JABS User Guide

The JABS Project Directory

A JABS project is a directory of video files and their corresponding pose estimation files. The first time a project directory is opened in JABS, it will create a subdirectory called "rotta", which contains various files created by JABS to save project state, including labels and current predictions.

Example JABS project directory listing:

```
NV11-CBAX2+2019-07-26+MDX0009_2019-07-26_08-00-00_500.avi
NV11-CBAX2+2019-07-26+MDX0009_2019-07-26_08-00-00_500_pose_est_v3.h5
NV11-CBAX2+2019-07-26+MDX0009_2019-07-26_09-00-00_500.avi
NV11-CBAX2+2019-07-26+MDX0009_2019-07-26_09-00-00_500_pose_est_v3.h5
NV11-CBAX2+2019-07-26+MDX0009_2019-07-26_10-00-00_500.avi
NV11-CBAX2+2019-07-26+MDX0009_2019-07-26_10-00-00_500_pose_est_v3.h5
NV11-CBAX2+2019-07-26+MDX0009_2019-07-26_11-00-00_500.avi
NV11-CBAX2+2019-07-26+MDX0009_2019-07-26_11-00-00_500_pose_est_v3.h5
NV11-CBAX2+2019-07-26+MDX0009_2019-07-26_12-00-00_500.avi
NV11-CBAX2+2019-07-26+MDX0009_2019-07-26_12-00-00_500_pose_est_v3.h5
NV11-CBAX2+2019-07-26+MDX0009_2019-07-26_13-00-00_500.avi
NV11-CBAX2+2019-07-26+MDX0009_2019-07-26_13-00-00_500_pose_est_v3.h5
NV11-CBAX2+2019-07-26+MDX0009_2019-07-26_14-00-00_500.avi
NV11-CBAX2+2019-07-26+MDX0009_2019-07-26_14-00-00_500_pose_est_v3.h5
rotta
```

Initializing A JABS Project Directory

The first time you open a project directory in with JABS it will create the "rotta" subdirectory. Features will be computed the first time the "Train" button is clicked. This can be very time consuming depending on the number and length of videos in the project directory.

The initialize_project.py script can also be used to initialize a project directory before it is opened in the JABS GUI. This script checks to make sure that a pose file exists for each video in the directory, and that the pose file and video have the same number of frames. Then, after these basic checks, the script will compute features for all of the videos in the project. Since initialize_project.py can compute features for multiple videos in parallel, it is significantly faster than doing so through the GUI during the training process.

initialize_project.py usage:

```
usage: initialize_project.py [-h] [-f] [-p PROCESSES] [-w WINDOW_SIZE]
                             project_dir

positional arguments:
  project_dir

optional arguments:
  -h, --help            show this help message and exit
  -f, --force           recompute features even if file already exists
  -p PROCESSES, --processes PROCESSES
                        number of multiprocessing workers
  -w WINDOW_SIZE        Specify window sizes to use for computing window
                        features. Argument can be repeated to specify multiple
                        sizes (e.g. -w 2 -w 5). Size is number of frames
                        before and after the current frame to include in the
                        window. For example, '-w 2' results in a window size
                        of 5 (2 frames before, 2 frames after, plus the
                        current frame). If no window size is specified, a
                        default of 5 will be used.
```

initialize_project.py example

The following command runs the initialize_project.py script to compute features using window sizes of 2, 5, and 10. The script will use up to 8 processes for computing features (-p8). If no -p argument is passed, initialize_project.py will use up to 4 processes.

```
./initialize_project.py -p8 -w2 -w5 -w10 <path/to/project/dir>
```

The rotta directory

JABS creates a subdirectory called "rotta" inside of the project directory (this directory is called "rotta" for historical reasons and may change prior to the 1.0.0 release of JABS). This directory contains app-specific data such as project settings, generated features, user labels, cache files, and the latest predictions.

project.json

This file contains project settings and metadata.

rotta/annotations

This directory stores the user's labels, stored in one JSON file per labeled video.

rotta/archive

This directory contains archived labels. These are compressed files (gzip) containing labels for behaviors that the user has removed from the project. Rotta only archives labels. Trained classifiers and predictions are deleted if a user removes a behavior from a project.

rotta/cache

Files cached by Rotta to speed up performance. Some of these files may not be portable, so this directory should be deleted if a Rotta project is copied to a different platform.

rotta/classifiers

This directory contains trained classifiers. Currently, these are stored in Python Pickle files and should be considered non-portable.

rotta/features

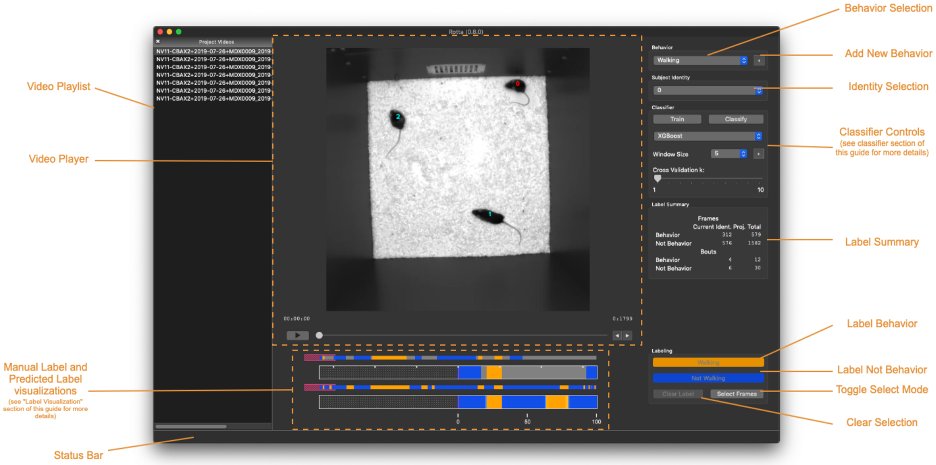
This directory contains the computed features. There is one directory per project video, and within each video directory there will be one feature directory per identity. Feature files are usually portable, but Rotta may need to recompute the features if they were created with a different version of Rotta.

rotta/predictions

This directory contains prediction files. There will be one subdirectory per behavior containing one prediction file per video. Prediction files are automatically opened and displayed by Rotta if they exist. Prediction files are portable, and are the same format as the output of the command line classifier tool (`classify.py`).

GUI

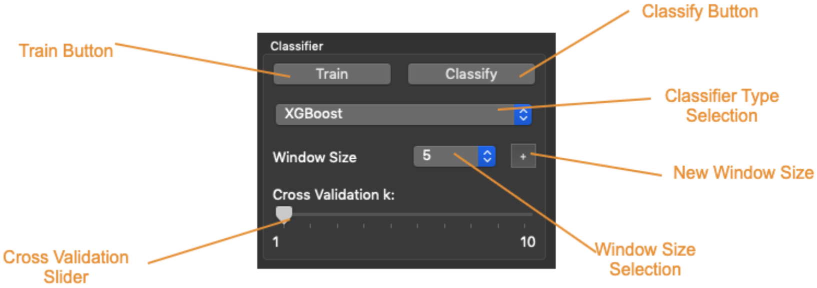
Main Window



Frames	Current Ident.	Proj. Total
Behavior	312	579
Not Behavior	576	1582
Bouts		
Behavior	4	12
Not Behavior	6	30

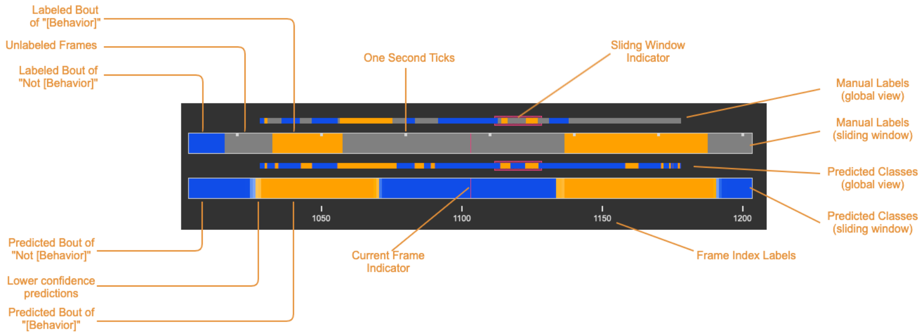
- **Behavior Selection:** Select current behavior to label
- **Add New Behavior Button:** Add new behavior label to project
- **Identity Selection:** Select subject mouse to label (subject can also be selected by clicking on mouse in the video)
- **Classifier Controls:** Configure and train classifier. Use trained classifier to infer classes for unlabeled frames. See "Classifier Controls" section for more details.
- **Label Summary:** Counts of labeled frames and bouts for the subject identity in the current video and across the whole project.
- **Label "Behavior" Button:** Label current selection of frames as showing behavior. This button is labeled with the current behavior name.
- **Label "Not Behavior" Button:** Label current selection of frames as not showing behavior This button is labeled with "Not <current behavior name>".
- **Clear Selection Button:** remove labels from current selection of frames
- **Toggle Select Mode Button:** toggle select mode on/off (turning select mode on will begin selecting frames starting from that point)
- **Video Playlist:** list of videos in the current project. Click a video name to make it the active video.
- **Video Player:** Displays the current video. See "Video Player" section for more information.
- **Manual Label and Predicted Label Visualizations:** see "Label Visualizations" for more information.
- **Status Bar:** Displays periodic status messages.

Classifier Controls



- **Train Button:** Train the classifier with the current parameters. This button is disabled until minimum number of frames have been labeled for a minimum number of mice (increasing the cross validation k parameter increases the minimum number of labeled mice)
- **Classify Button:** Infer class of unlabeled frames. Disabled until classifier is trained. Changing classifier parameters may require retraining before the Classify button becomes active again.
- **Classifier Type Selection:** Users can select from a list of supported classifiers.
- **Window Size Selection:** Number of frames *on **each side*** of the current frame to include in window feature calculations for that frame. A "window size" of 5 means that 11 frames are included into the window feature calculations for each frame (5 previous frames, current frame, 5 following frames).
- **New Window Size:** Add a new window size to the project.
- **Cross Validation Slider:** Number of "Leave One Out" cross validation iterations to run while training.

Label Visualizations


Labeled Bout of "[Behavior]"
Unlabeled Frames
Labeled Bout of "Not [Behavior]"
One Second Ticks
Slidng Window Indicator
Manual Labels (global view)
Manual Labels (sliding window)
Predicted Classes (global view)
Predicted Classes (sliding window)
1050
1100
1150
1200
Predicted Bout of "Not [Behavior]"
Lower confidence predictions
Predicted Bout of "[Behavior]"
Current Frame Indicator
Frame Index Labels

- **Manual Labels (sliding window):** Displays manually assigned labels for a sliding window of frames. The window range is the current frame +/- 50 frames. Orange indicates frames labeled as showing the behavior, blue indicates frames labeled as not showing the behavior. Unlabeled frames are colored gray.
- **Manual Labels (global view):** Displays a zoomed out view of the manual labels for the entire video
- **Predicted Classes (sliding window):** Displays predicted classes (if the classifier has been run). Color opacity indicates prediction probability for the predicted class. Manually assigned labels are also displayed with probability of 100%.
- **Predicted Class (global view):** Displays a zoomed out view of the predicted classes for the entire video.
- **Sliding Window Indicator:** highlights the section of the global views that correspond to the frames displayed in the "sliding window" views.

All visualizations are for the current "subject".

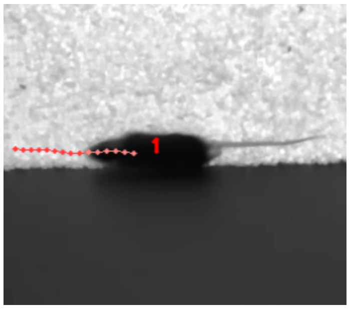
Menu

FileOpen Project: Select a project directory to open. If a project is already opened, it will be closed and the newly selected project will be opened.

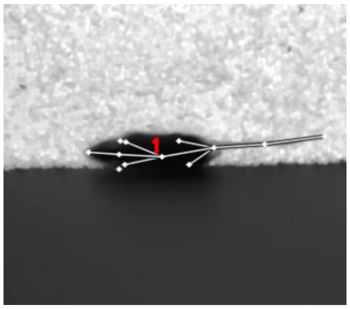
FileExport Training Data: Create a file with the information needed to share a classifier. This exported file is written to the project directory and has the form `<Behavior_Name>_training_<YYYYMMDD_hhmmss>.h5`. This file is used as one input for the `classify.py` script in the Rotta root app directory.

ViewView Playlist: can be used to hide/show video playlist

ViewShow Track: show/hide track overlay for the subject. The track overlay shows the nose position for the previous 5 frames and the next 10 frames. The nose position for the next 10 frames is colored red, and the previous 5 frames it is a shade of pink.



ViewOverlay Pose: overlay the pose on top of the subject mouse



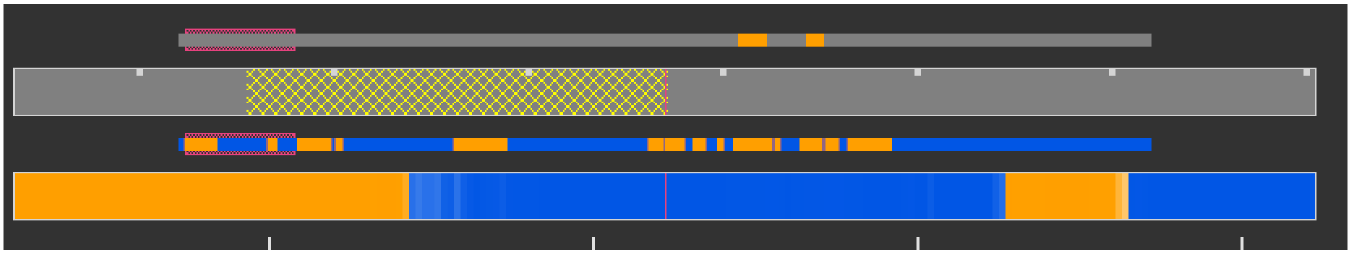
Labeling

This section describes how a user can add or remove labels. Labels are always applied to the subject mouse and the current subject can be changed at any time. A common way to approach labeling is to scan through the video for the behavior of interest, and then when the behavior is observed select the mouse that is showing the behavior. Scan to the start of the behavior, and begin selecting frames. Scan to the end of the behavior to select all of the frames that belong to the bout, and click the label button.

Selecting Frames

When "Select Mode" is activated, JABS begins a new selection starting at that frame. The current selection is from the selection start frame through the current frame. Applying a label, or removing labels from the selection clears the current selection and leaves "Select Mode".

The current selection range is shown on the "Manual Labels" display:



Clicking the "Select Frames" button again or pressing the Escape key will unselect the frames and leave select mode without making a change to the labels.

Applying Labels

The "Label Behavior Button" will mark all of the frames in the current selection as showing the behavior. The "Label Not Behavior" button will mark all of the frames in the current selection as not showing the behavior. Finally, the "Clear Labels" button will remove all labels from the currently selected frames.

Labeling Shortcuts

Using the keyboard controls can be the fastest way to label.

Navigation Controls

The arrow keys can be used for stepping through video. The up arrow skips ahead 10 frames, and the down arrow skips back 10 frames. The right arrow advances one frame, and the left arrow goes back one frame.

Labeling Controls.

The z, x, and c keys can be used to apply labels.

If in select mode:

z: label current selection as "behavior"

x: clear labels from current selection

c: label current selection as "not behavior"

If not in select mode:

z, x, c: start selecting frames.

The Classifier

Training

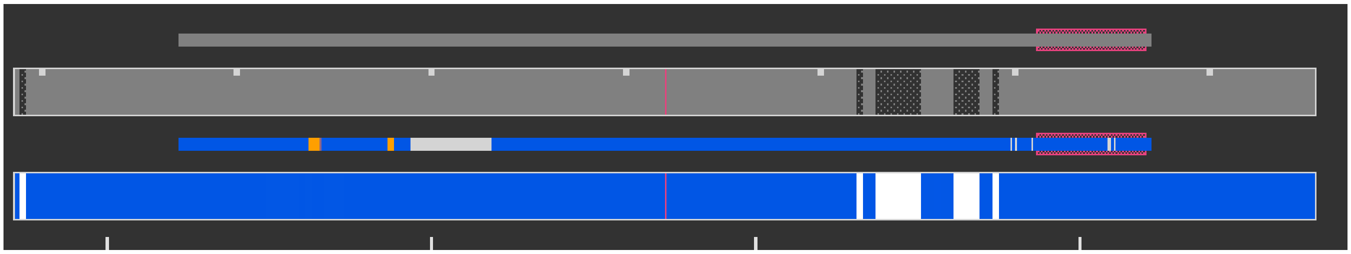
TODO

Classification

TODO

Identity Gaps

Identities can have gaps if the mouse becomes obstructed or the pose estimation failed for those frames. In the manual label visualization, these gaps are indicated with a pattern fill instead of the solid gray/orange/blue colors. In the predicted class visualization, the gaps are colored white.



All Keyboard Shortcuts

File Menu

Actions under the file menu have keyboard shortcuts.

Control Q (Command Q on Mac) quit Rotta

Control T (Command T on Mac) export training data

Navigation

left arrow: move to previous frame

right arrow: move to next frame

up arrow: move forward 10 frames (TODO: make configurable)

down arrow: move back 10 frames (TODO: make configurable)

space bar: toggle play/pause

Labeling

while in select mode:

z: label current selection <behavior>and leave select mode

x: clear current selection labels and leave select mode

c: label current selection not <behavior> and leave select mode

Escape: exit select mode without applying/clearing labels for current selection

while not in select mode:

z x c: enter select mode

Other

t: toggle track overlay for subject

p: toggle pose overlay for subject

l: toggle closest/closest fov overlay

The Command Line Classifier

Rotta includes a script called `classify.py`, which can be used to classify a single video from the command line.

Usage:

```
usage: classify.py [-h] [--random-forest | --gradient-boosting | --xgboost]
                   --training TRAINING --input-pose INPUT_POSE --out-dir
                   OUT_DIR [--fps FPS]

optional arguments:
  -h, --help            show this help message and exit
  --fps FPS             frames per second, default=30

required arguments:
  --training TRAINING   Training data exported from Rotta
  --input-pose INPUT_POSE
                        input HDF5 pose file (v2 or v3).
  --out-dir OUT_DIR     directory to store classification output

Optionally override the classifier specified in the training file (the following options are mutually
exclusive):
  --random-forest       Use Random Forest
  --gradient-boosting   Use Gradient Boosting
  --xgboost             Use XGBoost
```

The script has three required arguments:

--training: path to the training file exported by the JABS GUI to use to train the classifier

--input-pose: path to the pose file for the video to classify (classify.py does not need the .avi file)

--out-dir: directory to write results to

In addition to the required arguments, there are several optional arguments

--help: display help text and exit

--fps: specify the frames per second (used for scaling time unit for speed and velocity features from "per frame" to "per second"). Defaults to 30 since that is our typical capture frame rate.

--random-forest, --gradient-boosting, --xgboost: override the classifier specified in the JABS training file. Note: xgboost may be unavailable on Mac OS if libomp is not installed. See --help output for list of classifiers supported in the current environment.

Batch Processing of Classification

In this section we describe how to perform batch processing of classification with JABS. The batch script is specific to the sumner cluster at JAX but with minor modification it should work on any cluster that supports the SLURM scheduler and running Singularity VMs. In order to perform classification you must first copy poses from their source (usually tier 2 storage or dropbox) to the Sumner cluster. There are several ways to do this. One way is with rsync using a file listing similar to:

```
rsync -av --files-from=./networkPointNotFoundBXD.txt "${share_root}" login.sumner.jax.org:/fastscratch/sheppk/networkPointNotFoundBXD
```

For detailed documentation on other ways to do this see the "Data Transfers" section of JAX's cluster documentation: https://jacksonlaboratory.sharepoint.com/sites/ResearchIT/SitePages/Documentation.aspx

Once you have copied all of the poses over you need to also copy or create a batch file to be used by the SLURM self-submitting script. Documentation for how to do this as well as how to run the script can be found in a large comment block toward the top of the script:

behavior-classify-batch.sh

```
#!/bin/bash
#
#SBATCH --job-name=behavior-classify
#
#SBATCH --qos=batch
#SBATCH --time=6:00:00
#SBATCH --ntasks=1
#SBATCH --cpus-per-task=1
#SBATCH --mem=16G

# This is a self-submitting SLURM script which can be used to classify a batch
# of video poses on JAX's sumner cluster. This script assumes that there will be
# a "behavior-classifier.sif" Singularity VM image in the same directory as this
# script. You can build this VM using the "behavior-classifier-vm.def" Singularity
# definition in the repository or use one that has been pre-built.
#
# This script expects two positional command line arguments:
# 1) a fully qualified path to an exported Rotta classifier HDF5 file
# 2) a fully qualified path to a batch file. A batch file is a plain
#    text file which contains newline separated network IDs for each
#    pose file that should be classified. Note that even though we
#    are performing classification on poses, the batch file is
#    expected to contain "*.avi" entries in order to conform to
#    our network IDs. This batch file should be placed at the root
#    directory of all poses that we want to process. So for example,
#    if we have a bunch of poses in "/a/b/c" one of which is
#    "/a/b/c/d/e_pose_est_v3.h5" we should have a batch file
#    "/a/b/c/mybatch.txt" that contains a "d/e.avi" entry.
#
# Example script usage:
#
#   ~/behavior-classify-batch.sh \
#       /projects/kumar-lab/USERS/sheppk/temp/rearing-batch-2021-02-23-leilani/rearing-classifiers-2020-02-18/leinani-hession/Rearing_supported_training_20210216_122124.h5 \
#       /projects/kumar-lab/USERS/sheppk/temp/rearing-batch-2021-02-23-leilani/batch.txt
#
# And if we look at the contents of batch.txt:
#
#   head -n 4 /projects/kumar-lab/USERS/sheppk/temp/rearing-batch-2021-02-23-leilani/batch.txt
#
# we see:
#
#   LL1-B2B/2016-05-05_SPD/LL1-3_100492-F-AX27-9-42416-3-S111.avi
#   LL1-B2B/2017-01-01_SPD/LL1-4_002105-M-AX12-5.28571428571429-42640-4-S331.avi
#   LL1-B2B/2017-01-12_SPD/LL1-4_001144-F-F29-4-42661-4-S344.avi
#   LL1-B2B/2016-05-23_SPD/B6J_Male_S6730806_ep3-PSY.avi

trim_sp() {
    local var="$*"
    # remove leading whitespace characters
    var="${var#"${var%%[![:space:]]*}"}"
    # remove trailing whitespace characters
    var="${var%"${var##*[![:space:]]}"}"
    echo -n "$var"
}

if [[ -z "${SLURM_JOB_ID}" ]]
then
    # the script is being run from command line. We should do a self-submit as an array job
    if [[ ( -f "${1}" ) && ( -f "${2}" ) ]]
    then
        # echo "${1} is set and not empty"
        echo "Preparing to submit classification using ${1} on batch file: ${2}"
        batch_line_count=$(wc -l < "${2}")
        echo "Submitting an array job for ${batch_line_count} videos"

        # Here we perform a self-submit
        sbatch --export=ROOT_DIR="$(dirname "${0}")",CLASSIFIER_FILE="${1}",BATCH_FILE="${2}" --array="
1-${batch_line_count}%500" "${0}"
    else
        echo "ERROR: missing classification and/or batch file." >&2
        echo "Expected usage:" >&2
        echo "behavior-classify-batch.sh CLASSIFIER.h5 BATCH_FILE.txt" >&2
        exit 1
    fi
else
    # the script is being run by slurm
    if [[ -z "${SLURM_ARRAY_TASK_ID}" ]]
    then
        echo "ERROR: no SLURM_ARRAY_TASK_ID found" >&2
        exit 1
    fi

    if [[ -z "${CLASSIFIER_FILE}" ]]
    then
        echo "ERROR: the CLASSIFIER_FILE environment variable is not defined" >&2
        exit 1
    fi

    if [[ -z "${BATCH_FILE}" ]]
    then
        echo "ERROR: the BATCH_FILE environment variable is not defined" >&2
        exit 1
    fi

    # here we use the array ID to pull out the right video from the batch file
    VIDEO_FILE=$(trim_sp $(sed -n "${SLURM_ARRAY_TASK_ID}{p;q;}" < "${BATCH_FILE}"))
    echo "BATCH VIDEO FILE: ${VIDEO_FILE}"

    # the "v1" is for output format versioning. If format changes this should be updated
    OUT_DIR="${VIDEO_FILE%.*}_behavior/v1"

    cd "$(dirname "${BATCH_FILE}")"
    POSE_FILE_V3="${VIDEO_FILE%.*}_pose_est_v3.h5"
    POSE_FILE="${POSE_FILE_V3}"

    if [[ ! ( -f "${POSE_FILE}" ) ]]
    then
        POSE_FILE_V2="${VIDEO_FILE%.*}_pose_est_v2.h5"
        POSE_FILE="${POSE_FILE_V2}"
    fi

    if [[ ! ( -f "${POSE_FILE}" ) ]]
    then
        echo "ERROR: failed to find either pose file (${POSE_FILE_V2} or ${POSE_FILE_V3}) for ${VIDEO_FILE}" >&2
        exit 1
    fi

    echo "DUMP OF CURRENT ENVIRONMENT:"
    env
    echo "BEGIN PROCESSING: ${POSE_FILE} for ${VIDEO_FILE}"
    module load singularity
    singularity run "${ROOT_DIR}/behavior-classifier.sif" --xgboost --training "${CLASSIFIER_FILE}" --input-
pose "${POSE_FILE}" --out-dir "${OUT_DIR}"
```

```
    echo "FINISHED PROCESSING: ${POSE_FILE}"
fi
```

You can find a shared copy of this script (ready to work with a shared singularity VM) here on the sumner cluster:

`/projects/kumar-lab/USERS/sheppk/behavior-classification-env/behavior-classify-batch.sh`

File Formats

This section documents the format of JABS output files that may be needed for downstream analysis.

Inference File

An inference file represents the predicted classes for each identity present in one video file.

Location

The prediction files are saved in `<JABS project dir>/rotta/predictions/<behavior_name>/<video_name>.h5` if they were generated by the JABS GUI. The `classify.py` script saves inference files in `<out-dir>/<behavior_name>/<video_name>.h5`

Contents

The H5 file contains one group, called "predictions". This group contains three datasets

- predictions
    - predicted_class
    - probabilities
    - identity_to_track

The file also has one attribute, called "version". This attribute contains an integer version number, and will be incremented if an incompatible change is made to the file format.

predicted_class

dtype: 8-bit integer

shape: #identities x #frames

This dataset contains the predicted class. Each element contains one of three values:

- 0: "not behavior"
- 1: "behavior"
- -1: "identity not present in frame".

probabilities

dtype: 32-bit floating point

shape: #identities x #frames

This dataset contains the probability (0.0-1.0) of each prediction. 0.0 indicates that the identity doesn't exist at that frame (there was no prediction). -1.0 is used to flag that the corresponding class in the predicted_class dataset was actually manually assigned by a labeler and was not an inference.

identity_to_track

dtype: 32-bit integer

shape: #identities x #frames

This dataset maps each Rotta-assigned identity back to the original track ID from the pose file at each frame. -1 indicates the identity does not map to a track for that frame.