Nicolas Shu

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Education

Georgia Tech
PhD Machine Learning, 2023 3.7/4.0
MS Electrical Eng., 2021 3.7/4.0
MS Computer Sci., 2021 3.7/4.0
Specialization: Machine Learning

Boston University
MS Biomed. Eng., 2017 3.9/4.0
Late Entry Accelerated Program
Specialization: Robotics

Binghamton University
BS Biochemistry, 2015 3.6/4.0

Skills

- Tensorflow
- PyTorch
- Python
- Linux
- D3.js
- Javascript
- Matlab
- OpenCV
- Scipy / Sklearn
- Pandas
- Docker
- SLURM / PBS
- Inkscape
- C++
- Array Signal Processing

Audio / Speech Processing

AUDIOSOCKETS
- Created a Python package with socket programming which would allow one to break from the synchronous behavior of Python, and allow one to do real-time audio processing via distributed computing with low latency
- Software was used in 30+ embedded devices for real-time processing and storage of data under a built environment

SHORT-TIME SPEAKER IDENTIFIER
- Created a speaker identification system which achieved over 87% accuracy over 1148 speaker classes under a two-second window

FEW-SHOT (FS) AND ZERO-SHOT SPEAKER IDENTIFIER
- Hybridized an x-vector system with prototypical networks to identify speakers, reaching accuracies up to 87%
- Coupled FS system with detection theory to detect new speakers within only 2.5 seconds, reaching F1 scores up to 0.92
- Created system to simultaneously detect new speakers and identify registered speakers in real-time via zero-shot learning

SPEECH/NOISE/MUSIC CLASSIFIER
- Created a speech/noise/music classifier which achieved over 96% macro F1 score in 0.5s, 1s, 2s windows of audio using a Bahdanau attention layer

3D AUDIO DIRECTION OF ARRIVAL WITH MICROPHONE ARRAY
- Expanded array signal processing techniques to create a 3D direction of arrival framework for audio signals
- Implemented MUSIC and SRP-PHAT algorithms in two dimensions
- Created a 3D visualizer to analyze a 2D signal which evolves in time, using D3.js

Controls

MAXIMUM COVERAGE CONTROL OF OMNIDIRECTIONAL SENSORS OVER NON-SIMPLY CONNECTED ENVIRONMENTS
- Created a new framework to perform max. cov. control in a swarm of directional and omnidirectional agents
- Designed control barrier functions and improved on Lloyd's algorithm to allow swarm to maximize coverage in non-simply connected environments
- Ran Monte-Carlo simulations to estimate the optimal number of devices in a built environment before reaching diminishing returns

AUTOMATED SEMI-GUIDED MAZE PATH PLANNING WITH TURTLEBOTS
- Run Turtlebot simulations on Gazebo
- Image classification using KNN and implement a PID controller in order to find the goal of a maze

Q-LEARNING ALGORITHM FOR PATH PLANNING
- Followed dynamic programming to implement a Q-learning algorithm to find the shortest path
- Use Q-learning to perform path planning on a probabilistic field where the goal dynamically changed

ONLINE LEARNING CLASSIFICATION OF LIDAR OBSERVATIONS FOR AN ENVIRONMENT
- Implemented Bayesian linear regression, perceptrons, and SVMs to classify environments based on LIDAR data

Classic ML

FACE DETECTION WITH DALAL-TRIGGS ALGORITHM

USING LEVEL SETS TO DEVELOP ACTIVE SHAPE MODELS OF IMAGES

IMAGE SEGMENTATION WITH GAUSSIAN MIXTURE MODELS AND KNN

ADVERSARIAL SEARCH ON A QUEENS ISOLATION GAME WITH MINIMAX AND ALPHA-BETA PRUNING

ASL INTERPRETATION WITH DYNAMIC TIME WARPING ALGORITHMS AND HMMS

Other Topics of Proficiency

- Few-shot Learning
- Statistical Signal Processing
- Array Signal Processing
- Networked Control
- Probabilistic Graphical Models
- Classical Computer Vision
- Photography
- Transformers
- Attention Networks
- Speech Processing
- Kalman Filters

Relevant Research & Work

ESP LAB, GEORGIA INSTITUTE OF TECHNOLOGY

Graduate Research Assistant — Sep 2020-Present

- Created a speech/noise/music classifier with an attention layer with accuracy of above 96%, while maintaining a low footprint of 335MB in memory, making it suitable for embedded systems
- Expanded the MUSIC and SRP-PHAT algorithms to 2D to determine direction of arrival of signals arriving at simulated microphone arrays
- Wrote a GUI to process LIDAR data to map the interior of a home, using D3.js
- Created method to hybridize few-shot learning with probabilistic models in detection theory to detect appearance of new classes within 2.5 seconds, obtaining F1 scores up to 0.92
- Created method to convert few-shot algorithm to zero-shot learning, allowing speaker identifier to detect new speakers, auto-enroll speakers, and identify speakers with adaptive statistics in a coupled online algorithm. This is capable of working on 2.5s of audio of never-seen before speakers.
- Developed a networking framework for Python communication of different computers via a local area network
- Setup a networked platform between multiple RPis and a server to run auto-enrollment and speaker identification in real-time, storing de-identified speaker information in a time-series database InfluxDB
- Created a front-end dashboard using React.js to show real-time digestible information from InfluxDB

CLIFFORD LAB, EMORY UNIVERSITY SCHOOL OF MEDICINE, ATLANTA GA

Graduate Research Assistant — May 2018-April 2022

- Reviewed dozens of biomedical signal processing submissions to the conference Computing in Cardiology from 2019 to 2022
- Cooperatively organized and performed an installation of 35+ RPis across a built environment for the monitoring of people with mild-cognitive impairment, including cameras, microphones, and temp/humidity/light sensors, working with electricians to install the devices
- Collaborated with cross-functional teams consisting up to 31 people from different labs, schools, and departments
- Operated on several PHI datasets with HIPAA regulations, and handlabeled PHI datasets in audio, video and text domains
- Developed a calibration method and calibrated 140 microphones in 35 microphone arrays to be used in a built environment
- Setup initial time-series database InfluxDB to log data collected from various devices in a built environment
- Implemented a speech recognition system that would be vocally activated by a keyphrase trained on a particular individual

IROBOT, BEDFORD MA

Machine Learning Intern — May 2019-Aug 2019

- Developed computer vision algorithms to assist robots to achieve improved docking
- Utilized green screens to create augmented datasets of different docking stations
- Won 1st place intern competition for creating novel robot to bring to market

NATIONAL EMERGING INFECTIOUS DISEASES LABORATORIES, BOSTON MA

Graduate Research Assistant — May 2016-July 2017

- Developed fluoroscopic screening assays in synthetic biology for directed evolution experiments for the development of enzyme-based biosensors targetting nicotine
- Perform multiple microarray assays to optimize hydrogen peroxide detection in cell-free assays
- Expressed and purified enzymes for enzymatic assays using various methods including Fast Protein Liquid Chromatography
- Proposed new pathway for the prokaryotic transcription factor lysR via ChIP-Seq

Teach

GEORGIA TECH: Instructor of Record

- GTA Preparation

CERTIFICATIONS

1) Center for the Integration of Research, Teaching and Learning - Associate Level

2) QPR Gatekeeper Certificate

GEORGIA TECH: Teaching Assistant

- Artificial Intelligence (Sum2022, F2022, Spr2022, F2023, Spr2024)
- Advanced Digital Signal Processing (Sum2023)
- Introduction to Signal Processing (F2017, Spr2018)

BOSTON UNIVERSITY: Teaching Assistant

- Quantitative Analytical Chemistry (Sum. 2016)
- Organic Chemistry II (Sum. 2016)

Papers

1. **N. Shu**, D. Anderson, "Coupled Auto-Enrollment and Speaker Identification Platform in Real-Time" (Under preparation)
2. **N. Shu**, D. Caulley, D. Anderson, "A Complete Derivation of the Probabilistic Linear Discriminant Analysis" (Under preparation)
3. Y. Wang, **N. Shu**, D. Anderson, "HAPPi: A Hybrid Attentional Prototypical Networks Framework with Pi-Model for Few-Shot Sound Classification" Knowledge-Based Systems (Under Review)
4. **N. Shu**, Y. Wang, D. Caulley, D. Anderson, "SlimNet: A Lightweight Attentive Network for Speech-Music-Noise Classification and Voice Activity Detection" IEEE Edge 2024 (Under Review)
5. **N. Shu**, D. Anderson, "Audiosockets: A Python socket package for Real-Time Audio Processing" arXiv
6. G. Clifford, J. Zelko, **N. Shu**, P. Suresha, A. Cakmak "System and Methods for tracking behavior and detecting abnormalities" US Patent App. 17/430, 414, 2022
7. C. Feustel, **N. Shu**, G. Clifford, D. Anderson, C. Zimring "Practical High-Fidelity Sensing of the Sleep Environment in the Home" Proc. PErvasive Technologies Related to Assistive Environments, 2022
8. S. Hanz, **N. Shu**, J. Qian, N. Christman, P. Kranz, M. An, C. Grewer, W. Qiang "Protonation-Driven Membrane Insertion of a pH-Low Insertion Peptide", Angew Chem Int Ed Engl. 2016, 55 (40):12376-81 DOI:10.1002/anie.201605203.
9. **N. Shu**, M. Chung, L. Yao, M. An, and W. Qiang "Residue-specific structures and membrane locations of the pH-Low insertion peptides by solid-state nuclear magnetic resonance", Nature Communications, 2015, 6 (7787) DOI: 10.1038/ncomms8787
10. W. Qiang, R. Akinlolu, M. Nam, and **N. Shu** "Structural Evolution and Membrane Interaction of the 40-Residue \beta-Amyloid Peptides: Differences in the Initial Proximity between Peptides and the Membrane Bilayer Studied by Solid-State Nuclear Magnetic Resonance Spectroscopy" Biochemistry, 2014, 53 (48), pp 7503-7514 DOI: 10.1021/bi/501003n