DLC Labeling Protocol

Using Locally Installed GUI and Colab for GPUs

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Information About This File

This file sits in the root directory of the CV@hugs-lab.org Google Drive.
It is restricted. To view, you must log in as CV@hugs-lab.org
Last update: 230314 by Manon@hugs-lab.org

HUGS-Lab Account

To be able to manage data and train pose estimation models more effectively, add this account to your Google dashboard:

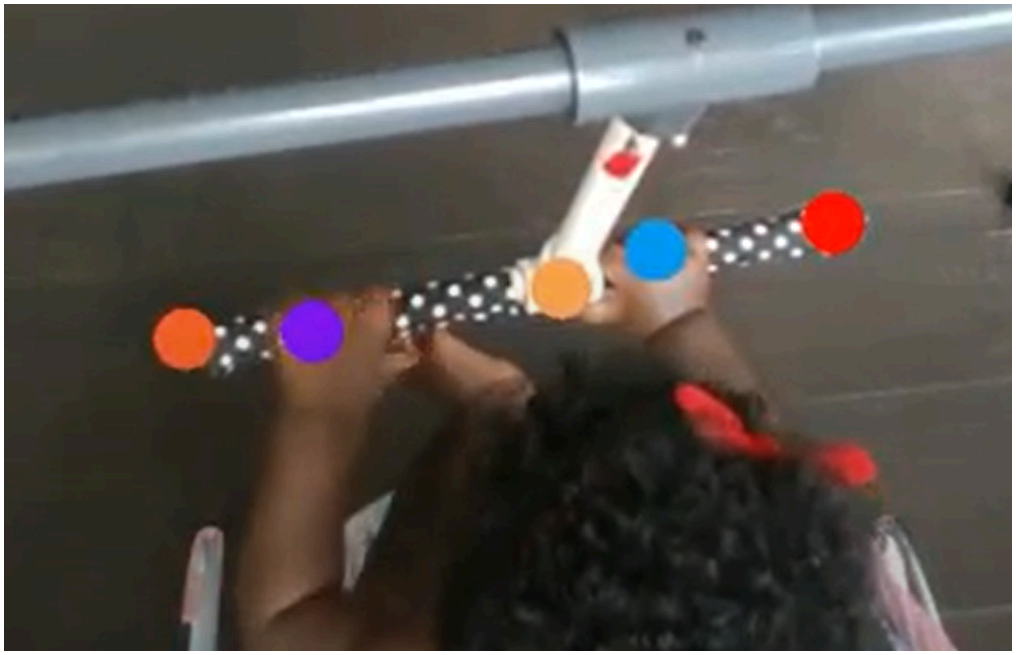
User: cv@hugs-lab.org
PW: Inf@nt$TUDY

You will need to log in as cv@hugs-lab.org in order to our Google Colab account

Pose Estimation With DeepLabCut™ (DLC)

What is Pose Estimation?

Pose estimation is the technique we are using to determine the pixel coordinates of the anatomical points of interest (PoI) on babies in our videos frame to frame. In the picture at the left, we were interested in understanding how the baby played with the toy bar and her hands, as well as landmarks on the bar, are noted with colored dots. Once we know the location of the baby's hands in each frame, we can track them across ALL the frames in the video and measure aspects of the baby's movement: kinematics.



In this project, we are working to track the upper body movement and hand use of twins as they develop from three to 12 months of age. One twin had a typical birth but his brother had some problems, so his development was delayed.

What is DeepLabCut™?

DeepLabCut™ is a software package for markerless pose estimation based on transfer learning with deep neural networks. It can achieve excellent results (i.e. you can match human labeling accuracy) with minimal training data (typically 50-200 frames). The package is open source, and was collaboratively developed by the Mathis Group &

Mathis Lab at École Polytechnique Fédérale de Lausanne, EPFL (releases prior to 2.1.9 were developed at Harvard University).

Two main activities need to be done in DLC to estimate infant poses: Labeling a sample set of PoI and Training DLC's neural network to identify these PoI across all of the videos.

Labeling PoI - DLC GUI

Python underlies all DLC functions, however the software includes a GUI interface that provides you a menu-drive structure for labeling PoI. You can install the DLC GUI on your own laptop. Instructions for installing DLC are HERE. They work well for both Windows 10 and 11.

Training DLC's DeepLearning Algorithm to Recognize PoI

Once you have labeled data, you use it to train DLC's neural network to recognize infant PoI. Training is done in the cloud using Google Colab. CV@hugs-lab.org has access to a Colab Pro account which provides access to faster GPUs (Graphical Processing Units) for algorithm training.

To do this, we upload the labeled data file to Google Colab and train there. Model Colab files are in the CV@hugs-lab.org Google Drive, HERE.

Instructions for this part of the process are linked through the Hugs Lab Google Colab page.

LABELING WORKFLOW

To label the twins' PoI, we will follow the process (workflow) described in:

Nath, T., Mathis, A., Chen, A. C., Patel, A., Bethge, M., & Mathis, M. W. (2019). Using DeepLabCut for 3D markerless pose estimation across species and behaviors. Nature Protocols, 14(7), 2152–2176. https://doi.org/10.1038/s41596-019-0176-0

You can download/read the whole article HERE.

The steps for labeling video and training the DLC algorithm to recognize PoI follow.

Step 1: Identify Behaviors of Interest and Environmental Variants Across Spontaneous Movement Videos

As Nath et al. recommend, the ideal scenario is to select representative videos across *all* the data you will be including in your project.. Therefore, the first step is to

a) view all of the videos and

b) record any notable characteristics in a corresponding comments file.

★ This file will be a document that we can reference going forward as more work is done on the dataset. A sample comments file is linked in bullet **B** below.

- First, download the infant video (.avi) files you will be working with.
- These videos reside on the Catholic University secure Google Drive. They will be shared with you.
- Click HERE for a video on how to access these shared .avi files on the twins.
- Scan the group of .AVI files in your work set:
- **A. Notice that the file names follow a naming pattern or convention**
    - The file below describes the identifiers that make up the convention
        - File Naming Conventions.docx
    - We use a convention so that videos can all be put in a single folder with no confusion as to what each one is.

- **B. Open a Word or doc file to record your comments on the video. Give the doc/docx file the same name as the video.**
    - Watch the video.
        - You can start out in Premiere Pro. You will given license information to download and install the software.
    - Make comments on anything distinctive about the video as you are watching it.
        - Diletta will provide you initial guidance on what sorts of things to look for and advise you as you audit your videos.
    - Click HERE for a sample comments file.
    - Click HERE to view the video it provides comments on.
    - This comments file will help the team get a better grasp of potential issues in the video that will impact both pose estimation AND the kinematics we will later use the movement coordinates to generate.
    - Click HERE for a video giving examples of the kinds of behaviors you need to be aware of and specifically identify for DLC when you move on to labeling video.

Step 2. Create a “Train/Test” Dataset

When you have characterized all of your videos, create *a* **training set** of videos. You do this by creating clips, frame sequences, from each of the infant videos you characterized.

You will want to make clips for the training set that illustrate all the conditions and behaviors you wrote down in your comments file.

In addition, make sure you select video frame sequences from each twin, at each time point/video session date. (Note: each session date may have more than one video or no video.Sometimes, if one of the twins was too fussy, we were not able to get the video on that baby done. Other times, if the baby was giving us good data and was happy in the baby seat, we just took an additional video.)

Create clips in each video showing behaviors of interest. This VIDEO shows how to do that in Premiere Pro.

- As you are making your clips, apply the naming convention described in section A earlier. Your initials and date/time stamp at the end will distinguish them.

Step 3. Label Points of Interest (PoI)

- Label PoI in selected video frames using the DLC GUI as we did previously in the Pilot, shoulder, elbow, wrist, left and right sides. The infant's left is "left" and vice versa. Also label the navel (belly button) area. In most videos, a gold lapel pin in the safety belt marks the approximate place.
    - Referring back to the Nath et al. article, the goal is to label as few frames as possible -- they report good results with only 200. That's why the selection of frames is important.
- The webpage below provides instructions for installing and running the DLC GUI on your laptop for video labeling.

    - https://sites.google.com/hugs-lab.org/hugs-lab/software/deeplabcut
    - ***Click on Download and Install Anaconda***
- A GPU is not needed to run the labeling portion of the GUI.
- Having the DLC GUI on your laptop or other personal computer frees you from the necessity of working on the computer in the lab.

Step 4. Train/Test In Google Colab

Note: The notebooks below are located in the Colab Notebooks folder in the root of the CV@hugs-lab.org Google Drive**.**

- DLC's_Tutorial_Notebook_for_AR_Processing.ipynb
    - https://colab.research.google.com/drive/1xKPq0v4OU0YEsRMSdISg4jn3EHs6SSb_?usp=sharing

  Has instructions for running DLC training, testing, and analysis on Colab. It's a well-annotated Jupyter notebook with step-by-step instructions.
- The process is similar to testing/training and analysis on the desktop, but we have use of Colab's GPUs.
- The relevant files (most specifically, the coordinate .csv files) output from the process on Colab will be in the same structures they are on the desktop. The only difference is that those structures will be created on the CV@hugs-lab.org Google Drive.
- Follow the steps in the markdown in the notebook relative to iterations and evaluation of the test results.

- If it is not good, that means something needs to be adjusted: labels checked to make sure they are correct, more frames labeled based on what you see in the skeleton files and the confidence levels in the .csv files.
- Success of DLC's method is the end result of fewer than 10% of all frames labeled!

More Information on Colab Etc.

- For more information on Colab, Jupyter notebooks etc. browse through the notebook linked below.
    - CV's Copy of Making the Most of your Colab Subscription.ipynb
    - https://colab.research.google.com/drive/1TyhmAbxicUOB0HMmCYel64vVg8GnMwE8?usp=sharing

Step 5. Depth File Alignment

- Future effort
    - Diletta will advise