BIOGRAPHICAL SKETCH

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NAME: **Yuanyuan Gao**

eRA COMMONS USER NAME (credential, e.g., agency login): **GAOY8YUAN**

POSITION TITLE: **Postdoctoral Scholar**

EDUCATION/TRAINING *(Begin with baccalaureate or other initial professional education, such as nursing, include postdoctoral training and residency training if applicable. Add/delete rows as necessary.)*

INSTITUTION AND LOCATION	DEGREE *(if applicable)*	Completion Date MM/YYYY	FIELD OF STUDY
Beihang University	BS	07/2010	Aircraft Environment and Life security
Beihang University	MS	07/2013	Mechanical Engineering
Rensselaer Polytechnic Institute	Ph.D.	08/2020	Mechanical Engineering
Boston University	Postdoc	02/2023	Biomedical Engineering

A. Personal Statement

My research background in advanced functional near infrared spectroscopy (fNIRS) data analysis methods provides me with unique skills to successfully undertake the proposed research. Functional NIRS measures blood flow in surface areas of the brain and serves as a proxy for neural activity. Using this technique, I have gained expertise in neuroimaging experimental design, data collection and analytical techniques of brain activity related to motor and psychological (cognitive and affective) processes, under the supervision of Prof. Xavier Intes. During my first postdoctoral training term, I built up and validated innovated fNIRS data analysis models working under the supervision of the founder and active leader in fNIRS community, Prof. David Boas. This experience has allowed me to further gain expertise in advanced fNIRS data analysis methods, including image reconstruction and functional brain connectivity. It has also broadened my collaborative experience of working on multi-disciplinary research topics, such as cognitive science and clinical translational applications. This proposed project would give me a unique opportunity to gain experience of the application of advanced fNIRS data analysis methods in clinical topics under the supervision of Prof. Allan Reiss. Regular interaction with our collaborating UC Berkley research group will also enhance my knowledge base through regular exposure to, and discussion of epidemiologic principles as applied to early pediatric exposures. I am eager to secure my own funding to build my track record as well as increase my research output. I wish to become an independent investigator and pursue a career in academia.

a. **Gao Y**, Kruger U, Intes X, Schwaitzberg S, De S**.** (2020). The effects of transcranial electrical stimulation on human motor functions: A comprehensive review of functional neuroimaging studies, *Frontiers in Neuroscience*, 14:744.
b. **Gao Y,** Rogers D, von Lühmann A, Ortega-Martinez A, Yücel MA, Boas DA. (2022). Short separation regression incorporated diffuse optical tomography (SS-DOT). In *Society of fNIRS conference*, Boston, USA
c. **Gao Y,** Yan P, Kruger U, De S, Intes X. (2019). Neuroimaging biomarkers for surgical skill level prediction. In *SPIE Bios,* San Francisco, USA.
d. **Gao Y,** Yan P, De S, Intes X. (2019). fNIRS as a quantitative tool to assess and predict surgical skills. In *Biophotonics Congress: Biomedical Optics (Translational Microscopy, OCT, OTS, BRAIN), page BM4A.2, Optica Publishing Group.*

B. Positions, Scientific Appointments, and Honors

Positions and Employment

2015-2018 Teaching Associate, Department of Mechanical Engineering, Rensselaer Polytechnic Institute, NY, USA.
2015-2020 Research Assistant, Department of Mechanical Engineering, Rensselaer Polytechnic Institute, NY, USA.
2019 Visiting Scholar, Department of Civil Engineering, University at Buffalo, Buffalo, NY, USA.
2020-2023 Postdoctoral Researcher, Neurophotonics Center, Boston University, Boston, MA, USA.
2021 Teaching Assistant, fNIRS workshop, Boston University, Boston, MA, USA.
2021 Organizing Committee Member, V-SfNIRS Conference, Boston, MA, USA.
2021 Panel Host, V-SfNIRS Conference, Boston, MA, USA.
2022 Organizing Committee Member, SfNIRS Conference, Boston, MA, USA.
2022 Committee for undergraduate senior projects, Biomedical Engineering Department, Boston University, Boston, MA, USA.
2023- Postdoctoral Researcher, Center for Interdisciplinary Brain Sciences Research, Stanford University, USA.

Professional Memberships

2020 - 2021 The International Society for Optics and Photonics (SPIE)
2020 - 2021 Optical Society of America (OSA)
2020 - The Society for functional near-infrared spectroscopy (SfNIRS)

Honors

2007 BUAA undergraduate Students Second Prize Scholarship
2011 BUAA Graduate Students Second Prize
2013 Outstanding Graduate in Beijing
2020 Young Investigator Competition Finalist Award for Excellence, Military Health System Research Symposium
2022 Poster Excellence Award, Society of fNIRS conference

C. Contributions to Science

1. The works during my Ph.D. stage served the purpose of fine human motor skill acquisition enhancement using neuroimaging techniques. First, I contributed to the review of the neuroimaging field by composing a comprehensive review paper on neuroimaging studies, including fNIRS, fMRI, EEG, PET, and MEG modalities, on how those neuroimaging techniques revealed human motor learning nature and how transcranial electrical stimulation affects it. This work is well received by peer scholars. Based upon this review work, I identified the research gap and designed a human subject neuroimaging study on fine motor skill learning procedure. In this work, I observed brain activation moving from the prefrontal regions to the motor regions along the motor learning timeline. I demonstrated neuromodulation interventions to enhance learning procedures by strengthening brain activation in the M1 area and reducing performance errors. Through this work, I have validated the potential of longitudinal fNIRS monitoring experimentally. Part of this work resulted in several peer-reviewed publications whereby I was primary author.

    a. **Gao Y,** Cavuoto L, Yan P, Kruger U, Silvestri J, Schwaitzberg S, Norfleet JE, Makled BA, Intes X, De S (2020). Monitoring the effect of transcranial electric current stimulation (tES) during a bimanual motor task via functional near-infrared spectroscopy (fNIRS). In *Biophotonics Congress: Biomedical Optics (Translational Microscopy, OCT, OTS, BRAIN),* page JTh2A.29, Optica Publishing Group.

b. **Gao Y,** Cavuoto L, Dutta A, Kruger U, Yan P, Nemani A, Norfleet JE, Makled BA, Silvestri J, Schwaitzberg S, Intes X, De S (2021). Transcranial direct current stimulation speeds up surgical bimanual motor learning and increases functional activation. In *MHSRS, Young Investigator breakout session*.
c. **Gao Y,** Cavuoto L, Yan P, Kruger U, Silvestri J, Schwaitzberg S, Norfleet JE, Makled BA, Intes X, De S (2021). Decreasing the surgical errors by neurostimulation of primary motor cortex and the associated brain activation via neuroimaging. *Frontiers in Neuroscience*, 15:651192.

2. Machine/deep learning methodologies have been heavily utilized throughout the works and have been a powerful tool for extracting features from behavior and fNIRS data. First, I achieved to predict surgical training outcomes by setting up a machine learning model, kernel partial least squares (KPLS), on retrospective datasets, enabling personalizing curriculum before the surgical training to avoid extravagance. Second, I explore the possibility of emulating the surgical skill evaluation metric, namely the FLS score, by combining neuroimaging data and machine learning methodologies for potential fast and bedside implementation. In this context, we have validated a deep neural network that accurately predicts performance scores from brain hemodynamic data obtained using functional near-infrared spectroscopy (fNIRS). In this work, motion artifacts induced by surgical motions contaminated the fNIRS data resulting in the discarding of 30% of trials. It motivated me to do a side project to remove motion artifacts automatically. I achieved it by implementing a deep learning model, denoising autoencoder structure (DAE). The following papers represent the efforts to extract features from fNIRS data using machine learning approaches.

   a. **Gao Y**, Kruger U, Intes X, Schwaitzberg S, De S**.** (2020). A machine learning approach to predict surgical learning curves, *Surgery*, 167(2): 321-327.
   b. **Gao Y,** Yan P, Kruger U, Cavuoto L, Schwaitzberg S, De S, Intes X. (2021). Functional brain imaging reliably predicts bimanual motor skill performance in a standardized surgical task. *IEEE Transactions on Biomedical Engineering*, 68(7): 2058-2066.
   c. **Gao Y,** Chao H, Cavuoto L, Yan P, Kruger U, Norfleet JE, Makled BA, Schwaitzberg S, De S, Intes X. (2022). Deep learning-based motion artifact removal in functional near-infrared spectroscopy. *Neurophotonics*, 9(4): 041406.

3. My postdoctoral research is on advanced fNIRS data analysis methods, including image reconstruction and connectivity analysis validation. Removing extracerebral signal contamination in functional near-infrared spectroscopy (fNIRS) measurements is critical to correctly estimate the brain response and thus has been investigated for decades. However, the best practice is still under exploration. Two widely adopted methods are short-separation regression (SS) and diffuse optical tomography (DOT) image reconstruction. Each of these methods has been demonstrated to individually facilitate the separation of brain activation and physiological signals, with further improvement using both sequentially. Motivated by these previous works, I propose simultaneously performing SS and DOT methods (SS-DOT). I have shown that the SS-DOT model improves the image quality by increasing the contrast to background noise ratio (CBR) by 3-fold compared to the traditional models. Besides the image reconstruction work, I am investigating the connectivity analysis methods in fNIRS data. The large brain networks have been reliably observed in fMRI studies for decades, and the strength of the correlation between the networks is a stable biomarker for aging, Schizophrenia, depression, anxiety, autism, and other measures. I am exploring the best practice when deriving connectivity properties using fNIRS. A side collaborative project is comparing the performance of time-domain fNIRS to continuous wave fNIRS with carefully fine-tuned parameters. Related publications are listed below.

   a. Nemani A, Kamat A, **Gao Y**, Yucel MA, Gee D, Cooper C, Ortega-Martinez A, Schwaitzberg S, Intes X, Dutta A, De S. (2021). Functional brain connectivity related to surgical skill dexterity in physical and virtual simulation environments, *Neurophotonics,* 8(1):015008.
   b. **Gao Y,** Rogers D, von Lühmann A, Ortega-Martinez A, Yücel MA, Boas DA. (2021). Short separation generalized linear model (GLM) based image reconstruction of functional near-infrared spectroscopy (fNIRS) data. In *Society of fNIRS virtual conference*.

c. Ortega-Martinez A, Rogers D, Anderson J, Farzam P, **Gao Y,** Zimmermann B, Yücel MA, Boas DA. (2022). How much do time-domain functional near-infrared spectroscopy (fNIRS) moments improve estimation of brain activity over traditional fNIRS? *Neurophotonics,* 10(1):013504.
d. **Gao Y,** Rogers D, von Lühmann A, Ortega-Martinez A, Yücel MA, Boas DA. (2023). Short-separation regression incorporated diffuse optical tomography (SS-DOT) image reconstruction modeling for high-density functional near-infrared spectroscopy (fNIRS). *Neurophotonics,* under review.

D. Research Support

2020 – 2023 National Institute of Health (NIH) [grant number 1U01EB029856-01]:
Awarded to Dr. David Boas.
Role: Postdoctoral Researcher