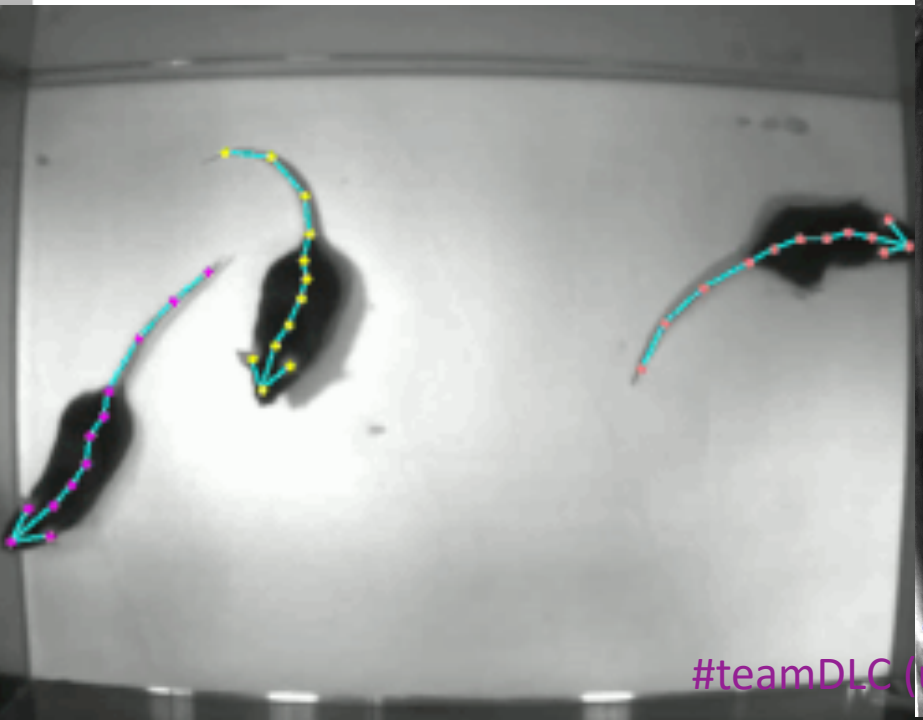
Nath et al, 2019



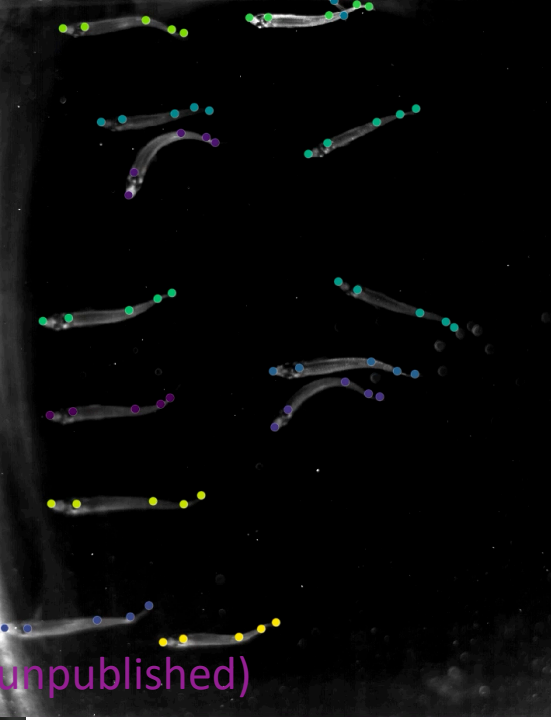
Hires Lab



Sawtell Lab



#teamDLC (unpublished)



# “Software 2.0” – integration of annotation, training and inference

Networks build on ResNets (2018),  
MobileNetV2 (2019), EfficientNets (2020)

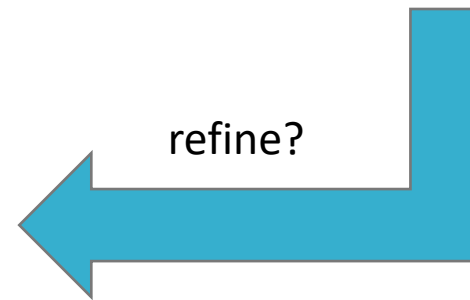
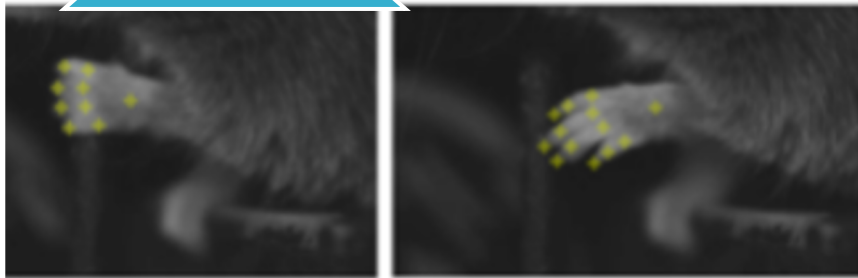
Create a project,  
extract frames, +  
GUIs to label your data

Select + Train your  
deep neural network

Evaluate network  
performance

(active learning + GUIs  
if improvement needed)

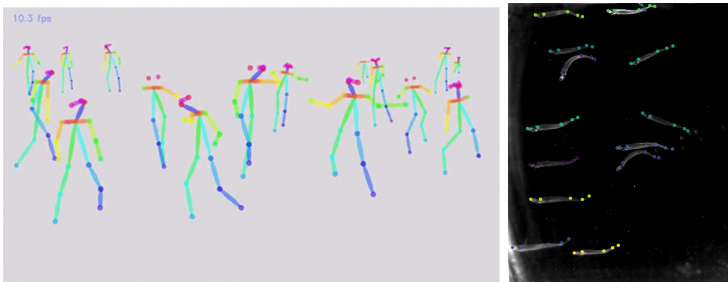
Run inference on  
new videos,  
create labeled videos,  
+ plot your results!



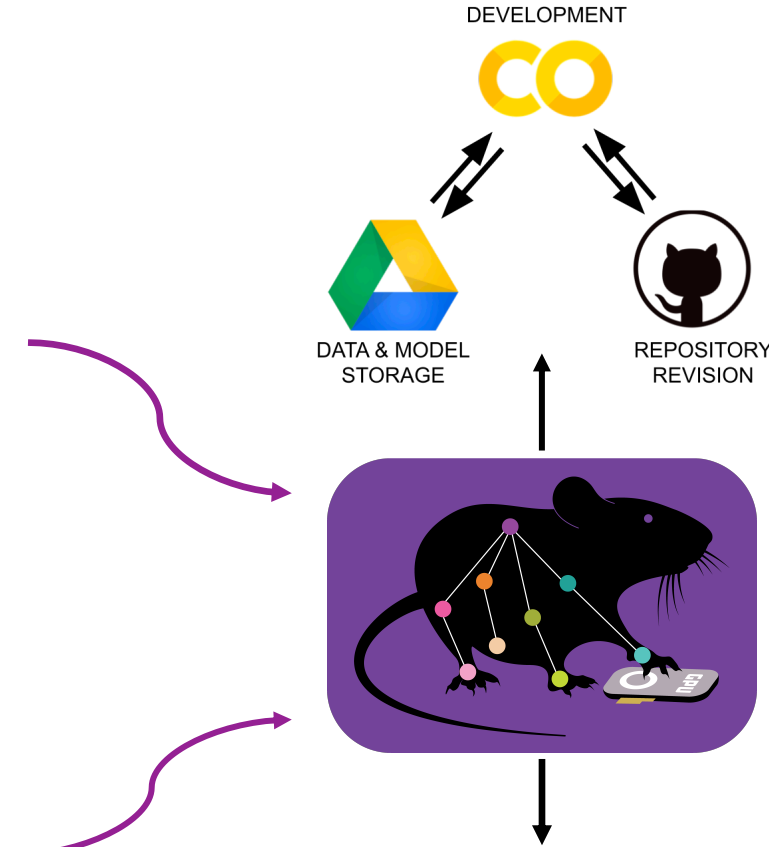
### Built on the open source python stack:



### Insights from Computer Vision:



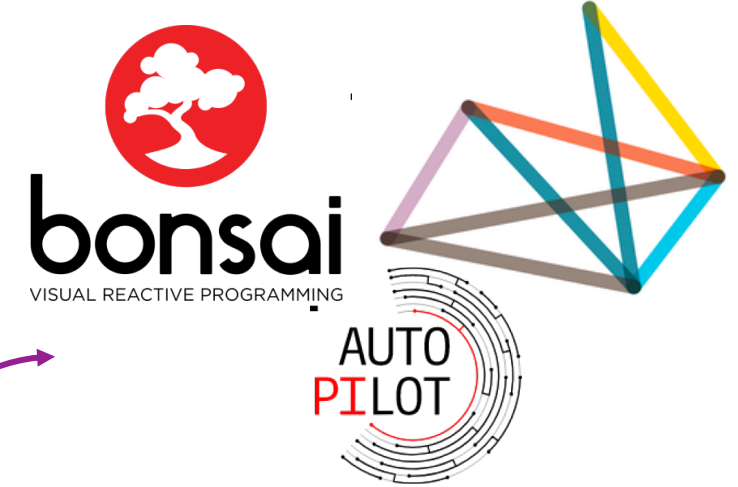
### User testing/dev & deployment:



### Larger scale pipeline computing:



### Neuroscience-specific tools:



### Post- pose estimation tools:

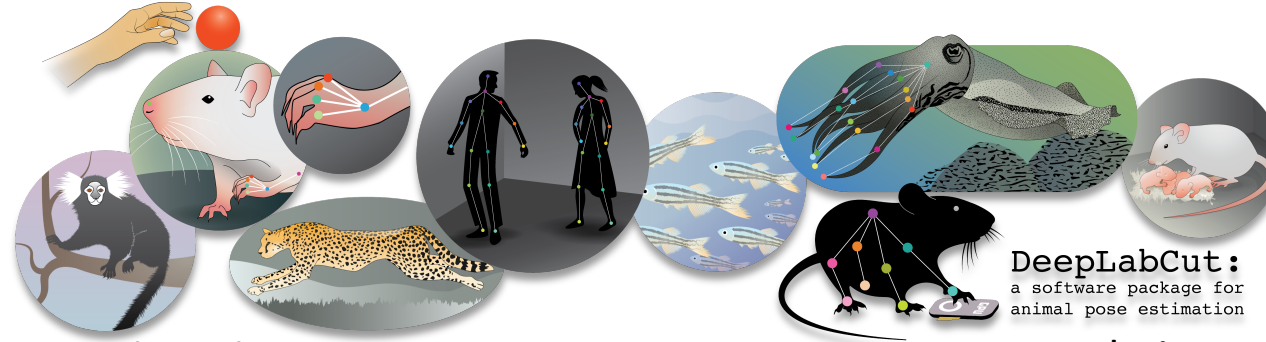


- Classifiers:** SVMs, Random Forrest, ANNs
  - B-SOID, ETH-DLC Analyzer, simba
- Models:** HMMs, decision-trees, ANNs
- Ethograms:** BORIS, BASIN, BENTO
- Clustering:** MoSeq, MotionMapper, JAABA
- Motor analysis:** KINEMATIK



# DeepLabCut: ongoing additions to the ecosystem

## Model Zoo



Multi-Animal Tracking

Real-Time Applications



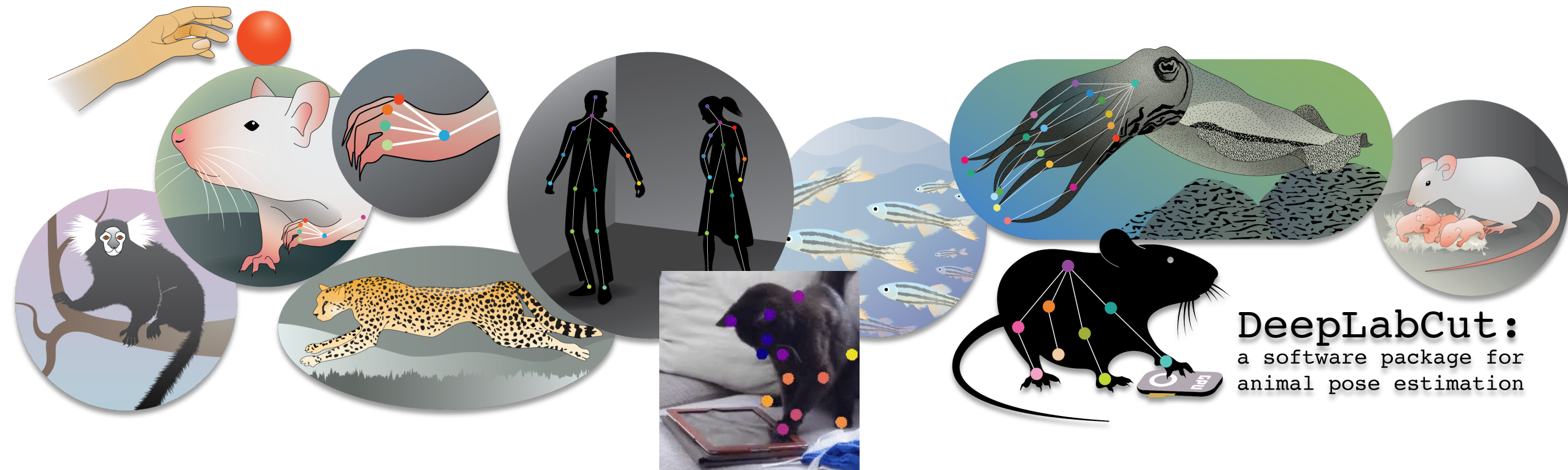
Lauer et al, coming soon  
Code beta released May 2020



Kane et al, eLife 2020 (today!)



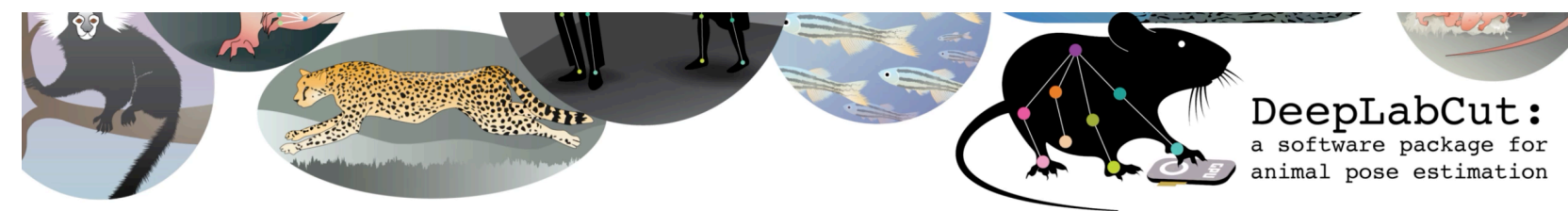
# Animal pose-estimation (DLC) Model Zoo



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a software package for  
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[modelzoo.deeplabcut.org](http://modelzoo.deeplabcut.org)

<http://modelzoo.deeplabcut.org>



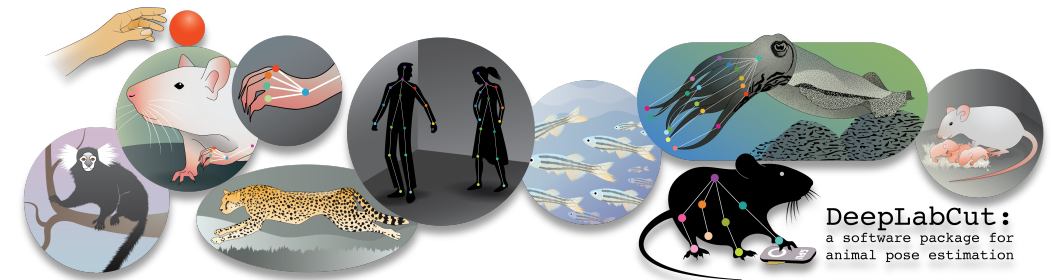
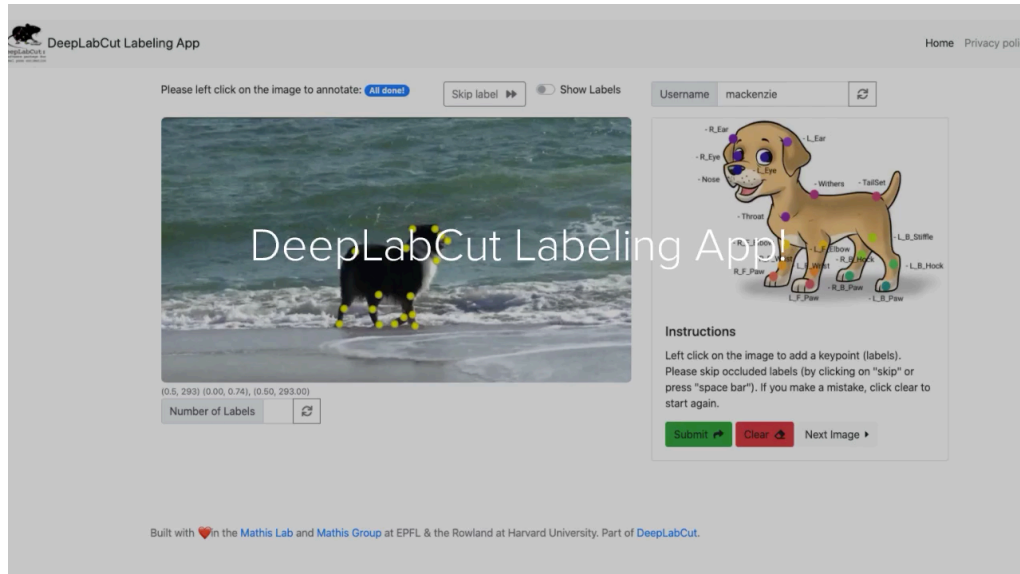
## DeepLabCut Model Zoo

Here we provide **model weights** that are **already trained on specific animals & scenarios**

You can use these models for video analysis

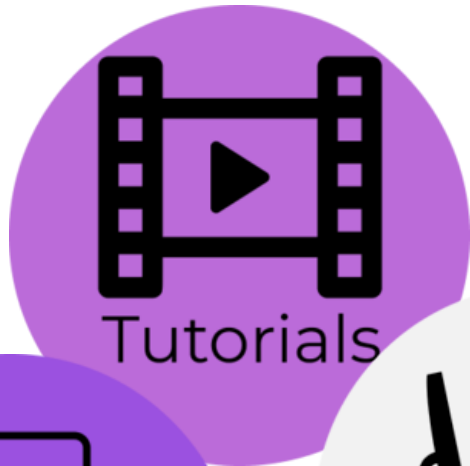


# <http://contrib.deeplabcut.org/>

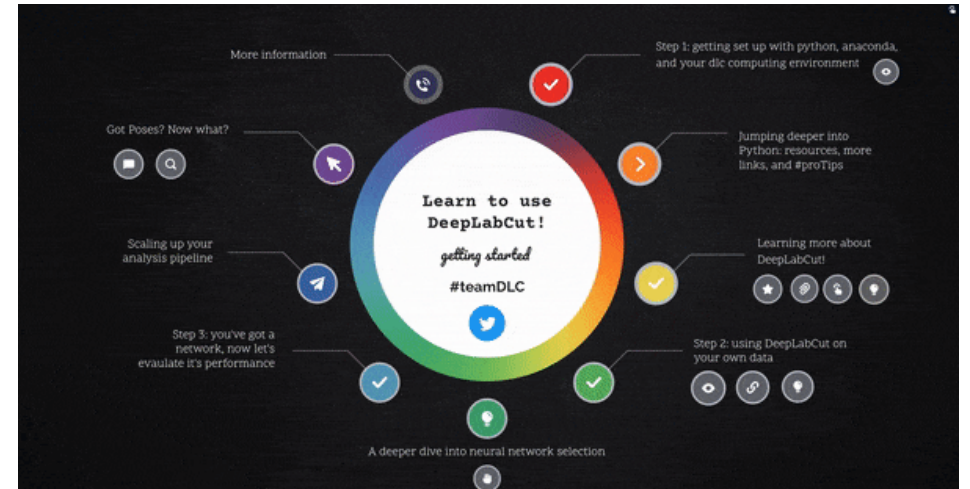


Labeling App: Steffen Schneider, Maxime Vidal

# Accessible User Education & Onboarding!



Mathis, Schneider,  
Lauer & Mathis  
2020 Neuron



[DLCcourse.deeplabcut.org](https://dlcourse.deeplabcut.org)

