Shixuan Gu

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Education

- **Carnegie Mellon University** — Pittsburgh, PA, United States
  M.S. in Biomedical Engineering - Research — *Sep. 2021 - Present*
  Biomedical Engineering Department Head's Fellowship
- **Shanghai Jiao Tong University** — Shanghai, China
  B.Eng. in Information Engineering - Artificial Intelligence, IEEE Honor Class — *Sep. 2017 - Jun. 2021*
  Outstanding Graduate of Shanghai Jiao Tong University

Research Interests

My research interest lies in geometric deep learning with applications in biomedical image analysis. My latest research focuses on 3D registration and reconstruction in EM imaging (Connectomics) and CT imaging (rib analysis). I also build robots for competition events and medical usage.

Publications

- ***RibSeg v2*: A Large-scale Benchmark for Rib Labeling and Anatomical Centerline Extraction**
  Liang Jin*, **Shixuan Gu***, Donglai Wei, Kaiming Kuang, Hanspeter Pfister, Bingbing Ni, Jiancheng Yang, and Ming Li
  IEEE Transactions on Medical Imaging (IEEE TMI), 2022 (under review)
  [preprint]

- **Deep Learning-based Surrogate Modeling for Isogeometric Analysis of a Phase-field Neuron Growth Simulator**
  Kuanren Qian, Ashlee Liao, **Shixuan Gu**, Victoria Webster-Wood, Jessica Zhang
  Scientific Reports, 2022 (under review)

- **RibSeg Dataset and Strong Point Cloud Baselines for Rib Segmentation from CT Scans**
  Jiancheng Yang*, **Shixuan Gu***, Donglai Wei, Hanspeter Pfister, Bingbing Ni
  International Conference on Medical Image Computing and Computer-Assisted Intervention (MICCAI), 2021
  [paper] [code] [dataset] [poster]

Research Experience

Visual Computing Group - Harvard University — Cambridge, MA, United States

- ***DenSpineEM*: 3D Dendritic Spine Instance Segmentation from EM Images**
  Advisor: Prof. Hanspeter Pfister, Prof. Donglai Wei, Prof. Jeff Lichtman — *May. 2022 - Present*
  - Developed the first dendritic spine segmentation benchmark with EM images of mouse somatosensory cortex, mouse visual cortex, and human frontal lobe, respectively.
  - Implemented a skeleton-based baseline method to perform dendritic spine segmentation (Dice $\approx 91\%$).
  - Proposed a geometric transformation to facilitate deep learning for elongated and curvy objects, such as neurites and blood vessels.
  - Paper ***FreNet: A Skeleton-based Method for Segmentation Along Generalized Cylinders*** is targeted for IEEE TMI 2022.

- ***RibSeg v2*: Benchmark for Rib Labeling and Anatomical Centerline Extraction**
  Advisor: Prof. Hanspeter Pfister, Prof. Donglai Wei, Prof. Bingbing Ni — *Jun. 2021 - Jul. 2022*
  - Extended *RibSeg* dataset and developed the first large public benchmark for rib labeling and anatomical centerline extraction, including 660 CT cases.
  - Proposed 1) a point-based deep learning method for end-to-end rib labeling, 2) a *TEASAR*-based method for rib anatomical centerline extraction, and 3) various metrics for each task to perform comprehensive evaluations.
  - Paper ***RibSeg v2: A Large-scale Benchmark for Rib Labeling and Anatomical Centerline Extraction*** submitted to IEEE TMI 2022 is under review.
  - Proposed a polyline template alignment-based deep learning method for robust rib anatomical centerline extraction, including *Global Affine* and *Differentiable Upsampling Deformation* blocks.
  - Paper ***Ribbon: Template Alignment-based Rib Anatomical Centerline Extraction from CT Scans*** is targeted for MICCAI 2023.

Computational Bio-Modeling Lab - Carnegie Mellon University Pittsburgh, PA, United States

- **Neuron Growth Simulation**
  Advisor: Prof. Jessica Zhang, Prof. Victoria Webster-Wood *Sep. 2022 - Present*
  - Implemented a CNN autoencoder baseline model, which achieved high simulation accuracy (MRE ≈ 1.19%) and efficiency (0.25s/case, $6^{10}\times$ faster than the IGA solver).
  - Implemented a physics-informed CNN-LSTM, where the loss function was combined with the governing equation of a phase-field model.
  - Paper ***Deep Learning-based Surrogate Modeling for Isogeometric Analysis of a Phase-field Neuron Growth Simulator*** submitted to Scientific Reports 2022 is under review.
- **Study on the Pathogenesis of Alzheimer's Disease and Vascular Cognitive Impairment Using Mouse Models**
  Advisor: Prof. Jessica Zhang, Prof. Kanekiyo Takahisa *Oct. 2022 - Present*
  - Collaborated with Mayo Clinic to study the differences in brain vascular structure using CT images.
  - Tested VesSAP on CT images of mouse brain to segment brain and reconstruct vasculature.
  - Implementing transfer learning-based method to generalize VesSAP to data from Mayo Clinic.
  - Computing vessel density, length, and size from the segmented CT images to compare brain vascular structures between several mouse groups such as male vs. female mice, and young vs. aged mice.

Biorobotics Lab - Carnegie Mellon University Pittsburgh, PA, United States

- **Robotic Ventilator: Patient Care Technologies for Permanent Ambulatory Artificial Lung Support**
  Advisor: Prof. Howie Choset, Prof. Keith E. Cook, Prof. Jason J. Rose *Sep. 2021 - Aug. 2022*
  - Collaborated with UPMC to design and build a portable O_2 concentrator for ICU ventilation.
  - Designed and built a clinical ventilation sensor for breathing data collection and interaction with an online database.
  - Developed a deep learning-based alarming system for lung-related diseases such as hyperinflation, and built an online database for breathing data.
  - Drafted a section of **Phase 1 NIH STTR research proposal** for a deep learning-based lung disease alarm system.

Vision and Learning Lab - Shanghai Jiao Tong University Shanghai, China

- **RibSeg Dataset and Strong Point Cloud Baselines for Rib Segmentation from CT Scans**
  Advisor: Prof. Bingbing Ni, Prof. Donglai Wei, Prof. Hanspeter Pfister *Oct. 2020 - Jun. 2021*
  - Developed *RibSeg*, the first public large-scale dataset, including 490 CT scans (11,719 individual ribs), for rib segmentation to enable downstream applications and method comparison.
  - Proposed a point cloud-based method to segment ribs from CT scans, which achieves high accuracy (Dice ≈ 95%) and efficiency (40×faster than prior arts).
  - Paper ***RibSeg Dataset and Strong Point Cloud Baselines for Rib Segmentation from CT Scans*** is accepted by MICCAI 2021.

Intelligent Robot Lab - Shanghai Jiao Tong University Shanghai, China

- **VEX Robotics Project: VEX U Robotics World Tournaments**
  Advisor: Prof. Chuntao Leng *Sep. 2018 - May. 2020*
  - Co-founded the SJTU VEX Lab, and won the first VEX robotics world championship for SJTU.
  - Designed and built the ejection structure crossbow, trebuchet, and flywheel for three prototypes, respectively.
  - Designed the scoring path and programmed control codes for the automation stage of the competition.

Awards

- **[2019] VEX U Skills Challenge World Champion, VEX U Division Champion, and World Finalist**
  2019 VEX U Robotics World Championship, Robotics Education & Competition Foundation
- **[2018] Create Award, Robot Skills Finalist, Silver Award**
  2018 12th Asia-Pacific Robotics Championship, Asian Robotics League
- **[2018] Nomination for Excellence Award, Amaze Award, Tournament Semifinalists**
  2018 China National VEX Robotics Competition
- **[2018] Student Ambassador, Excellent Student Presentation Award**
  2018 Student Learning Festival of C9+1 Symposium, The University of Hong Kong
- **[2016] First Prize, Best Con in Shanghai International Young Physicists' Tournament (IYPT Shanghai)**
  Shanghai Physical Society, China

Miscellaneous

- **Programming**: Python (PyTorch, scikit-learn, NumPy, Pandas), C++, Javascript, HTML, MATLAB.
- **Robotics**: Proficient in VEX robot design, RobotC, SolidWorks.
- **Tools**: ITK, MySQL, CyberTorcs, Neuroglancer.
- **Teaching Assistant**: UCLA Extension (Shanghai Pinghe) - Artificial Intelligence and Data Science (COM SCI - 960.01: Aug'21), Research Methodologies (ENGL 902: Aug'21), Academic Writing (ENGL 901: Aug'21).