Keith Carolus

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Accomplished and innovative full stack machine learning engineer offering a rare mix of expertise in deep/machine learning, computer vision, and software and computer engineering attained through significant and highly-complex project work in both industry and rigorous academic research environments.

EXPERIENCE

Staff Applied Machine Learning Engineer, EliteHRV/Spren Aug 2022 – present
Applied Machine Learning Engineer, EliteHRV/Spren Aug 2021 – Aug 2022

EliteHRV is transitioning from the leading heart rate variability (HRV) app with the CorSense sensor to now raising >$10M in seed funding to develop Spren: heart and respiration rate mobile computer vision SDKs and a B2B personalized wellness insights API.

- Integrate University of Alabama/MADE body composition computer vision algorithm, validating independently with 127 images from the team, ground truth DEXA scans, and varying lighting conditions on 3D models in Blender.
- Launched Athena data warehouse to power R&D as infrastructure as code (TypeScript AWS CDK app) combining production MySQL database replica via JDBC and unstructured JSON metadata in S3. Additional overnight Apache Parquet (column-oriented file) optimizations increase query speed by ~10x.
- Parallelized finger-on-lens HRV algorithm video benchmarking pipeline reducing time to run 400 videos from 6.5 hours to 30 minutes (92% speedup). Further launch 100 parallel runs to benchmark ~5000 videos in 15-20 minutes.
- Designed and implemented iOS SDK, Spren Vision, for finger-on-camera HR/HRV. Launched demo app (unlisted) written in SwiftUI with MVVM and atomic design.
    - Optimized real-time feature extraction from video by 56x with Metal.
    - Create turn-key customer integration as open-source UI library.
- Designed the Spren API which is RESTful, partially async, and serverless. Pioneered productionalizing R&D Python algorithms as container images for Lambda functions to deploy models/algorithms for stress, activity guidance, etc. quickly, enabling interoperability with engineering's legacy Javascript codebase.

Research Software Engineer, ACV Labs Oct 2018 – Aug 2021

ACV Labs is the R&D division of ACV Auctions, Buffalo's first tech unicorn that provides a dealer-only auction platform that sells inspected cars in 20 minute auctions. The company raised $100M series D and $150M series E rounds and recently IPOed.

- With the world's largest engine audio dataset from the ACV AMP™ app (>1.3M samples), developed deep learning models to detect anomalous engine activity, increasing accuracy of anomaly detection from ~60% to 92% with domain expert data QC, data annotation via custom Mechanical Turk tasks, and feature and hyperparameter tuning.
- Created the Virtual Lift™ iOS app, a flagship technology that lets users drive over an iPhone + hardware unit to scan a vehicle undercarriage, used to inspect thousands of cars daily. Built with a phase-correlation-based image stitching algorithm processing 1-2k 1080p video frames per image in ~20ms/frame. The product earned two patents (one as lead inventor, both pending) and saves ACV >$1.6M/year in estimated arbitration costs related to undisclosed undercarriage issues.
- Created novel algorithms for:
    - Vehicle drive over detection with the iPhone magnetometer.
    - Automatic crop to hardware unit mirror with a moving average and line detection approach.

    - Glare removal from images via high pass filtering.
    - Locating and smoothing lines from camera exposure changes with peak detection and a custom smoothing/interpolation method.
    - Mirror streak removal with thresholding, line detection, and averaging.
- Created first ever 3D Virtual Lift™ image with iPhone TrueDepth pointcloud data (structured infrared).

Research Assistant, Buffalo Neuroimaging Analysis Center Feb 2015 – present

BNAC is a private research organization affiliated with the University at Buffalo that conducts MS research via MRI.
Hired to a connectomics research team and later worked on innovative work in disconnectomics, which led to collaboration with Cornell professor Dr. Amy Kuceyeski. Served in full-time and part-time/consultant capacities according to need.

- Developed DeepGRAI, a 3D UNet based deep learning model and 3D image augmentation technique suite for thalamus segmentation from MRI that achieved state-of-the-art results on novel multiscanner BNAC dataset. The project led to co-authoring a platform presentation delivered by the project's principal investigator at the American Academy of Neurology conference.
- Built highly-complex automated MRI processing pipelines to overlay MS damage on a normal connectome database to measure tract disconnection. Applied to five-year study data to establish relationship between new tract disconnection and atrophy to connected regions longitudinally. Further applied to ten-year serial annual clinical trial MRI and conducted a time-series analysis to understand the timeline of this localized neurodegeneration in MS.
- Won three grants totalling ~$10K, including one grant from Nvidia.

Deep Learning Intern, NASA June 2018 – Aug 2018

- Developed dataset and proof-of-concept deep learning models for object detection and keypoint estimation (adapted DenseNet, YOLOv3) for autonomous docking with the International Docking Standard from Canadarm optical imagery on the International Space Station with the goal of replacing heavy RADAR and LIDAR sensors with cameras.
- Created a highly configurable and easily deployable ITAR-restricted imagery dataset annotation tool for internal use at NASA incorporating NGINX, SSL, Flask, MongoDB, React, and Leaflet.js.

Deep Learning Intern, Air Force Research Laboratory June 2017 – June 2018

- Achieved 99.3% accuracy on an eight-class problem classifying vehicles in the MSTAR synthetic aperture radar imagery dataset with fine tuned SGD-based optimization.
- Implemented white box and black box adversarial example generation algorithms (FGSM, ILLC, DeepFool, and others) to benchmark model robustness and retrain with augmented data.

EDUCATION

BS Computer Engineering, University at Buffalo (2018) GPA: 3.7

- Selected as Honors College student graduation speaker (video)
- TA for Intro to Computer Science I & II, Computer Organization, and Microprocessors.
- Created hardware simulator for custom RISC ISAs used by Compilers students that won Best Hardware Hack at UB Hacking Hacknight Finale 2018.
- Won Piazza Award in CSE474: Machine Learning for answering 164 ML questions on Piazza.
- Developed robust handheld flight data recorder (black box) data acquisition device. Based on embedded debian and the PINE64 embedded development board. Reverse engineered Honeywell proprietary RS-422 handshaking signals and wrote Linux IO wrapper framework and minimal touchscreen UI for CSE453: Hardware/Software Integration with KGB Aviation.

- Inspired by ENIAC, developed 16-bit ISA in VHDL, switch programmable with 16 switches and LEDs, and executable on Basys 3 Artix-7 FPGA for CSE 490: Computer Architecture.

PATENTS

- U.S. Patent 16/749,585: “Vehicle Audio Capture and Diagnostics”, Jan 22, 2019
- Lead inventor U.S. Patent 16/373,393: “Undercarriage Imaging System” (software component), Apr 2, 2019
- U.S. Patent 16/373,405: “Undercarriage Imaging System” (hardware component), Apr 2, 2019

SELECT PUBLICATIONS

- Keith Carolus, et al. Time Course of Lesion-Induced Atrophy in MS. Journal of Neurology. April 2022. (link)
- Michael G. Dwyer, Keith Carolus, et al. Deep Learning Enables Thalamic Atrophy Measurement on Clinical Quality T2 FLAIR Images. American Academy of Neurology (AAN), Philadelphia, PA; May 4-10, 2019. (link)
- Keith Carolus, et al. Accelerated subcortical atrophy following new lesion accrual in directly connected tracts is significant and appears limited to the first year. American Academy of Neurology (AAN), Los Angeles, CA; April 21-27, 2018. (link)
- Tom Fuchs, Keith Carolus, et al. Impact of Focal White Matter Damage on Localized Subcortical Gray Matter Atrophy in Multiple Sclerosis: A 5-Year Study. American Journal of Neuroradiology. August 2018. (link)
- Full list at Google Scholar