Yi Liu

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Education

University of Delaware — Newark, DE
Ph.D. in Computer Science (GPA 4.0/4.0) — Sept. 2017 – May 2022
Advisor: Dr. Chandra Kambhamettu
Computer Vision, Image Processing, Deep Learning, Image Segmentation

University of Maryland — College Park, MD
Masters in Structural Engineering (GPA 3.9/4.0) — Jan. 2016 – Aug. 2017
Computational Structural Engineering, Finite Element Analysis

Hunan University — Changsha, China
Bachelors in Structural Engineering (Top 3 Graduation Project) — Sept. 2011 – June 2015

Research Summary

- My research interests lie in the general area of **computer vision** and **machine learning**. My most recent project is to collaborate with Biologists at Delaware Biotechnology Institute and develop methods to quantify filamentous structures in cells from microscopic images. My project's topic involves **image segmentation, instance segmentation, object detection, data augmentation, tracking, and clustering analysis**. Collaborators have been using the method I developed to accelerate their biological research.

Research Highlights | *Video/Image Modeling and Synthesis Lab*

Instance Segmentation on thin and elongated objects | **Github link** — Jan. 2020 – Present

- Researched methods for instance segmentation on thin and elongated objects which is a challenging but not well studied problem
- Implemented a program and created a synthetic dataset for thin and elongated objects, which alleviated the problem of data shortage
- Designed a deep neural network consisting of a CNN encoder and an LSTM network to addresses complexity caused by overlapping, which achieves higher accuracy and improves tracking performance in the following steps

Quantification analysis of microtubule in microscopic images | **Github link** — Jan. 2017 – Present

- Collaborated with Delaware Biotechnology Institute and researched contour-based and deep learning based approaches for automated quantification analysis of microtubules in microscopic images
- Developed a pipeline for data collection, which reduced average annotation time from 2 hours to 20 minutes per image, and collected a microtubule dataset with 50 high-resolution microscopic images
- Proposed a neural network for binary segmentation on filamentous structures, which increased 33% accuracy compared to the contour-based method, and 2% accuracy compared U-net
- Designed an orientation aware neural network with a terminus pairing algorithm to segment filaments at the instance level, which increased 39% accuracy and reduced average running time from 1 hour to 5 minutes per image compared to the existing approaches

Quantification analysis of actin filaments in microscopic images | **Github link** — Jan. 2017 – Present

- Collaborated with Delaware Biotechnology Institute and collected a actin dataset for deep learning based research
- Developed a keypoint detection neural network and a fast-marching algorithm to extract fragments in actin filaments network, which reduced average analyzing time from 1 hour to 2 minute and enabled biologists to perform on time-series data
- Performed quantification analysis on segmented actins and clustered actins with a probabilistic framework, which facilitated us to generate a more realistic synthetic dataset

Tracking Movement of Stromules — Sept. 2019 – Dec. 2019

- Adopted U-Net to segment microtubules and stromules in time-series microscopic images
- Applied active contour to track the deformation and movement of each segmented stronmule, and successfully captured the interactions between stromules and microtubules, which was done manually before
- Clustered stromules with a probabilistic framework, and obtained other metrics such as curvatures, length, and movement

Tracking Spherical Objects' Response to Water Waves in Flumes | **Github link** May 2018 – Dec. 2018

- Collaborated with Ocean Engineering Lab at the University of Delaware and developed methods for automated quantification analysis of munition mobility experiments in a wave flume based on videos of a bird view camera
- Applied threshold-based methods and morphological operations to detect multiple spherical objects and adopted Kalman-filter to track the objects and successfully obtained their trajectories when objects are occluded

Publications

- **Yi Liu**, Alexander Nedo, Kody Seward, Jeffrey Caplan, Chandra Kambhamettu, *Quantifying Actin Filaments in Microscopic Images using Keypoint Detection Techniques and A Fast Marching Algorithm, ICIP, 2020.* Paper link
- **Yi Liu**, Abhishek Kolagunda, Wayne Treible, Alex Nedo, Jeffrey Caplan, Chandra Kambhamettu, *Intersection To Overpass: Instance Segmentation on Filamentous Structures with An Orientation-Aware Neural Network and Terminus Pairing Algorithm*, CVPR Bioimaging Workshop, 2019. Paper link
- W. Treible*, P. Saponaro*, **Y. Liu**, A. Das Gupta, V. Veerendraveer, S. Sorensen, C. Kambhamettu., *CATS 2: Color And Thermal Stereo Scenes with Semantic Labels. Vision for All Seasons: Bad Weather and Nighttime (CVPRW)*, 2019. Paper link
- **Liu, Y.**, Treible, W., Kolagunda, A., Nedo, A., Saponaro, P., Caplan, J. and Kambhamettu, C., *Densely Connected Stacked U-Network for Filament Segmentation in Microscopy Images*, ECCV Workshops, 2018. Paper link

Papers Under Review

- **Yi Liu**, Jeffrey Caplan, Chandra Kambhamettu, *Extracting and clustering of Actin Segments in time-series microscopic images, to be submitted to ICIP 2021.*
- **Yi Liu**, Alexander Nedo, Jeffrey Caplan, Chandra Kambhamettu, *Quantification of filamentous structures in microscopic images, to be submitted to PAMI*
- **Yi Liu**, Alexander Nedo, Lauren Olson, Jeffrey Caplan, Chandra Kambhamettu, *Instance segmentation on thin and elongated objects with LSTM network, to be submitted to ICCV 2021.*
- Wayne Treible, Alexander Nedo, Kody Seward, **Yi Liu**, Jeffrey Caplan, Chandra Kambhamettu, *Automatic Classification and Quantification of Stromule Dynamics from Microscopy Images, to be submitted*

Conference Talks/Presentations

- **Yi Liu**, Alexander Nedo, Kody Seward, Jeffrey Caplan, Chandra Kambhamettu, *Quantifying Actin Filaments in Microscopic Images using Keypoint Detection Techniques and A Fast Marching Algorithm, ICIP, 2020.* Dubai, United Arab Emirates Video link
- **Yi Liu**, Abhishek Kolagunda, Wayne Treible, Alex Nedo, Jeffrey Caplan, Chandra Kambhamettu, *Intersection To Overpass: Instance Segmentation on Filamentous Structures with An Orientation-Aware Neural Network and Terminus Pairing Algorithm*, CVPR Bioimaging Workshop, 2019. Long Beach, CA, USA
- **Liu, Y.**, Treible, W., Kolagunda, A., Nedo, A., Saponaro, P., Caplan, J. and Kambhamettu, C., *Densely Connected Stacked U-Network for Filament Segmentation in Microscopy Images*, ECCV Workshops, 2018. Munich, Germany

Industry Experience

Computer Vision Research Intern May 2019 – Sept. 2019
Malong Technologies Shenzhen, China

- Explored methods to detect cloth fibers in microscopic images and observed that existing anchor-based object detection frameworks, such as Faster-RCNN, are not suitable for this task after experiments
- Reconstructed the problem by modeling fibers as sequences of points; implemented methods to convert COCO format binary mask to sequence data and avoided extra expenses on annotation
- Proposed a neural network based on human pose estimation methods to predict the skeleton of fibers, which addresses the heavily overlapping issue and outperformed other existing object detection frameworks for this task

Technical Skills

- **Languages**: Python, Matlab, Java, C++, SQL
- **Frameworks**: Pytorch, Keras, Tensorflow
- **Tools and MISC**: NumPy, OpenCV, OpenGL, MySQL Cplex; Linux, Git, Latex