



ICONIP 2023

November 20-23, 2023, Changsha, China

Tutorial/ Workshop Proposal for ICONIP2023

Title: Transfer Learning for EEG-based Brain-Computer Interfaces

Duration: Half day (3 hours)

Organizers:

Professor Dongrui Wu

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Dongrui Wu (IEEE Fellow) received a B.E in Automatic Control from the University of Science and Technology of China, Hefei, China, in 2003, an M.Eng in Electrical and Computer Engineering from the National University of Singapore in 2006, and a PhD in Electrical Engineering from the University of Southern California, Los Angeles, CA, in 2009. He is now Professor and Deputy Director of the Key Laboratory of the Ministry of Education for Image Processing and Intelligent Control, School of Artificial Intelligence and Automation, Huazhong University of Science and Technology, Wuhan, China.

Prof. Wu's research interests include brain-computer interface, machine learning, computational intelligence, and affective computing. He has more than 200 publications (11000+ Google Scholar citations; h=55). He received the IEEE Computational Intelligence Society (CIS) Outstanding PhD Dissertation Award in 2012, the IEEE Transactions on Fuzzy Systems Outstanding Paper Award in 2014, the IEEE Systems, Man and Cybernetics (SMC) Society Early Career Award in 2017, the USERN Prize in Formal Sciences in 2020, the IEEE Transactions on Neural Systems and Rehabilitation Engineering Best Paper Award in 2021, the Chinese Association of Automation Early Career Award in 2021, and the Ministry of Education Young Scientist Award in 2022. His team won the First Prize of the China Brain-Computer Interface Competition in four successive years (2019-2022). Prof. Wu is Editor-in-Chief of the IEEE Transactions on Fuzzy Systems.

Description:

Tutorial Abstract:

A brain-computer interface (BCI) enables a user to communicate with a computer directly using brain signals. Electroencephalograms (EEGs) used in BCIs are weak, non-stationary for the same subject, and vary across different subjects and sessions. Thus, sophisticated machine learning approaches are needed for accurate and reliable EEG-based BCIs. This talk will introduce the basic concepts of BCIs, review the latest progress, and describe several newly proposed machine learning approaches for BCIs. Transfer learning (TL) utilizes data or knowledge from one or more source domains to facilitate learning in a target domain. It is particularly useful when the target domain has very few or no labeled data, due to annotation expense, privacy concerns, etc. Its applications on brain-computer interfaces are explored. This tutorial describes how TL can be considered in as many components of a BCI system as possible, and introduces a complete TL pipeline for EEG-based BCIs. Examples on multiple datasets demonstrate the advantages of considering TL in multiple components of EEG-based BCIs. Especially, integrating data alignment and sophisticated TL approaches can significantly improve the classification performance, and hence greatly reduces the calibration effort.

Tutorial Outline:

1. Brain-Computer Interface (BCI) (20 min)
2. Signal Acquisition for BCIs (15 min)
3. Signal Preprocessing for BCIs (20 min)
4. Signal Analysis for BCIs (100 min)
 - Transfer Learning (15 min)
 - Data Alignment (20 min)
 - Unsupervised Domain Adaptation (20 min)
 - Source-free Domain Adaptation (15 min)
 - Domain Generalization (15 min)
 - Test-Time Adaptation (15 min)
5. Conclusions and Discussion (25 min)

Relevant Publications

- [1] **D. Wu***, X. Jiang and R. Peng, "Transfer Learning for Motor Imagery Based Brain-Computer Interfaces: A Tutorial," *Neural Networks*, 153:235-253, 2022.
- [2] **D. Wu**, B. -L. Lu, B. Hu and Z. Zeng, "Affective Brain-Computer Interfaces (aBCIs): A Tutorial," *Proceedings of the IEEE*, 2023, early access.
- [3] W. Zhang, L. Deng, L. Zhang, and **D. Wu***, "A survey on negative transfer," *IEEE/CAA Journal of Automatica Sinica*, vol. 10, no. 2, pp. 305–329, 2023.
- [4] **D. Wu***, Y. Xu and B-L Lu, "Transfer Learning for EEG-Based Brain-Computer Interfaces: A Review of Progress Made Since 2016," *IEEE Trans. on Cognitive and Developmental Systems*, 14(1):4-19, 2022.
- [5] K. Xia, W. Duch, Y. Sun, K. Xu, W. Fang, H. Luo, Y. Zhang, D. Sang, X. Xu, F.-Y. Wang, and **D. Wu***, "Privacy-Preserving Brain-Computer Interfaces: A

Systematic Review,” IEEE Trans. on Computational Social Systems, 2022, early access.

- [6] W. Zhang, **Z. Wang** and **D. Wu***, “Multi-Source Decentralized Transfer for Privacy-Preserving BCIs,” IEEE Trans. on Neural Systems and Rehabilitation Engineering, vol. 30, pp. 2710–2720, 2022.
- [7] **S. Li**, H. Wu, L. Ding, and **D. Wu***, “Meta-learning for fast and privacy-preserving source knowledge transfer of EEG-based BCIs,” IEEE Computational Intelligence Magazine, vol. 17, no. 4, pp. 16–26, 2022.
- [8] W. Zhang and **D. Wu***, “Manifold Embedded Knowledge Transfer for Brain-Computer Interfaces,” IEEE Trans. on Neural Systems and Rehabilitation Engineering, 28(5), pp. 1117-1127, 2020.
- [9] H. He and **D. Wu***, “Different Set Domain Adaptation for Brain-Computer Interfaces: A Label Alignment Approach,” IEEE Trans. on Neural Systems and Rehabilitation Engineering, 28(5):1091-1108, 2020.
- [10] H. He and **D. Wu***, “Transfer Learning for Brain-Computer Interfaces: A Euclidean Space Data Alignment Approach,” IEEE Trans. on Biomedical Engineering, 26(2), pp. 399-410, 2020.

Confirmed and/or potential speakers:

- **Dongrui Wu** (IEEE Fellow), is currently Professor and Deputy Director of the Key Laboratory of the Ministry of Education for Image Processing and Intelligent Control, School of Artificial Intelligence and Automation, Huazhong University of Science and Technology, Wuhan, China. drwu@hust.edu.cn
- **Ziwei Wang**, is currently a Ph.D. student at the School of Artificial Intelligence and Automation, Huazhong University of Science and Technology, Wuhan, China. zwwang0606@hust.edu.cn
- **Siyang Li**, is a currently Ph.D. student at the School of Artificial Intelligence and Automation, Huazhong University of Science and Technology, Wuhan, China. syoungli@hust.edu.cn

Link to organizer's web page and/or tutorial/workshop website (optional).

- Google Scholar: <https://scholar.google.com/citations?user=UYGzCPEAAAAJ&hl=en&oi=ao>
- Lab: <https://lab.bciml.cn/en/home/>
- Faculty: http://faculty.hust.edu.cn/drwu/zh_CN/index.htm

Previous Tutorials:

- [1] “**Machine Learning Pipeline for EEG-based Brain-Computer Interfaces**” at IJCNN 2023.
- [2] “**Machine Learning for Brain-Computer Interfaces**” at IJCNN 2021.
- [3] “**Transfer Learning for Brain-Computer Interfaces**” at ICONIP 2020.
- [4] “**Signal Processing and Machine Learning for Brain-Computer Interfaces**” at ICONIP 2017.