VADER: A Hardware and Simulation Platform for Visually Aware Drone Autonomy Research

Andrew Buck[a], Matthew Deardorff[a], Derek T Anderson[a], Timothy Wilkin[b], James M Keller[a], Grant Scott[a], Robert H Luke III[c], and Raub Camaioni[c]

[a]Department of Electrical Engineering and Computer Science, University of Missouri, Columbia, MO, USA

[b]School of Information Technology, Deakin University, Geelong, Victoria, AU

[c]US Army DEVCOM C5ISR Center, Fort Belvoir, VA, USA

SPIE Unmanned Systems Technology XXIII

April 2021

Presented by Andrew Buck

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Outline

- Motivation
  - What is VADER?
- Hardware platform
  - Drone assembly and testing
- Simulation environment
  - Gazebo, AirSim, Unreal Engine
- Example applications
  - 3D mapping, detection, tracking, data fusion, …
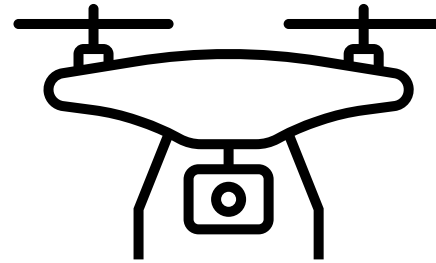- Future work

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Motivation: UAS Academic Research

▶ What is VADER?

  ▶ VADER is a hardware and software framework for end-to-end academic research using a drone or Unmanned Aerial System (UAS).

▶ Potential research areas:

  ▶ Data collection

  ▶ Mapping

  ▶ Autonomy
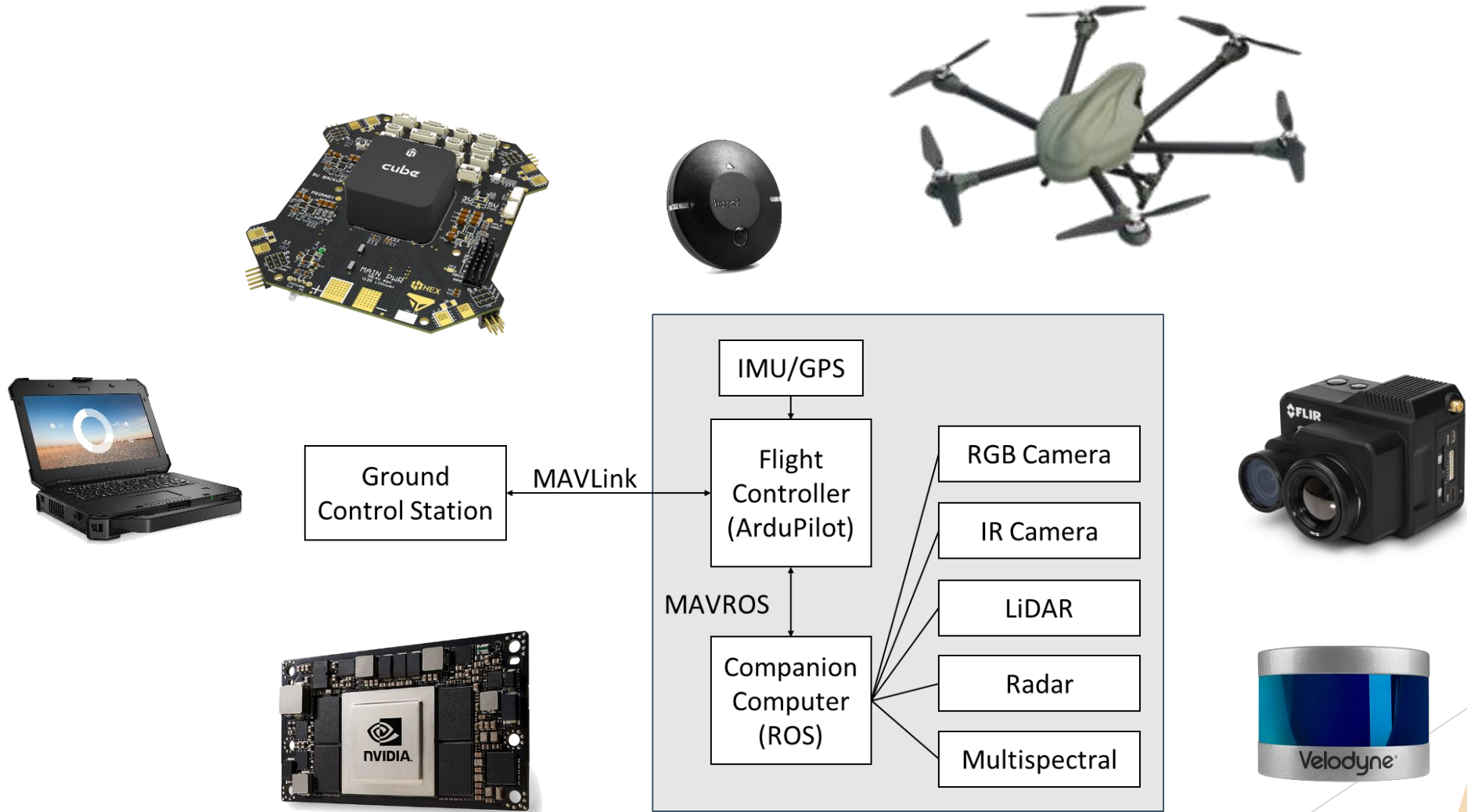
  ▶ Human-robot teaming

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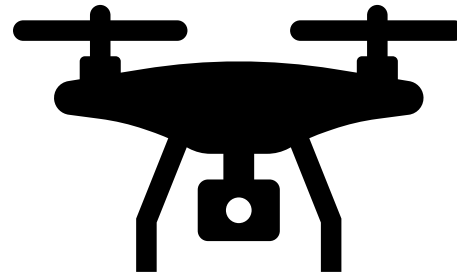
Need for Research Platforms

▶ Required expertise:

  ▶ Hardware design

  ▶ Flight physics

  ▶ Electrical and computer engineering

  ▶ Software programming / AI

▶ Commercial solutions exist but may not offer flexibility

▶ Our goal:

  ▶ Bring together tools from multiple disciplines

  ▶ Show how they can be utilized to achieve a wide variety of research goals

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Hardware Platform

IMU/GPS

Ground
Control Station

MAVLink

Flight
Controller
(ArduPilot)

RGB Camera

IR Camera

LiDAR

Radar

Multispectral

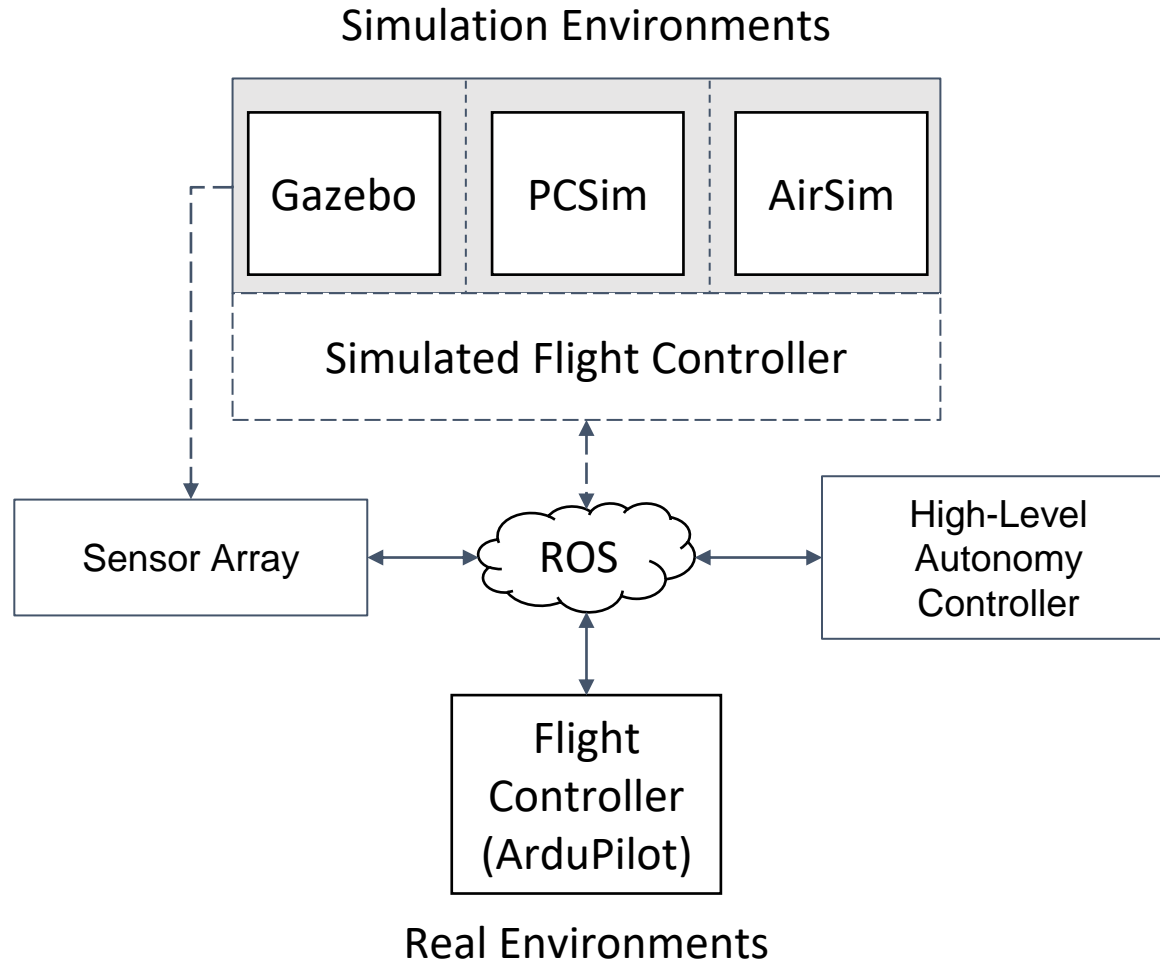MAVROS

Companion
Computer
(ROS)

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Assembly and Testing

▶ Drone build was guided by online documentation

▶ Firmware calibration using Mission Planner

▶ Assembly of the drone was incomplete due to COVID-19

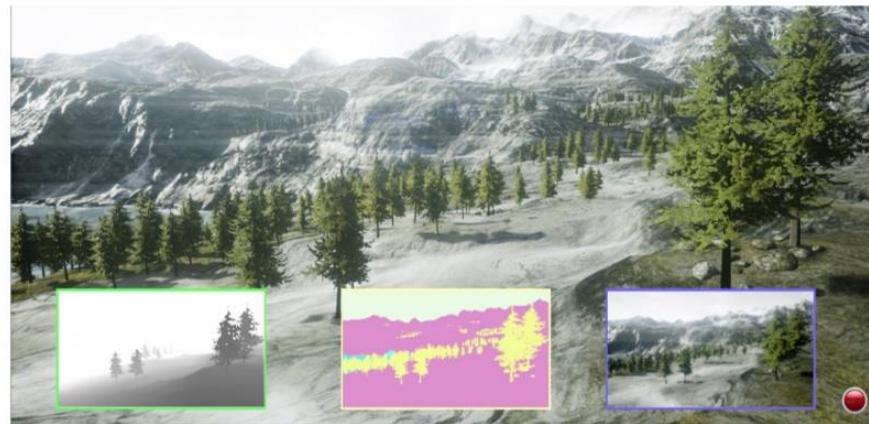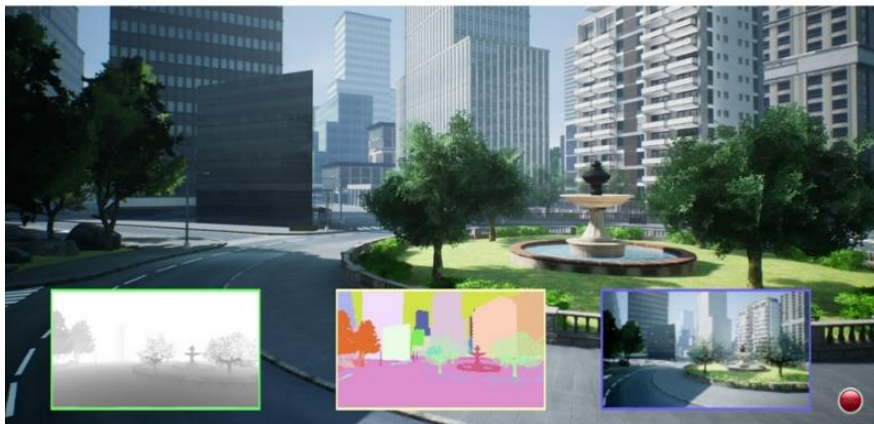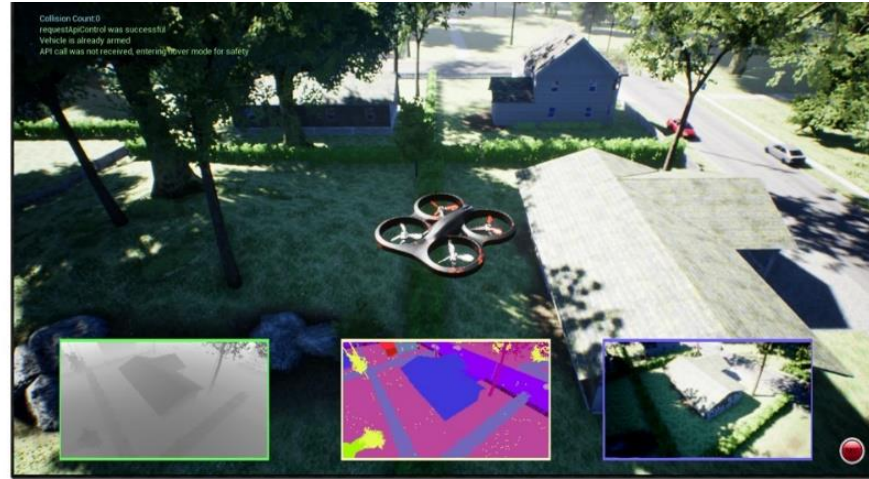▶ However, we were able to demonstrate manual flight and a pre-scripted waypoint mission

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Software and Simulation Environments

Gazebo Simulator

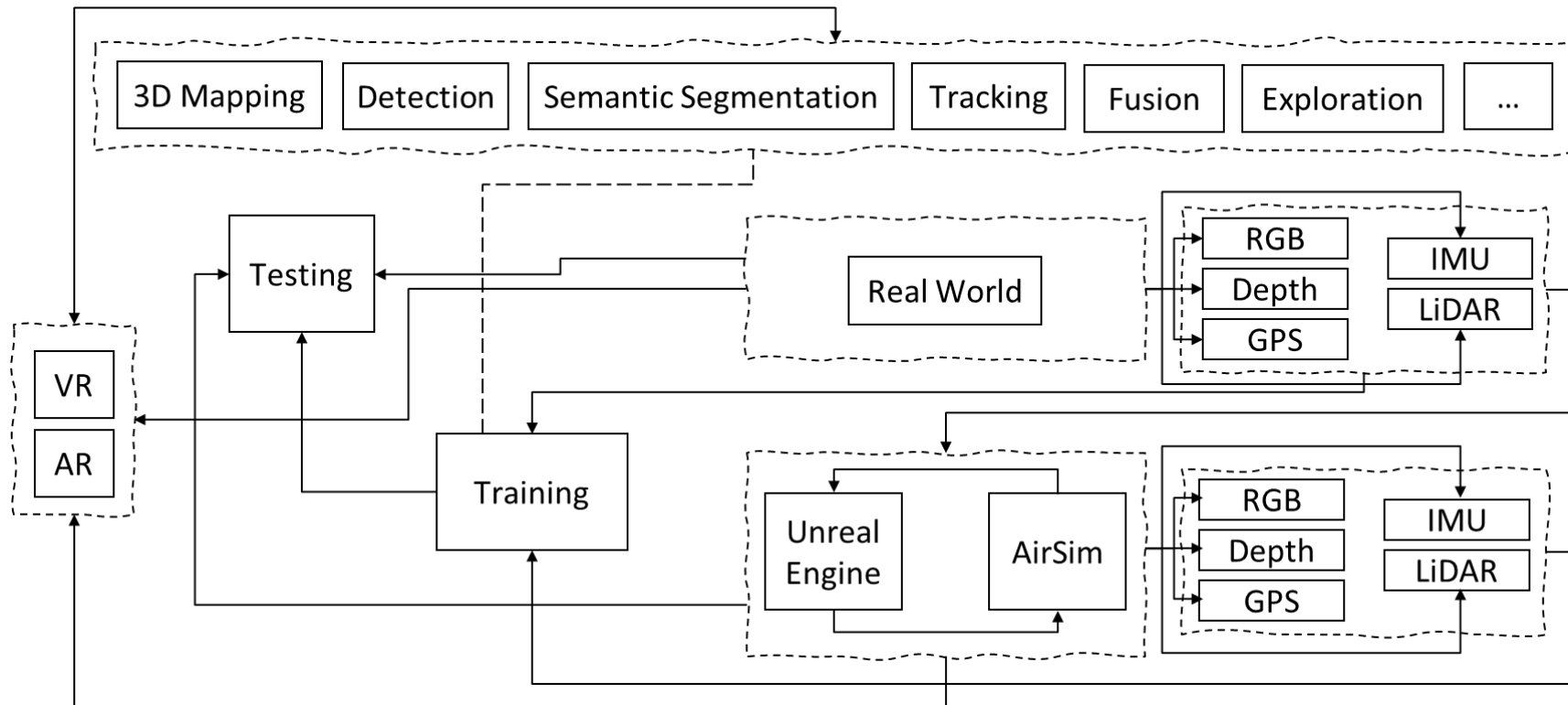University of Missouri

AimSim Environments

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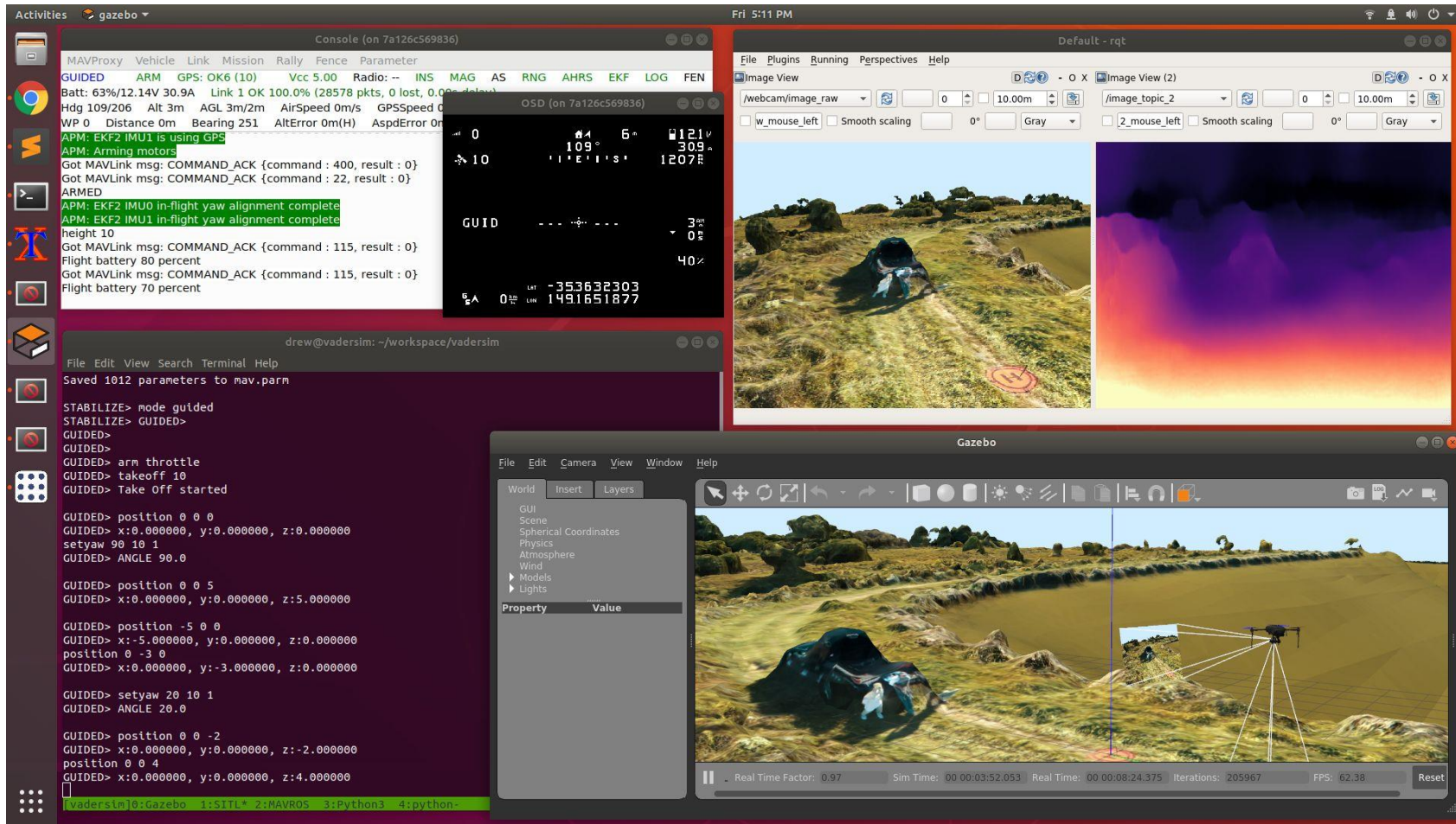
PCSim Environments

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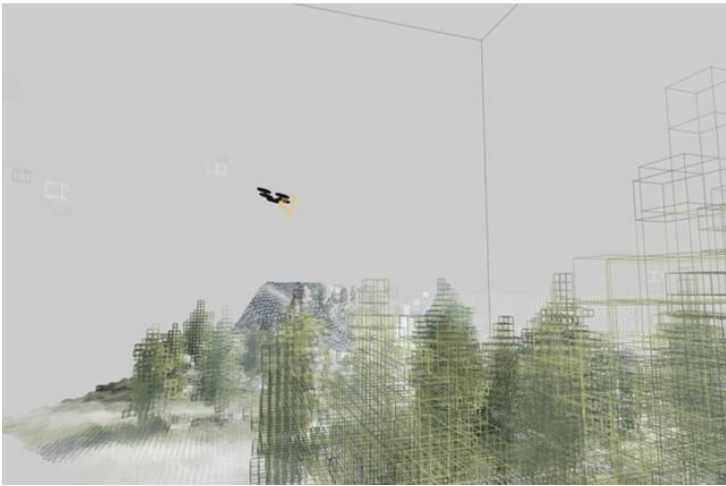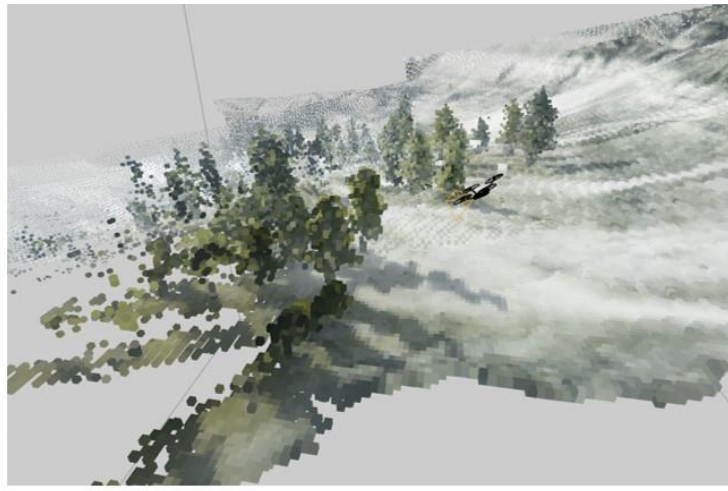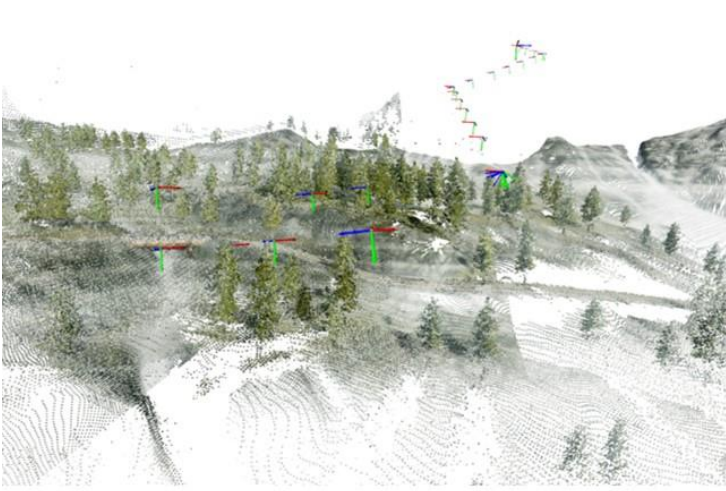
# Inter-connectivity of VADER Applications

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How to explore the environment?

- Agent is tasked with exploring the environment

- Needs to decide where to look next

- Multiple criteria to consider:
  - How far away?
  - How likely to discover new information?
  - Risk of collision?

- What is the best vantage point?

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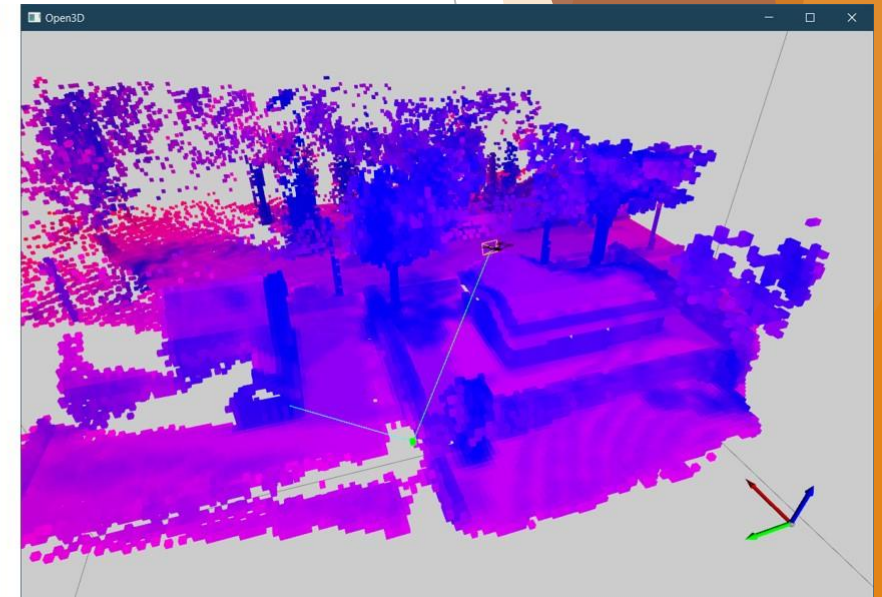
Real-Time Response: Search and Rescue

▶ Prototype basic autonomy mission scenarios in Gazebo and ROS

▶ Detect person with YOLO and land when found

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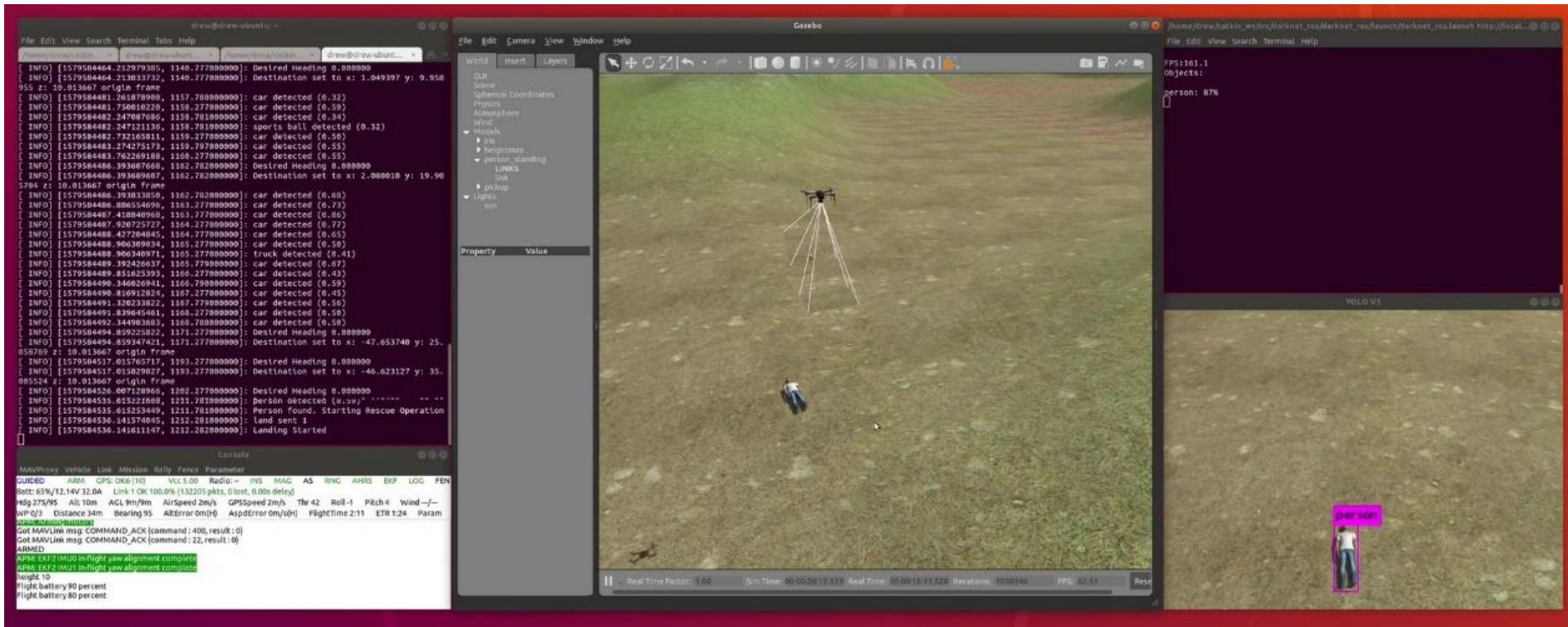
# How to Estimate Depth?

- ▶ Useful for collision avoidance
- ▶ Monocular depth estimation from a moving camera image sequence
- ▶ Compare real data with simulated data with known ground truth

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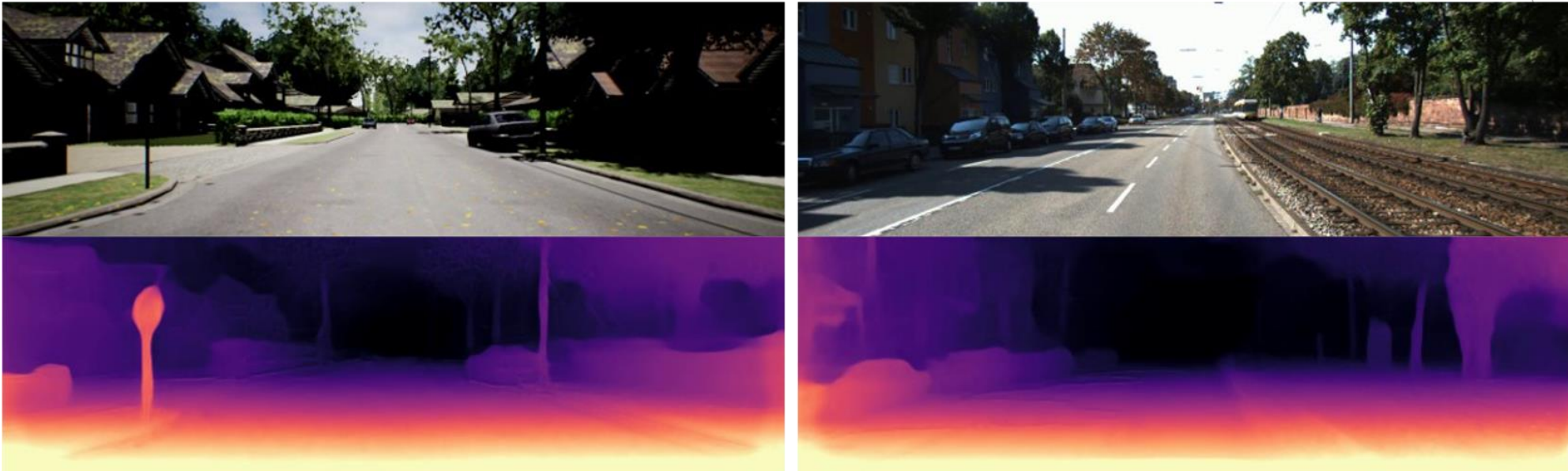
Can we Use Simulation for Training?

▶ Can use simulated data to help augment training

▶ Evaluating real-time computer vision algorithms like YOLO

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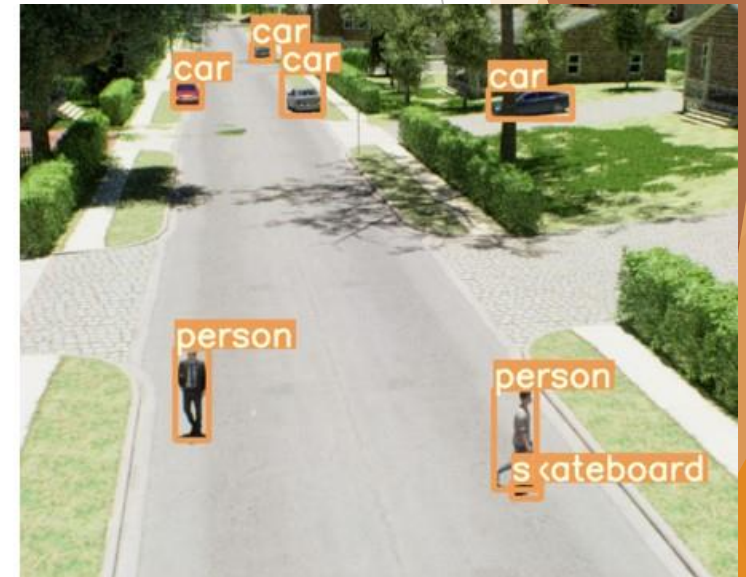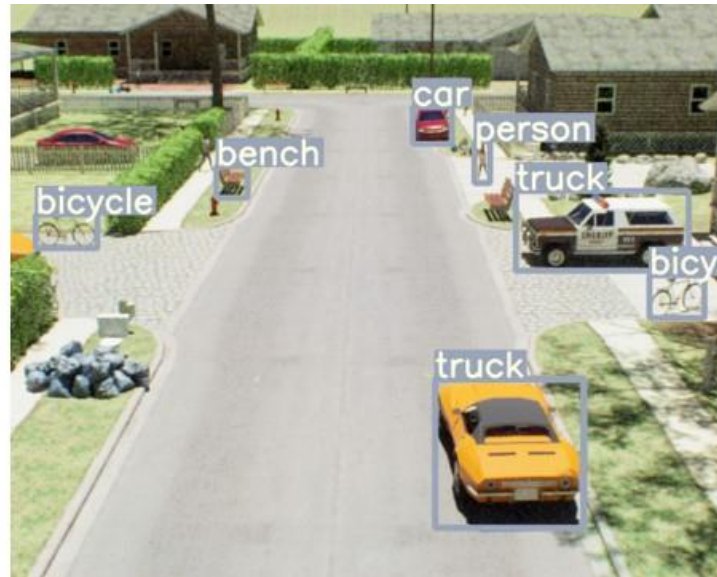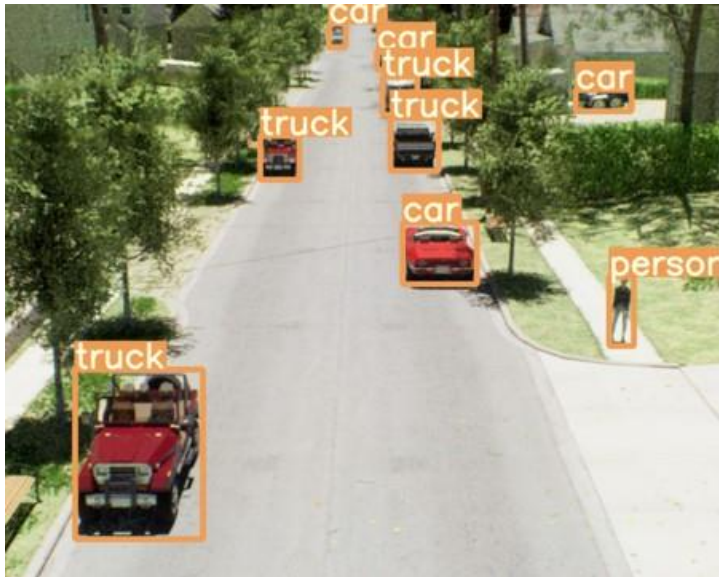
What About Data Augmentation?

- ▶ Consider using a UAS to detect explosive hazards in a variety of environments
- ▶ Simulation gives precise control over data collection
  - ▶ Can vary altitude, time of day, background

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Let's Use Augmented and Virtual Reality!

▶ Increase immersion with AR/VR to simulate human-robot interaction

▶ Show streaming point cloud as a manipulatable holographic map

▶ Explore 3D spaces along with drone at full scale with VR

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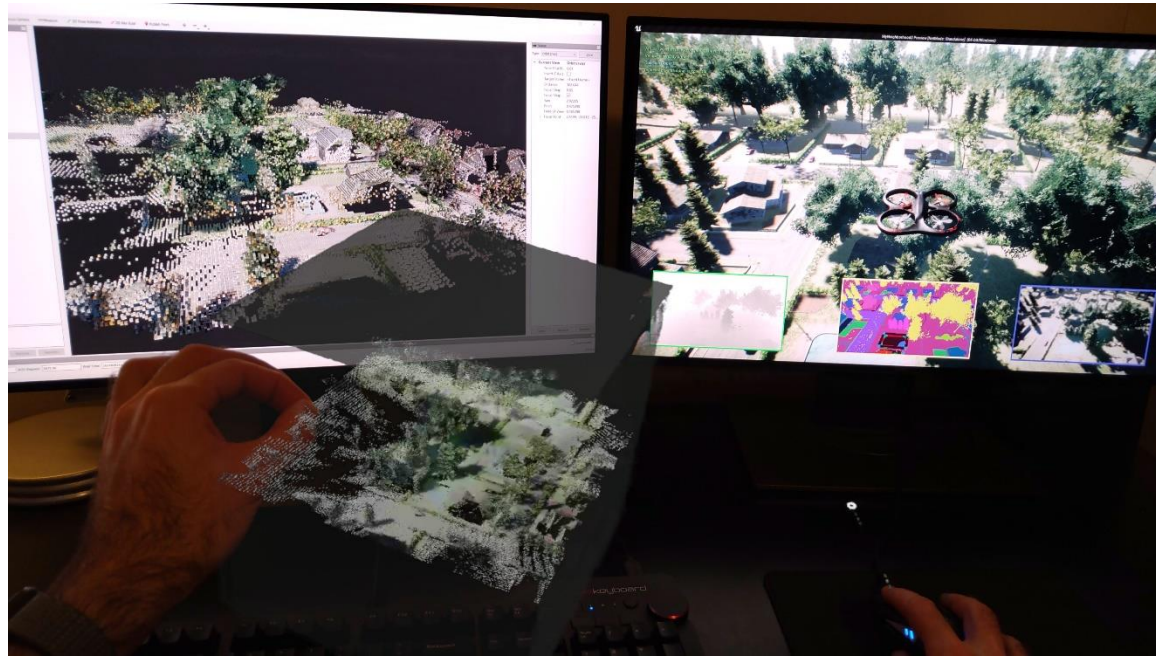
Conclusion

- VADER presents our vision for the possibility of drone autonomy research.

  - We hope this can serve as a guide for future researchers.

- Hardware and software have matured to enable rapid prototyping using commercially available off-the-shelf components and open-source software.

- Simulation environments can provide realistic scenarios for algorithm development and computer vision applications.

- Thanks for listening!

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