Harry Freeman

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EDUCATION

Carnegie Mellon University, **School of Computer Science**, Pittsburgh, PA — Current
PhD in Robotics — GPA: 4.23

Carnegie Mellon University, **School of Computer Science**, Pittsburgh, PA — Awarded August 2023
Master of Science in Robotics — GPA: 4.23

Cornell University, **College of Engineering**, Ithaca, NY — Awarded May 2017
Bachelor of Science in Electrical and Computer Engineering — GPA: 3.73

PUBLICATIONS

Under Review

- **Autonomous Apple Fruitlet Sizing and Growth Rate Tracking using Computer Vision**
  Harry Freeman, Mohamad Qadri, Abhisesh Silwal, Paul O'Connor, Zachary Rubinstein, Daniel Cooley, George Kantor
  Submitted to IEEE Transactions on Robotics (T-RO)
  [Preprint][Video]

- **Autonomous Apple Fruitlet Sizing with Next Best View Planning**
  Harry Freeman, George Kantor
  Accepted to IEEE International Conference on Robotics and Automation (ICRA), 2024
  [Preprint][Video]

Peer-Reviewed Conferences

- **3D Reconstruction-Based Seed Counting of Sorghum Panicles for Agricultural Inspection**
  Harry Freeman, Eric Schneider, Chung Hee Kim, Moonyoung Lee, George Kantor
  IEEE International Conference on Robotics and Automation (ICRA), 2023
  [PDF][Video]

- **3D Human Reconstruction in the Wild with Collaborative Aerial Cameras**
  Cherie Ho, Andrew Jong, **Harry Freeman**, Rohan Rao, Rogerio Bonatti, Sebastian Scherer
  International Conference of Intelligent Robots and Systems (IROS), 2021
  [PDF][Video]

Workshops

- **Towards Autonomous Apple Fruitlet Sizing with Next Best View Planning**
  Harry Freeman, George Kantor
  AI for Agriculture and Food Systems (AIAFS), 2023
  [PDF]

- **Toward Semantic Scene Understanding for Fine-Grained 3D Modeling of Plants**
  Mohamad Qadri, **Harry Freeman**, Franz Eric Schneider, George Kantor
  AI for Agriculture and Food Systems (AIAFS), 2022
  [PDF][Video]

Thesis

- **Computer Vision-Based Phenotyping in Agriculture: Leveraging Semantic Information for Non-Destructive Small Crop Analysis**
  Harry Freeman
  Master's Thesis, 2023
  [PDF]

RESEARCH EXPERIENCE

Kantor Lab - Carnegie Mellon University, Pittsburgh, PA   August 2021 – Present
Research in computer vision, 3D reconstruction, and next-best-view planning for phenotyping small crops in agriculture
- Developed a method to create high-quality 3D models of sorghum panicles to non-destructively estimate seed counts. Used seeds as semantic 3D landmarks in global registration to improve reconstruction. Presented a novel metric for assessing point cloud reconstruction quality in the absence of ground truth. Paper accepted to ICRA 2023.
- Created a computer vision-based approach to size and track growth rates of apple fruitlets using single stereo-image pairs collected by a hand-held camera. Used a hybrid of classical and deep learning-based methods to detect, segment, cluster, size, and temporally associate the fruitlets. The full end-to-end pipeline was able to predict abscise rates within 3.5% of ground truth. Paper in submission at IEEE T-RO.
- Developed a novel next-best-view planning approach to enable a 7 DoF robotic arm to autonomously capture images of apple fruitlets. Utilized a coarse and fine dual-map representation along with an attention-guided information gain formulation to determine the next best camera pose. Presented a robust estimation and graph clustering approach to associate fruit detections across images in the presence of wind and sensor error. Paper in accepted to ICRA 2024.

AirLab - Carnegie Mellon University, Pittsburgh, PA   August 2020 – July 2021
Research in multi-drone collaboration for 3D human reconstruction
- Was primary contributor to the 3D reconstruction pipeline for research on 3D human reconstruction with collaborative aerial cameras. Investigated the performance of deep pose estimation networks and multi-view reconstruction algorithms on real and simulated data. Modified AirSim and Unreal Engine source code to extracted simulated ground truth skeletal mesh and bone positions of actor. Integrated and tested OpenVINO with ROS for real-time person detection to run on Intel NUC. Paper accepted to IROS 2021.

Technology for Avian Birds and Environmental Research - Cornell University, Ithaca, NY   August 2016 – May 2017
Research in developing small, light-weight, and energy efficient transponding tags to study the migration patterns of birds
- Investigated the performance of different data modulation schemes, including FSK, ASK, and QAM, and evaluated their performance with regard to power, signal integrity, and data loss. Improved average power consumption by enabling low-power mode configuration on the microcontroller. Results of work deployed to study flight patterns of barn swallows migrating from California to Argentina.

RELEVANT GRADUATE COURSEWORK

Deep Learning for Robotics	Learning for 3D Vision	Computer Vision
Introduction to Robot Learning	Learning-based Image Synthesis	Graduate Artificial Intelligence

RELEVANT ONLINE COURSEWORK

Reinforcement Learning (U)	Artificial Intelligence for Robotics (U)	Deep Learning Specialization (C)
U – courses taken through Udacity	C – courses taken through Coursera	

WORK EXPERIENCE

Amazon AWS AI Devices, Palo Alto, CA   August 2020 – August 2021
Senior Software Development Engineer
- Senior embedded software engineer for AWS Panorama – a machine learning appliance that allows IP cameras to run computer vision and deep learning applications at the edge.
- Developed multi-threaded and multi-process application-level software that ran on the device. Supported the full application lifecycle from OTA to deployment to inference which allowed customers to run custom applications.
- Led the design and development of the entitlement and encryption service, a service which utilizes MQTT to communicate with the cloud and securely manages the IP of 1P and 3P applications.
- Contributed to the development of the data source service to allow customers to stream data from RTSP cameras and video files in real time.

Eversight, Palo Alto, CA July 2019 – August 2020
Software Engineer
- Improved price recommendation system speed by 80% by re-designing backend container-driven system architecture using Kubernetes and Google Cloud Platform. The system could effectively scale and process resource heavy tasks, including processing millions of transaction records daily and optimizing in-store prices using customer data.
- Led the architecture design that loaded customer data into our system using a scalable event driven architecture and Apache Beam, reducing the time of the overall process by 50%.

Edelman Financial Engines, Sunnyvale, CA April 2018 – July 2019
Senior Software Engineer
- Developed an online financial planning tool to provide a new medium for financial advisors to offer financial advice.
- Led the design of a microservice to automated the migration of customer data from a competitor's platform to ours.
- Led the design of a report generation service to aggregate customer information and present likelihood of retirement goal success.

Macdonald, Dettwiler, and Associates, Vancouver, BC August 2017 – March 2018
Embedded Software Engineer
- Acted as part of a small research and development team whose goal was to determine the feasibility and performance of implementing SAR image processing algorithms on FPGAs for real-time sea vessel detection and classification.
- Improved classification and detection speed by three orders of magnitude by successfully constructing embedded RTL designs in C and VHDL to implement SAR signal processing algorithms.
- Evaluated performance of system with regard to memory, time, and quantization constraints.

SKILLS

Programming Languages	C++, C, Python, Matlab, Java, VHDL, SQL
Robotics	ROS, Gazebo, MoveIt, AirSim
Software	Docker, Cloud Computing, Multi-threaded and Multi-process systems
Computer Vision	3D Reconstruction, NeRF, Image Processing, Deep Learning, Pytorch, OpenCV
Reinforcement Learning	Isaac Gym, skrl, Stable-Baselines3, OpenAI gym, imitation
Hardware	Oscilloscope, Spectrum Analyzer, Logic Analyzer, Microcontrollers

PROJECTS

Graduate
- Investigated deep reinforcement learning methods to learn a unified policy that controls a quadruped mounted with a camera on a mobile arm with the task of tracking a moving target. The hypothesis is that this configuration enables the robot to explore more complex terrains when compared to using a fixed egocentric camera. Agent is trained using PPO in an Isaac Gym simulated environment.
  [Project Writeup] [Code Repo]

- Applied deep reinforcement learning techniques towards informative path planning for drone mapping. Agent learns an optimal policy to intelligently explore an unknown map and visit areas of high interest. Experimented with both on-policy and off-policy approaches in addition to model-based and model-free algorithms.
  [Project Writeup] [Code Repo]

- Utilized NeuS to create accurate, watertight meshes of plants from sparse 2D images. Models were made generalizable by incorporating Reptil meta-learning into training. Results demonstrate that meta-learning improves reconstructions with fewer training iterations, and our approach is able to generate realistic meshes and novel view syntheses with sparser 2D images compared to naïve approaches.
  [Project Writeup] [Data Repo] [Code Repo]

- Utilized Generative-Adversarial Networks for coarse style and scene data augmentation. Method was based off Swapping AutoEncoders. Results successfully demonstrated that swapping latent style codes is effective approach for data augmentation to allow models to better generalize and not overfit the training data.
  [Project Webpage] [Code Repo]

Undergraduate
- Built an iOS controlled massage vest that allows the user to create a custom massage by controlling the pattern, region, and intensity over Bluetooth. Designed both the hardware-control system and multi-threaded software. Published article in *Circuit Cellar* Issue 330. Massage Vest Uses PIC32 – Controlled with an iOS App. [Project Webpage]
- Built a competition-winning Arduino-based autonomous robot that could self-navigate and map a maze to be displayed on a remote video-base station. Achieved the lowest average navigation time with no obstacle collision.

Personal
- Built a real-time face detection system in Cython and C using a variation of Histogram of Oriented Gradients. SVM was trained using LFW dataset, and overlapping bounding boxes are reduced using non-maximum suppression. [Project Webpage] [GitHub Repo]
- Built scale and rotation invariant keypoint descriptor in Matlab based of Lowe's SIFT algorithm. Dictionary was built using Home Objects Dataset. [GitHub Repo]
- Built a voice-recorder using PIC32 that could record and play back audio with adjustable sampling rate. Utilized internal ADC, DMA, PWM and flash storage with external microphone and amplifier. [GitHub Repo]
- Built a quaternion and complementary-filter based system to accurately track orientation of an MPU9255 IMU which was used to control a mouse. Orientation was implemented from scratch without use of a Digital Motion Processor. [GitHub Repo]
- Designed a system to control television over Bluetooth from phone using ATMega2560 microcontroller. [GitHub Repo]

SERVICE

- Reviewer for International Conference on Robotics and Automation (ICRA), International Conference on Intelligent Robot and Systems (IROS), Robotics and Automation Letter (RA-L)
- CMU Graduate Application Support Program Mentor

TALKS

- Computer Vision-Based Phenotyping in Agriculture: Leveraging Semantic Information for Non-Destructive Small Crop Analysis – Master's Thesis, August 2023
- Towards Autonomous Apple Fruitlet Sizing with Next-Best-View Planning – AI for Agriculture and Food Systems, February 2023

OTHER ACTIVITIES

Cornell Varsity Squash Team   August 2013 – May 2017
- Competed on the Cornell Varsity Squash Team. Trained, travelled, and competed six days a week.
- Captained the team my Senior year. Led and managed the team alongside the coach.
- Played at the number one position Junior and Senior years.
- CSA Scholar Athlete Junior and Senior years.
- Three-time recipient of team sportsmanship award.
- Two-time recipient of team most improved award.