ibllib Documentation

International Brain Laboratory

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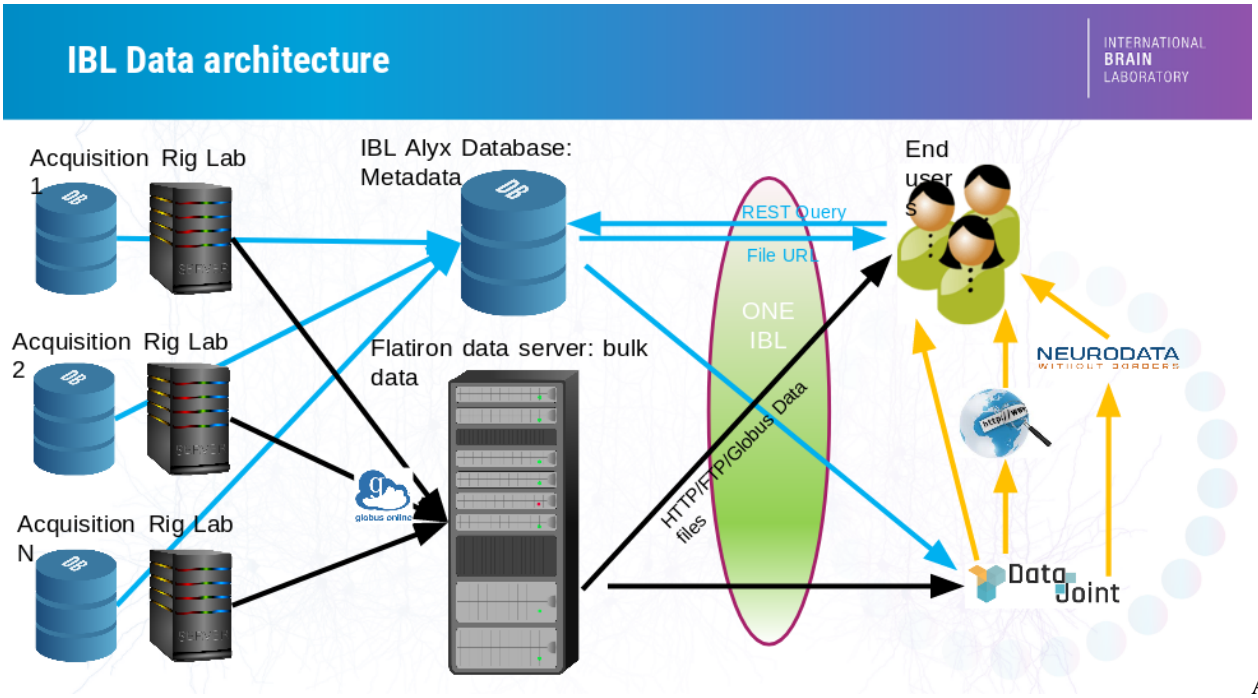
CHAPTER 1

Overview

1.1 IBL data structure



Alyx data structure

- **Alyx**: database that stores meta-data in a relational manner. Lives on the cloud.
- **Datajoint**: processing Pipeline for IBL neuroscience data.
- **FlatIron**: storage of bulky raw data time-series. The Alyx database points to the files on this server. It is accessible through HTTP, FTP and Globus.

- **ONE**: set of normalized functions to access the IBL data. It queries the Alyx database and downloads data files from the FLatIron.

1.1.1 Getting started:

Ipython notebook here

CHAPTER 2

Python Installation and Tutorial

2.1 IBLLIB Python Installation Guide

2.1.1 Python-specific Dependencies

Python-specific dependency : **Python 3.6 or higher**.

Install Anaconda/Miniconda onto your machine

Download and install the Anaconda python distribution from here (chosing the right OS): https://www.anaconda.com/download/#download *Note* : Download the latest version.

2.1.2 Initialisation

Before you begin, make sure you have installed ibllib properly on your system as per the previous instructions. Make sure your computer is connected to an IBL accredited network.

The following steps will indicate how to :

1. setup a virtual environment using Anaconda
2. install requirements and packages
3. define ONE connection settings
4. test for the installation All of that can be done using shell terminal command lines.

Setup a virtual environment using Anaconda

In a shell terminal, type the following commands:

Linux:

```
cd ibllib/
virtualenv iblenv --python=python3.7
source ./venv/bin/activate
```

Windows:

```
conda create -n iblenv python=3.7
conda activate iblenv
```

Mac OS:

```
conda create -n iblenv python=3.7 anaconda
source activate iblenv
```

Install requirements and packages

All OS:

```
pip install ibllib
```

NB: make sure you did activate your environment as shown above before installing !

Instantiate One class: Define connection settings

The first step is to instantiate the **One class**: behind the scenes, the constructor connects to the IBL cloud database and gets credentials.

The connections settings are defined in a JSON parameter file (named *.one_params*).

- In Linux, the file is in `~/.one_params`.
- In Windows, the file is in the Roaming App directory `C:\Users\CurrentUser\AppData\Roaming\.one_params`.
- In Mac OS, the file is in the user directory `/Users/CurrentUser/.one_params`.

In case of doubt, type the command `io.getappdir` in a Matlab prompt, `from pathlib import Path; print(Path.home())` in Python. It will return the directory of the JSON *.one_params* file.

***Note*: The JSON *.one_params* file is uniquely stored, and shared across Matlab and Python.**

There are two ways to define the connection settings.

1. The `setup()` static method

In a Python terminal, type:

```
from oneibl.one import ONE
ONE.setup() # For first time use, need to define connection credentials
```

Note:

- you can access a python terminal from a shell terminal by typing the command `python` in the ibllibenv virtual environment) For an `ipython` console, `pip install ipython` in the environment.
- To run with *Spyder*, link the Python Interpreter to the virtual environment you created.

- To run with *Jupyter*, type in the command `jupyter notebook` with your virtual environment activated as above (`pip install jupyter` will install jupyter if it's not already available).

You will be asked to enter the following information:

```
ALYX_LOGIN                                  # Input your IBL user name
ALYX_PWD                                  # Input your IBL password
ALYX_URL:                                  # Should be automatically set as: https://
↪alyx.internationalbrainlab.org - press ENTER
CACHE_DIR:                                  # Local repository, can ammend or press␣
↪ENTER
FTP_DATA_SERVER:                  # Should be automatically set as: ftp://ibl.
↪flatironinstitute.org - press ENTER
FTP_DATA_SERVER_LOGIN:         # Should be automatically set as: iblftp - press ENTER
FTP_DATA_SERVER_PWD                  # Request Password for FTP from Olivier
HTTP_DATA_SERVER:                  # Should be automatically set as: http://ibl.
↪flatironinstitute.org  - press ENTER
HTTP_DATA_SERVER_LOGIN: # Should be automatically set as: iblmember  - press ENTER
HTTP_DATA_SERVER_PWD         # Request Password for HTTP from IBL admins
```

Note: using `one.setup` changes the JSON *.one_params* file. Again, the file is shared across Python and Matlab platforms.

2. Edit the JSON *.one_params* file manually

Note: In Mac OS/Linux, use the command `nano` in a terminal.

Once the connections settings are defined, there is no need to setup the class One again if willing to connect with the credentials saved in the JSON *.one_params* file.

The tutorial in the next section will show you how to change credentials withough changing the JSON file (useful for seldom connection with different credentials).

2.2 IBLLIB Python Developer installation guide

1. Install Git onto your machine
   - **Linux** : Git comes with Linux.
   - **Mac OS** : Download and install Git from here: https://git-scm.com/download/mac .
   - **Windows** : Download and install Git from here: https://github.com/git-for-windows/git/releases/ .
2. Activate/install your target Python 3.6 or greater environment. For example on Linux:

Linux:

```
cd ibllib/
virtualenv iblenv --python=python3.7
source ./venv/bin/activate
```

Windows:

```
conda create -n iblenv python=3.7
conda activate iblenv
```

Mac OS:

```
conda create -n iblenv python=3.7 anaconda
source activate iblenv
```

1. Clone the ibllib repository and install ibllib in place:

```
git clone https://github.com/int-brain-lab/ibllib.git
cd ibllib
pip install -r requirements.txt
pip install -e .
```

1. Run tests
   - In a shell terminal, in the ibllib folder with the proper environment activated:
     - **Linux and Mac OS**: `source run_tests`
     - **Windows**: `call run_tests.bat` Console output should end with `OK`

2.3 ONE Tutorial Python

Before you begin, make sure you have installed ibllib properly on your system as per the previous instructions. Here is a shorter introduction to the One module in Ipython notebook format.

2.3.1 Create ONE object

Once the One class is instantiated and setup, we can create an **one object** (here labelled `one`).

With default connection settings

Type in python prompt:

```
from oneibl.one import ONE
one = ONE() # need to instantiate the class to have the API. You will have to write␣
↪these lines of code everytime you re-open python.
```

Reminder: connection parameters inserted via `one.setup()` will modify the JSON *.one_params* file see here

With different connection settings for single time use

For this tutorial we will be connecting to a **test database** with a **test user**. As these credentials will be used for this tutorial only, we do not want to change the base parameters of the JSON *.one_params* file.

```
from oneibl.one import ONE
one = ONE(username='test_user',
          password='TapetesBloc18',
          base_url='https://test.alyx.internationalbrainlab.org')
```

2.3.2 Find an experiment

Each experiment is identified by a unique string known as the "experiment ID" (EID). To find an EID, use the `one.search` command.

The following example shows how to find the experiment(s) performed by the user `olivier`, on the 24 Aug 2018:

```
from ibllib.misc import pprint
eid = one.search(users='olivier', date_range=['2018-08-24', '2018-08-24'])
pprint(eid)
```

returns

```
[
    "cf264653-2deb-44cb-aa84-89b82507028a"
]
```

For full information dictionary about the session:

```
eid, ses_info= one.search(users='olivier', date_range=['2018-08-24', '2018-08-24'],␣
↪details=True)
```

The searchable fields are listed with the following method:

```
one.search_terms()

# Example search keywords:
['dataset_types',
 'date_range',
 'lab',
 'location',
 'number',
 'performance_gte',
 'performance_lte',
 'subject',
 'task_protocol',
 'users']
```

2.3.3 List method

Once you know the EID, you can list all the datasets for the experiment using the list command:

```
one.list(eid)
```

returns

```
['_ibl_lickPiezo.raw', '_ibl_lickPiezo.timestamps', '_ibl_wheel.position', 'channels.
↪brainLocation', 'channels.probe', 'channels.rawRow', 'channels.site', 'channels.
↪sitePositions', 'clusters._phy_annotation', 'clusters.depths', 'clusters.peakChannel
↪', 'clusters.probes', 'clusters.templateWaveforms', 'clusters.waveformDuration',
↪'eye.area', 'eye.blink', 'eye.timestamps', 'eye.xyPos', 'licks.times', 'probes.
↪description', 'probes.insertion', 'probes.rawFilename', 'probes.sitePositions',
↪'spikes.amps', 'spikes.clusters', 'spikes.depths', 'spikes.times', 'spontaneous.
↪intervals', 'unknown']
```

For more detailed datasets info, this will return a dataclass with `dataset_type`, `data_url` and `dataset_id` fields amongst others:

```
d = one.list(eid, details=True)
print(d)
```

To get the full contextual information about the session, get all fields:

```
one.list(eid, 'all')
```

To navigate the database, it may be useful to get the range of possible keywords values to search for sessions. For example to print a list of the dataset-types, users and subjects in the command window:

```
one.list(None, 'dataset-types')
one.list(None, 'users')
one.list(None, 'subjects')
one.list(None, 'labs')
```

2.3.4 Load method

General Use

To load data for a given EID, use the `one.load` command:

```
dataset_types = ['clusters.templateWaveforms', 'clusters.probes', 'clusters.depths']
eid = 'cf264653-2deb-44cb-aa84-89b82507028a'
wf, pr, d = one.load(eid, dataset_types=dataset_types)
```

Depending on the use case, it may be handier to wrap the arrays in a dataclass (a structure for Matlab users) so that a bit of context is included with the array. This would be useful when concatenated information for datasets belonging to several sessions.

```
my_data = one.load(eid, dataset_types=dataset_types, dclass_output=True)
from ibllib.misc import pprint
print(my_data.local_path)
pprint(my_data.dataset_type)
```

```
[
    "/home/owinter/Downloads/FlatIronCache/clusters.templateWaveforms.2291afac-1d42-
↪4021-a07c-c5539865f42c.npy",
    "/home/owinter/Downloads/FlatIronCache/clusters.probes.66567f54-a5f4-45d1-a9e6-
↪b103ece86339.npy",
    "/home/owinter/Downloads/FlatIronCache/clusters.depths.a26662b5-ff9c-4f15-a8cf-
↪5e9c9e85690f.npy"
]
[
    "clusters.templateWaveforms",
    "clusters.probes",
    "clusters.depths"
]
```

The dataclass contains the following keys, each of which contains a list of 3 items corresponding the the 3 queried datasets

- data (*numpy.array*): the numpy array
- dataset_id (*str*): the UUID of the dataset in Alyx
- local_path (*str*): the local full path of the file
- dataset_type (*str*): as per Alyx table
- url (*str*): the link on the FlatIron server
- eid (*str*): the session UUID in Alyx

It is also possible to query all datasets attached to a given session, in which case the output has to be a dictionary:

```
eid = one.search(subjects='flowers')
my_data = one.load(eid[0])
pprint(my_data.dataset_type)
```

Specific cases

If a dataset type queried doesn't exist or is not on the FlatIron server, an empty list is returned. This allows to keep the proper order of output arguments

```
eid = 'cf264653-2deb-44cb-aa84-89b82507028a'
dataset_types = ['clusters.probes', 'thisDataset.IveJustMadeUp', 'clusters.depths']
t, empty, cl = one.load(eid, dataset_types=dataset_types)
```

Returns an empty list for *cr* so that *t* and *cl* still get assigned the corresponding datasets values.

2.3.5 Search method

The search methods allows to query the database to filter the list of UUIDs according to the following fields:

- dataset_types
- users
- subject
- date_range

One-to-one matches: subjects

This is the simplest case that queries EEIDs (sessions) associated with a subject. There can only be one subject per session.

```
eid = one.search(subject='flowers')
pprint(eid)
```

The list of search terms can be queried through:

```
ONE.search_terms()
```

Here is the simple implementation of the filter, where we query for the EEIDs (sessions) co-owned by all of the following users: olivier and test_user (case-sensitive).

```
eid = one.search(users=['test_user', 'olivier'])
```

To get all context information about the returned sessions, use the flag details:

```
eid, session_details= one.search(users=['test_user', 'olivier'], details=True)
```

The following would get all of the dataset for which olivier is an owner or a co-owner:

```
eid  = one.search(users=['olivier'])
pprint(eid)
```

It is also possible to filter sessions using a date-range:

```
eid = one.search(users='olivier', date_range=['2018-08-24', '2018-08-24'])
```

CHAPTER 3

Matlab Installation and Tutorial

3.1 IBLLIB Matlab Installation Guide

3.1.1 Matlab-specific Dependencies

Matlab-specific dependency : **Matlab R2016b or higher**.

Install Matlab onto your machine

Download and install the latest Matlab version from here: https://www.mathworks.com/downloads/

3.1.2 Initialisation

Clone or download the repository here: https://github.com/int-brain-lab/ibllib-matlab

Launch Matlab. Set the Matlab path, add with subfolders the full `.\ibllib-matlab` directory.

Instantiate One class: Define connection settings

The first step is to instantiate the **One class**: behind the scenes, the constructor connects to the IBL cloud database and gets credentials.

The connections settings are defined in a JSON parameter file (named *.one_params*).

- In Linux, the file is in `~/.one_params`.
- In Windows, the file is in the Roaming App directory `C:\Users\olivier\AppData\Roaming\.one_params`.
- In Mac OS, the file is in the user directory `/Users/olivier/.one_params`.

In case of doubt, type the command `io.getappdir` in a Matlab prompt. It will return the directory of the JSON `.one_params` file.

There are two manners to define the connection settings.

1. The `setup()` static method in Matlab

In a Matlab prompt, write:

```
One.setup
```

You will be asked to enter the following information:

```
ALYX_LOGIN                                  % Input your IBL user name
ALYX_PWD                                  % Input your IBL password
ALYX_URL:                                  % Should be automatically set as: https://
↪alyx.internationalbrainlab.org - press ENTER
CACHE_DIR:                                  % Local repository, can ammend or press␣
↪ENTER
FTP_DATA_SERVER:                   % Should be automatically set as: ftp://ibl.
↪flatironinstitute.org - press ENTER
FTP_DATA_SERVER_LOGIN:         % Should be automatically set as: iblftp - press ENTER
FTP_DATA_SERVER_PWD                 % Request Password for FTP from Olivier
HTTP_DATA_SERVER:                  % Should be automatically set as: http://ibl.
↪flatironinstitute.org  - press ENTER
HTTP_DATA_SERVER_LOGIN: % Should be automatically set as: iblmember  - press ENTER
HTTP_DATA_SERVER_PWD        % Request Password for HTTP from Olivier
```

The path to the *.one_params* file is displayed in the Matlab prompt as `ans`.

Note: using `One.setup` changes the JSON *.one_params* file. Also note that the file is shared across Python and Matlab platforms.

2. Edit the JSON *.one_params*

Note: In Mac OS or Linux, use the command `nano` in a terminal.

Once the connections settings are defined, there is no need to setup the class One again if willing to connect with the credentials saved in the JSON *.one_params* file.

The tutorial in the next section will show you how to change credentials without changing the JSON file (useful for a temporary connection with different credentials).

Run tests

Once the One class is instantiated with your IBL credentials, run the suite of Unit tests to check the installation:

```
RunTestsIBL('All')
```

If you see any Failure message, please report on GitHub or contact data admins (Olivier / Niccolo). If not, you are ready for the tutorial - go to next section !

3.2 ONE Tutorial Matlab

Before you begin, make sure you have installed ibllib properly on your system as per the previous instructions.

3.2.1 Create ONE object

Once the One class is instantiated and setup, we can create an **one object** (here labelled `one`).

With default connection settings

Type in Matlab prompt:

```
one = One();  % this line of code will be the first line to write everytime you re-
↪open Matlab
```

Reminder: connection parameters inserted via `one.setup` will modify the JSON `.one_params` file see installation notes here

With different connection settings for single time use

For this tutorial we will be connecting to a **test database** with a **test user**. As these credentials will be used for this tutorial only, we do not want to change the base parameters of the JSON `.one_params` file.

To change the credentials without changing the JSON `.one_params` file, type:

```
one = One(        'alyx_login', 'test_user', ...
                  'alyx_pwd', 'TapetesBloc18', ...
                  'alyx_url', 'https://test.alyx.internationalbrainlab.org');
```

You now have created an one object. This object has several fields, the following are of interest for analysis. Type help to retrieve the documentation on each field:

```
help one.list
help one.load
help one.search
```

3.2.2 Find an experiment

Each experiment is identified by a unique string known as the "experiment ID" (EID). To find an EID, use the `one.search` command.

The following example shows how to find the experiment(s) performed by the user `olivier`, on the 24 Aug 2018:

```
[eid, ses] = one.search('users', {'olivier'}, 'date_range', datenum([2018 8 24 ; 2018␣
↪8 24])) ;
```

returns

```
eid =
    'cf264653-2deb-44cb-aa84-89b82507028a'
```

The searchable fields are listed by calling the search method with no parameters:

```
one.search

% Example search keywords:
        'dataset_types'
        'date_range'
        'labs'
        'subjects'
        'users'
```

3.2.3 List method

Once you know the EID, you can list all the datasets for the experiment using the list command:

```
one.list(eid)
```

returns

```
ans =

  29×1 cell array

    {'_ibl_lickPiezo.raw'         }
    {'_ibl_lickPiezo.timestamps'  }
    {'_ibl_wheel.position'        }
    {'_ibl_wheel.timestamps'      }
    {'channels.brainLocation'     }
    {'channels.probe'             }
    {'channels.rawRow'            }
    {'channels.site'              }
    {'channels.sitePositions'     }
    {'clusters._phy_annotation'   }
    {'clusters.depths'            }
    {'clusters.peakChannel'       }
    {'clusters.probes'            }
    {'clusters.templateWaveforms'}
    {'clusters.waveformDuration'  }
    {'eye.area'                   }
    {'eye.blink'                  }
    {'eye.timestamps'             }
    {'eye.xyPos'                  }
    {'licks.times'                }
    {'probes.description'         }
    {'probes.insertion'           }
    {'probes.rawFilename'         }
    {'probes.sitePositions'       }
    {'spikes.amps'                }
    {'spikes.clusters'            }
    {'spikes.depths'              }
    {'spikes.times'               }
    {'spontaneous.intervals'      }
```

For more detailed datasets info, this command will return a dataclass with `dataset_type`, `data_url` and `dataset_id` fields amongst others:

```
[dtypes details] = one.list(eid);
details =
```

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```
  struct with fields:

              id: {29×1 cell}
            name: {29×1 cell}
    dataset_type: {29×1 cell}
        data_url: {29×1 cell}
     data_format: {29×1 cell}
             url: {29×1 cell}
             eid: {29×1 cell}
```

To get the full contextual information about the session, get all fields:

```
ses_info = one.list(eid, 'keyword', 'all')
```

To navigate further the database, it may be useful to get the range of possible keywords values to search for sessions. For example to print a list of the dataset-types, users and subjects in the command window:

```
one.list([],'keyword', 'labs')
one.list([],'keyword', 'datasets')
one.list([],'keyword', 'users')
one.list([],'keyword', 'subjects')
```

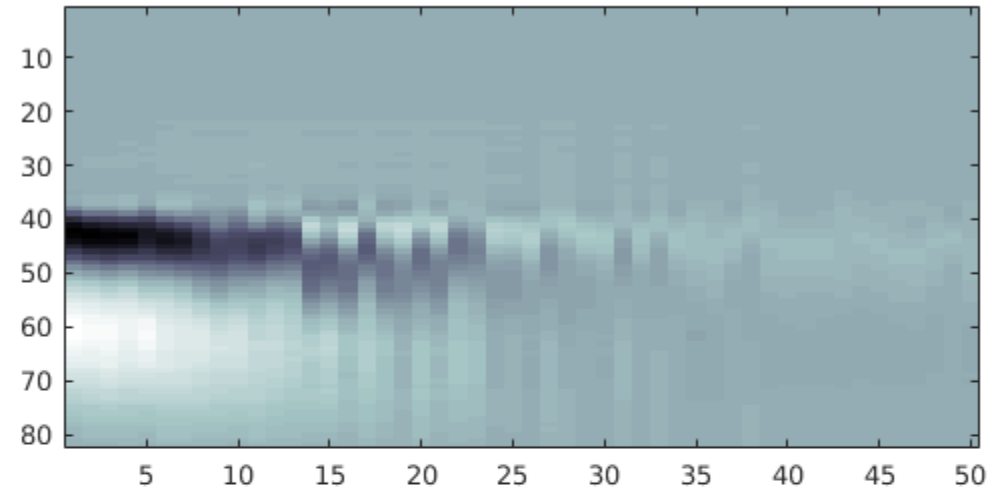
3.2.4 Load method

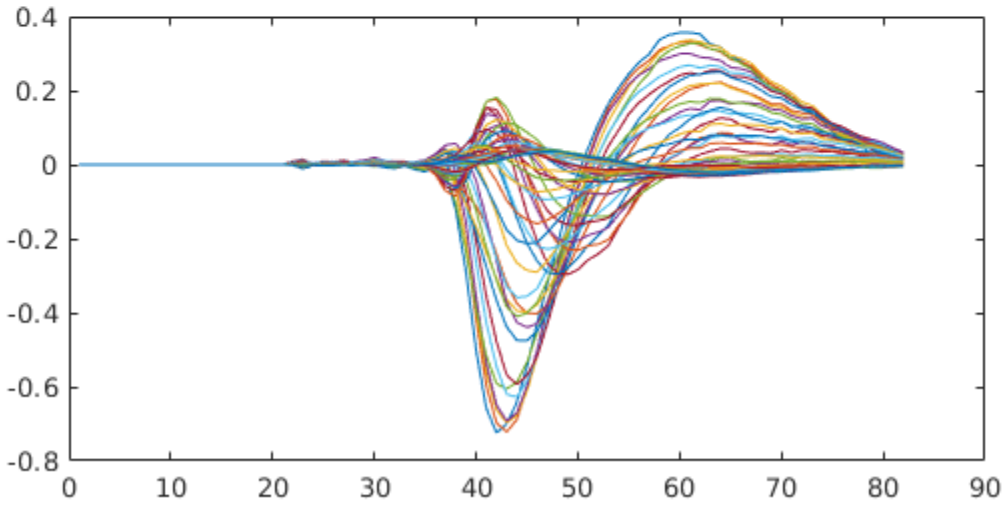
General Use

To load data for a given EID, use the `One.load` command:

```
dataset_types = {'clusters.templateWaveforms', 'clusters.probes', 'clusters.depths'};
eid = 'cf264653-2deb-44cb-aa84-89b82507028a';
[wf, pr, d ]= one.load(eid, 'data' ,dataset_types);

figure,
imagesc(squeeze(wf(1,:,:)), 'Parent', subplot(2,1,1)), colormap('bone')
plot(subplot(2,1,2), squeeze(wf(1,:,:)))
```





Alyx

data structure

Depending on the use case, it may be handier to wrap the arrays in a dataclass (a structure for Matlab users) so that a bit of context is included with the array. This would be useful when concatenated information for datasets belonging to several sessions.

```
D = one.load(eid, 'data' ,dataset_types, 'dclass_output', true);

disp(D.local_path)
disp(D.dataset_type)
disp('dimensions: ')
disp(cellfun(@(x) length(x), D.data))
```

will print in the command window the following:

```
    '/home/owinter/Downloads/FlatIron/mainenlab/Subjects/clns0730/2018-08-24/1/
↪clusters.templateWaveforms.5e7f6ede-2618-41d2-95ee-ce144ea12851.npy'
    '/home/owinter/Downloads/FlatIron/mainenlab/Subjects/clns0730/2018-08-24/1/
↪clusters.probes.c41dd877-d511-42cb-90a3-01bb19297117.npy'
    '/home/owinter/Downloads/FlatIron/mainenlab/Subjects/clns0730/2018-08-24/1/
↪clusters.depths.42507ace-1ced-4358-a5ef-c4ddd8b7071c.npy'

    'clusters.templateWaveforms'
    'clusters.probes'
    'clusters.depths'

dimensions:
        1109
        1109
        1109
```

The dataclass contains the following keys, each of which contains a list of 3 items corresponding the the 3 queried datasets

- data `cell(*array*)`: the array
- dataset_id `cell(*str*)`: the UUID of the dataset in Alyx
- local_path `cell(*str*)`: the local full path of the file
- dataset_type `cell(*str*)`: as per Alyx table
- url `cell(*str*)`: the link on the FlatIron server
- eid `cell(*str*)`: the session UUID in Alyx

It is also possible to query all datasets attached to a given session, in which case the output has to be a table/structure as seen above:

```
[eid, ses_info ]= one.search('subjects', 'flowers');
D = one.load(eid);
```

In this case it will return a table with 5 datasets.

Specific cases

If a dataset type queried doesn't exist or is not on the FlatIron server, an empty list is returned. This allows to keep the proper order of output arguments

```
eid = 'cf264653-2deb-44cb-aa84-89b82507028a';
dataset_types = {'clusters.probes', 'thisDataset.IveJustMadeUp', 'clusters.depths'};
[t, empty, cl ] = one.load(eid, 'data', dataset_types)
isempty(empty) % true !
```

Returns an empty array for `empty` so that `t` and `cl` still get assigned the corresponding datasets values.

3.2.5 Search method

The search methods allows to query the database to filter the list of UUIDs according to the following fields:

- `dataset_types`
- `users`

- subject
- date_range

One-to-one matches: subjects

This is the simplest case that queries EEIDs (sessions) associated with a subject. There can only be one subject per session.

```
eid = one.search('subject', 'flowers');
```

Another use case is to query EEIDs associated with a dataset type.

```
[eids,ses] = one.search('data', 'channels.brainLocation')
```

Here is the simple implementation of the filter, where we query for the EEIDs (sessions) co-owned by all of the following users: olivier and niccolo (case-sensitive).

```
eid = one.search('users',{'test_user', 'olivier'});
```

The following would get all of the dataset for which olivier is an owner or a co-owner:

```
[eid, ses_info] = one.search('users', 'olivier');
```

Note that unlike the first example, here we used an optional second output argument , to get all context information about the returned sessions.

It is also possible to filter sessions using a date-range:

```
eid = one.search('users','olivier', 'date_range', ['2018-08-24'; '2018-08-24'])
```

In the example above we used strings to specify the date however it is a safer practice to cast the range as a 2 elements datenum vector.

```
drange = datenum(['2018-08-24'; '2018-08-24'])
eid = one.search('users','olivier', 'date_range', drange)
```

CHAPTER 4

Reference Information on ALF and ONE

4.1 Reference

4.1.1 Open Neurophysiology Environment

Neurophysiology needs data standardization. A scientist should be able to analyze data collected from multiple labs using a single analysis program, without spending untold hours figuring out new file formats. Substantial efforts have recently been put into developing neurodata file standards, with the most successful being the Neurodata Without Borders (NWB) format. The NWB format has a comprehensive and careful design that allows one to store all data and metadata pertaining to a neurophysiology experiment. Nevertheless, its comprehensive design also means a steep learning curve for potential users, which has limited its adoption.

How the open neurophysiology environment works

Here we provide a solution to this problem: a set of four simple functions, that allow users to access and search data from multiple sources. To adopt the standard, data providers can use any format they like - all they need to do is implement these functions to fetch the data from their server and load it into Python or MATLAB. Users can then analyze this data with the same exact code as data from any other provider. The learning curve will be simple, and the loader functions would be enough for around 90% of common use cases.

By a *data provider* we mean an organization that hosts a set of neurophysiology data on an internet server (for example, the International Brain Lab). The Open Neurophysiology Environment (ONE) provides a way for scientists to analyze data from multiple data providers using the same analysis code. There is no need for the scientist to explicitly download data files or understand their format - this is all handled seamlessly by the ONE framework. The ONE protocol can also be used to access a scientist's own experiments stored on their personal computer, but we do not describe this use-case here.

When a user wants to analyze data released by a provider, they first import that provider's loader functions. In python, to analyze IBL data, they would type

```
from oneibl.one import ONE
```

Because it is up to data providers to maintain the loader functions, all a user needs to do to work with data from a specific provider is import their loader module. To analyze Allen data, they could instead type `import one_allen`. After that, all other analysis code will be the same, regardless of which provider's data they are analyzing.

Every experiment a data provider releases is identified by an *experiment ID* (eID) – a small token that uniquely identifies a particular experiment. It is up to the data provider to specify the format of their eIDs.

Loading data

If a user already knows the eID of an experiment they are interested in, they can load data for the experiment using a command like:

```
st, sc, cbl = ONE.load(eID, dataset_types=['spikes.times', 'spikes.clusters',
↪'clusters.brain_location'])
```

This command will download three datasets containing the times and cluster assignments of all spikes recorded in that experiment, together with an estimate of the brain location of each cluster. (In practice, the data will be cached on the user's local machine so it can be loaded repeatedly with only one download.)

Many neural data signals are time series, and synchronizing these signals is often challenging. ONE will provide a function to interpolate any required timeseries to an evenly or unevenly-sampled timescale of the user's choice. For example the command:

```
hxy, hth, t = ONE.loadTS(eID, dataset_types=['headTracking.xyPos', 'lfp.raw'], sample_
↪rate=1000)
```

would interpolate head position and lfp to a common 1000 Hz sampling rate. The sample times are returned as `t`.

Searching for experiments

Finally, a user needs to be able to search the data released by a provider, to obtain the eIDs of experiments they want to analyze. To do so they would run a command like:

```
eIDs = ONE.search(lab='CortexLabUCL', subject='hercules', dataset_types=['spikes.times
↪', 'spikes.clusters','headTracking.xyPos'])
eIDs, eInfo = ONE.search(details=True, lab='CortexLabUCL', subject='hercules',␣
↪dataset_types=['spikes.times', 'spikes.clusters','headTracking.xyPos'])
```

This would find the eIDs for all experiments collected in the specified lab for the specified experimental subject, for which all of the required data is present. There will be more metadata options to refine the search (e.g. dates, genotypes, experimenter), and additional metadata on each matching experiment is returned in `eInfo`. However, the existence of dataset types is normally enough to find the data you want. For example, if you want to analyze electrophysiology in a particular behavior task, the experiments you want are exactly those with datasets describing the ephys recordings and that task's parameters.

Standardization

The key to ONE's standardization is the concept of a "standard dataset type". When a user requests one of these (such as `'spikes.times'`), they are guaranteed that each data provider will return them the same information, organized in the same way - in this case, the times of all extracellularly recorded spikes, measured in seconds relative to experiment start, and returned as a 1-dimensional column vector. It is guaranteed that any dataset types of the form `*.times` or `*.*_times` will be measured in seconds relative to experiment start. Furthermore, all dataset types differing only in their last word (e.g. `spikes.times` and `spikes.clusters`) will have the same number of rows, describing multiple attributes of the same objects. Finally, words matching across dataset types encode references: for

example, `spikes.clusters` is guaranteed to contain integers, and to find the brain location of each of these one looks to the corresponding row of `clusters.brain_location`, counting from 0.

Not all data can be standardized, since each project will do unique experiments. Data providers can thereform add their own project-specific dataset types. The list of standard dataset types will be maintained centrally, and will start small but increase over time as the community converges on good ways to standardize more information. It is therefore important to distinguish dataset types agreed as universal standards from types specific to individual projects. To achieve this, names beginning with an underscore are guaranteed never to be standard. It is recommended that nonstandard names identify the group that produces them: for example the dataset types `_ibl_trials.stimulusContrast` and `clusters._ibl_task_modulation` could contain information specific to the IBL project.

Versioning and subcollections

Data are often released in multiple versions. Most users will want always to have the latest version, but sometimes a user working will want to continue working with a historical version even after it has been updated, to maintain consistency with previous work. To enable versioning, the ONE functions will have accept an optional argument of the form `version='v1'`, which will ensure this specific version is loaded. If the argument is not passed, the latest version will be loaded.

Sometimes the data will contain multiple measurements of the same type, for example if recordings are made with multiple recording probes simultaneously. In these cases, the dataset types for probe 0 will have names like `probe00/spikes.times`, `probe00/spikes.clusters`, and `probe00/clusters.brain_location`; data for probe 1 will be `probe01/spikes.times`, etc. Encoding of references works within a subcollection: i.e. the entries of `probe00/spikes.clusters` point to the rows of `probe00/clusters.brain_location`, starting from 0, and independently of any datasets starting with `probe01/`.

For data sharers

Data standards are only adopted when they are easy to use, for both providers and users of data. For users, the three ONE functions will be simple to learn, and will cover most common use cases.

For providers, a key advantage of this framework is its low barrier to entry. To share data with ONE, providers do not need to run and maintain a backend server, just to upload their data to a website. We provide a "ONE light" implementation of the ONE loader functions that searches, downloads and caches files from a web server. This will allow producers who do not have in-house computational staff two simple paths to achieve ONE compatibility. The first is to place the data in a directory, using a standard file-naming convention described below, in standard formats including `npy`, `csv`, `json`, and `tiff`. Next, the user runs a program in this directory, which uploads the files to a website or to figshare. Users can then access this data using ONE light. And example of ONE light data is here. The ONE light code is here.

4.1.2 ALF

ALF stands for "ALyx Files". It not a format but rather a format-neutral file-naming convention. ALF is how IBL organizes files that will be loaded via the ONE protocol.

In ALF, the measurements in an experiment are represented by collections of files in a directory. Each filename has three parts, for example `spikes.times.npy` or `spikes.clusters.npy`. The first two correspond to the ONE dataset type, and we refer to them as the *object* and the *attribute*. The third part of the filename, the *extension*, specifies what physical format the file is in - we primarily use .npy and .tsv but you could use any format, for example video or json .

Each file contains information about particular attribute of the object. For example `spikes.times.npy` indicates the times of spikes and `spikes.clusters.npy` indicates their cluster assignments. You could have another file `spikes.amplitudes.npy` to convey their amplitudes. The important thing is that every file describing an object

has the same number of rows (i.e. the 1st dimension of an npy file, number of frames in a video file, etc). You can therefore think of the files for an object as together defining a table, with column headings given by the attribute in the file names, and values given by the file contents.

ALF objects can represent anything. But three types of object are special:

Event series

If there is a file with attribute `times`, (i.e. filename `obj.times.ext`), it indicates that this object is an event series. The `times` file contains a numerical array containing times of the events in seconds, relative to a universal timescale common to all files. Other attributes of the events are stored in different files. If you want to represent times relative to another timescale, do this by appending to `timescale` after an underscore (e.g. `spikes.times_ephysClock.npy`). By convention, any other file with attribute that ends in `_times` is understood to be a time in universal seconds; for example `trials.reward_times.npy`. An attribute ending with `_times_timescale` is by convention a time in that timescale.

Interval series

If there is a file with attribute `intervals`, (i.e. filename `tones.intervals.npy`), it should have two columns, indicating the start and end times of each interval relative to the universal timescale. Again, other attributes of the events can be stored in different files (e.g. `tones.frequencies.npy`. Event times relative to other timescales can be represented by a file with attribute `intervals_timescale`. Again, any other attributes of the form `trials.cue_intervals.npy` are by convention measured in universal seconds.

Continuous timeseries

If there is a file with attribute `timestamps`, it indicates the object is a continuous timeseries. The timestamps file represents information required to synchronize the timeseries to the universal timebase, even if they were unevenly sampled. There are 2 possibilities:

- The `timestamps` file contains a single column containing time of every sample within the timescale.
- The `timestamps` file contains two rows. Each row of the `timestamps` file represents a synchronization point, with the first column giving the sample number (counting from 0), and the second column giving the corresponding time in universal seconds. The times corresponding to all samples are then found by linear interpolation. Note that the `timestamps` file is an exception to the rule that all files representing a continuous timeseries object must have one row per sample, as it will often have substantially less. Note that an evenly-sampled recording should have just two timestamps, giving the times of the first and last sample.

File types

ALF can deal with any sort of file, as long as it has a concept of a number of rows (or primary dimension). The type of file is recognized by its extension. Preferred choices:

.npy: numpy array file. This is recommended over flat binary since datatype and shape is stored in the file. If you want to name the columns, use a metadata file. If you have an array of 3 or more dimensions, the first dimension counts as the number of rows. To access npy files from MATLAB use this.

.tsv: tab-delimited text file. This is recommended over comma-separated files since text fields often have commas in. All rows should have the same number of columns. The first row contains tab-separated names for each column.

.bin: flat binary file. It's better to use .npy for storing binary dat,a but some recording systems save in flat binary. Rather than convert them, you can ALFize a flat binary file by adding a metadata file, which specifies the number of

columns (as the size of the "columns" array) and the binary datatype as a top-level key "dtype", using numpy naming conventions.

Relations

Encoding of relations between objects can be achieved by a simplified relational model. If the attribute name of one file matches the object name of a second, then the first file is guaranteed to contain integers referring to the rows of the second. For example, `spikes.clusters.npy` would contain integer references to the rows of `clusters.brain_location.json` and `clusters.probes.npy`; and `clusters.probes.npy` would contain integer references to `probes.insertion.json`. Be careful of plurals (`clusters.probe.npy` would not correspond to `probes.insertion.json`) and remember we count arrays starting from 0.

Longer file names

A proposed extension to ALF would allow encoding of additional information in filenames with more than 3 parts. In this proposal, file names could have as many parts as you like: object.attribute.x1.x2. ... .xN.extension. The extra name parts play no formal role in the ALF conventions, but can serve several additional purposes. For example, if you want unique file names to make archiving and backups easier, they could contain a unique string, for example a Dataset ID from Alyx, or the md5 hash of the file. Extra parts could be used to encode the subject name if you are worried about accidentally moving files between directories. The filenames might get long; however the important information in the filename is in the first two parts, which users can tab-autocomplete when typing them at the command line; also, because the extension is last, they can also double-click the file to open it with a default application such as a movie viewer.

Finally, if there are multiple files with the same object, attribute, and extensions but different extra parts, these should be treated as files to be concatenated, for example to allow multiple-part tif files as produced by scanimage to be encoded in ALF. The concatenation would happen in hierarchical lexicographical order: i.e. by lexicographic order of x1, then x2 if x1 is equal, etc.

Metadata

Sometimes you will want to provide metadata on the columns or rows of a data file. For example, clusters.ccf_location.tsv could be a 4-column tab-delimited text file in which the first 3 columns contain xyz coordinates of a cluster and the 4th contains its inferred brain location as text. In this case, an additional JSON file clusters.ccf_location.metadata.json can provide information about the columns and rows. The metadata file can contain anything, but if it has a top-level key "columns", that should be an array of size the number of columns, and if it has a top-level key "rows" that should be an array of size the number of rows. If the entries in the columns and rows arrays have a key "name" that defines a name for the column or row; a key "unit" defines a unit of measurement. You can add anything else you want.

Note that in ALF you should not have generally two data files with the same object and attribute: if you have tones.frequencies.npy, you can't also have tones.frequencies.tsv. Metadata files are an exception to this: if you have tones.frequencies.npy, you can also have tones.frequencies.metadata.json.

Versioning and subcollections

Versioning and subcollections are achieved with subdirectories. If your main ALF directory contains a subfolder `v1`, any files in there are assumed to be version `v1`. The root directory is assumed to contain the most recent files.

Subcollections are also achieved with subdirectories: a subfolder `probe00` of the main ALF directory contains the files specific to probe 0; you can also have a subcollection within a version such as `v1/probe00`.

CHAPTER 5

Docstrings Reference

5.1 Python Modules Docstrings

5.1.1 alf module

alf.io	Generic ALF I/O module.
alf.folders	

alf.io

Generic ALF I/O module. Provides support for time-series reading and interpolation as per the specifications For a full overview of the scope of the format, see: https://ibllib.readthedocs.io/en/develop/04_reference.html#alf

alf.io.**check_dimensions**(*dico*)
Test for consistency of dimensions as per ALF specs in a dictionary. Raises a Value Error.

Alf broadcasting rules: only accepts consistent dimensions for a given axis a dimension is consistent with another if it's empty, 1, or equal to the other arrays dims [a, 1], [1, b] and [a, b] are all consistent, [c, 1] is not

Parameters **dico** – dictionary containing data

Returns status 0 for consistent dimensions, 1 for inconsistent dimensions

alf.io.**exists**(*alfpath*, *object*, *attributes=None*, *glob='.*'*)
Test if ALF object and optionally specific attributes exist in the given path :param alfpath: str or pathlib.Path of the folder to look into :param object: str ALF object name :param attributes: list or list of strings for wanted attributes :param glob: (".*") glob pattern to look for files or list of parts as per ALF specifications :return: Bool. For multiple attributes, returns True only if all attributes are found

alf.io.**is_uuid_string**(*string*)
Bool test to c

alf.io.**load_file_content**(*fil*)
Returns content of files. Designed for very generic file formats: so far supported contents are *json*, *npy*, *csv*, *tsv*,

ssv, *jsonable*

Parameters **fil** – file to read

:return:array/json/pandas dataframe depending on format

alf.io.**load_object**(*alfpath*, *object=None*, *glob='.*'*, *short_keys=False*)
Reads all files (ie. attributes) sharing the same object. For example, if the file provided to the function is *spikes.times*, the function will load *spikes.time*, *spikes.clusters*, *spikes.depths*, *spike.amps* in a dictionary whose keys will be *time*, *clusters*, *depths*, *amps* Full Reference here: https://github.com/cortex-lab/ALF Simplified example: _namespace_object.attribute.part1.part2.extension

Parameters

- **alfpath** – any alf file pertaining to the object OR directory containing files
- **object** – if a directory is provided, need to specify the name of object to load
- **glob** – a file filter string like one used in glob: "*.amps.*" for example
- **short_keys** – by default, the output dictionary keys will be compounds of attributes and any eventual parts separated by a dot. Use True to shorten the keys to the bare attribute.

Returns a dictionary of all attributes pertaining to the object

example: spikes = ibllib.io.alf.load_object('/path/to/my/alffolder/', 'spikes')

alf.io.**read_ts**(*filename*)
Load time-series from ALF format t, d = alf.read_ts(filename)

alf.io.**remove_uuid_file**(*file_path*, *dry=False*)
Renames a file without the UUID and returns the new pathlib.Path object

alf.io.**remove_uuid_recursive**(*folder*, *dry=False*)
Within a folder, recursive renaming of all files to remove UUID

alf.io.**save_metadata**(*file_alf*, *dico*)
Writes a meta data file matching a current alf file object. For example given an alf file *clusters.ccf_location.ssv* this will write a dictionary in json format in *clusters.ccf_location.metadata.json* Reserved keywords:

- **columns**: column names for binary tables.
- **row**: row names for binary tables.
- **unit**

Parameters

- **file_alf** – full path to the alf object
- **dico** – dictionary containing meta-data.

Returns None

alf.io.**save_object_npy**(*alfpath*, *dico*, *object*, *parts=''*)
Saves a dictionary in alf format using object as object name and dictionary keys as attribute names. Dimensions have to be consistent. Reference here: https://github.com/cortex-lab/ALF Simplified example: _namespace_object.attribute.part1.part2.extension

Parameters

- **alfpath** – path of the folder to save data to
- **dico** – dictionary to save to npy
- **object** – name of the object to save

- **parts** – extra parts to the ALF name

Returns List of written files

example: ibllib.io.alf.save_object_npy('/path/to/my/alffolder/', spikes, 'spikes')

alf.folders

alf.folders.**find_sessions**(*folder: Union[str, pathlib.Path]*) → List[str]
Returns all sessions found in all subfolders of a main data folder

alf.folders.**find_subject_folders**(*folder: Union[str, pathlib.Path]*) → List[pathlib.Path]
Returns all subject folders found from a main data folder

alf.folders.**find_subject_names**(*folder: Union[str, pathlib.Path]*) → List[str]
Returns all subject names found from a main data folder

alf.folders.**next_num_folder**(*session_date_folder: str*) → str
Return the next number for a session given a session_date_folder

alf.folders.**remove_empty_folders**(*folder: Union[str, pathlib.Path]*) → None
Will iteratively remove any children empty folders

alf.folders.**session_name**(*path: Union[str, pathlib.Path]*) → str
Returns the session name (subject/date/number) string for any filepath useing session_path

alf.folders.**session_path**(*path: Union[str, pathlib.Path]*) → str
Returns the session path from any filepath if the date/number pattern is found

alf.folders.**subjects_data_folder**(*folder: pathlib.Path*, *rglob: bool = False*) → pathlib.Path
Given a root_data_folder will try to find a 'Subjects' data folder. If Subjects folder is passed will return it directly.

5.1.2 ibllib module

ibllib.behaviour.wheel	
ibllib.dsp.fourier	Low-level functions to work in frequency domain for n-dim arrays
ibllib.dsp.utils	Window generator, front detections, rms
ibllib.ephys.ephysqc	Quality control of raw Neuropixel electrophysiology data.
ibllib.io.extractors.biased_trials	
ibllib.io.extractors.biased_wheel	
ibllib.io.extractors.ephys_fpga	
ibllib.io.extractors.ephys_trials	
ibllib.io.extractors.training_audio	
ibllib.io.extractors.training_trials	**ALF extractors** are a collection of functions that extract alf files from the PyBpod rig raw data.
ibllib.io.extractors.training_wheel	Training wheel extractor from Pybpod output.
ibllib.io.flags	
ibllib.io.params	
ibllib.io.raw_data_loaders	Raw Data Loader functions for PyBpod rig
ibllib.io.spikeglx	
ibllib.misc.misc	
ibllib.misc.version	

Continued on next page

Table 2 – continued from previous page

ibllib.pipes.experimental_data	Entry point to system commands for IBL behaviour pipeline.
ibllib.pipes.extract_session	Find task name Check if extractors for specific task exist Extract data OR return error to user saying that the task has no extractors
ibllib.pipes.purge_rig_data	Purge data from RIG - Find all files by rglob - Find all sessions of the found files - Check Alyx if corresponding datasetTypes have been registered as existing sessions and files on Flatiron - Delete local raw file if found on Flatiron
ibllib.pipes.transfer_rig_data	
ibllib.graphic	
ibllib.plots	

ibllib.dsp.fourier

Low-level functions to work in frequency domain for n-dim arrays

ibllib.dsp.fourier.**bp**(*ts*, *si*, *b*, *axis=None*)

Band-pass filter in frequency domain

Parameters

- **ts** – time serie
- **si** – sampling interval in seconds
- **b** – cutout frequencies: 4 elements vector or list
- **axis** – axis along which to perform reduction (last axis by default)

Returns filtered time serie

ibllib.dsp.fourier.**fexpand**(*x*, *ns=1*, *axis=None*)

Reconstructs full spectrum from positive frequencies Works on the last dimension (contiguous in c-stored array)

Parameters

- **x** – numpy.ndarray
- **axis** – axis along which to perform reduction (last axis by default)

Returns numpy.ndarray

ibllib.dsp.fourier.**freduce**(*x*, *axis=None*)

Reduces a spectrum to positive frequencies only Works on the last dimension (contiguous in c-stored array)

Parameters

- **x** – numpy.ndarray
- **axis** – axis along which to perform reduction (last axis by default)

Returns numpy.ndarray

ibllib.dsp.fourier.**fscale**(*ns*, *si=1*, *one_sided=False*)

numpy.fft.fftfreq returns Nyquist as a negative frequency so we propose this instead

Parameters

- **ns** – number of samples
- **si** – sampling interval in seconds

- **one_sided** – if True, returns only positive frequencies

Returns fscale: numpy vector containing frequencies in Hertz

ibllib.dsp.fourier.**hp**(*ts*, *si*, *b*, *axis=None*)
High-pass filter in frequency domain

Parameters

- **ts** – time serie
- **si** – sampling interval in seconds
- **b** – cutout frequencies: 2 elements vector or list
- **axis** – axis along which to perform reduction (last axis by default)

Returns filtered time serie

ibllib.dsp.fourier.**lp**(*ts*, *si*, *b*, *axis=None*)
Low-pass filter in frequency domain

Parameters

- **ts** – time serie
- **si** – sampling interval in seconds
- **b** – cutout frequencies: 2 elements vector or list
- **axis** – axis along which to perform reduction (last axis by default)

Returns filtered time serie

ibllib.dsp.utils

Window generator, front detections, rms

class ibllib.dsp.utils.**WindowGenerator**(*ns*, *nswin*, *overlap*)
wg = WindowGenerator(ns, nswin, overlap)

Provide sliding windows indices generator for signal processing applications. For straightforward spectrogram / periodogram implementation, prefer scipy methods !

Example of implementations in test_dsp.py.

firstlast
Generator that yields first and last index of windows

Returns tuple of [first_index, last_index] of the window

print_progress()
Prints progress using a terminal progress bar

slice
Generator that yields slices of windows

Returns a slice of the window

slice_array(*sig*, *axis=-1*)
Provided an array or sliceable object, generator that yields slices corresponding to windows. Especially useful when working on memmpaps

Parameters

- **sig** – array

- **axis** – (optional, -1) dimension along which to provide the slice

Returns array slice Generator

tscale(*fs*)
Returns the time scale associated with Window slicing (middle of window) :param fs: sampling frequency (Hz) :return: time axis scale

ibllib.dsp.utils.**falls**(*x*, *axis=-1*, *step=-1*)
Detects Falling edges of a voltage signal, returns indices

Parameters

- **x** – array on which to compute RMS
- **axis** – (optional, -1) negative value
- **step** – (optional, -1) value of the step to detect

Returns numpy array

ibllib.dsp.utils.**fronts**(*x*, *axis=-1*, *step=1*)
Detects Rising and Falling edges of a voltage signal, returns indices and

Parameters

- **x** – array on which to compute RMS
- **axis** – (optional, -1) negative value
- **step** – (optional, -1) value of the step to detect

Returns numpy array of indices, numpy array of rises (1) and falls (-1)

ibllib.dsp.utils.**rises**(*x*, *axis=-1*, *step=1*)
Detect Rising edges of a voltage signal, returns indices

Parameters

- **x** – array on which to compute RMS
- **axis** – (optional, -1)
- **step** – (optional, 1) amplitude of the step to detect

Returns numpy array

ibllib.dsp.utils.**rms**(*x*, *axis=-1*)
Root mean square of array along axis

Parameters

- **x** – array on which to compute RMS
- **axis** – (optional, -1)

Returns numpy array

ibllib.ephys.ephysqc

Quality control of raw Neuropixel electrophysiology data.

ibllib.ephys.ephysqc.**amplitude_cutoff**(*amplitudes*, *num_histogram_bins=500*, *histogram_smoothing_value=3*)
Calculate approximate fraction of spikes missing from a distribution of amplitudes

Assumes the amplitude histogram is symmetric (not valid in the presence of drift)

Inspired by metric described in Hill et al. (2011) J Neurosci 31: 8699-8705

amplitudes [numpy.ndarray] Array of amplitudes (don't need to be in physical units)

fraction_missing [float] Fraction of missing spikes (0-0.5) If more than 50% of spikes are missing, an accurate estimate isn't possible

ibllib.ephys.ephysqc.**extract_rmsmap**(*fbin*, *out_folder=None*, *force=False*, *label=''*)

Wrapper for rmsmap that outputs _ibl_ephysRmsMap and _ibl_ephysSpectra ALF files

Parameters

- **fbin** – binary file in spike glx format (will look for attached metatdata)
- **out_folder** – folder in which to store output ALF files. Default uses the folder in which the *fbin* file lives.
- **force** – do not re-extract if all ALF files already exist
- **label** – string or list of strings that will be appended to the filename before extension

Returns None

ibllib.ephys.ephysqc.**isi_violations**(*spike_train*, *min_time*, *max_time*, *isi_threshold*, *min_isi=0*)

Calculate ISI violations for a spike train.

Based on metric described in Hill et al. (2011) J Neurosci 31: 8699-8705

modified by Dan Denman from cortex-lab/sortingQuality GitHub by Nick Steinmetz

spike_train : array of spike times min_time : minimum time for potential spikes max_time : maximum time for potential spikes isi_threshold : threshold for isi violation min_isi : threshold for duplicate spikes

fpRate [rate of contaminating spikes as a fraction of overall rate] A perfect unit has a fpRate = 0 A unit with some contamination has a fpRate < 0.5 A unit with lots of contamination has a fpRate > 1.0

num_violations : total number of violations

ibllib.ephys.ephysqc.**rmsmap**(*fbin*)

Computes RMS map in time domain and spectra for each channel of Neuropixel probe

Parameters **fbin** (*str or pathlib.Path*) – binary file in spike glx format (will look for attached metatdata)

Returns a dictionary with amplitudes in channeltime space, channelfrequency space, time and frequency scales

ibllib.ephys.ephysqc.**spike_sorting_metrics**(*spike_times*, *spike_clusters*, *spike_amplitudes*, *params={'drift_metrics_interval_s': 51, 'drift_metrics_min_spikes_per_interval': 10, 'isi_threshold': 0.0015, 'max_spikes_for_nn': 10000, 'max_spikes_for_unit': 500, 'min_isi': 0.000166, 'n_neighbors': 4, 'n_silhouette': 10000, 'num_channels_to_compare': 13, 'presence_bin_length_secs': 20, 'quality_metrics_output_file': 'metrics.csv'}*, *epochs=None*)

Spike sorting QC metrics

ibllib.ephys.ephysqc.**validate_ttl_test**(*ses_path*, *display=False*)

For a mock session on the Ephys Choice world task, check the sync channels for all device properly connected and perform a synchronization if dual probes to check that all channels are recorded properly :param ses_path:

session path :param display: show the probe synchronization plot if several probes :return: True if tests pass, errors otherwise

ibllib.io.extractors.biased_trials

ibllib.io.extractors.biased_trials.**get_contrastLR**(*session_path*, *save=False*, *data=False*, *settings=False*)

Get left and right contrasts from raw datafile. Optionally, saves _ibl_trials.contrastLeft.npy and _ibl_trials.contrastRight.npy to alf folder.

Uses signed_contrast to create left and right contrast vectors.

Parameters

- **session_path** (*str*) – absolute path of session folder
- **save** (*bool, optional*) – whether to save the corresponding alf file to the alf folder, defaults to False

Returns numpy.ndarray

Return type dtype('float64')

ibllib.io.extractors.biased_wheel

ibllib.io.extractors.ephys_fpga

ibllib.io.extractors.ephys_fpga.**align_with_bpod**(*session_path*)

Reads in trials.intervals ALF dataset from bpod and fpga. Asserts consistency between datasets and compute the median time difference

Parameters **session_path** –

Returns dt: median time difference of trial start times (fpga - bpod)

ibllib.io.extractors.ephys_fpga.**extract_all**(*session_path*, *save=False*)

For the IBL ephys task, reads ephys binary file and extract:

- sync
- wheel
- behaviour
- video time stamps

Parameters

- **session_path** – '/path/to/subject/yyyy-mm-dd/001'
- **save** – Bool, defaults to False
- **version** – bpod version, defaults to None

Returns None

ibllib.io.extractors.ephys_fpga.**extract_behaviour_sync**(*sync*, *output_path=None*, *save=False*, *chmap=None*)

Extract wheel positions and times from sync fronts dictionary

Parameters

- **sync** – dictionary 'times', 'polarities' of fronts detected on sync trace for all 16 chans
- **output_path** – where to save the data
- **save** – True/False
- **chmap** – dictionary containing channel index. Default to constant. chmap = {'bpod': 7, 'frame2ttl': 12, 'audio': 15}

Returns trials dictionary

ibllib.io.extractors.ephys_fpga.**extract_camera_sync**(*sync*, *output_path=None*, *save=False*, *chmap=None*)

Extract camera timestamps from the sync matrix

Parameters

- **sync** – dictionary 'times', 'polarities' of fronts detected on sync trace
- **output_path** – where to save the data
- **save** – True/False
- **chmap** – dictionary containing channel indices. Default to constant.

Returns dictionary containing camera timestamps

ibllib.io.extractors.ephys_fpga.**extract_sync**(*session_path*, *save=False*, *force=False*, *ephys_files=None*)

Reads ephys binary file (s) and extract sync whithin the binary file folder Assumes ephys data is whithin a *raw_ephys_data* folder

Parameters

- **session_path** – '/path/to/subject/yyyy-mm-dd/001'
- **save** – Bool, defaults to False
- **force** – Bool on re-extraction, forces overwrite instead of loading existing sync files

Returns list of sync dictionaries

ibllib.io.extractors.ephys_fpga.**extract_wheel_sync**(*sync*, *output_path=None*, *save=False*, *chmap=None*)

Extract wheel positions and times from sync fronts dictionary for all 16 chans

Parameters

- **sync** – dictionary 'times', 'polarities' of fronts detected on sync trace
- **output_path** – where to save the data
- **save** – True/False
- **chmap** – dictionary containing channel indices. Default to constant. chmap = {'rotary_encoder_0': 13, 'rotary_encoder_1': 14}

Returns dictionary containing wheel data, 'wheel_ts', 're_ts'

ibllib.io.extractors.ephys_fpga.**get_ibl_sync_map**(*ef*, *version*)

Gets default channel map for the version/binary file type combination :param ef: ibllib.io.spikeglx.glob_ephys_file dictionary with field 'ap' or 'nidq' :return: channel map dictionary

ibllib.io.extractors.ephys_trials

ibllib.io.extractors.ephys_trials.**extract_all**(*session_path*, *save=False*, *data=False*)
Extract all behaviour data from Bpod whithin the specified folder. The timing information from FPGA is extracted in *ephys_fpga()*

Parameters

- **session_path** (*str or pathlib.Path*) – folder containing sessions
- **save** – bool
- **data** – raw Bpod data dictionary

Returns dictionary of trial related vectors (one row per trial)

ibllib.io.extractors.training_audio

ibllib.io.extractors.training_audio.**welchogram**(*fs*, *wav*, *nswin=262144*, *overlap=131072.0*, *nperseg=512*)
Computes a spectrogram on a very large audio file.

Parameters

- **fs** – sampling frequency (Hz)
- **wav** – wav signal (vector or memmap)
- **nswin** – n samples of the sliding window
- **overlap** – n samples of the overlap between windows
- **nperseg** – n samples for the computation of the spectrogram

Returns tscale, fscale, downsampled_spectrogram

ibllib.io.extractors.training_trials

ALF extractors are a collection of functions that extract alf files from the PyBpod rig raw data.

Each DatasetType in the IBL pipeline should have one extractor function.

ibllib.io.extractors.training_trials.**check_alf_folder**(*session_path*)
Check if alf folder exists, creates it if it doesn't.

Parameters **session_path** (*str*) – absolute path of session folder

ibllib.io.extractors.training_trials.**get_camera_timestamps**(*session_path*, *data=False*, *save=False*, *settings=False*)
Get the camera timestamps from the Bpod

The camera events are logged only during the events not in between, so the times need to be interpolated

Parameters

- **session_path** – Absolute path of session folder
- **save** – bool, optional

Returns numpy.ndarray

ibllib.io.extractors.training_trials.**get_choice**(*session_path*, *save=False*, *data=False*, *settings=False*)

Get the subject's choice in every trial. **Optional:** saves _ibl_trials.choice.npy to alf folder.

Uses signed_contrast and trial_correct. -1 is a CCW turn (towards the left) +1 is a CW turn (towards the right) 0 is a no_go trial If a trial is correct the choice of the animal was the inverse of the sign of the position.

```
>>> choice[t] = -np.sign(position[t]) if trial_correct[t]
```

Parameters

- **session_path** (*str*) – absolute path of session folder
- **save** (*bool, optional*) – wether to save the corresponding alf file to the alf folder, defaults to False

Returns numpy.ndarray

Return type dtype('int64')

ibllib.io.extractors.training_trials.**get_contrastLR**(*session_path*, *save=False*, *data=False*, *settings=False*)

Get left and right contrasts from raw datafile. Optionally, saves _ibl_trials.contrastLeft.npy and _ibl_trials.contrastRight.npy to alf folder.

Uses signed_contrast to create left and right contrast vectors.

Parameters

- **session_path** (*str*) – absolute path of session folder
- **save** (*bool, optional*) – wether to save the corresponding alf file to the alf folder, defaults to False

Returns numpy.ndarray

Return type dtype('float64')

ibllib.io.extractors.training_trials.**get_feedbackType**(*session_path*, *save=False*, *data=False*, *settings=False*)

Get the feedback that was delivered to subject. **Optional:** saves _ibl_trials.feedbackType.npy

Checks in raw datafile for error and reward state. Will raise an error if more than one of the mutually exclusive states have been triggered.

Sets feedbackType to -1 if error state was trigered (applies to no-go) Sets feedbackType to +1 if reward state was triggered

Parameters

- **session_path** (*str*) – absolute path of session folder
- **save** (*bool, optional*) – wether to save the corresponding alf file to the alf folder, defaults to False

Returns numpy.ndarray

Return type dtype('int64')

ibllib.io.extractors.training_trials.**get_feedback_times**(*session_path*, *save=False*, *data=False*, *settings=False*)

Get the times the water or error tone was delivered to the animal. **Optional:** saves _ibl_trials.feedback_times.npy

Gets reward and error state init times vectors, checks if theintersection of nans is empty, then merges the 2 vectors.

Parameters

- **session_path** (*str*) – Absolute path of session folder
- **save** – wether to save the corresponding alf file to the alf folder, defaults to False
- **save** – bool, optional

Returns numpy.ndarray

Return type dtype('float64')

ibllib.io.extractors.training_trials.**get_goCueOnset_times**(*session_path*, *save=False*, *data=False*, *settings=False*)

Get trigger times of goCue from state machine.

Current software solution for triggering sounds uses PyBpod soft codes. Delays can be in the order of 10's of ms. This is the time when the command to play the sound was executed. To measure accurate time, either getting the sound onset from the future microphone OR the new xonar soundcard and setup developed by Sanworks guarantees a set latency (in testing).

Parameters

- **session_path** (*str*) – Absolute path of session folder
- **save** – bool, optional

Returns numpy.ndarray

Return type dtype('float64')

ibllib.io.extractors.training_trials.**get_goCueTrigger_times**(*session_path*, *save=False*, *data=False*, *settings=False*)

Get trigger times of goCue from state machine.

Current software solution for triggering sounds uses PyBpod soft codes. Delays can be in the order of 10's of ms. This is the time when the command to play the sound was executed. To measure accurate time, either getting the sound onset from xonar soundcard sync pulse (latencies may vary).

Parameters

- **session_path** (*str*) – Absolute path of session folder
- **save** – wether to save the corresponding alf file to the alf folder, defaults to False
- **save** – bool, optional

Returns numpy.ndarray

Return type dtype('float64')

ibllib.io.extractors.training_trials.**get_intervals**(*session_path*, *save=False*, *data=False*, *settings=False*)

Trial start to trial end. Trial end includes 1 or 2 seconds after feedback, (depending on the feedback) and 0.5 seconds of iti. **Optional:** saves _ibl_trials.intervals.npy

Uses the corrected Trial start and Trial end timpestamp values form PyBpod.

Parameters

- **session_path** (*str*) – Absolute path of session folder
- **save** – wether to save the corresponding alf file to the alf folder, defaults to False
- **save** – bool, optional

Returns 2D numpy.ndarray (col0 = start, col1 = end)

Return type dtype('float64')

ibllib.io.extractors.training_trials.**get_iti_duration**(*session_path*, *save=False*, *data=False*, *settings=False*)

Calculate duration of iti from state timestamps. **Optional:** saves _ibl_trials.iti_duration.npy

Uses Trial end timestamp and get_response_times to calculate iti.

Parameters

- **session_path** (*str*) – Absolute path of session folder
- **save** – wether to save the corresponding alf file to the alf folder, defaults to False
- **save** – bool, optional

Returns numpy.ndarray

Return type dtype('float64')

ibllib.io.extractors.training_trials.**get_repNum**(*session_path*, *save=False*, *data=False*, *settings=False*)

Count the consecutive repeated trials. **Optional:** saves _ibl_trials.repNum.npy to alf folder.

Creates trial_repeated from trial['contrast']['type'] == 'RepeatContrast'

```
>>> trial_repeated = [0, 1, 1, 0, 1, 0, 1, 1, 1, 0]
>>> repNum =         [0, 1, 2, 0, 1, 0, 1, 2, 3, 0]
```

Parameters

- **session_path** (*str*) – absolute path of session folder
- **save** (*bool, optional*) – wether to save the corresponding alf file to the alf folder, defaults to False

Returns numpy.ndarray

Return type dtype('int64')

ibllib.io.extractors.training_trials.**get_response_times**(*session_path*, *save=False*, *data=False*, *settings=False*)

Time (in absolute seconds from session start) when a response was recorded. **Optional:** saves _ibl_trials.response_times.npy

Uses the timestamp of the end of the closed_loop state.

Parameters

- **session_path** (*str*) – Absolute path of session folder
- **save** – wether to save the corresponding alf file to the alf folder, defaults to False
- **save** – bool, optional

Returns numpy.ndarray

Return type dtype('float64')

ibllib.io.extractors.training_trials.**get_rewardVolume**(*session_path*, *save=False*, *data=False*, *settings=False*)

Load reward volume delivered for each trial. **Optional:** saves _ibl_trials.rewardVolume.npy

Uses reward_current to accumulate the amount of

Parameters

- **session_path** (*str*) – Absolute path of session folder
- **save** – wether to save the corresponding alf file to the alf folder, defaults to False
- **save** – bool, optional

Returns numpy.ndarray

Return type dtype('int64')

ibllib.io.extractors.training_trials.**get_stimOn_times**(*session_path*, *save=False*, *data=False*, *settings=False*)

Find the time of the statemachine command to turn on hte stim (state stim_on start or rotary_encoder_event2) Find the next frame change from the photodiodeafter that TS. Screen is not displaying anything until then. (Frame changes are in BNC1High and BNC1Low)

ibllib.io.extractors.training_trials.**get_stimOn_times_ge5**(*session_path*, *data=False*)

Find first and last stim_sync pulse of the trial. stimOn_times should be the first after the stim_on state. (Stim updates are in BNC1High and BNC1Low - frame2TTL device) Check that all trials have frame changes. Find length of stim_on_state [start, stop]. If either check fails the HW device failed to detect the stim_sync square change Substitute that trial's missing or incorrect value with a NaN. return stimOn_times

ibllib.io.extractors.training_trials.**get_stimOn_times_lt5**(*session_path*, *data=False*)

Find the time of the statemachine command to turn on hte stim (state stim_on start or rotary_encoder_event2) Find the next frame change from the photodiodeafter that TS. Screen is not displaying anything until then. (Frame changes are in BNC1High and BNC1Low)

ibllib.io.extractors.training_wheel

Training wheel extractor from Pybpod output.

ibllib.io.extractors.training_wheel.**check_alf_folder**(*session_path*)

Check if alf folder exists, creates it if it doesn't.

Parameters **session_path** (*str*) – absolute path of session folder

ibllib.io.extractors.training_wheel.**get_velocity**(*session_path*, *save=False*, *data_wheel=None*)

Compute velocity from non-uniformly acquired positions and timestamps. **Optional:** save _ibl_trials.velocity.npy

Uses signed_contrast to create left and right contrast vectors.

Parameters

- **session_path** (*str*) – absolute path of session folder
- **save** (*bool, optional*) – wether to save the corresponding alf file to the alf folder, defaults to False

Returns numpy.ndarray

Return type dtype('float64')

ibllib.io.extractors.training_wheel.**get_wheel_data**(*session_path*, *bp_data=None*, *save=False*)

Get wheel data from raw files and converts positions into centimeters and timestamps into seconds. **Optional:** saves _ibl_wheel.times.npy and _ibl_wheel.position.npy

Times: Gets Rotary Encoder timestamps (ms) for each position and converts to times.

Uses time_converter to extract and convert timstamps (ms) to times (s).

Positions: Positions are in (cm) of RE perimeter relative to 0. The 0 resets every trial.

cmtick = radius (cm) * 2 * pi / n_ticks cmtick = 3.1 * 2 * np.pi / 1024

Parameters

- **session_path** (*str*) – absolute path of session folder
- **data** (*dict, optional*) – dictionary containing the contents pybpod jsonable file read with raw.load_data
- **save** (*bool, optional*) – wether to save the corresponding alf file to the alf folder, defaults to False

Returns Numpy structured array.

Return type numpy.ndarray

ibllib.io.extractors.training_wheel.**time_converter_session**(*session_path*, *kind*)

Create interp1d functions to convert values from one clock to another given a set of synchronization pulses.

The task global sync pulse is at trial_start from Bpod to: Rotary Encoder, Cameras and e-phys system. Depends on getter functions that extract from the raw data the timestamps of the trial_start sync pulse event for each clock.

2b	•	re2b	cam2b,	ephys2b
2re	b2re	•	cam2re	ephys2re
2cam	b2cam	re2cam	•	ephys2cam
2ephys	b2ephys	re2ephys	cam2ephys	•

Default converters for times are assumed to be of kind *2b* unless ephys data is present in that case converters for 'times' will be of kind *2ephys*

Parameters

- **session_path** (*str*) – absolute path of session folder
- **kind** (*str, optional*) – ['re2b', 'b2re'], defaults to 're2b'

Returns Function that converts from clock A to clock B defined by kind.

Return type scipy.interpolate.interpolate.interp1d

ibllib.io.extractors.training_wheel.**time_interpolation**(*tref*, *target*)

From 2 arrays of timestamps, return an interpolation function that allows to go from one to the other. If sizes are different, only work with the first elements.

ibllib.io.flags

ibllib.io.flags.**excise_flag_file**(*fname*, *removed_files=None*)
Remove one or several specific files if they figure within the file If no file is left, deletes the flag.

Parameters **fname** (*str or pahlib.Path*) – full file path of the flag file

Returns None

ibllib.io.flags.**read_flag_file**(*fname*)
Flag files are *.flag files within a session folder used to schedule some jobs If they are empty, should return True

Parameters **fname** (*str or pahlib.Path*) – full file path of the flag file

Returns None

ibllib.io.flags.**write_flag_file**(*fname*, *file_list: list = None*, *clobber=False*)
Flag files are *.flag files within a session folder used to schedule some jobs Each line references to a file to extract or register

Parameters

- **fname** (*str or pathlib.Path*) – full file path of the flag file
- **file_list** (*list*) – None or list of relative paths to write in the file
- **clobber** (*bool, optional*) – (False) overwrites the flag file if any

Returns None

ibllib.io.params

ibllib.io.params.**getfile**(*str_params*)

Returns full path of the param file per system convention: linux/mac: ~/.str_params, Windows: APPDATA folder

Parameters **str_params** – string that identifies parm file

Returns string of full path

ibllib.io.params.**read**(*str_params*, *default=None*)
Reads in and parse Json parameter file into dictionary

Parameters

- **str_params** – path to text json file
- **default** – default values for missing parameters

Returns named tuple containing parameters

ibllib.io.params.**write**(*str_params*, *par*)
Write a parameter file in Json format

Parameters

- **str_params** – path to text json file
- **par** – dictionary containing parameters values

Returns None

ibllib.io.raw_data_loaders

Raw Data Loader functions for PyBpod rig

Module contains one loader function per raw datafile

ibllib.io.raw_data_loaders.**get_port_events**(*events: dict*, *name: str = ''*) → list
Return all timestamps from bpod raw data trial['behavior_data']['Events timestamps'] that match name

ibllib.io.raw_data_loaders.**load_ambient_sensor**(*session_path*)
Load Ambient Sensor data from session.

Probably could be extracted to DatasetTypes: _ibl_trials.temperature_C, _ibl_trials.airPressure_mb, _ibl_trials.relativeHumidity Returns a list of dicts one dict per trial. dict keys are: dict_keys(['Temperature_C', 'AirPressure_mb', 'RelativeHumidity'])

Parameters **session_path** (*str*) – Absoulte path of session folder

Returns list of dicts

Return type list

ibllib.io.raw_data_loaders.**load_bpod**(*session_path*)
Load both settings and data from bpod (.json and .jsonable)

Parameters **session_path** – Absolute path of session folder

Returns dict settings and list of dicts data

ibllib.io.raw_data_loaders.**load_data**(*session_path*, *time='absolute'*)
Load PyBpod data files (.jsonable).

Bpod timestamps are in microseconds (µs) PyBpod timestamps are is seconds (s)

Parameters **session_path** (*str*) – Absolute path of session folder

Returns A list of len ntrials each trial being a dictionary

Return type list of dicts

ibllib.io.raw_data_loaders.**load_encoder_events**(*session_path*, *settings=False*)
Load Rotary Encoder (RE) events raw data file.

Assumes that a folder called "raw_behavior_data" exists in folder.

On each trial the RE sends 3 events to Bonsai 1 - meaning trial start/turn off the stim; 2 - meaning show the current trial stimulus; and 3 - meaning begin the closed loop making the stim move with the RE. These events are triggered by the state machine in the corrensponding states: trial_start, stim_on, closed_loop

Raw datafile Columns: Event, RE timestamp, Source, data, Bonsai Timestamp

Event is always equal 'Event' Source is always equal 'StateMachine'. For this reason these columns are dropped.

```
>>> data.columns
>>> ['re_ts',    # Rotary Encoder Timestamp (ms) 'numpy.int64'
     'sm_ev',    # State Machine Event           'numpy.int64'
     'bns_ts']   # Bonsai Timestamp (int)        'pandas.Timestamp'
    # pd.to_datetime(data.bns_ts) to work in datetimes
```

Parameters **session_path** (*[type]*) – [description]

Returns dataframe w/ 3 cols and (ntrials * 3) lines

Return type Pandas.DataFrame

ibllib.io.raw_data_loaders.**load_encoder_positions**(*session_path*, *settings=False*)
Load Rotary Encoder (RE) positions from raw data file within a session path.

Assumes that a folder called "raw_behavior_data" exists in folder. Positions are RE ticks [-512, 512] == [-180º, 180º] 0 == trial stim init position Positive nums are rightwards movements (mouse) or RE CW (mouse)

Variable line number, depends on movements.

Raw datafile Columns: Position, RE timestamp, RE Position, Bonsai Timestamp

Position is always equal to 'Position' so this column was dropped.

```
>>> data.columns
>>> ['re_ts',    # Rotary Encoder Timestamp (ms)      'numpy.int64'
     're_pos',  # Rotary Encoder position (ticks)    'numpy.int64'
     'bns_ts']  # Bonsai Timestamp                   'pandas.Timestamp'
    # pd.to_datetime(data.bns_ts) to work in datetimes
```

Parameters **session_path** (*str*) – Absoulte path of session folder

Returns dataframe w/ 3 cols and N positions

Return type Pandas.DataFrame

ibllib.io.raw_data_loaders.**load_encoder_trial_info**(*session_path*)
Load Rotary Encoder trial info from raw data file.

Assumes that a folder calles "raw_behavior_data" exists in folder.

NOTE: Last trial probably inexistent data (Trial info is sent on trial start and data is only saved on trial exit...) max(trialnum) should be N+1 if N is the amount of trial data saved.

Raw datafile Columns:

```
>>> data.columns
>>> ['trial_num',      # Trial Number                      'numpy.int64'
     'stim_pos_init', # Initial position of visual stim  'numpy.int64'
     'stim_contrast', # Contrast of visual stimulus      'numpy.float64'
     'stim_freq',     # Frequency of gabor patch         'numpy.float64'
     'stim_angle',    # Angle of Gabor 0 = Vertical      'numpy.float64'
     'stim_gain',     # Wheel gain (mm/° of stim)        'numpy.float64'
     'stim_sigma',    # Size of patch                    'numpy.float64'
     'bns_ts' ]       # Bonsai Timestamp                 'pandas.Timestamp'
    # pd.to_datetime(data.bns_ts) to work in datetimes
```

Parameters **session_path** (*str*) – Absoulte path of session folder

Returns dataframe w/ 8 cols and ntrials lines

Return type Pandas.DataFrame

ibllib.io.raw_data_loaders.**load_mic**(*session_path*)
Load Microphone wav file to np.array of len nSamples

Parameters **session_path** (*str*) – Absoulte path of session folder

Returns An array of values of the sound waveform

Return type numpy.array

ibllib.io.raw_data_loaders.**load_settings**(*session_path*)
Load PyBpod Settings files (.json).

[description]

Parameters **session_path** (*str*) – Absolute path of session folder

Returns Settings dictionary

Return type dict

ibllib.io.raw_data_loaders.**trial_times_to_times**(*raw_trial*)
Parse and convert all trial timestamps to "absolute" time. Float64 seconds from session start.

0—BpodStart—TrialStart0———TrialEnd0——TrialStart1—TrialEnd1. . . 0—ts0—ts1— tsN. . . absTS = tsN + TrialStartN - BpodStart

Bpod timestamps are in microseconds (µs) PyBpod timestamps are is seconds (s)

Parameters **raw_trial** (*dict*) – raw tiral data

Returns trial data with modified timestamps

Return type dict

ibllib.io.spikeglx

class ibllib.io.spikeglx.**Reader**(*sglx_file*)
Class for SpikeGLX reading purposes Some format description was found looking at the Matlab SDK here https://github.com/billkarsh/SpikeGLX/blob/master/MATLAB-SDK/DemoReadSGLXData.m

compress_file(*keep_original=True*, ***kwargs*)
Compresses :param keep_original: defaults True. If False, the original uncompressed file is deleted

and the current spikeglx.Reader object is modified in place

Parameters **kwargs** –

Returns pathlib.Path of the compressed *.cbin file

decompress_file(*keep_original=True*, ***kwargs*)
Decompresses a mtscomp file :param keep_original: defaults True. If False, the original compressed file is deleted

and the current spikeglx.Reader object is modified in place

Returns pathlib.Path of the decompressed *.bin file

fs

Returns sampling frequency (Hz)

nc

Returns number of channels

ns

Returns number of samples

read(*nsel=slice(0, 10000, None)*, *csel=slice(None, None, None)*, *sync=True*)
Read from slices or indexes :param slice_n: slice or sample indices :param slice_c: slice or channel indices :return: float32 array

read_samples(*first_sample=0*, *last_sample=10000*, *channels=None*)
reads all channels from first_sample to last_sample, following numpy slicing convention sglx.read_samples(first=0, last=100) would be equivalent to slicing the array D D[:,0:100] where the last axis represent time and the first channels.

param first_sample first sample to be read, python slice-wise

param last_sample last sample to be read, python slice-wise

return numpy array of int16

read_sync(*_slice=slice(0*, *10000*, *None)*, *threshold=1.2*)
Reads all sync trace. Convert analog to digital with selected threshold and append to array :param _slice: samples slice :param threshold: (V) threshold for front detection, defaults to 1.2 V :return: int8 array

read_sync_analog(*_slice=slice(0*, *10000*, *None)*)
Reads only the analog sync traces at specified samples using slicing syntax >>> sync_samples = sr.read_sync_analog(slice(0,10000))

read_sync_digital(*_slice=slice(0*, *10000*, *None)*)
Reads only the digital sync trace at specified samples using slicing syntax >>> sync_samples = sr.read_sync_digital(slice(0,10000))

type

Returns ap, lf or nidq. Useful to index dictionaries

ibllib.io.spikeglx.**get_hardware_config**(*config_file*)
Reads the neuropixel_wirings.json file containing sync mapping and parameters :param config_file: folder or json file :return: dictionary or None

ibllib.io.spikeglx.**glob_ephys_files**(*session_path*, *suffix='.meta'*, *recursive=True*)
From an arbitrary folder (usually session folder) gets the ap and lf files and labels Associated to the subfolders where they are the expected folder tree is: ├── 3A │ ├── imec0 │ │ ├── sync_testing_g0_t0.imec0.ap.bin │ │ └── sync_testing_g0_t0.imec0.lf.bin │ └── imec1 │ ├── sync_testing_g0_t0.imec1.ap.bin │ └── sync_testing_g0_t0.imec1.lf.bin └── 3B

├── sync_testing_g0_t0.nidq.bin ├── imec0 │ ├── sync_testing_g0_t0.imec0.ap.bin │ └── sync_testing_g0_t0.imec0.lf.bin └── imec1

├── sync_testing_g0_t0.imec1.ap.bin └── sync_testing_g0_t0.imec1.lf.bin

Parameters

- **session_path** – folder, string or pathlib.Path
- **glob_pattern** – pattern to look recursively for (defaults to '*.ap.*bin)

Returns a list of dictionaries with keys 'ap': apfile, 'lf': lffile and 'label'

ibllib.io.spikeglx.**read**(*sglx_file*, *first_sample=0*, *last_sample=10000*)
Function to read from a spikeglx binary file without instantiating the class. Gets the meta-data as well.

```
>>> ibllib.io.spikeglx.read('/path/to/file.bin', first_sample=0, last_sample=1000)
```

Parameters

- **sglx_file** – full path the the binary file to read
- **first_sample** – first sample to be read, python slice-wise
- **last_sample** – last sample to be read, python slice-wise

Returns Data array, sync trace, meta-data

ibllib.io.spikeglx.**read_meta_data**(*md_file*)
Reads the spkike glx metadata file and parse in a dictionary Agnostic: does not make any assumption on the keys/content, it just parses key=values

Parameters **md_file** – last sample to be read, python slice-wise

Returns Data array, sync trace, meta-data

ibllib.io.spikeglx.**split_sync**(*sync_tr*)
The synchronization channelx are stored as single bits, this will split the int16 original channel into 16 single bits channels

Parameters **sync_tr** – numpy vector: samples of synchronisation trace

Returns int8 numpy array of 16 channels, 1 column per sync trace

ibllib.misc.misc

ibllib.misc.misc.**print_progress**(*iteration*, *total*, *prefix=''*, *suffix=''*, *decimals=1*, *length=100*, *fill=''*)
Call in a loop to create terminal progress bar

Parameters

- **iteration** – Required : current iteration (Int)
- **total** – Required : total iterations (Int)
- **prefix** – Optional : prefix string (Str)
- **suffix** – Optional: suffix string (Str)
- **decimals** – Optional: positive number of decimals in percent complete (Int)
- **length** – Optional: character length of bar (Int)
- **fill** – Optional: bar fill character (Str)

Returns None

ibllib.misc.version

ibllib.misc.version.**eq**(*v1*, *v2*)
check if v1 == v2

Parameters

- **v1** (*str*) – version string, in the form "1.23.3"
- **v2** (*str*) – version string, in the form "1.23.3"

Returns bool

ibllib.misc.version.**ge**(*v1*, *v2*)
check if v1 >= v2

Parameters

- **v1** (*str*) – version string, in the form "1.23.3"
- **v2** (*str*) – version string, in the form "1.23.3"

Returns bool

ibllib.misc.version.**gt**(*v1*, *v2*)
check if v1 > v2

Parameters

- **v1** (*str*) – version string, in the form "1.23.3"
- **v2** (*str*) – version string, in the form "1.23.3"

Returns bool

ibllib.misc.version.**le**(*v1*, *v2*)
check if v1 <= v2

Parameters

- **v1** (*str*) – version string, in the form "1.23.3"
- **v2** (*str*) – version string, in the form "1.23.3"

Returns bool

ibllib.misc.version.**lt**(*v1*, *v2*)
check if v1 < v2

Parameters

- **v1** (*str*) – version string, in the form "1.23.3"
- **v2** (*str*) – version string, in the form "1.23.3"

Returns bool

ibllib.pipes.experimental_data

Entry point to system commands for IBL behaviour pipeline. Each function below corresponds to a command-line tool.

ibllib.pipes.experimental_data.**compress_ephys**(*root_data_folder*, *dry=False*, *max_sessions=5*)
Compress ephys files looking for *compress_ephys.flag* whithin the probes folder Original bin file will be removed The registration flag created contains targeted file names at the root of the session

ibllib.pipes.experimental_data.**extract**(*root_data_folder*, *dry=False*)
Extracts behaviour only

ibllib.pipes.experimental_data.**extract_ephys**(*root_data_folder*, *dry=False*, *max_sessions=10*)
Extracts ephys session only

ibllib.pipes.experimental_data.**raw_ephys_qc**(*root_data_folder*, *dry=False*, *max_sessions=10*, *force=False*)
Computes raw electrophysiology QC

ibllib.pipes.experimental_data.**sync_merge_ephys**(*root_data_folder*, *dry=False*)

After spike sorting, if single probe output ks2 to ALF, if several probes merge spike sorting output to ALF folder

To start the job for a session, all electrophysiology ap files from session need to be associated with a *sync_merge_ephys.flag* file Outputs individual probes

ibllib.pipes.extract_session

Find task name Check if extractors for specific task exist Extract data OR return error to user saying that the task has no extractors

ibllib.pipes.extract_session.**get_session_extractor_type**(*session_path*)
From a session path, loads the settings file, finds the task and checks if extractors exist task names examples: :param session_path: :return: bool

ibllib.pipes.extract_session.**get_session_path**(*path_object*)
From a full file path or folder path, gets the session root path :param path_object: pathlib.Path or string :return:

ibllib.pipes.extract_session.**get_task_extractor_type**(*task_name*)
Splits the task name according to naming convention: - ignores everything _iblrig_tasks_biasedChoiceWorld3.7.0 returns "biased" _iblrig_tasks_trainingChoiceWorld3.6.0 returns "training' :param task_name: :return:

ibllib.pipes.purge_rig_data

Purge data from RIG - Find all files by rglob - Find all sessions of the found files - Check Alyx if corresponding datasetTypes have been registered as existing sessions and files on Flatiron - Delete local raw file if found on Flatiron

ibllib.pipes.transfer_rig_data

ibllib.graphic

ibllib.graphic.**login**(*title='Enter Credentials'*, *default_username=None*, *default_passwd=None*, *add_fields=None*)
Dialog box prompting for username and password.

Parameters

- **title** – Window title
- **default_username** – default field for username
- **default_passwd** – default field for password
- **add_fields** – list of new fields to be added to the dialog

Returns

ibllib.graphic.**strinput**(*title*, *prompt*, *default='COM'*, *nullable=False*)
Example: >>> strinput("RIG CONFIG", "Insert RE com port:", default="COM")

ibllib.plots

ibllib.plots.**squares**(*tscale*, *polarity*, *ax=None*, ***kwargs*)
Matplotlib display of rising and falling fronts in a square-wave pattern

Parameters

- **tscale** – time of indices of fronts
- **polarity** – polarity of front (1: rising, -1:falling)
- **ax** – matplotlib axes object

Returns None

ibllib.plots.**traces**(*w*, ***kwargs*)
Matplotlib display of traces

Parameters

- **w** – 2D array (numpy array dimension nsamples, ntraces)
- **fs** – sampling frequency
- **gain** – display gain
- **ax** – matplotlib axes object

Returns None

ibllib.plots.**vertical_lines**(*x*, *ymin=0*, *ymax=1*, *ax=None*, ***kwargs*)
From a x vector, draw separate vertical lines at each x location ranging from ymin to ymax

Parameters

- **x** – numpy array vector of x values where to display lnes
- **ymin** – lower end of the lines (scalar)
- **ymax** – higher end of the lines (scalar)
- **ax** – (optional) matplotlib axis instance

Returns None

ibllib.plots.**wiggle**(*w*, *fs=1*, *gain=0.71*, *color='k'*, *ax=None*, *fill=True*, *linewidth=0.5*, *t0=0*, ***kwargs*)
Matplotlib display of wiggle traces

Parameters

- **w** – 2D array (numpy array dimension nsamples, ntraces)
- **fs** – sampling frequency
- **gain** – display gain
- **color** – ('k') color of traces
- **ax** – (None) matplotlib axes object
- **fill** – (True) fill variable area above 0
- **t0** –

(0) timestamp of the first sample

Returns None

5.1.3 oneibl module

oneibl.one
oneibl.registration
oneibl.webclient

oneibl.one

class oneibl.one.**ONE**(*username=None*, *password=None*, *base_url=None*, *silent=False*)

static keywords()
Returns possible keywords to be used in the one.list method

Returns a tuple containing possible search terms:

Return type tuple

list(*eid=None*, *keyword='dataset-type'*, *details=False*)
From a Session ID, queries Alyx database for datasets-types related to a session.

Parameters

- **eid** (*str or list of strings*) – Experiment ID, for IBL this is the UUID String of the Session as per Alyx database. Example: '698361f6-b7d0-447d-a25d-42afdef7a0da' If None, returns the set of possible values. Only for the following keys: ('users', 'dataset-types', subjects')
- **keyword** (*str*) – The attribute to be listed.
- **details** (*bool*) – returns a second argument with a full dictionary to provide context

Returns list of strings, plus list of dictionaries if details option selected

Return type list, list

for a list of keywords, use the methods *one.search_terms()*

load(*eid*, *dataset_types=None*, *dclass_output=False*, *dry_run=False*, *cache_dir=None*, *download_only=False*, *clobber=False*, *offline=False*, *keep_uuid=False*)
From a Session ID and dataset types, queries Alyx database, downloads the data from Globus, and loads into numpy array.

Parameters

- **eid** (*str*) – Experiment ID, for IBL this is the UUID of the Session as per Alyx database. Could be a full Alyx URL: 'http://localhost:8000/sessions/698361f6-b7d0-447d-a25d-42afdef7a0da' or only the UUID: '698361f6-b7d0-447d-a25d-42afdef7a0da'. Can also be a list of the above for multiple eids.
- **dataset_types** (*list*) – [None]: Alyx dataset types to be returned.
- **dclass_output** (*bool If None or an empty dataset_type is specified, the output will be a dictionary by default.*) – [False]: forces the output as dataclass to provide context.
- **cache_dir** (*str*) – temporarly overrides the cache_dir from the parameter file
- **download_only** (*bool*) – do not attempt to load data in memory, just download the files
- **clobber** (*bool*) – force downloading even if files exists locally
- **keep_uuid** (*bool*) – keeps the UUID at the end of the filename (defaults to False)

Returns List of numpy arrays matching the size of dataset_types parameter, OR a dataclass containing arrays and context data.

Return type list, dict, dataclass SessionDataInfo

search(*details=False*, *limit=None*, ***kwargs*)

Applies a filter to the sessions (eid) table and returns a list of json dictionaries corresponding to sessions.

For a list of search terms, use the methods

```
>>> one.search_terms()
```

Parameters

- **details** (*bool*) – default False, returns also the session details as per the REST response
- **limit** (*int List of possible search terms*) – default None, limits results (if pagination enabled on server)
- **dataset_types** (*list of str*) – list of dataset_types
- **users** (*list or str*) – a list of users
- **subjects** (*list or str*) – a list of subjects nickname
- **lab** (*list or str*) – a str or list of lab names
- **date_range** (*list*) – list of 2 strings or list of 2 dates that define the range
- **number** (*str or int*) – session number

Returns list of eids, if details is True, also returns a list of json dictionaries, each entry corresponding to a matching session

Return type list, list

static search_terms()
Returns possible search terms to be used in the one.search method.

Returns a tuple containing possible search terms:

Return type tuple

static setup()
Interactive command tool that populates parameter file for ONE IBL.

oneibl.registration

class oneibl.registration.**RegistrationClient**(*one=None*)
Object that keeps the ONE instance and provides method to create sessions and register data.

create_sessions(*root_data_folder*, *dry=False*)
Create sessions looking recursively for flag files

Parameters

- **root_data_folder** – folder to look for create_me.flag
- **dry** – bool. Dry run if True

Returns None

register_sync(*root_data_folder*, *dry=False*)
Register sessions looking recursively for flag files

Parameters

- **root_data_folder** – folder to look for register_me.flag
- **dry** – bool. Dry run if True

Returns

oneibl.webclient

class oneibl.webclient.**AlyxClient**(***kwargs*)

Class that implements simple GET/POST wrappers for the Alyx REST API http://alyx.readthedocs.io/en/latest/api.html

authenticate(*username=''*, *password=''*, *base_url=''*)

Gets a security token from the Alyx REST API to create requests headers. Credentials are in the params_secret_template.py file

Parameters

- **username** (*str*) – Alyx database user
- **password** (*str*) – Alyx database password
- **base_url** (*str*) – Alyx server address, including port and protocol

delete(*rest_query*)

Sends a DELETE request to the Alyx server. Will raise an exception on any status_code other than 200, 201.

Parameters **rest_query** (*str*) – examples: '/weighings/c617562d-c107-432e-a8ee-682c17f9e698' 'https://test.alyx.internationalbrainlab.org/weighings/c617562d-c107-432e-a8ee-682c17f9e698'.

Returns (dict/list) json interpreted dictionary from response

get(*rest_query*)

Sends a GET request to the Alyx server. Will raise an exception on any status_code other than 200, 201. For the dictionary contents and list of endpoints, refer to: https://alyx.internationalbrainlab.org/docs

Parameters **rest_query** (*str*) – example: '/sessions?user=Hamish'.

Returns (dict/list) json interpreted dictionary from response

patch(*rest_query*, *data=None*)

Sends a PATCH request to the Alyx server. For the dictionary contents, refer to: https://alyx.internationalbrainlab.org/docs

Parameters

- **rest_query** (*str*) – (required)the endpoint as full or relative URL
- **data** (*None, dict or str*) – json encoded string or dictionary

Returns response object

post(*rest_query*, *data=None*)

Sends a POST request to the Alyx server. For the dictionary contents, refer to: https://alyx.internationalbrainlab.org/docs

Parameters

- **rest_query** (*str*) – (required)the endpoint as full or relative URL
- **data** (*None, dict or str*) – dictionary or json encoded string

Returns response object

put(*rest_query*, *data=None*)

Sends a PUT request to the Alyx server. For the dictionary contents, refer to: https://alyx.internationalbrainlab.org/docs

Parameters

- **rest_query** (*str*) – (required)the endpoint as full or relative URL
- **data** (*None, dict or str*) – dictionary or json encoded string

Returns response object

rest (*url=None*, *action=None*, *id=None*, *data=None*, ***kwargs*)
alyx_client.rest(): lists endpoints alyx_client.rest(endpoint): lists actions for endpoint alyx_client.rest(endpoint, action): lists fields and URL

Example with a rest endpoint with all actions

```
>>> alyx.client.rest('subjects', 'list')
    alyx.client.rest('subjects', 'list', field_filter1='filterval')
    alyx.client.rest('subjects', 'create', data=sub_dict)
    alyx.client.rest('subjects', 'read', id='nickname')
    alyx.client.rest('subjects', 'update', id='nickname', data=sub_dict)
    alyx.client.rest('subjects', 'partial_update', id='nickname', data=sub_
↪ict)
    alyx.client.rest('subjects', 'delete', id='nickname')
```

Parameters

- **url** – endpoint name
- **action** – 'list', 'create', 'read', 'update', 'partial_update', 'delete'
- **id** – lookup string for actions 'read', 'update', 'partial_update', and 'delete'
- **data** – data dictionary for actions 'update', 'partial_update' and 'create'
- ****kwargs** – filter as per the REST documentation

Returns list of queried dicts ('list') or dict (other actions)

oneibl.webclient.**dataset_record_to_url** (*dataset_record*)
Extracts a list of files urls from a list of dataset queries.

Parameters **dataset_record** (*list*) – dataset Json from a rest request.

Returns (list) a list of strings representing files urls corresponding to the datasets records

oneibl.webclient.**file_record_to_url** (*file_records*, *urls=[]*)
Translate a Json dictionary to an usable http url for downlading files.

Parameters

- **file_records** (*dict*) – json containing a 'data_url' field
- **urls** (*list*) – a list of strings containing previous data_urls on which new urls will be appended

Returns urls: (list) a list of strings representing full data urls

oneibl.webclient.**http_download_file** (*full_link_to_file*, ***, *clobber=False*, *offline=False*, *username=''*, *password=''*, *cache_dir=''*)

Parameters

- **full_link_to_file** (*str*) – http link to the file.
- **clobber** (*bool*) – [False] If True, force overwrite the existing file.
- **username** (*str*) – ['] authentication for password protected file server.
- **password** (*str*) – ['] authentication for password protected file server.

- **cache_dir** (*str*) – [''] directory in which files are cached; defaults to user's Download directory.

Returns (str) a list of the local full path of the downloaded files.

oneibl.webclient.**http_download_file_list**(*links_to_file_list*, ***kwargs*)

Downloads a list of files from the flat Iron from a list of links. Same options behaviour as http_download_file

Parameters **links_to_file_list** (*list*) – list of http links to files.

Returns (list) a list of the local full path of the downloaded files.

- genindex

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