In-Vivo-Imaging-Pipeline

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CHAPTER

ONE

EXPERIMENTMANAGEMENT

1.1 BrukerMetaModule module

```
class BrukerMetaModule.BrukerMeta(ImagingMetaFile, *args)
    Bases: object
    Module for bruker meta data
    import_meta_data()
    static load_meta_data(ImagingMetaFile, *args)
```

1.2 ExperimentHierarchy module

```
class ExperimentHierarchy.BehavioralStage(Meta: Tuple[str, str], Stage: str)
```

Bases: ExperimentStage

Data Class for a generic day of a behavioral task

Required Inputs

Meta: Passed meta from experimental hierarchy (directory, mouse_id)

Stage: Title of Stage

Properties

```
mouse_id : Identifies which mouse this data belongs to
instance_data : Identifies when this behavioral stage was created
```

Attributes

data: Pandas dataframe of synced data

folder_dictionary: A dictionary of relevant folders for this behavioral stage

modifications: List of modifications made to this behavioral stage

meta: bruker metadata

multi_index: Pandas multi-index of behavioral components *state_index*: look-up table / index relating states to integers

trial_parameters : behavioral parameters

Methods

```
add_image_sampling_folder : Generates a folder for containing imaging data of a specific sampling rate
load_data : Loads all data
record_mod : Records a modification made to the behavioral stage (Date & Time)
update_folder_dictionary : This function reindexes all folders in the folder dictionary
oad data(Imaging Parameters: Optional Union dict list dict list dict list of the loads are seen to sampling and data (Imaging Parameters: Optional Union dict list dict list dict list of the loads are seen to sampling rate
load_data : Loads all data
record_mod : Records a modification made to the behavioral stage (Date & Time)
update_folder_dictionary : This function reindexes all folders in the folder dictionary
```

 $\begin{subarray}{l} \textbf{load_data}(ImagingParameters: Optional[Union[dict, list[dict]]] = None, *args: Optional[Tuple[str, str]], \\ **kwargs) \rightarrow Self \end{subarray}$

Loads all data

Parameters

- **ImagingParameters** (*Optional* [*dict*]) Parameters for some imaging dataset or list of datasets (e.g., for two different sampling rates)
- args (Tuple[str, str]) Optionally pass Sync Key to synchronize bruker recordings
- **kwargs** passed to internal functions taking kwargs

Return type

Any

class ExperimentHierarchy.CollectedDataFolder(Path: str)

Bases: object

This is a class for managing a folder of unorganized data files

Required Inputs

Path: path to folder

Self Methods

```
find_matching_files : Finds all matching files
reindex : Function that indexed the files within folder again
find_all_ext : Finds all files with specific extension
```

Properties

```
instance_data : Data created
  path : path to folder
  files : List of files in folder
property files: List[str]
```

find_all_ext(Ext: str) \rightarrow Optional[List[str]]

Finds all files with specific extension

Parameters

Ext (str) – Filename extension

Returns

List of files

```
Return type
                   List[str]
     find_matching_files(Filename: str, Folder: Optional[str] = None) \rightarrow Optional[Tuple[str]]
           Finds all matching files
               Parameters
                   • Filename (str) – Filename or ID to search for
                   • Folder (Any) – Specify folder filename in
               Returns
                   Matching file/s
               Return type
                   Any
     property folders: dict
           Dictionary of folders in path
               Return type
                   dict
     property instance_date: str
           Date Created
               Return type
                   str
     property path: str
           Path to folder
               Return type
                   str
     reindex() \rightarrow Self
           Function that indexes the files within folder again
class ExperimentHierarchy.CollectedFiguresFolder(Path: str)
     Bases: CollectedDataFolder
     A class for storing figures, inherits collected data folder
     view_figure(Name: str) \rightarrow plt.Figure
           Function identifies and views a figure based on supplied name
               Parameters
                   Name (str) – Name of figure (can be partial)
               Returns
                   the plotted figure
               Return type
class ExperimentHierarchy.CollectedImagingAnalysisFolder(Path: str)
     Bases: CollectedDataFolder
     Class specifically for imaging analysis folders, inherits collected data folder
     Self Methods
```

load_fissa_exports: loads fissa exported files

load_cascade_exports: loads cascade exported files

load_suite2p : loads suite2p exported files

export_registration_to_denoised : moves registration to new folder for namespace compatibility when skipping denoising step

clean_up_motion_correction: This function removes the reg_tif folder and registered.bin generated during motion correction.

clean_up_compilation : This function removes the compiled tif files

add_notes: Function adds notes

 $add_notes(Step: str, KeyOrDict: Union[str, dict], Notes: Optional[Any] = None) \rightarrow Self$

Function adds notes indicating steps

Parameters

- Step Step of Analysis
- **Step** str
- **KeyOrDict** (*Union[str, dict]*) Either a Key or a dictionary containing multiple key-value (note) pairs
- Notes (Optional [Any]) If using key, then notes is the paired value

Return type

Any

$clean_up_compilation() \rightarrow Self$

This function removes the compiled tif files generated inside CompiledImagingData (You can avoid the creation of these in the first place by changing suite2p parameters)

Return type

Any

clean_up_motion_correction() → Self

This function removes the reg_tif folder and registered.bin generated during motion correction.

(You can avoid the creation of these in the first place by changing suite2p parameters)

Return type

Any

property current_stage: str

Stage of Analysis

Return type

str

default_folders()

export_registration_to_denoised()

moves registration to new folder for namespace compatibility

Returns

 $\textbf{load_cascade_exports()} \rightarrow \text{Tuple}[\text{ndarray}, \text{ndarray}, \text{ndarray}, \text{dict}]$

This function loads the Spike Times, Spike Prob, Discrete Approximation and ProcessedInferences files exported from Cascade

```
Returns
                   SpikeTimes, SpikeProb, DiscreteApproximation, Processed Inferences
               Return type
                   tuple[Any, Any, Any, dict]
     \textbf{load\_fissa\_exports()} \rightarrow \textbf{Tuple[dict, dict, dict]}
           This function loads the prepared and separated files exported from Fissa
               Returns
                   Prepared, Separated, ProcessedTraces
               Return type
                   tuple[dict, dict, dict]
     load_suite2p(*args: str)
class ExperimentHierarchy.CollectedImagingFolder(Path: str)
     Bases: CollectedDataFolder
     Class specifically for folders containing raw images, inherits collected data folder
     property channels
     property file_format
     property frames
     property height
     property imaging_files
     property meta_files
     property num_imaging_files
     property num_meta_files
     property planes
     reorganize_bruker_files() → None
           This function extracts out the meta files and saves in a new directory
               Return type
                   None
     property width
class ExperimentHierarchy.ExperimentData(**kwargs)
     Bases: object
     Class for Organizing & Managing Experimental Data Across Sessions
     Keyword Arguments
           Logfile: Path to existing log file (str, default None)
           Mouse: Mouse ID (str, default None)
           Condition: Experimental Condition (str, default None)
           Directory: Directory for hierarchy (str, default None)
```

Study: Study (str, default None)

```
StudyMouse: Study ID (str, default None)
```

Class Methods

```
load_experiments : Function that loads the entire experimental hierarchy
get_date: Function returns date
get_time : Function returns time
check_path : Checks Path
_generate_directory_structure : Generates the Directory Structure (The structured folders where data
stored)
_generate_histology_directory : Generates Histology Folder
_generate_roi_matching_index_directory : Generate ROI Matching Folder
_generate_experiment_stage_directory : Generate Behavioral Stage Folder
_generate_behavior_subdirectory : Generate Behavioral Folder
_generate_imaging_subdirectory : Generate Imaging Folder
_generate_computation_subdirectory : Generate Computation Folder
_generate_analysis_technique_subdirectory : Generate Analysis Technique
```

Static Methods

```
_generate_read_me : Generate a read me file
```

Self Methods

```
pass_meta : Passes directory/mouse id
record_mod : Record modification of experiment
record_stage_mod : Record modification of experiment and behavioral stage
save_experiments : Saves Hierarchy to pickle
create_log_file : Creates log file
start_log : Starts Log
check_log : Checks Log Status
create : This function generates the directory hierarchy in one step
```

Properties

```
mouse_id : ID of Mouse
log_file : Log Filename Path
experimental_condition : Experiment condition of the mouse
instance_data : Date when this experimental hierarchy was created
```

Attributes

```
directory : Experimental Hierarchy Directory
study : Study
study_mouse : ID of mouse in study
modifications : modifications made to this file
check_log() → Self
Checks log status
```

```
Return type
             Any
classmethod check_path(Path: str) \rightarrow bool
create() \rightarrow Self
     This function generates the directory hierarchy in one step
         Return type
              Any
create\_experimental\_stage(Stage: str, Type: Optional[str, object] = 'ExperimentStage', **kwargs') \rightarrow
     Generates an experiment stage folder and attribute
     Kwargs are passed to underlying functions
         Parameters
              • Stage (str) – Name of experimental stage
              • Type (Optional[str, object]) - Type of experimental stage (Optional, default = Ex-
               perimentStage)
         Return type
             Any
create_log_file() \rightarrow Self
     Creates log file
         Return type
             Any
end_log() \rightarrow Self
     Ends Logging
         Return type
             Any
property experimental_condition: str
     Experiment condition of the mouse
         Return type
classmethod get_date()
classmethod get_time()
property instance_date: str
     Date when this experimental hierarchy was created
         Return type
             str
classmethod load_experiments(ExperimentDirectory: str) \rightarrow ExperimentData
     Function that loads the entire experimental hierarchy
         Parameters
             ExperimentDirectory (str) – Directory containing the experimental hierarchy pickle file
         Returns
             ExperimentData
```

```
Return type
             Experiment Management. Experiment Hierarchy. Experiment Data \\
property log_file:
     Log Filename Path
         Return type
              str
property mouse_id: str
     ID of Mouse
         Return type
              str
pass_meta() \rightarrow Tuple[str, str]
     Passes directory/mouse id
         Returns
              directory/mouse id
         Return type
             tuple[str, str]
record_mod(*args: str) \rightarrow Self
     Record modification of experiment (Data, Time, *args)
         Parameters
              args (str) – A string explaining the modification
         Return type
              Any
record_stage_mod(StageKey: str, *args) \rightarrow Self
     Record modification of experiment (Data, Time, *args)
         Parameters
              • StageKey (str) – The key name for the stage
              • args (str) – A string explaining the modification
         Return type
             Any
save_experiments() \rightarrow Self
     Saves Hierarchy to pickle
         Return type
              Any
start_log() \rightarrow Self
     Starts Log
         Return type
              Any
update_all_folder_dictionaries() → Self
     This function iterates through all behavioral stages to update their folder dictionaries
         Return type
              Any
```

class ExperimentHierarchy.**ExperimentStage**(*Meta: Tuple[str, str], Stage: str*)

Bases: object

Data Class for a generic experiment stage **Required Inputs** | *Meta* : Passed meta from experimental hierarchy (directory, mouse_id) | *Stage* : Title of Stage

Properties | *mouse_id* : Identifies which mouse this data belongs to | *instance_data* : Identifies when this behavioral stage was created

Attributes | *folder_dictionary* : A dictionary of relevant folders for this behavioral stage | *modifications* : List of modifications made to this behavioral stage | *meta* : bruker metadata

Methods | *add_image_sampling_folder* : Generates a folder for containing imaging data of a specific sampling rate | *load_data* : Loads all data | _*generate_imaging_sampling_rate_subdirectory* : Generate Sample Frequency Folder Innards | _*generate_read_me* : Generate a read me file | *record_mod* : Records a modification made to the behavioral stage (Date & Time) | *update_folder_dictionary* : This function reindexes all folders in the folder dictionary

$add_image_sampling_folder(SamplingRate: int) \rightarrow Self$

Generates a folder for containing imaging data of a specific sampling rate

Parameters

SamplingRate (int) – Sampling Rate of Dataset in Hz

Return type

Any

property instance_date: str

Date created

Return type

str

 $\begin{tabular}{l} \textbf{load_data}(ImagingParameters: Optional[Union[dict, list[dict]]] = None, *args: Optional[Tuple[str, str]], \\ **kwargs) \rightarrow Self \end{tabular}$

Loads all data

Parameters

- **ImagingParameters** (Optional[dict]) Parameters for some imaging dataset or list of datasets (e.g., for two different sampling rates)
- $\bullet \ \ \, args \, (\textit{Tuple[str, str]}) \, \, Optionally \, pass \, Sync \, \, Key \, to \, synchronize \, bruker \, recordings \, \\$
- **kwargs** passed to internal functions taking kwargs

Return type

Any

Return type

Any

property mouse_id: str

ID of mouse

Return type

str

$record_mod() \rightarrow Self$

Records a modification made to the behavioral stage (Date & Time)

Return type

Any

CHAPTER

TWO

BEHAVIOR

2.1 BehaviorUtilities module

BehaviorUtilities.extract_specific_data($DataFrame: DataFrame, KeyValuePairs: Union[Tuple[Str, Union[str, int, float, list]]], Tuple[str, Union[str, int, float, list]]], **kwargs: bool) <math>\rightarrow$ DataFrame

This Function extracts some specific portion of the behavior

Parameters

- DataFrame (Any) synced behavioral data
- **KeyValuePairs** (Union[tuple[str, Union[str, int, float]], tuple[str, Union[str, int, float]]]) A tuple containing a column name in the data and expression for pattern matching. Can use tuple of tuples for multiple extracts. ORDER MATTERS.
- **keep_index** whether to keep original index on export (bool, default True)

Returns

some subset of the dataset

Return type

pd.DataFrame

BehaviorUtilities.lowpass_filter($Data: ndarray, SamplingFrequency: float, Cutoff: float, Order: Optional[int] = None) <math>\rightarrow$ ndarray

Low pass filter (butter)

Parameters

- Data (Any) Data to be filtered
- SamplingFrequency (float) Sampling frequency of data
- Cutoff (float) Cutoff Frequency for filter
- Order (Optional [int]) Optional Order of Filter

Returns

Filtered Data

Return type

Anv

BehaviorUtilities.time_spent_in_burrow(BehavioralObject: FearConditioning, *args: int) \rightarrow Tuple[float] Calculates time spent in burrow via the gate signal

Parameters

- BehavioralObject (Any) FearConditioning Behavioral Stage Object
- args (int) Number of trials per stimulus to drop due to forced retraction

Returns

Time spent in burrow (%) per stage

Return type

Tuple[float]

2.2 BurrowFearConditioning module

Bases: object

Module for importing deeplabcut data

static calculate_distance(X: ndarray, Y: ndarray) \rightarrow ndarray

Function calculates the euclidean distance for each pair of points in (X, Y):param X: A numpy array of X positions:param Y: A numpy array of Y positions:return: A numpy array containing the distance between each sequential pair of points:rtype: Any

classmethod convert_dataframe_to_physical_units(DataFrame: DataFrame, oldMin: int, oldMax: int, idx: Union[str, Tuple[str]], **kwargs: int) \rightarrow DataFrame

Converts data range to physical range

Parameters

- DataFrame (pd.DataFrame) dlc data
- **oldMin** (*int*) value representing left-side
- **oldMax** (*int*) value representing right-side
- idx Which columns to rescale
- idx Union[str, Tuple[str]]
- **new_min** value representing new left-side (int, default 0)
- **new_max** value representing new right-side (int, default 140)

Returns

DataFrame with rescaled data

Return type

pd.DataFrame

static convert_to_mean_zero(*DataFrame: DataFrame, idx: Union[str, Tuple[str]]*) → DataFrame Converts data range to mean zero

Parameters

- DataFrame (pd.DataFrame) dlc data
- idx Which columns to rescale
- idx Union[str, Tuple[str]]

Returns

DataFrame with rescaled data

Return type

pd.DataFrame

classmethod load_data(DataFolderDLC: CollectedDataFolder, DataFolderBehavioralExports: CollectedDataFolder) \rightarrow Tuple[DataFrame, DataFrame]

Load DeepLabCut Data

Parameters

- DataFolderDLC (object) Collected Data Folder object for deep lab cut folder
- **DataFolderBehavioralExports** (*object*) Collected Data Folder object for behavioral exports folder

Returns

pre_trial_data, trial_data

Return type

tuple[pd.DataFrame, pd.DataFrame]

 $\textbf{classmethod merge_dlc_data}(\textit{DataFrame}; \textit{DataFrame}, \textit{DLC}: \texttt{DeepLabData}, \textit{StateCastDict}: \textit{dict}) \rightarrow \texttt{DataFrame}$

Function to merge DLC data with some DataFrame

Parameters

- DataFrame (pd.DataFrame) Data to merge with
- DLC (DeepLabData) Data to merge
- $\bullet \ \, \textbf{StateCastDict} \ (\textit{dict}) \text{dictionary relating the state integers with pre-trial and trial states} \\$

Returns

the DataFrame with DLC data merged and time-matched

Return type

pd.DataFrame

class BurrowFearConditioning.FearConditioning(Meta: Tuple[str, str], Stage: str)

Bases: BehavioralStage

Instance Factory for Fear Conditioning Data

See BehavioralStage for more information

 $static\ check_sync_plot(DataFrame:\ DataFrame) \rightarrow None$

Visualized syncing of the data

Parameters

DataFrame - The data

Returns

Plots in matplotlib

Return type

None

 $\label{load_data} \textbf{[ImagingParameters: Optional[Union[dict, list[dict]]] = None, *args: Optional[Tuple[int, int]], \\ **kwargs) \rightarrow \textbf{Self}$

Loads all data (Convenience Function)

Parameters

```
• ImagingParameters – Parameters for some imaging dataset
```

- args(Tuple[int, int]) Optional input indicating min/max of video actuator range
- **kwargs** passed to internal functions taking kwargs

```
Return type
```

Any

```
property num_stim: int
property num_trials: int
property trial_groups: Optional[Tuple[Tuple]]
property trials_per_stim: int
property unique_stim: List[Any]
```

BurrowFearConditioning.plot_burrow_coordinates(Coordinates)

```
BurrowFearConditioning.plot_column_by_trial_type(BehavioralObject: FearConditioning, ColumnName: str, *args: Tuple[str, Union[str, int, float, list]], **kwargs: str) \rightarrow Figure
```

This function plots some column organized by trial type

Parameters

- BehavioralObject (Any) The FearConditioning object
- **ColumnName** (*str*) Name of the column to be plotted
- args Second tuple for data extraction
- cmap string identifying desired colormap

Returns

figure

Return type

Any

BurrowFearConditioning.plot_trial(BehavioralObject: FearConditioning, ColumnNames: list[str], Trials: list[int], **kwargs: str) \rightarrow plt.Figure

CHAPTER

THREE

IMAGING

3.1 Coloring module

```
class Coloring.ColorImages(Images: ndarray, Stats: ndarray, Cells: ndarray)
     Bases: object
     property background
     property background_cutoffs
     property background_style
     property color_video
     property neuron_subsets
     property neuronal_ids
     property num_frames
     property num_neurons
     property overlays
     {\tt preview\_background()} \to Figure
     preview_color(idx)
     property total_rois
     property xpix
     property ypix
Coloring.colorize_complete_image(Images: ndarray, cmap: Union[Colormap, str]) → ndarray
     Colorizes an Image
          Parameters
               • Images (Any) – Image to be colorized
               • cmap – Matplotlib colormap [Object or str]
          Type
             Any
```

```
Returns
```

Colorized Image

Return type

Any

Coloring.colorize_rois(Images: ndarray, Stats: ndarray, ROIs: Optional[List[int]] = None, *args: Optional[Colormap]) \rightarrow ndarray

Generates a colorized roi overlay video

Parameters

- Images (Any) Images To Extract ROI Overlay
- Stats (Any) Suite2P Stats
- ROIs (list[int] | None) Subset of ROIs

Returns

Colorized ROIs

Return type

Any

 $\texttt{Coloring.convert_grayscale_to_color}(\mathit{Image: ndarray}) \rightarrow \mathsf{ndarray})$

Converts Image to Grayscale

Parameters

Image (Any) – Image to be converted

Returns

Color-Grayscale Image

Return type

Any

Coloring.generate_background(Images: ndarray, Option: str = 'True', Cutoffs: Tuple[float, float] = (0, 100)) \rightarrow ndarray

Coloring.generate_custom_map(Colors: List[str]) \rightarrow Colormap

Generates a custom linearized colormap

Parameters

Colors (list[str]) – List of colors included

Returns

Colormap

Return type

Any

 $\texttt{Coloring.generate_pixel_pairs}(\textit{Stats: ndarray}, \textit{ROIs: List[int]}) \rightarrow \texttt{Tuple[Tuple[int, int]]}$

Generates a tuple containing a list of each pixel pair from every ROI

Parameters

- Stats (Any) Suite2P Stats
- ROIs (list[int]) List of ROIs

Returns

List of each pixel for every ROI

Return type

tuple[tuple[int, int]]

 $\label{lem:coloring.merge_background} \textbf{(Background: ndarray, NewVideo: ndarray, PixelPairs: Tuple[Tuple[int, int]])} \rightarrow \\ \textbf{ndarray}$

Merges background video and new video at each specified pixel pair

Parameters

- Background (Any) Background video
- NewVideo (Any) Images to merge with
- PixelPairs (tuple[int,int]]) Pairs of pixels at which merging will occur

Returns

Merged Image

Return type

Any

Coloring.normalize_image(Image: ndarray) \rightarrow ndarray

Normalizes an image for color-mapping

Parameters

Image (Any) – Image to be normalized

Returns

Normalized Image

Return type

Any

Coloring.overlay_colorized_rois(Background: ndarray, ColorizedVideo: ndarray, *args: Optional[float]) \rightarrow ndarray

This function overlays colorized videos onto background video

param Background

Background Images in Grayscale

type Background

Any

param ColorizedVideo

Colorized Overlays In Colormap Space + Alpha Channel

type ColorizedVideo

Any

param args

Alpha for Background

type args

float

return

Merged Images

rtype

Any

Coloring.rescale_images (Images: ndarray, LowCut: float, HighCut: float) \rightarrow ndarray Rescale Images within percentiles

Parameters

- **Images** (Any) Images to be rescaled
- LowCut (float) Low Percentile Cutoff
- HighCut (float) High Percentile Cutoff

Returns

Rescaled Images

Return type

Any

3.2 Colorizer module

Colorizer.colorize_complete_image(Images: ndarray, cmap: Union[Colormap, str]) \rightarrow ndarray Colorizes an Image

Parameters

- Images (Any) Image to be colorized
- cmap Matplotlib colormap [Object or str]

Type

Any

Returns

Colorized Image

Return type

Any

Colorizer.colorize_rois(Images: ndarray, Stats: ndarray, ROIs: Optional[List[int]] = None, *args: Optional[Colormap]) \rightarrow ndarray

Generates a colorized roi overlay video

Parameters

- Images (Any) Images To Extract ROI Overlay
- Stats (Any) Suite2P Stats
- ROIs (list[int]|None) Subset of ROIs

Returns

Colorized ROIs

Return type

Any

Colorizer.colorize_video(Images: ndarray, Stats: ndarray, ROIs: Optional[List[int]] = None, Cutoffs: Optional[Tuple[float, float, float, float]] = None, **kwargs) \rightarrow ndarray

This function generates a video (i.e., numpy array [Z x Y x X]) in which the ROIs or subsets of ROIs utilize a different colormap

Keyword Arguments

```
cmap : Colormap to use on ROIs (str, default None)
colors : colors which will be used to generate custom colormap
(tuple[tuple[float]], default None)
Example -> ((0, 0, 0), (0.074, 0.624, 1.000), (0.074, 0.624, 1.000))
background : boolean indicating whether to overlay on a blank image
or the background of input image (bool , default True)
white_background : boolean indicating whether to use a white or black background
(bool, default False)
write : boolean indicating whether to write video to file
(bool, default False)
filename : file path for saving video (str, default None)
```

Parameters

- **Images** (Any) The images to be colorized
- Stats (Any) Suite2P Stats file
- ROIs (list[int]) A List of ROIs
- **Cutoffs** (tuple[float]) Percentile cutoffs for rescaling data. Data below or above these cutoffs will be replaced by the smallest or largest value in the data type
- cmap Colormap to use on ROIs (str, default None)
- **colors** colors which will be used to generate custom colormap (default None, overrides cmap is not None) (Tuple of Tuples of Floats, RGB, ranged 0.0-1.0)(default None)
- **background** boolean indicating whether to overlay on a blank image or the background of input image (default True)
- **white_background** Boolean indicating whether to use a white or black background (default False, requires background = False)
- write boolean indicating whether to write video to file (default False)
- **filename** str file path for saving video(default None, which saves to current directory)

Returns

Colorized Images

Return type

Any

Colorizer.generate_custom_map(Colors: List[str]) \rightarrow Colormap

Generates a custom linearized colormap

Parameters

Colors (list[str]) – List of colors included

Returns

Colormap

Return type

Any

Colorizer.generate_pixel_pairs(Stats: ndarray, ROIs: List[int]) → Tuple[Tuple[int, int]]

Generates a tuple containing a list of each pixel pair from every ROI

Parameters

3.2. Colorizer module 19

```
• Stats (Any) – Suite2P Stats
```

• ROIs (list[int]) - List of ROIs

Returns

List of each pixel for every ROI

Return type

tuple[tuple[int, int]]

 $\label{lem:colorizer.merge_background} \textbf{(Background: ndarray, NewVideo: ndarray, PixelPairs: Tuple[Tuple[int, int]])} \rightarrow \textbf{ndarray}$

Merges background video and new video at each specified pixel pair

Parameters

- Background (Any) Background video
- NewVideo (Any) Images to merge with
- PixelPairs (tuple[int,int]]) Pairs of pixels at which merging will occur

Returns

Merged Image

Return type

Any

Colorizer.overlay_colorized_rois(Background: ndarray, ColorizedVideo: ndarray, *args: Optional[float]) \rightarrow ndarray

This function overlays colorized videos onto background video

param Background

Background Images in Grayscale

type Background

Any

param ColorizedVideo

Colorized Overlays In Colormap Space + Alpha Channel

type ColorizedVideo

Any

param args

Alpha for Background

type args

float

return

Merged Images

rtype

Any

3.3 IO module

IO.determine_bruker_folder_contents(ImageDirectory: str) → Tuple[int, int, int, int, int]

Function determine contents of the bruker folder

Parameters

ImageDirectory (str) – Directory containing bruker imaging data

Return type

tuple

IO.load_all_tiffs(ImageDirectory: str) \rightarrow ndarray

Load a sequence of tiff stacks

Parameters

ImageDirectory (str) – Directory containing a sequence of tiff stacks

Returns

complete_image numpy array [Z x Y x X] as int16

Return type

Any

IO.load_binary_meta(Filename: str) \rightarrow Tuple[int, int, int, str]

Loads meta file for binary video

Parameters

Filename (str) – The meta file (.txt ext)

Returns

A tuple containing the number of frames, y pixels, and x pixels [Z x Y x X]

Return type

tuple[int, int, int, str]

IO.load_bruker_tiffs(ImageDirectory: str) → Union[ndarray, Tuple[ndarray]]

Load a sequence of tiff files from a directory.

Designed to compile the outputs of a certain imaging utility that exports recordings such that each frame is saved as a single tiff.

Parameters

ImageDirectory (str) – Directory containing a sequence of single frame tiff files

Returns

complete_image: All tiff files in the directory compiled into a single array (Z x Y x X, uint16)

Return type

Any

IO.load_mapped_binary(Filename: str, MetaFile: str, *args: Optional[str], **kwargs: str) \rightarrow memmap

Loads a raw binary file in the workspace without loading into memory

Enter the path to autofill (assumes Filename & meta are path + binary_video, video_meta.txt)

Parameters

- **Filename** (str) filename for binary video
- MetaFile (str) filename for meta file
- args(str) Path

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• **mode** – pass mode to numpy.memmap (str, default = "r")

Returns

memmap(numpy) array [Z x Y x X]

Return type

Any

 $\textbf{10.load_raw_binary}(\textit{Filename: Optional[str]}, \textit{MetaFile: Optional[str]}, *args: \textit{Optional[str]}) \rightarrow \textbf{ndarray}$

Loads a raw binary file

Enter the path to autofill (assumes Filename & meta are path + binary_video, video_meta.txt)

Parameters

- **Filename** (str) filename for binary video
- MetaFile (str) filename for meta file
- **args** (*str*) path to a directory containing Filename and MetaFile

Returns

numpy array [Z x Y x X]

Return type

Any

IO.load_single_tiff(Filename: str, NumFrames: int) \rightarrow ndarray

Load a single tiff file

Parameters

- **Filename** (str) filename
- NumFrames (int) number of frames

Returns

numpy array [Z x Y x X]

Return type

Any

10.repackage_bruker_tiffs(ImageDirectory: str, OutputDirectory: str, *args: Union[int, tuple[int]]) → None Repackages a sequence of tiff files within a directory to a smaller sequence of tiff stacks. Designed to compile the outputs of a certain imaging utility that exports recordings such that each frame is saved as a single tiff. :param ImageDirectory: Directory containing a sequence of single frame tiff files :type ImageDirectory: str :param OutputDirectory: Empty directory where tiff stacks will be saved :type OutputDirectory: str :param args: optional argument to indicate the repackaging of a specific channel and/or plane :type args: int :rtype: None

IO. save_raw_binary(Images: ndarray, ImageDirectory: str) \rightarrow None

This function saves a tiff stack as a binary file

Parameters

- Images (np.ndarray) Images to be saved $[Z \times Y \times X]$
- **ImageDirectory** (*str*) Directory to save images in

Return type

None

IO. save_single_tiff(Images: ~numpy.ndarray, Filename: str, Type: ~typing.Optional[~numpy.dtype] = <class 'numpy.int16'>) \rightarrow None

Save a numpy array to a single tiff file as type int16

Parameters

- **Images** (*Any*) numpy array [frames, y pixels, x pixels]
- **Filename** (str) filename
- Type (Optional [Any]) type for saving

Return type

None

IO. save_tiff_stack(Images: str, OutputDirectory: str, Type: ~typing.Optional[~numpy.dtype] = <class 'numpy.int16'>) \rightarrow None

Save a numpy array to a sequence of tiff stacks

Parameters

- Images (Any) A numpy array containing a tiff stack [Z x Y x X]
- OutputDirectory (str) A directory to save the sequence of tiff stacks in int16
- Type (Optional [Any]) type for saving

Return type

None

I0. save_video(Images: ndarray, Filename: str, fps: Union[float, int] = 30) \rightarrow None Function writes video to .mp4

Parameters

- Images (Any) Images to be written
- **Filename** (*str*) Filename (Or Complete Filename Path)
- **fps** (*Union*[float, int]) frame rate

Return type

None

3.4 ImageProcessing module

 $\label{lockwise_fast_filter_tiff} Image Processing. \textbf{blockwise_fast_filter_tiff} (Images: ndarray, Footprint: Optional[ndarray] = None, \\ **kwargs: int) \rightarrow \text{ndarray}$

GPU-parallelized multidimensional median filter performed in overlapping blocks.

Designed for use on arrays larger than the available memory capacity.

Footprint is of the form np.ones((Z pixels, Y pixels, X pixels)) with the origin in the center

Requires CuPy

Parameters

- Images (Any) Images stack to be filtered
- **Footprint** (*Any*) Mask of the median filter (Optional, Default 3 x 3 x 3)
- **block_size** Integer indicating the size of each block. Must fit within memory. (int, default 21000)
- **block_buffer_region** Integer indicating the size of the overlapping region between blocks (int, default 500)

Returns

Images: numpy array [Z x Y x X]

Return type

Any

 $\label{lem:mage} Image Processing. \textbf{fast_filter_images}(\textit{Images: ndarray}, \textit{Footprint: Optional[ndarray]} = \textit{None}) \rightarrow \textit{ndarray} \\ GPU-parallelized multidimensional median filter$

Footprint is of the form np.ones((Z pixels, Y pixels, X pixels)) with the origin in the center Requires CuPy

Parameters

- **Images** (Any) Image stack to be filtered [Z x Y x X]
- **Footprint** (*Any*) Mask of the median filter (Optional, Default 3 x 3 x 3)

Returns

filtered_image [Z x Y x X]

Return type

Any

 $\textbf{ImageProcessing.filter_images}(\textit{Images: ndarray}, \textit{Footprint: Optional[ndarray]} = \textit{None}) \rightarrow \textbf{ndarray}$

Denoise a tiff stack using a multidimensional median filter

This function simply calls scipy.ndimage.median_filter

Footprint is of the form np.ones((Z pixels, Y pixels, X pixels)) with the origin in the center

Parameters

- **Images** (*Any*) Images stack to be filtered [Z x Y x X]
- **Footprint** (*Any*) Mask of the median filter (Optional, Default 3 x 3 x 3)

Returns

filtered images [Z x Y x X]

Return type

Any

 $\label{lem:lemonton} \begin{tabular}{ll} Image Processing. {\bf grouped_z_project}(Images:\ ndarray,\ BinSize:\ Union[Tuple[int,\ int,\ int],\ int],\ Downsample Function:\ Callable[[ndarray],\ ndarray]) \to ndarray \\ \end{tabular}$

Utilize grouped z-project to downsample data

Downsample example function -> np.mean

Parameters

- **Images** (Any) A numpy array containing a tiff stack [Z x Y x X]
- **BinSize** (*Union* [tuple, int]) Size of each bin passed to downsampling function
- DownsampleFunction (Any) Downsampling function

Returns

downsampled image [Z x Y x X]

Return type

Any

 $Image Processing. \textbf{remove_shuttle_artifact}(\textit{Images: ndarray}, **kwargs: int) \rightarrow ndarray$

Function to remove the shuttle artifacts present at the initial imaging frames

Parameters

- Images (Any) Images array with shape Z x Y x X
- kwargs -
- artifact_length number of frames considered artifact (int)
- **chunk_size** number of frames per chunk_size (makes divisible by value) (int)

Returns

Images

Return type

Any

3.5 PowerSpectrum module

3.6 SignalProcessing module

```
SignalProcessing.anisotropicDiffusion(Trace, **kwargs)
```

SignalProcessing.anisotropic_diffusion(img, niter=1, kappa=50, gamma=0.1, voxelspacing=None, option=1)

SignalProcessing.bin_data(NeuralDataTensorForm, BinSizeInFrames)

SignalProcessing.bind_data(NeuralData, BinSize)

SignalProcessing.calculateFiringRate(SpikeProb, FrameRate)

SignalProcessing.calculate_dFoF(Traces: ndarray, FrameRate: float, **kwargs: Union[bool, float])

SignalProcessing.calculate_mean_firing_rate(NeuralData)

 $\label{eq:calculate_standardized_noise} Signal Processing. \textbf{calculate_standardized_noise}(DFF: ndarray, FrameRate: float) \rightarrow Union[float, ndarray]$

Calculates standardized noise, see: https://www.nature.com/articles/s41593-021-00895-5

Parameters

- **DFF** (*Any*) Fluorescence over Baseline (DF/F)
- **FrameRate** (*float*) Imaging framerate

Returns

standardized noise

Return type

Any

SignalProcessing.detrendTraces(Traces, **kwargs)

SignalProcessing.detrendTraces_TiffOrg(Traces, **kwargs)

SignalProcessing.normalizeSmoothFiringRates(FiringRates, Sigma)

```
SignalProcessing.smoothTraces(Traces, **kwargs)
SignalProcessing.smoothTraces_TiffOrg(Traces, **kwargs)
```

3.7 Utilities module

```
Utilities.generateCovarianceMatrix(NeuralActivity, ActivityMeasure, **kwargs)
Utilities.generateSpikeMatrix(SpikeTimes, NumFrames)
Utilities.generate_features(FramesPerTrial, NumTrials, TrialParameters)
Utilities.mergeTraces(Traces, **kwargs)
Utilities.pruneNaN(NeuralActivity, **kwargs)
Utilities.pruneTracesByNeuronalIndex(Traces, NeuronalIndex)
Utilities.trial_matrix_org(DataFrame, NeuralData)
```

3.8 Visualization module

Visualization.assessSpikeInference(SpikeProb, SpikeTimes, Traces, FrameRate)

 $\begin{tabular}{ll} Visualization. {\bf compareTraces}(RawTraces:\ ndarray,\ SmoothTraces:\ ndarray,\ FrameRate:\ float,\ Frames:\ int)\\ &\rightarrow None \end{tabular}$

Compare two sets of traces interactively

Parameters

- RawTraces (Any) Trace Set 1
- SmoothTraces (Any) Trace Set 2
- **FrameRate** (*float*) FrameRate
- Frames (int) Number of Frames

Return type

None

 $\begin{tabular}{ll} Visualization. {\bf compareTraces2} (RawTraces: ndarray, SmoothTraces: ndarray, FrameRate: float, Frames: int) \\ &\rightarrow None \end{tabular}$

Compare two sets of traces interactively

Parameters

- RawTraces (Any) Trace Set 1
- SmoothTraces (Any) Trace Set 2
- **FrameRate** (*float*) FrameRate
- **Frames** (*int*) Number of Frames

Return type

None

 $\label{eq:compareTraces} \begin{tabular}{ll} Visualization. {\bf compareTraces3} (RawTraces: ndarray, SmoothTraces: ndarray, FrameRate: float, Frames: int) \\ \rightarrow None \end{tabular}$

Compare two sets of traces interactively

Parameters

- RawTraces (Any) Trace Set 1
- SmoothTraces (Any) Trace Set 2
- FrameRate (float) FrameRate
- Frames (int) Number of Frames

Return type

None

Visualization.interactive_traces($Traces: ndarray, FrameRate: float, **kwargs) \rightarrow None$

Visualization.plotFiringRateMatrix(FiringRates, FrameRate, **kwargs)

Visualization.plotNeuralHeatMap(NeuralActivity: ndarray, FrameRate: float, *args: $Optional[Tuple[Union[List[int], Tuple[int, int]]]]) \rightarrow None$

Visualization.plotNoise(Traces, FrameRate)

Visualization.plotROC(TPR, FPR, **kwargs)

Visualization.plotSpikeInference(SpikeProb, SpikeTimes, Traces, FrameRate, **kwargs)

Visualization.view_image(Images: ndarray, FPS: float, **kwargs: Union[str, int]) \rightarrow List[object] Visualize a numpy array [Z x Y x X] as a video

Parameters

- Images (Any) A numpy array $[Z \times Y \times X]$
- FPS (float) Frames Per Second
- **cmap** colormap (str, default binary_r)
- **interpolation** interpolation method (str, default none)
- **SpeedUp** FPS multiplier (int, default 1)
- **Vmin** minimum value of colormap (int, default 0)
- Vmax maximum value of colormap (int, default 32000)

Returns

Figure Animation

Return type

list[matplotlib.pyplot.figure, matplotlib.pyplot.axes, matplotlib.pyplot.axes,

matplotlib.pyplot.axes, Any, Any]

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CHAPTER

FOUR

THEORY

4.1 DecodingAnalysis module

```
class DecodingAnalysis.DecodingModule(**kwargs)
     Bases: object
     This a super class passing conserved functions for decoding modules
     Properties
         imported_neural_organization: the structure of the passed neural data
         imported_feature_organization: the structure of the passed feature data
     assessFit(**kwargs)
     cleanKwargs()
     classmethod collapseFeatures(Features, **kwargs)
     commonAssessment(**kwargs)
     static createTrialIndicator(NumTrials, FramesPerTrial)
     dep_shuffle_trials()
     property feature_matrix
     property feature_tensor
     fitModel(**kwargs)
     fullAssessment(**kwargs)
     property imported_feature_organization
             Return type
                 str
     property imported_neural_organization
             Return type
     classmethod loadFeatures(FeatureFile)
```

```
loadFeaturesFile(_feature_data_file)
     makePrediction(**kwargs)
     property neural_matrix
     property neural_tensor
     property num_frames
     property num_neurons
     property num_trials
             Return type
                 int
     plotROCs(**kwargs)
     printAssessment()
     saveModel(OutputFolder)
     static shuffleByTrialIndex(NeuralActivityInTrialForm, TrialIndex)
     classmethod shuffleEachNeuron(NeuralActivityInMatrixForm)
     classmethod shuffleFrames(DataInMatrixForm, **kwargs)
     classmethod shuffleLabels(Labels)
     shuffle_trial_labels()
     shuffle_trials()
     static shuffled_trials_by_group(NumTrials, TrialIndex)
     splitData(**kwargs)
     classmethod split_by_trials(NeuralDataTensor, FeatureDataTensor, DataSplits, TrialGroups)
     structural_report()
     validate_data_sets()
DecodingAnalysis.PerformanceMetrics(Type, NumberOfSplits)
```

4.2 LSTMRegression module

```
class LSTMRegression.LongShortTermMemoryRegression(**kwargs)
    Bases: DecodingModule
    fitModel(**kwargs)
    makeAllPredictions(**kwargs)
    makePrediction(**kwargs)
```

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4.3 LinearNonLinearRegression module

```
class LinearNonLinearRegression.LinearNonLinearRegression(**kwargs)
    Bases: DecodingModule
    assessFit(**kwargs)
    fitModel(**kwargs)
    makePrediction(**kwargs)
```

4.4 LinearRegression module

```
class LinearRegression.LinearRegression(**kwargs)
     Bases: DecodingModule
     assessFit(**kwargs)
     commonAssessment(**kwargs)
     fitModel(**kwargs)
     fullAssessment(**kwargs)
     makeAllPredictions()
     makePrediction(**kwargs)
class LinearRegression.WienerFilterDecoder
     Bases: object
     Class for the Wiener Filter Decoder
     There are no parameters to set.
     This simply leverages the scikit-learn linear regression.
     fit(X_flat_train, y_train, **kwargs)
          Train Wiener Filter Decoder
          X_flat_train: numpy 2d array of shape [n_samples,n_features]
               This is the neural data. See example file for an example of how to format the neural data correctly
          y_train: numpy 2d array of shape [n_samples, n_outputs]
               This is the outputs that are being predicted
     predict(X_flat_test)
          Predict outcomes using trained Wiener Cascade Decoder
          X_flat_test: numpy 2d array of shape [n_samples,n_features]
               This is the neural data being used to predict outputs.
          y_test_predicted: numpy 2d array of shape [n_samples,n_outputs]
               The predicted outputs
```

4.5 LogisticRegression module

4.6 SupportVectorMachine module

```
class SupportVectorMachine.SVM(**kwargs)
    Bases: DecodingModule
    assessFit(**kwargs)
    commonAssessment(**kwargs)
    fitModel()
    makeAllPredictions()
    makePrediction(**kwargs)
```

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CHAPTER

FIVE

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