Interpretable Machine Learning Aided Understanding of Complex Brain Structural and Functional Interaction Underlying Spectra of Individual Differences in Cognitive Behaviour

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Project Period: **Jun 2019 - May 2021**

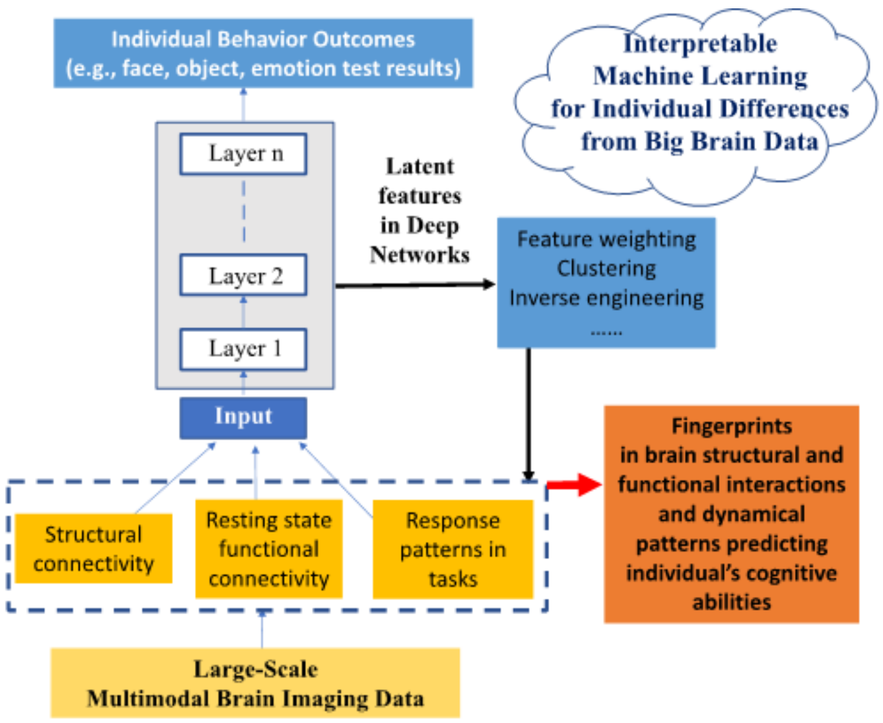
OBJECTIVES

1. To develop a core set of machine and deep learning models and tools for big brain data
2. To gain new understanding of how the brain employ specific systems for selected social cognition tasks
3. To further develop and apply methods to assess autistic trait

Key Issues

Q1: Characterize multi-dimensional spectra of individual differences in the brain structural and functional connectome and their relationships with social-cognitive behavior using machine learning applied to big brain data.

Q2: Identify multimodal biomarkers in brain structure, functional activity, and social-cognitive performance along with their relationships with autistic trait tendency.



Schematics of the project

Large-scale, multimodal brain imaging data will be used to derived brain structural connectivity, functional connectivity and response patterns in tasks. The Deep Networks will learn the relationships between network structural, activity and behavioural outcomes across individuals. Then the "black-box" of the Deep Networks will be opened to examine the latent features to learn the brain structural and dynamical finger prints that are eligible at predicting individual's cognitive abilities. Interpret the results in cognitive neuroscience.

Dataset 1: *Human Connectome Project, 1200 young healthy subjects; MRI and behavioural tests.*

Dataset 2: *Autistic trait and brain EEG among 150 young adults and 40 children. Under collection by HKBU Interdisciplinary Research Matching Scheme IRMS-16-17-04 (CS Zhou and M Lui).*

Anticipated Impact

☐ Short-term Impact (within project period of two years)

- Improved understanding of brain-behavior relationship for selected task category, whose action and evidence are:
  a) Develop a core set of models and methods for best predicting individuals' cognitive abilities in the selected task category.
  b) Publish high quality research outcomes in scientific journals or conferences.
  c) Build banks of models, methods and toolboxes for future research and to help the research community.
  d) Submit proposal to major external grant by the end of project period.
- Interdisciplinary knowledge development and team synergy, whose action and evidence are:
  a) Young researchers (postdoctoral fellows, research assistant and research postgraduate students) will be recruited and co-supervised by PI and Co-Is to receive training through joint discussion groups and regular journal clubs to accumulate knowledge and skills on the interdisciplinary topics.
  b) International collaborators will visit HKBU and young researchers will make research stay in their labs.
  c) Organize focused workshop or conference to invite experts to HKBU to promote academic exchange with our in-house team and enhance the visibility of HKBU in this research field.

☐ Long-term Impact

- Integrating machine learning and neuroscience to promote neurocognitive research
- Applications in early detection of disorder risks

SELECTED PUBLICATIONS

[1] D.P. Yang, H.J. Zhou and C.S. Zhou, "Co-emergence of Multi-scale Cortical Activities of Irregular firing, Oscillations and Avalanches Achieves Cost-efficient Information Capacity", PLoS Computational Biology 13, e1005384 (2017).

[2] Y.L. Zha, T. Zhou and C.S. Zhou, "Unfolding Large-scale Collaborative Human Dynamics", Proc Natl Acad Sci USA. 113, 14627 (2016).

[3] Q.Q. Shi, Y.M. Cheung, Q.B. Zhao and H.P. Lu, "Feature Extraction for Incomplete Data via Low-rank Tensor Decomposition with Feature Regularization", IEEE Transactions on Neural Networks and Learning Systems, DOI:10.1109/TNNLS.2018. 2873655.

[4] Y.M. Cheung, F.Q. Gu, H.L. Liu, K.C. Tan and H. Huang, "Objective-Domain Dual Decomposition: An Effective Approach to Optimizing Partial Differentiable Objective Functions", IEEE Transactions on Cybernetics, DOI: 10.1109/TCYB.2018.2870487.

[5] M. Lui, W.C. So and Y.K. Tsang, "Neural Evidence for Reduced Automaticity in Processing Emotional Prosody among Men with High Levels of Autistic Traits", Physiology & Behavior, 196, 47-58, 2018.

[6] M. Lui, K.F.H. Lui, A.C.N. Wong and J.P. Rosenfeld, "Suppression of 12-Hz SSVEPs when Viewing Familiar Faces: An Electrophysiological Index to Detect Recognition", International Journal of Psychophysiology, 133, 159-168, 2018.

[7] G. Ouyang G, A. Hildebrandt A, W. Sommer, C.S. Zhou (2017). Exploiting the intra-subject latency variability from single-trial event-related potentials in the P3 time range: A review and comparative evaluation of methods. Neuroscience & Biobehavioral Reviews. 75, 1-21 (2017)