Carl Hildebrandt

Ph.D. Candidate, University of Virginia

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I am interested in the intersection of software analysis and autonomous systems. My primary work focuses on the safety of autonomous systems through the validation and verification of their software.

Education

2018 – **University of Virginia**, USA
Ph.D. Computer Science
Advisor: Dr. Sebastian Elbaum
Lab: LESS (less-lab-uva.github.io)

2013 – 2016 **University of Pretoria**, South Africa
B.Eng. in Computer Engineering

Experience

2018 – Research Assistant, LESS Lab, University of Virginia (less-lab-uva.github.io)
2017 – 2018 Research Assistant, Nimbus Lab, University of Nebraska (nimbus.unl.edu)
2016 – 2017 Software Engineer, Cheesecake Trails, South Africa

Honors & Awards

External

2020 **Distinguished Artifact Award**
Feasible and Stressful Trajectory Generation for Mobile Robots (ISSTA)

2018 **Best Paper Award on Safety, Security, and Rescue Robotics**
Fire-Aware Planning of Aerial Trajectories and Ignitions (IROS)

Internal

2021 **Best Poster Design**
The University of Virginia - Computer Science Research Symposium

2020 **Best Presentation**
The University of Virginia - Computer Science Virtual Research Symposium

Publications

2022 **Carl Hildebrandt**, Meriel von Stein, and Sebastian Elbaum, "PhysCov: Physical Test Coverage for Autonomous Vehicles," 2022 **(Under Development)**
Description: Quantifying the coverage of seen behaviors in autonomous vehicles is challenging as the autonomous vehicle's behavior is influenced by its physical environment that is often large and highly complex. This work describes a way to abstract its physical environment and subsequently generate a coverage metric that can be used to determine the extent to which an autonomous vehicle was tested.

2022 **Carl Hildebrandt**, Wen Ying, Seongkook Heo, and Sebastian Elbaum, "Mimicking Real Forces on a UAV Through a Haptic Suit," 2022 **(Under Review)**
Description: Robots operate under a variety of forces that affect their behavior. Validating the system's behavior under the effect of such forces can be difficult and costly. This work introduces a framework to overcome such challenges by mimicking external forces. The framework consists of a suit-like structured set of directional propellers that can be mounted onto a drone, a force simulator that maps user-specified forces to setpoints for the suit directional propellers, and a controller for those propellers.

2022 **Carl Hildebrandt**, Meriel von Stein, Trey Woodlief, and Sebastian Elbaum, "Preparing Software Engineers to Develop Robot Systems," in *2022 IEEE/ACM 44th International Conference on Software Engineering: Software Engineering Education and Training (ICSE-SEET)*, IEEE, 2022 **(To Appear)**
Description: Robotics is a rapidly expanding field that needs software engineers. However, most of our undergraduates are not equipped to manage the unique challenges associated with the development of software for modern robots. This work introduces a course to better prepare students to develop software for robotic systems.

2021 **Carl Hildebrandt**, and Sebastian Elbaum, "World-in-the-Loop Simulation for Autonomous Systems Validation," in *2021 IEEE International Conference on Robotics and Automation (ICRA)*, IEEE, 2021, pp. 10 912–10 919
Description: Simulation can only approximate the real world, leading to a gap between simulation and reality where undesirable system behaviors can go unnoticed. To address that gap, we present a novel approach, world-in-the-loop simulation, which integrates sensing data from simulation and the real world to provide autonomous systems with a mixed-reality.

2020 **Carl Hildebrandt**, Sebastian Elbaum, Nicola Bezzo, and Matthew B Dwyer, "Feasible and stressful trajectory generation for mobile robots," in *Proceedings of the 29th ACM SIGSOFT International Symposium on Software Testing and Analysis*, 2020, pp. 349–362 **(Distinguished Artifact Award)**
Description: Generating stressful yet feasible trajectories for autonomous systems is challenging. This work proposes a framework that 1) integrates kinematic and dynamic physical models and 2) incorporates a parameterizable scoring model to efficiently generate physically valid yet stressful trajectories for a broad range of mobile robots.

2020 **Carl Hildebrandt**, Sebastian Elbaum, and Nicola Bezzo, "Blending kinematic and software models for tighter reachability analysis," in *2020 IEEE/ACM 42nd International Conference on Software Engineering: New Ideas and Emerging Results (ICSE-NIER)*, IEEE, 2020, pp. 33–36
Description: Reachability sets are critical for path planning and navigation of mobile autonomous systems. Traditionally, these sets are computed using system models instantiated with their physical bounds. This work explores the degree to which bounds manifested in the software can affect the computation of reachability sets.

2018 Evan Beachly, Carrick Detweiler, Sebastian Elbaum, Brittany Duncan, **Carl Hildebrandt**, Dirac Twidwell, and Craig Allen, "Fire-aware planning of aerial trajectories and ignitions," in *2018 IEEE/RSJ International Conference on Intelligent Robots and Systems (IROS)*, IEEE, 2018, pp. 685–692 **(Best Paper Award)**
Description: Prescribed fires can lessen wildfire severity and control invasive species. This work introduces an approach that integrates a lightweight fire simulator and a planner for trajectories and ignition sphere drop waypoints to start controlled fires automatically.

Patents

2020 **Carl Hildebrandt**, Jefferson Griscavage, Victor Aquino, Melony Bennis, and Tien Comlekoglu, Vuetech Health Innovations LLC, "Systems and Methods for Safety, Security and Well-Being of Individuals", Patent No. 11282367

Talks

2021 **Carl Hildebrandt** "World-in-the-Loop Simulation for Autonomous Systems Validation", International Conference on Robotics and Automation, May 30th

2020 **Carl Hildebrandt** "Feasible and Stressful Trajectory Generation for Mobile Robots", International Conference on Software Engineering, July 7th

2020 **Carl Hildebrandt** "Blending Kinematic and Software Models for Tighter Reachability Analysis", International Symposium on Software Testing and Analysis, July 21st

Community Service

2022 **Graduate Student Council**, The University of Virginia, Computer Science Department (CSGSG).

2021 **Paper Reviewer**, IEEE International Conference on Robotics and Automation Society (ICRA)

2021 **Student Volunteer**, IEEE/ACM International Conference on Software Engineering (ICSE)

Teaching

2021 Lab Designer and Guest Lecturer, **Robotics for Software Engineers**, The University of Virginia

2020 Lab Designer and Teaching Assistant, **Robotics for Software Engineers**, The University of Virginia

2016 Head Teaching Assistant, **Data Structures and Algorithms in Java**, The University of Pretoria

2015 Head Teaching Assistant, **Program Design in C++**, The University of Pretoria

2015 Teaching Assistant, **Data Structures and Algorithms in Java**, The University of Pretoria

2014 Teaching Assistant, **Introduction to Programming in C**, The University of Pretoria

Skills

Licences: Commercial drone license for small unmanned aircraft systems

Advanced: Python, C++, ROS, Shell Scripting, LaTeX, Quadrotors, Ubuntu, Windows, MacOS

Experienced: C, Java, Solidworks, Keras, Tensorflow, Unity, Control Theory, Arduino, Raspberry Pi, Odroid

Proficient: Lua, C#, Assembly, HTML, CSS, Javascript, ONNX, FPGA, Soldering, Digital Logic

Achievements

2019 National Club Field Hockey Champions - The University of Virginia

2017 Half Iron Man - South Africa

2017 Comrades Ultra Marathon - South Africa

2016 Summited Kilimanjaro - Tanzania

2012 National u18B Field Hockey Team - South Africa