

Tutorial 6 — Exporting to hctsa (MATLAB)

“ Auto-generated from [tutorial_notebook/6_Ethoscopy_to_hctsa_tutorial.ipynb](#). Executed against the seaborn canvas so every figure is inline as a static PNG. Plotly-only cells are kept for context and marked as placeholders — for the interactive version, run the source notebook.

Ethoscopy - Behavpy to HCTSA

This tutorial will take you through converting a behavpy dataset into a format that can be input into HCTSA, a time series comparative analysis software. Currently the full suite of software only works in Matlab. So this tutorial shows you have to convert the data into .mat file that you can then use in the HCTSA environment. The .mat file will include the time series data per specimen, the labels (id), and keywords per specimen.

If you want to just stick with python see tutorial 5 which uses HCTSA smaller toolbox catch22, that uses the top 22 most common analytical methods from HCTSA in a python environment.

1. Load the dummy dataset

```
import ethoscopy as etho
import pandas as pd
import numpy as np
from functools import partial
# we need the scipy function savemat to create a .mat file
from scipy.io import savemat
```

One-time setup: fetch the tutorial datasets

The tutorial pickle files (~36 MB total, dominated by `overview_data.pkl`) are **not** bundled with the PyPI package, to keep `pip install ethoscopy` lean.

Run the cell below **once per environment** to download them into the installed package directory. Subsequent runs are idempotent (already-present files are skipped).

You can also fetch them manually from

https://github.com/gilestrolab/ethoscopy/tree/main/src/ethoscopy/misc/tutorial_data.

```
# Idempotent: skips files that are already present.
import ethoscopy as etho
etho.download_tutorial_data()
```

```
[skip] overview_data.pkl (already present)
[skip] overview_meta.pkl (already present)
[skip] circadian_data.pkl (already present)
[skip] circadian_meta.pkl (already present)
[skip] 4_states_F_WT.pkl (already present)
[skip] 4_states_M_WT.pkl (already present)
Tutorial data ready in: /home/gg/.cache/ethoscopy/tutorial_data
```

```
PosixPath('/home/gg/.cache/ethoscopy/tutorial_data')
```

```
# Load in the data from the overview tutorial
from ethoscopy.misc.get_tutorials import get_tutorial
data, metadata = get_tutorial('overview')
df = etho.behavpy(data, metadata, check = True)
```

2. Choose the variable you want to analyse in HCTSA

```
# Lets use x (the position of the fly) for this tutorial
var = 'x'
```

HCTSA needs time series data of the same length so we need to do some data curation

```
# The ethoscope if loading with sleep_annoation will interpolate data about sleep, this causes
NaN values for the normal variables other than 'asleep'
# So we need to filter it out
df = df[df['is_interpolated'] == False]
```

```
# check to see if any NaN values are left
df[df[var].isnull()]
```

	t	x	y	w	h	phi	max _vel ocit y	mea n_v eloc ity	dist anc e	inter acti ons	bea m_c ross es	mov ing	micr o	walk	is_i nter pola ted	asle ep
id																

```
# The most basic curation is to pick a specific time period
df = df.t_filter(start_time = 24, end_time = 48)
```

```
# We can also use interpolate to fill in the missing data points, this can be useful if it's
only a few points missing per specimen
df_i = df.interpolate_linear(variable = 'x', step_size = 60, t_column = 't')
```

```
/home/gg/Code/ethoscope_project/ethoscopy/src/ethoscopy/behavpy_core.py:1611: FutureWarning:
DataFrameGroupBy.apply operated on the grouping columns. This behavior is deprecated, and in a
future version of pandas the grouping columns will be excluded from the operation. Either pass
`include_groups=False` to exclude the groupings or explicitly select the grouping columns
after groupby to silence this warning.
```

```
tdf.groupby("id", group_keys=False).apply(
```

```
/home/gg/Code/ethoscope_project/ethoscopy/src/ethoscopy/behavpy_core.py:1459: FutureWarning:
DataFrameGroupBy.apply operated on the grouping columns. This behavior is deprecated, and in a
future version of pandas the grouping columns will be excluded from the operation. Either pass
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after groupby to silence this warning.
```

```
data.groupby("id", group_keys=False).apply(
```

```
# We can also group several rows together by increasing the t diff, here we increase
# from 60 to 120, so we find the average of every two rows if there
df_bt = df.bin_time(variable = var, bin_secs = 120, function = 'mean')
```

```
/home/gg/Code/ethoscope_project/ethoscopy/src/ethoscopy/behavpy_core.py:1611: FutureWarning:
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future version of pandas the grouping columns will be excluded from the operation. Either pass
`include_groups=False` to exclude the groupings or explicitly select the grouping columns
after groupby to silence this warning.
```

```
tdf.groupby("id", group_keys=False).apply(
```

```
# Once we've completed our curation or if we just want to remove specimens that don't have
enough values,
# we can call curate to remove all specimens with too few points still
df_c = df.curate(points = ((24*60*60) / 60)-1) # 24*60*60 = seconds in a day and then divided
by are t diff per row.
```

```
# Note: The interpolate method returns rows 1 shorter than before so you'll need to add a
minus 1 if using curate after
```

```
# Note: If you've called the above bin_time this curate will return an empty dataframe
```

```
# lets just use the interpolate method
```

```
df = df.interpolate_linear(variable = 'x', step_size = 60, t_column = 't')
```

```
/home/gg/Code/ethoscope_project/ethoscopy/src/ethoscopy/behavpy_core.py:1611: FutureWarning:
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future version of pandas the grouping columns will be excluded from the operation. Either pass
`include_groups=False` to exclude the groupings or explicitly select the grouping columns
after groupby to silence this warning.
```

```
data.groupby("id", group_keys=False).apply(
```

```
# When using x position data the interesting part is how the fly positions itself in relation
to the food
```

```
# However this will be different on the x,y axis for flies on either side of the ethoscope, so
lets normalise it
```

```
# You only need to run this is using the x variable
```

```
df_r = df.xmv('region_id', list(range(11,21)))
```

```
df_l = df.xmv('region_id', list(range(1,11)))
df_r['x'] = 1 - df_r['x']
df = etho.concat(df_l, df_r)
```

3. Normalise the data

The ethoscope data can do with a bit of augmentation to make it perform better in HCTSA

```
# First lets put our data into numpy arrays
list_x = df.groupby(df.index, sort = False)[var].apply(list)
arr_x = np.array([np.array(x) for x in list_x])
# Here we grab the ids of each for the labels that we'll use later
list_id = list_x.index.tolist()
```

```
# Use some or all of these functions to normalise the data between specimens

# norm transforms the data to be between 0 and 1
def norm_01(x):
    return (x-np.nanmin(x))/(np.nanmax(x)-np.nanmin(x))
# or
# find the zscore
def zscore(x):
    return (x-np.mean(x))/(np.std(x))

# Only use this if looking at phi, it changes it be only from 0-90 or horizontal to vertical
as the ethoscope doesn't track direction
def norm_phi(x):
    return np.where(x > 90, 90 - (x - 90), x)

# Smooth out the time series data
def moving_average(a, n) :
    ret = np.cumsum(a, dtype=float)
    ret[n:] = ret[n:] - ret[:-n]
    return ret[n - 1:] / n
```

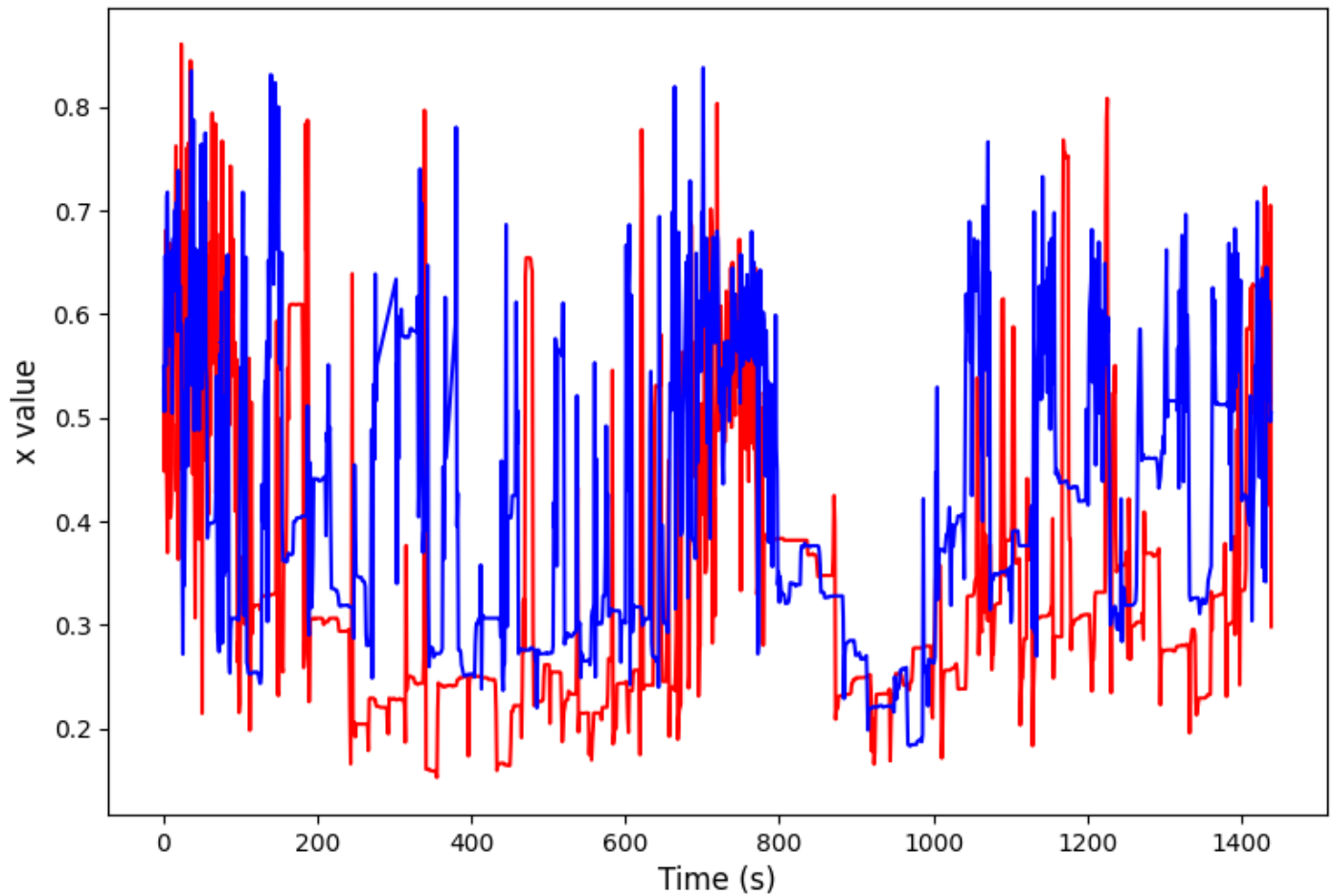
```
# We can have a look at this effect through some plots
import matplotlib.pyplot as plt
```

```

ind1 = np.random.randint(len(arr_x))
ind2 = np.random.randint(len(arr_x))

plt.figure(figsize=(9, 6))
plt.plot(arr_x[ind1], color = 'red')
plt.plot(arr_x[ind2], color = 'blue')
plt.xlabel('Time (s)', fontsize=12)
plt.ylabel(f'{var} value', fontsize=12)
plt.show()

```



```

# Apply the function along the axis
arr_x = np.apply_along_axis(norm_01, 1, arr_x)
arr_x = np.apply_along_axis(partial(moving_average, n = 5), 1, arr_x)

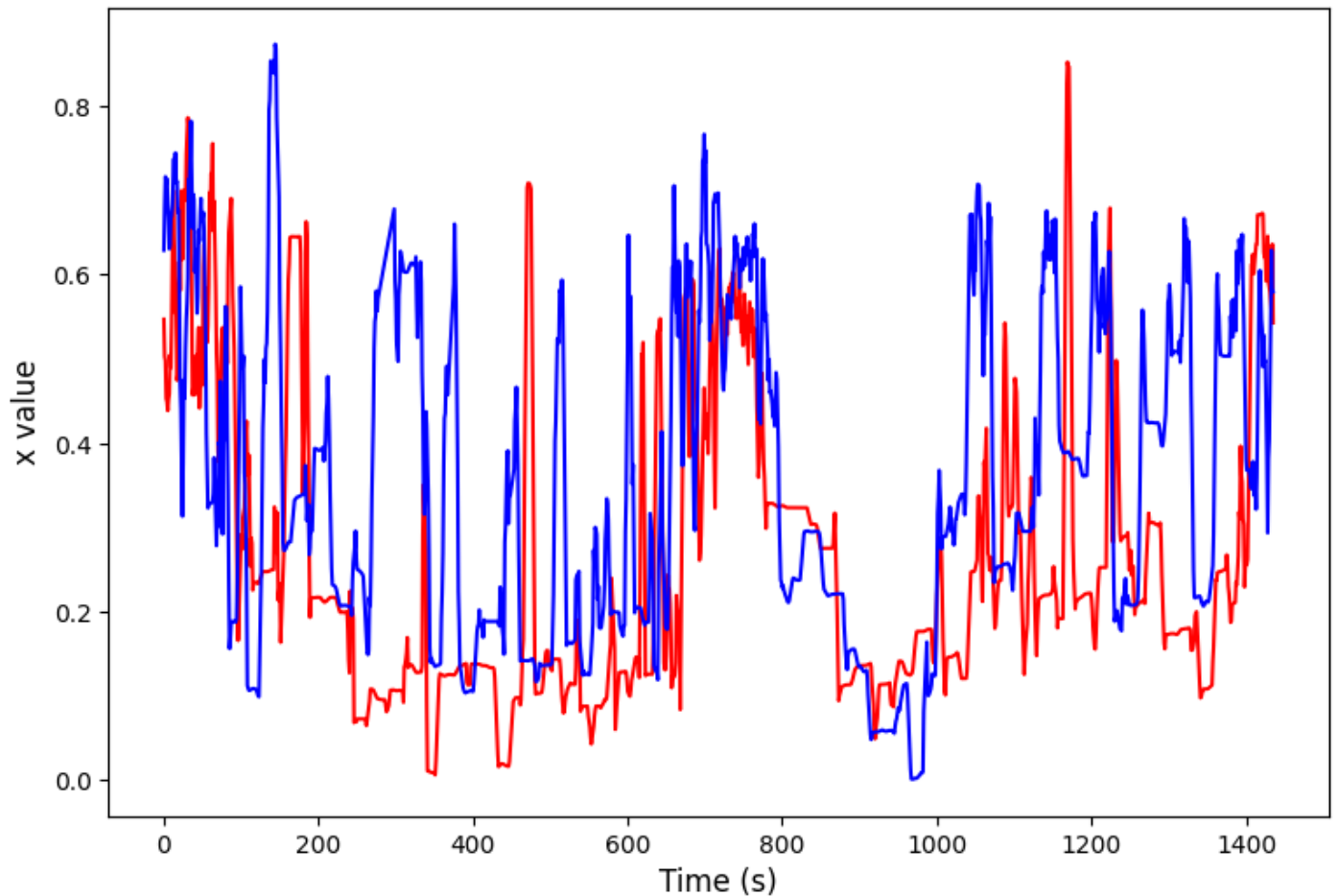
```

```

plt.figure(figsize=(9, 6))
plt.plot(arr_x[ind1], color = 'red')
plt.plot(arr_x[ind2], color = 'blue')
plt.xlabel('Time (s)', fontsize=12)
plt.ylabel(f'{var} value', fontsize=12)

```

```
plt.show()
```



4. Create the Time Series, Keywords, and labels for the .mat file

```
# Here the time series data is augmented to fit into the correct format
# it's stored as the variable ts_mat
ts_mat = np.zeros((len(arr_x),), dtype = object)
for i in range(len(arr_x)):
    ts_mat[i] = arr_x[i]
```

```
# HCTSA allows keywords to describe each series, we can grab these from the meta data
# Feel free to make your own lists of keywords if you haven't got them in your metadata, just
# make sure they have the right positions in relation to the ids
# Filter by the list_id to make sure we only grab those we retained from the data curation and
# it's the correct order
list_sex = df.meta['sex'].filter(list_id).tolist()
```

```
list_sle = df.meta['sleep_deprived'].filter(list_id).tolist()
```

```
# Add the keywords together into a single string to match the HCTSA format
```

```
list_key = np.array([f'{i},{q}' for i, q in zip(list_sex, list_sle)], dtype=object)
```

```
# Make the id/label list into an object tyoe numpy array so it formats properly
```

```
list_lab = np.array(list_id, dtype=object)
```

```
# Save to a .mat file
```

```
savemat('./ts.mat', {'timeSeriesData' : ts_mat, 'labels' : list_lab, 'keywords' : list_key})
```

Revision #2

Created 2026-04-22 10:33:40 UTC by Giorgio Gilestro

Updated 2026-04-22 10:33:42 UTC by Giorgio Gilestro