Examining Animal Behavior During a Two-Response Taste Detection Task Using a Machine Learning Methodology

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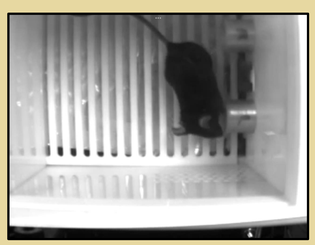
Introduction

Characterizing how naturalistic behaviors are altered by experimental manipulations or sensory stimuli can provide unique insight into the brain function. However, the manual assessment of motor movements associated with various behaviors is labor and time intensive. DeepLabCut (DLC) utilizes machine learning with deep neural networks to develop a model that is capable of recognizing specific user-defined locations in novel videos. The resulting data yields a frame-by-frame analysis of the spatial location of each user-defined point.

Goal

Determine whether movement patterns are correlated with gustatory stimuli or perceptual ability.

Taste Detection Task

Mice were trained in an operant conditioning chamber to discriminate between different concentrations of sodium chloride (NaCl) and water at different temperatures. The two-response taste detection task is a common approach to analyze sensory discrimination independent of the hedonic quality of the stimulus.

DEEPLABCUT

DeepLabCut is an effective, two-dimensional markerless pose estimation software which employs transfer learning with deep neural networks.

Frame Extraction and Labeling

A subset of video frames are randomly extracted, and the location of nose, head, and rear in these frames were marked. The status of the trial LED was marked to allow behavioral performance and stimulus presentation data to be associated with spatial location.

Training Efficiency

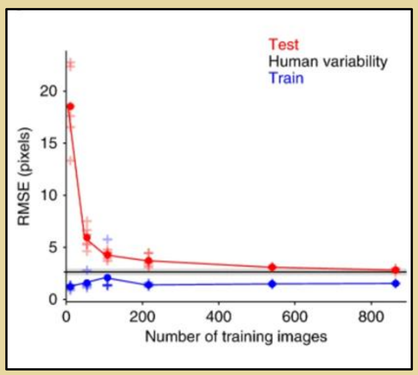
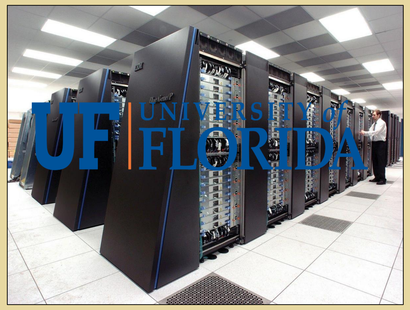
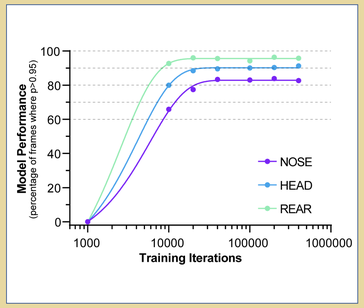


Figure from Mathis et al., 2018, which illustrates the root mean square error of a model as a function of the number of training images. After training the model on ~ 500 frames, this model achieved performance approaching that of human variability.

Training the Model

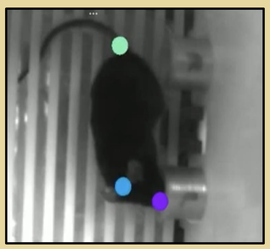
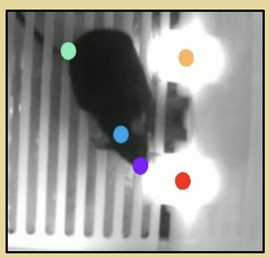
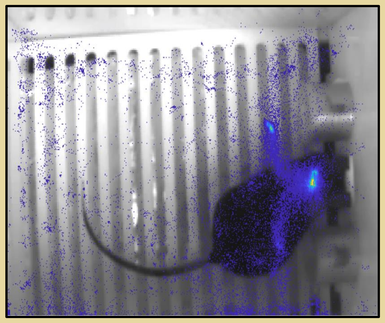


The project files were processed on the University of Florida's HiPerGator Compute Cluster. (A100 GPU, 8 CPU Cores, 64GB RAM)



Model performance as a function of training iterations. Model rapidly increases in accuracy with an eventual plateau around 200k training iterations.

Preliminary Data

Above: Positional heatmap of animal throughout experiment created in MATLAB
Left: Examples of model-inferred points of interest

References

- Mathis, A., Mamidanna, P., Cury, K. M., Abe, T., Murthy, V. N., Mathis, M. W., & Bethge, M. (2018, August 20). DeepLabCut: markerless pose estimation of user-defined body parts with deep learning. *Nature Neuroscience*. Springer Science and Business Media LLC. http://doi.org/10.1038/s41593-018-0209-y
- Nath, T., Mathis, A., Chen, A. C., Patel, A., Bethge, M., & Mathis, M. W. (2019, June 21). Using DeepLabCut for 3D markerless pose estimation across species and behaviors. *Nature Protocols*. Springer Science and Business Media LLC. http://doi.org/10.1038/s41596-019-0176-0