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.

***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.m” to see how the core functions for PHI 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 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 should be used. We will also implement REMCMC algorithm for searching the complex by April.

This toolbox is an update of our previous version of toolbox, phi\_toolbox available at figshare (doi:10.6084/m9.figshare.3203326). The main differences of the new version from phi\_toolbox at figshare are summarized in the table below.

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | 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 |

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***

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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. (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>