SAMUEL M. BATEMAN

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AWARDS

Awarded **NSF 2024 CISE (CSGrad4US) Graduate Fellowship** ($159,000 support over 3 years, identical support to NSF GRFP)

EDUCATION

University of Colorado - Boulder *May 2020*
B.S. in Computer Science
B.S. in Applied Mathematics
Overall GPA: 3.669

PUBLICATIONS

Y. Yang, X. Zhao, H. Zhao, S. Yuan, **S. Bateman**, T. Huang, W. Maddern, Undisclosed ICRA 2025 Submission, *In Submission.*

S. Bateman, N. Xu, H. Zhao, Y. Ben Shalom, V. Gong, G. Long, and W. Maddern, Exploring Real World Map Change Generalization of Prior-Informed HD Map Prediction Models, *2024 IEEE/CVF Conference on Computer Vision and Pattern Recognition (CVPR), Workshop on Autonomous Driving (WAD).*

- Investigated how prior-informed HD-Map prediction models trained on synthetically perturbed map priors generalize to a large scale, real-world map change dataset consisting of multiple years of autonomous driving data through a large scale study of different perturbation types and noise levels.
- Identified a substantial sim2real gap in the existing literature between synthetic map prior perturbation and sim2real transfer to real world map changes.

S. Bateman, K. Harlow and C. Heckman, Better Together: Online Probabilistic Clique Change Detection in 3D Landmark-Based Maps, *2020 IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS).*

- Developed a novel Bayesian feature persistence filter for robustly updating landmark based navigation maps and rejecting poor landmarks during robot operation to enable lifelong, continuous robot deployment and a true semantic, dynamic, probabilistic SLAM algorithm.
- The feature persistence filter leveraged semantic information to reason about the joint likelihood of feature persistence based on their grouped semantic relationship.
- Developed a 3D sensor simulation to compare performance of the Joint Clique Filter against previously developed persistence filters.

T. Teil. **S. Bateman** and H. Schaub, Autonomous On-Orbit Optical Navigation Techniques for Robust Pose-Estimation, *AAS Guidance, Navigation and Control Conference 2020.*

- Developed a novel hybrid learned/classical orbit estimator for the classically challenging on-orbit visual orbit determination task.
- The proposed estimator had $> 50\%$ reduced orbit position and velocity RMSE compared to prior art and was trained using synthetic data generated from high fidelity simulations.

- In addition, we developed new data augmentation techniques specific to the unique characteristics of deep learning for spacecraft optical navigation and spacecraft imagery.

T. Teil, **S. Bateman** and H. Schaub, Closed-Loop Software Architecture for Spacecraft Optical Navigation and Control Development, *AAS The Journal of Astronautical Sciences 2020.*

- Developed a realtime spacecraft camera simulator integrated with the high-fidelity Basilisk Astrodynamics Framework, allowing for hardware in the loop simulation of spacecraft algorithms incorporating visual data.

- Opened the door to further exploration of on-orbit navigation and other vision based algorithms.

PROFESSIONAL EXPERIENCE

Semantic Mapping and Perception - Autonomy - Nuro   May 2024 - Current
Senior Machine Learning Engineer - R&D Focus   *Mountain View, CA*

· Single handedly developed, trained, and deployed a full online detection and tracking pipeline end to end running on vehicle including the following: 3D object detector, 3D object tracker, detection taxonomy definitions, model dataset mining, model optimization, and model tuning for deployment.
· Research Projects:

Evaluating State of the Art Camera Encoders for Self Driving and proposing novel new Camera Encoders for Nuro's Unified Perception Model.

Multi task learning and representation learning for the Nuro's Unified Perception Model.

Semantic Mapping - Autonomy - Nuro   Dec 2022 - April 2024
Machine Learning Engineer - R&D Focus   *Mountain View, CA*

· Completed the literature review, design, prototyping, development, and integration of a state of the art online semantic mapping system in an onboard driverless system.
· Developed a petabyte scale label ingestion, data mining, and data dumping pipeline to support training large mapping models.
· Research Projects:

Multi-modal Transformer Based Online Mapping Models

Transformer Based Object Detection Models

Label Relevancy Filtering

Data Mining and Dataset Curriculum for training with severe class imbalance

Semi Supervised Learning Methods for Scaling Mapping Models

Evaluating Prior Based Online Mapping on real world change events

Mapping - Autonomy - Nuro   May 2022 - Nov 2022
Autonomy Software Engineer - R&D Focus   *Mountain View, CA*

· Developed formal processes around triage and long term iterative development of mapping algorithms.
· Further developed novel state estimation techniques for high accuracy offline mapping.
· Research Projects:

Continuous Time State Estimation

IMU Sensor Models for Factor Graphs

Automatic Sensor Noise Covariance Tuning

Mapping - Autonomy - Nuro   June 2020 - April 2022
Autonomy Junior Software Engineer - R&D Focus   *Mountain View, CA*

· Helped develop a high reliability, multi city scale, high precision HD mapping pipeline.
· Research Projects:

    Point Registration Covariance Estimation and Failure Detection

    Integration of Differential GNSS Measurements with Factor Graph Optimization

    Outlier Robust Point Registration and Factor Graph Optimization Methods

    Large scale dataset and evaluation suite for experimenting with scaling SLAM pipelines to city
scale.

Autonomous Robotics and Perception Group - Computer Science - CU Boulder May 2019
- June 2020
Undergraduate Researcher   *Boulder, CO*

· Studied under Professor Christoffer Heckman to develop a novel approach to the dynamic, semantic,
probabilistic SLAM problem for localization and mapping of long-term robotics deployments.
· Developed a novel scene change detection system utilizing a Bayes filter to jointly model the survival
statistics of keypoints existing on an object.
· Developed an object tracker that utilized Mask R-CNN to track static and dynamic objects in a scene
and track the survival statistics of keypoint features observed on those objects.

Autonomous Vehicle Lab - Aerospace Engineering - CU Boulder   Aug 2018 - May 2020
Research Assistant   *Boulder, CO*

· Developed much of the optical sensors and navigation simulation capabilities of the high-fidelity astro-
dynamics framework, Basilisk, as Python extensions written in C++.
· Worked closely with a PhD Student to perform novel research in the field of state estimation in astro-
dynamics using simulated optical sensors.

Massachusetts Institute of Technology - Lincoln Laboratory   May 2019 - Aug 2019
Summer Research Intern   *Boston, MA*

· Performed self-directed research on unsupervised deep learning for semantic segmentation.
· Worked with an interdisciplinary team in the Humanitarian Aid and Disaster Relief Systems group.

Polycom   May 2018 - Aug 2018
Software Engineering Intern   *Westminster, CO*

· Developed a customer facing, large scale web product for device deployment management utilizing Java
for backend APIs and modern Javascript frameworks for the front end.
· Developed a unique, legacy compatible, system design to improve upon an existing system.
· Worked with two other interns and one full time staff to lead a team of international engineers in
building this system.

Office of Information Technology - CU Boulder   Sept 2017 - May 2018
Desktop Support Technician   *Boulder, CO*

· Troubleshooted a variety of software and hardware IT issues for customers. Had exposure to a wide
variety of system types and configurations.

Department of Computer Science - CU Boulder   Sept 2017 - Dec 2017
Computer Systems Course Assistant   *Boulder, CO*

· Held office hours for the Computer Systems course in the Computer Science Department with topics including: Virtual Memory, System Interrupts, Buffer Overflow Attacks, Return-Oriented Programming, Pipelining, Caching, Instruction-Level Parallelism, Assembly Programming, Computer Architecture and more.

RELEVANT PROJECTS

Senior Thesis: An Exploration of Algorithms Enabling Dynamic, Semantic, Probabilistic SLAM
May 2020
Advised by Christoffer Heckman
Boulder, CO

· Developed a robust, real-time multi-object tracking system in C++, leveraging lidar and camera sensor inputs and Mask R-CNN for object detection.
· Said multi-object tracking system was capable of long term, multi-day deployments and would reidentify previously seen objects on a given trajectory.
· Applied this multi-object tracking system to data mine the Oxford Robot Car dataset to estimate feature survival time priors to be consumed by a feature persistence filter.

Chess-Playing Robot Arm
Dec 2018
CAIRO Lab
Boulder, CO

· A Sawyer robot arm was used with a Kinect 2 for pose and board state estimation, and Stockfish as the chess engine behind the moves.
· The system actively iteratively replans with changes in pose estimation and is robust to movement of the board.

Autonomous Sidewalk Robot
Dec 2019
ARPG Lab
Boulder, CO

· A Clearpath Jackel is used with an Nvidia Xavier for perception, 2x frame synced Intel Realsense D435s, and an Intel NUC for control and planning.
· We used Deeplab v3 with a Mobile Net backbone and TensorRT 16bit floating point mode trained on Cityscapes for segmentation.
· For mapping, we used both RGB-D ORB SLAM2 or DSO depending on the sequence.

SERVICE

ICRA 2021, 2022, 2023, 2024, 2025 Reviewer
IROS 2022 Reviewer
Instructor for Nuro ML University Internal Training Program
Organizer of Nuro Mapping Reading Group/Seminar

HONORS

CU Boulder Engineering Merit Scholarship
CU Boulder Engineering Discovery Learning Award for Outstanding Undergrad Research
Deans List

RELEVANT COURSES

Robotics Courses	Computer Vision, Advanced Robotics, Autonomous Vehicle Challenge Seminar, Introduction to Robotics
Applicable CS Courses	Data Structures, Algorithms, Operating Systems, Software Development and Tools, Computational Biology, Programming Languages and Interpreters, Human-Computer Interaction
Applicable Math Courses	Operations Research, Applied Probability, Markov Processes, Numerical Analysis, Discrete Mathematics, Applied Linear Algebra, Multivariable Calculus, Differential Equations, PDEs, Analysis, Multivariate Analysis, Complex Analysis, Mathematics of Cryptosystems, Chaotic Dynamics