HyperTools: A python toolbox for gaining geometric insights into high-dimensional data

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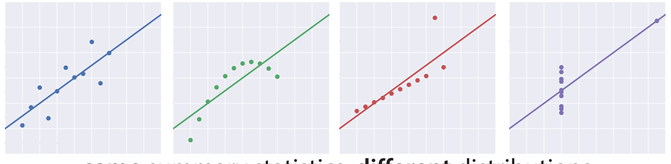
Overview

Visualizing data can reveal trends and patterns that are not otherwise obvious from the raw data or summary statistics.

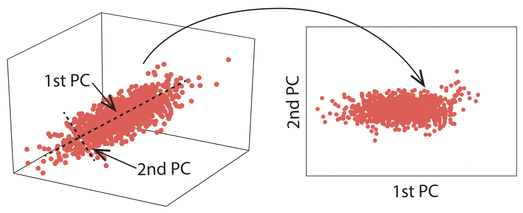
Anscombe's quartet



same summary statistics, **different** distributions

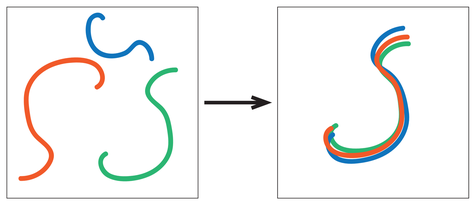
HyperTools is designed to facilitate dimensionality reduction-based visual explorations of high-dimensional data, allowing one to perform complex analyses often in a *single line of code*.

Dimensionality reduction



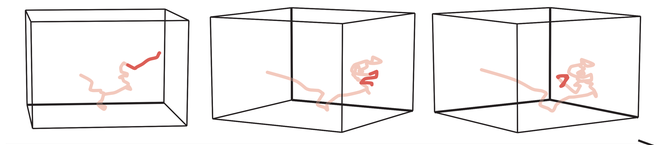
`hyp.plot(data, 'o')` `hyp.plot(data, 'o', ndims=2)`

Hyperalignment



`hyp.tools.align([array1, array2])`

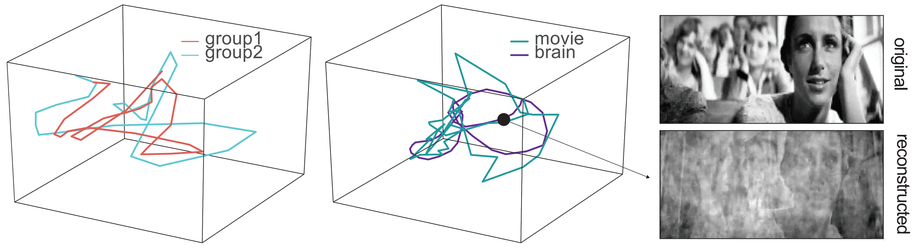
High-dimensional timeseries data can be visualized by reducing it to its first 3 principle components and plotting the resulting coordinates as a trajectory.



`hyp.plot(data, animate=True)`

Visualizing high dimensional neural data

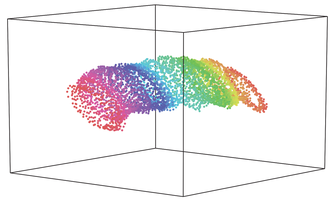
Aligning brains and movies to a common space



`hyp.plot([group1, group2])` `hyp.plot([movie, brain])`

(Left) Group-averaged hyperaligned activity (BOLD) from ventral visual cortex for two groups of subjects (each n=6) watching the same movie. (Middle) Ventral visual activity hyperaligned to the movie trajectory (changes in pixel intensity over time). (Right) Reconstructed movie frame from "movie-aligned" brain data.

Cyclic EEG patterns over time

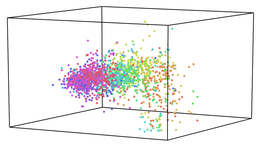


`hyp.plot(data, '.', group=time, azim=220)`

EEG (8 channels, n=1) recorded during rest reduced with principal components analysis. Each timepoint is plotted as a dot and colored by time. A cyclic pattern is present in 2 of the axes and the other is likely explained by signal drift.

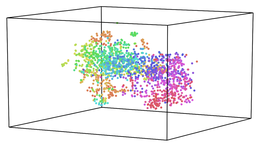
Spatial coding in hippocampal population responses

Principal Components Analysis



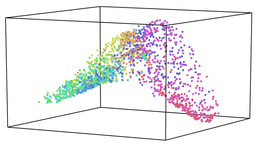
`hyp.plot(data, reduce='PCA')`

t-SNE



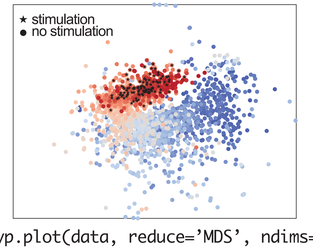
`hyp.plot(data, reduce='TSNE')`

Spectral Embedding



`hyp.plot(data, reduce='SpectralEmbedding')`

Multidimensional Scaling

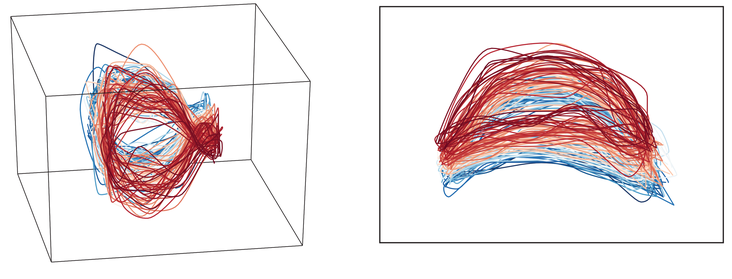


`hyp.plot(data, reduce='MDS', ndims=2)`

Single unit spikes (42 unique cells) were recorded from mouse hippocampus (dentate gyrus) during during locomotion on a linear track. The 3D plots above represent average population response patterns colored by location using different dimensionality reduction methods. Optogenetic stimulation was triggered for a subset of the cells at a particular spatial location. In the 2D plot to the left, stimulated locations are highlighted with a start and all locations are colored by track position. (Thank you Sam McKenzie for sharing this data!)

Visualizing other types of data

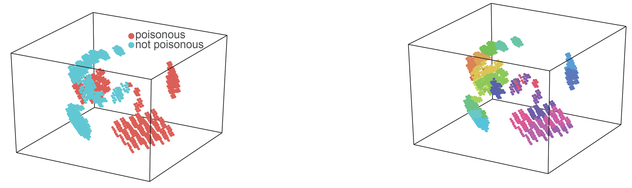
Cyclic global weather patterns over time



`hyp.plot(temps, group=year)` `hyp.plot(temps, group=year, ndims=2)`

Global temperatures are cyclic due to seasonal changes (left), but there is also a gradual increase in temperature over the past 130 years (right).

Feature vectors of various mushroom types



`hyp.plot(mushrooms, '.', group=labels)` `hyp.plot(mushrooms, '.', n_clusters=23)`

Descriptive features (i.e. cap size, color, odor) from a dataset of mushrooms. Mushrooms' poisonousness appears stable within each cluster (e.g. mushrooms that have similar features), but varies across clusters (left). Using the built-in k-means clustering algorithm, subclusters can be labeled and easily visualized (right).

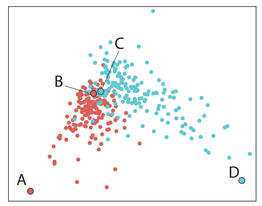
Topic models fit to political tweets

A
Why doesn't the failing @nytimes write the real story on the Clintons and women? The media is TOTALLY dishonest!

B
"@justiningly: @realDonaldTrump great speech today!! It's all about America and that's why you will become president!!!!" Thank you.

C
The labor movement pioneered the basic work that made America great: If you work hard and do your part you should be able to get ahead.

D
Obama on whether Trump could be trusted with US nuclear weapons: "Make your own judgement" https://t.co/6OZtrflwim https://t.co/Nj20PaXF2o



A
trump https donald vote today women president says millions believe https thank amp makeamericagreatagain crowd rights fight votetrump making realdonaldtrump clinton hillary https trump tax did woman rncincle failing

B
realdonaldtrump clinton hillary https trump tax did woman rncincle failing people americans https said speech enjoy american years history hillary trump https donald vote today women president says millions believe

C
trump https donald vote today women president says millions believe great america trump2016 https media plan carolina isis ratings tickets job work jobs better look wow man world life hard

D
trump https donald vote today women president says millions believe new https going say hillaryclinton york hillary timkaine people run president obama bad hillary states totally united person senator crooked

`hyp.plot(tweets, '.', group=labels, ndims=2)`

We fit topic models to tweets from Donald Trump and Hilary Clinton during the 2016 election (middle). On the right are the top 10 words for the 3 topics that best fit some exemplary tweets. Example tweets are shown on the left.

For questions, comments, or reprints, please visit our website: www.context-lab.com. This work was supported in part by NSF EPSCoR Award Number 1632738.