Yale-NJUPT Senior Project

Yale PET Center

Yale Positron Emission Tomography (PET) Research Center is dedicated to providing the highest quality of nuclear imaging research. PET is a non-invasive diagnostic scanning technique that provides researchers and clinicians with quantitative visual images of organ function. PET scans can detect biochemical changes in body tissues before structural changes occur from disease. This information allows clinicians to be proactive in their treatments and enables researchers to develop early biomarkers of disease that can aid diagnosis and advance drug development. Please see details at http://petcenter.yale.edu/.

Our research projects focus on 1) New algorithms for image reconstruction for PET, 2) Development of new image processing methodologies to improve the quality and quantitative accuracy of PET, 3) creation of mathematical models for novel radiopharmaceuticals to produce images of physiological parameters, and 4) application of PET tracers in clinical and preclinical populations for the study of disease mechanisms and treatment outcomes. Yale students and many international students in biomedical engineering and other disciplines participate in cutting-edge research in these areas.

Objective

The senior-year student is expected to perform his/her senior project which is closely related/in parallel to on-going cutting-edge researches under the guidance of mentor(s) at Yale University. He/she will receive intensive training in terms of research methodology, research-article reading skills, English oral-presentation skills and English writing skills. The final project report is expected be in both Chinese and English. Potential publication opportunities regarding the project depend on the quality of the study.

Mentors at Yale

Dr. Richard E. Carson (Professor of Biomedical Engineering & Radiology and Biomedical Imaging; Director of the Yale PET Center; Director of Graduate Studies in Biomedical Engineering)

Dr. Yihuan Lu (Associate Research Scientist of Radiology and Biomedical Imaging)

Qualifications

Programming skill: must be proficient in MATLAB, proficient in C/C++ and/or CUDA/Python is a plus. 2000+ lines minimal coding experience. Programming skill will be tested during the interview process. Computer science major is a plus.

GPA requirement: as long as the GPA is above 3.0, further evaluation of the candidate will NOT be based on the GPA level.

Knowledge: good understanding of Signal Processing and Signal & System; proficient in vector/matrix mathematical expressions (linear algebra); basic knowledge of statistics. Any knowledge of image processing/analysis or neural network is a plus.

Desired personality: skeptical, self-motivated, passionate and dedicated.

English: TOEFL iBT speaking/listening > 22 points or equivalent level is desired but not a must. English communication skill will be assessed during Skype interview.

Desirable qualifications: knowledge of optimization theory; experience in mathematical modeling; participation of any scientific project in one lab.

Project Duration and Cost

Six to ten months depending on the circumstances.

No tuition cost at Yale side. Living expenses and traveling medical insurances must be self-supported or supported by NJUPT. No school dormitory is provided but housing advice will be given. Living cost estimate: $600-800 (single room)/month or $900-$1400 (studio or one-bedroom apartment), and $300-600/month on food.

Academic Environment

The student will have free access to Yale University resources, such as Sterling Memorial Library (http://web.library.yale.edu/building/sterling-library), Yale Peabody Museum of Natural History (http://peabody.yale.edu), Yale University Art Gallery (http://artgallery.yale.edu), etc.

The student will have access to varieties of extramural activities organized by Yale Office of International Students and Scholars (http://oiss.yale.edu/calendar).

The student is encouraged to attend the seminars at Yale School of Medicine, such as weekly Yale PET center seminar (https://tauruspet.med.yale.edu/wiki/index.php/PET_Imaging_Lab_meeting) lead by Dr. Richard Carson, weekly Medical Grand Rounds (https://tools.medicine.yale.edu/calendar/) given by established researchers or clinicians, etc.

The student is encouraged to join other research group meetings, such as monthly Project Discussion meeting, weekly Deep Learning, etc. The student is also encouraged to communicate with all other researchers and staff members at the PET Center regarding not only research questions, but also studying and career plans.

Topics for Senior Project

Project 1. Deep-learning based head motion estimation

Head movement is a major limitation in brain PET imaging, which results in image artifacts and quantification errors. In the past, many methods have been proposed to correct head motion. However, to date, there is no approach that can track head motion continuously *without* using an external device. These challenges motivated us to develop an approach that can be used for real-time head motion tracking during PET imaging without the use of external devices, i.e., a data-driven method that only uses PET raw data. We propose to develop a deep learning-based framework capable of real time head motion tracking during brain PET imaging. The senior project will be focusing on implementing a machine learning/deep learning-based head motion estimation technique using maximum-intensity projection images of a brain for both High Resolution Research Tomograph and Siemens mCT PET scanners.

Project 2. Data-driven head motion correction with the aid of machine learning/deep learning-based image denoising technique for PET

There is a growing research interest in brain disease, e.g. Alzheimer, depression, and Parkinson's. PET brain imaging provides in-vivo images which help researchers/doctors to understand or stage the disease [1]. However, head motion during the PET study causes error in tracer uptake quantification (Figure 1 A) and even incorrect diagnosis of the disease. The Yale PET Center has been using hardware-based external motion tracking, i.e. Vicra system, which accurately detects/corrects head motion for the Siemens HRRT PET scanner (Figure 1 B); however, such approach is too complex for routine clinical use. Recently, Lu et al. [2] has established a data-driven head motion correction technique, however, such approach requires broad-distributed tracer to be robust in motion estimation using the image registration technique. The senior project will be focusing on implementing a machine learning/deep learning-based image denoising technique to improve the robustness of motion estimation for other more challenging tracers, e.g. ^{11}C-Raclopride. This study will help the data-driven method to be more widely used in the Yale PET Center and even other institutes.

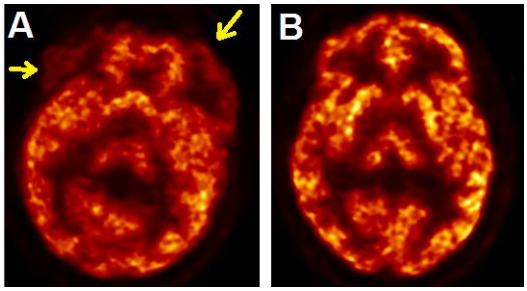

Figure 1. A) Reconstructed brain image without motion correction. Observable image blurring is shown (arrows). B) With event-by-event motion correction [2], the blurring is recovered.

Contact information

Please contact Prof. Liya Huang (黄丽亚) at NJUPT for application details. (Huangly@njupt.edu.cn)
Please contact Dr. Yihuan Lu for project details. (Yihuan.lu@yale.edu)

Reference

[1] S. J. Finnema, N. B. Nabulsi, *et al.*, "Imaging synaptic density in the living human brain," *Science Translational Medicine,* vol. 8, pp. 348ra96-348ra96, 2016.
[2] Y. Lu, M. Naganawa, *et al.*, "Data-driven motion detection and event-by-event correction for brain PET: Comparison with Vicra for dynamic studies", *Journal of Nuclear Medicine,* vol. (Submitted), 2019.