

# CNS2025: Homework 10

Due: 2025-11-12 23:59

## Exercise 1

Load the data from the file [hw10-data.npz](#), which contains two signals, `s` and `r`, each of 1000 data frames. Make a plot of the mutual information (MI) between two signals as a function of the relative frame shift  $\delta$  from -64 to +64. You can use the `numpy.roll` as introduced in [Lecture 4](#) to perform the shift on the array of response `r` before calculating the MI with `s`. There should be a peak in the plot. What is the peak position in the value of relative frame shift?

## Exercise 2

There are several ways of estimating the baseline of the MI. Firstly, you can randomize the order of (shuffle) the frames of the response `r` using:

```
rr = rng.permutation(r)
```

and calculate MI between `s` and the shuffled `rr`. Repeat the shuffling and calculation 1000 times to find the average MI, which estimates the baseline due to the finite sample size. Secondly, you can simply calculate MI for all possible relative shifts (use  $\delta$  from 0 to 999 with, e.g., the `numpy.roll` as well) and find the average MI. The later estimates the baseline without destroy the temporal structure of the signal itself. What are the values of baseline MI from the two estimates? Judging from your plots, which one is the better estimate for the specific data?