This is the README file for the codes and data of the paper 'An information-theoretic quantification of the content of communication between brain regions'

Content of the directories:
'FIT_src': MATLAB routines to compute Feature-specific Information Transfer (FIT) and Transfer Entropy (TE), that we release with this paper under the MIT license.

'Shannon information routines': MATLAB routines to compute Shannon information quantities, redistributed from Ref. [1]. Instructions on how to install the routines are in the 'Installation Instructions.txt' file in the directory.

'simulations': Codes to test FIT on simulated data. Each script has the name of the corresponding Figure (or Figure panel) in the paper main text or SM. We ran all simulations on a personal laptop running Windows 10, using MATLAB R2021a.

'real_data_analyses': Codes to run the analyses of real neural datasets. Codes used for the analysis of each dataset (MEG, EEG and spiking activity) is in a separate subdirectory. Further details on how to reproduce the analyses of each dataset are reported in a README file within each subdirectory. Each script has the name of the corresponding Figure (or Figure panel) in the paper. All neural dataset analyses ran on a server running Ubuntu 18.04, using MATLAB R2019b. The MEG and EEG analyses require MATLAB 'Parallel Computing Toolbox' and 'Image Processing Toolbox'.

'PID_theory': Includes script 'FIT_nullB.m' that we used to produce Fig. S2 and we mentioned in SM1.3.3.

'helpers': MATLAB functions used in different analyses of real datasets and/or in simulations.

Installing the software:
Running the simulations and analyses in the paper requires adding to the MATLAB path the new routines to compute FIT that we developed here, as well as installing the Shannon information routines that we redistribute from Ref. [1].

Instructions on how to install the Shannon information routines are in the 'Installation Instructions.txt' file in the 'Shannon information routines' directory. In brief, the installation requires two steps: 1) run the startup_toolbox.m script to add all toolbox subdirectories to the MATLAB path; 2) compile the toolbox MEX-files (Note: installation requires a MATLAB supported C/C++ compiler).

FIT routines:
The new quantities FIT and cFIT described here can be computed from the routines compute_FIT_TE.m and compute_FIT_TE_cFIT.m found in the 'FIT_src' directory. They take as input the discretized arrays with the values of the feature (S) and of the neural activity (past of activity of the sender X, and past and present activity of the receiver Y; compute_FIT_TE_cFIT.m also takes as input the past activity of the third region Z) in each trial. For example of how to run these routines,

see below. Note that compute_FIT_TE.m also allows computing FIT and TE values corrected for the limited sampling bias [2] using the quadratic extrapolation method.

Running simulations for all Figures in the main text and in the supplementary material:
The simulation results in Figures 2, S3, S4, S5, S6, S7, S8, S14 and S15 can be reproduced by running from MATLAB the script in directory 'simulations' with the corresponding file name. For example, to reproduce Fig. 2A, run the file Fig2A.m in directory 'simulations'. Note that scripts to reproduce simulations in Fig. S15 are Fig2A.m (for Fig. S15A) and Fig2B.m (for Fig. S15B).

Note on Real Neural Data:
The real MEG and EEG data reported in this paper are available from the public repository listed in the Supplementary Material file and in the original publications. The spiking activity data were obtained from the authors of the original publication and are reported in directory 'real_data_analyses\SpikingActivity\data'.

References:
[1] C. Magri, K. Whittingstall, V. Singh, N.K. Logothetis, S. Panzeri. A toolbox for the fast information analysis of multiple-site LFP, EEG and spike train recordings. BMC Neuroscience 10(1):81, 2009.
[2] S. Panzeri, R. Senatore, M. A. Montemurro, and R. S. Petersen. Correcting for the sampling bias problem in spike train information measures. Journal of Neurophysiology, 98(3):1064–1072, 2007.