Practical PHI toolbox for integrated information analysis

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This toolbox provides MATLAB codes of computation for practical versions of integrated information theory. This toolbox is an update of our previous version of the toolbox. In this new version, two new features are implemented: (1) Discrete distributions can be used for phi computation. (2) An efficient algorithm for the Minimum Information Partition (MIP) search, called Queyranne’s algorithm, is available. The main differences of the new version from the previous version are summarized in the table below.

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | Computation of practical measures of | | | | | | | | MIP search |
|  | Gaussian distribution | | | | Discrete distribution | | | |  |
| MI | SI |  |  | MI | SI |  |  |
| Previous | X | X | X | X |  |  |  |  |  |
| This version | X | X | X | X | X | X | X |  | X |

***General description***

**Computation of practical measures of integrated information**

This toolbox provides codes for computing practical measures of integrated information (PHI), namely, mutual information (Tononi, 2004), stochastic interaction (Ay, 2001, 2015; Barrett & Seth, 2011), integrated information based on mismatched decoding [1] and geometric integrated information [2]. Integrated information quantifies the amount of information that is integrated within a system. Please look at “demo\_phi\_Gauss.m” and “demo\_phi\_dis.m” to see how the core functions for PHI computation should be used.

**Search for the minimum information partition**

The codes for searching the minimum information partition (see Tononi, 2008, Biol Bull for example) are provided. Two types of algorithms for the MIP search are provided, namely, the exhaustive search and Queyranne’s algorithm [3,4]. Please look at “demo\_MIP\_Gauss.m” and “demo\_MIP\_dis.m” to see how the core functions for MIP search should be used.

You can freely use this toolbox at your own risk. Please cite this toolbox (doi:10.6084/m9.figshare.3203326) and the papers listed below when the toolbox is used for your publication. Comments, bug reports, and proposed improvements are always welcome.

The codes for Queyranne’s algorithm contained in the folder “QueyranneAlgorithm” were written by Shohei Hidaka at JAIST (Japan Advanced Institute of Science and Technology). The codes contained in the folder “minFunc\_2012” were written by Mark Schmidt, which is needed for solving unconstrained optimization. Please refer to the original webpage for the details.

<http://www.cs.ubc.ca/~schmidtm/Software/minFunc.html>

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***References***

[1] Oizumi, M., Amari, S, Yanagawa, T., Fujii, N., & Tsuchiya, N. (2016). Measuring integrated information from the decoding perspective. PLoS Comput Biol, 12(1), e1004654. <http://journals.plos.org/ploscompbiol/article?id=10.1371/journal.pcbi.1004654>

[2] Oizumi, M., Tsuchiya, N., & Amari, S. (2016). Unified framework for information integration based on information geometry. Proceedings of the National Academy of Sciences, 113(51), 14817-14822. <http://www.pnas.org/content/113/51/14817.short>

[3] Hidaka, S., & Oizumi, M. (2018). Fast and exact search for the partition with minimal information loss. PloS one, 13(9), e0201126.

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[4] Kitazono, J., Kanai, R., Oizumi, M. (2018). Efficient algorithms for searching the minimum information partition in integrated information theory. Entropy, 20, 173.

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