Practical PHI toolbox for integrated information analysis

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This toolbox provides MATLAB codes for end-to-end computation for practical versions of integrated information theory. This toolbox is an update of our previous version of the toolbox available at figshare (doi:10.6084/m9.figshare.3203326). In this new version, three new features are implemented: (1) Discrete distributions can be used for phi computation. (2) Algorithms for the MIP search are available. (3) Algorithms for the complex search are available. The main differences of the new version from the previous version at figshare are summarized in the table below.

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| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | Computation of practical measures of | | | | | | | | MIP search | Complex search |
|  | Gaussian distribution | | | | Discrete distribution | | | |  |  |
| MI | SI |  |  | MI | SI |  |  |
| figshare | X | X | X | X |  |  |  |  |  |  |
| This version | X | 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. Three types of algorithms for the MIP search are provided, namely, the exhaustive search, Queranne’s algorithm and Replica exchange Markov chain Monte Carlo (REMCMC). Please look at “demo\_MIP\_Gauss.m” and “demo\_MIP\_dis.m” to see how the core functions for MIP search should be used.

**Search for the complex**

At this point, only the exhaustive search for the complex is provided. Please look at “demo\_Complex\_Gauss.m” and “demo\_Complex\_dis.m” to see how the core functions for complex search should be used. We are also planning to implement REMCMC algorithm for the complex search by April.

The toolbox contains “minFunc” 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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You can freely use this toolbox at your own risk. Please cite this toolbox (URL) and the papers listed below when the toolbox is used for your publication. Comments, bug reports, and proposed improvements are always welcome.

***Acknowledgement***

We thank Shohei Hidaka for providing the codes for Queyranne’s algorithm.

***References***

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[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. (2017). Fast and exact search for the partition with minimal information loss. arXiv, 1708.01444. <https://arxiv.org/abs/1708.01444>

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

<http://www.mdpi.com/1099-4300/20/3/173>