AI-Enabled Vision-Cued LIDAR for Small Unmanned Vehicles

Milind Mahajan, Weiya Zhang, John Mansell, Adam Young, Ryan Brown, Craig Anderson, Alexandra Yanoschak
Mark Anderson, Mario Aguilar-Simon, Teledyne Scientific Company (TSC); Jon O'Brien, Erik Reikes (Eembed Inc.)

Modular Optical Aperture Building Blocks (MOABB)

Artificial Intelligence

Background

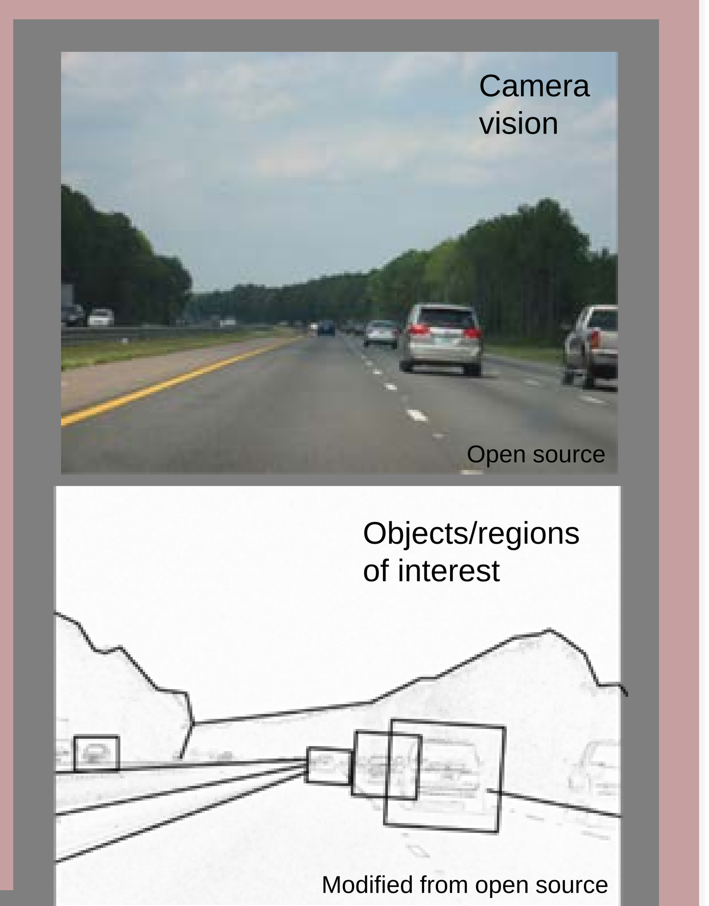
Current state of the art sensors for small autonomous platforms (e.g. stereo vision, flash LIDAR and scanning LIDAR) lack adequate range, spatial resolution, and speed. High speed navigation around cluttered small obstacles with acceptably low collision rate is not possible.

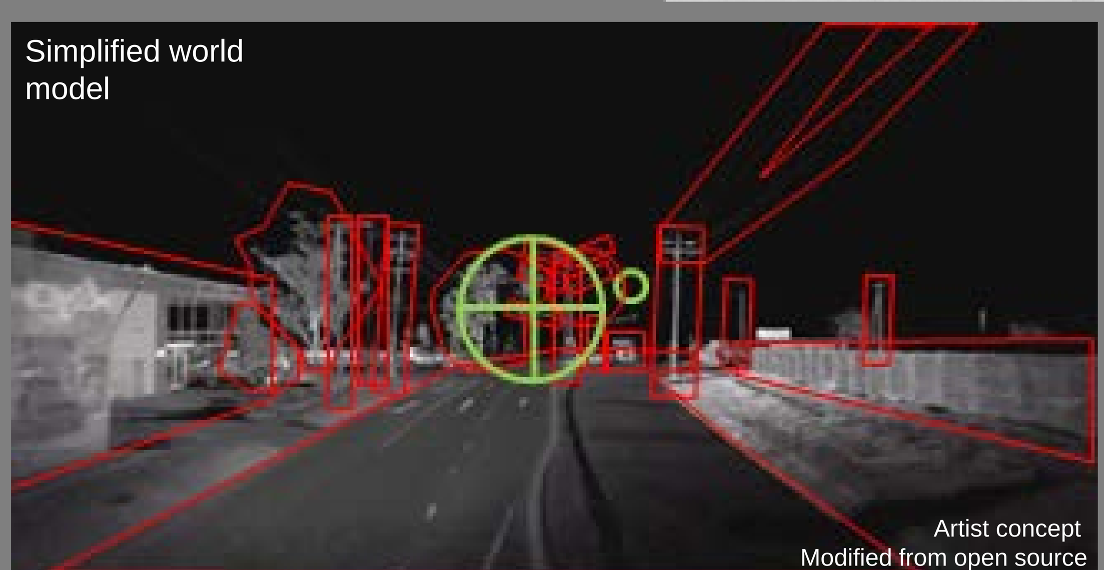
Key features of MOABB LIDAR:

- Unique, chip-scale photonic coherent LIDAR enabling a paradigm shifting approach to autonomous navigation
- Random access electro-optic pointing
  - Phased array steering in one dimension
  - Fast tunable laser/ fixed grating steers in other dimension
- Microseconds response time
- Narrow nearly diffraction limited beam
- High range resolution
- High immunity against background brightness

Enabling Innovative Approach to Autonomous Navigation

- AI enabled camera identifies and classifies objects, regions of interest to cue the LIDAR for random-access ranging: Very large reduction in data collection and handling needs
- Precise, line of sight (LOS) stabilized pointing in presence of challenging platform jitter
- Keep-out zones assigned around the detected objects
- Multiple voxels allow proper orientation of keep-out zones
- Forward-looking obstacle avoidance scan as a backup
- LIDAR data limited to several hundred points as opposed to hundreds of thousands
- System world model can be shared across platforms over low bandwidth data link



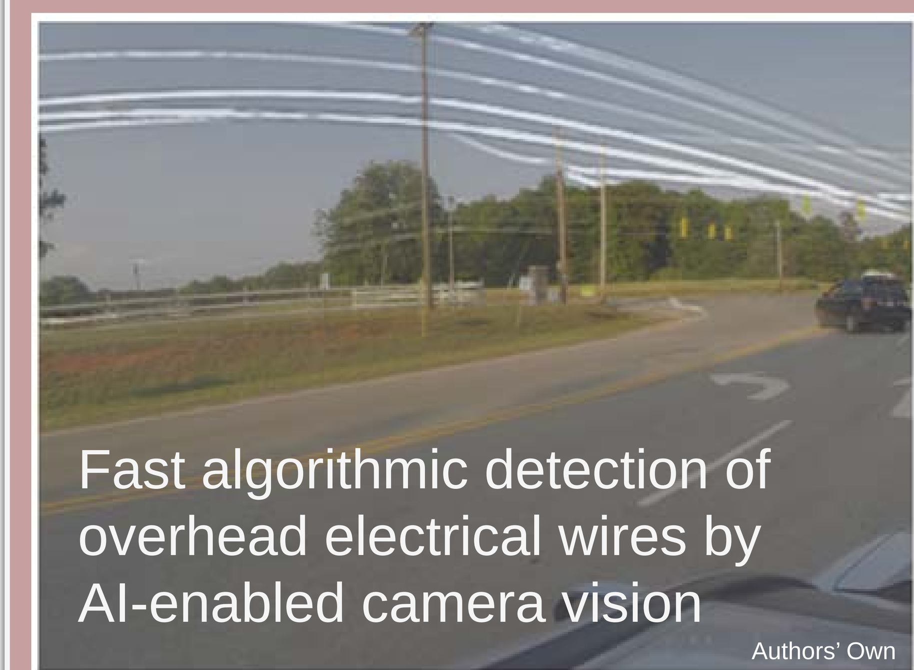


Results

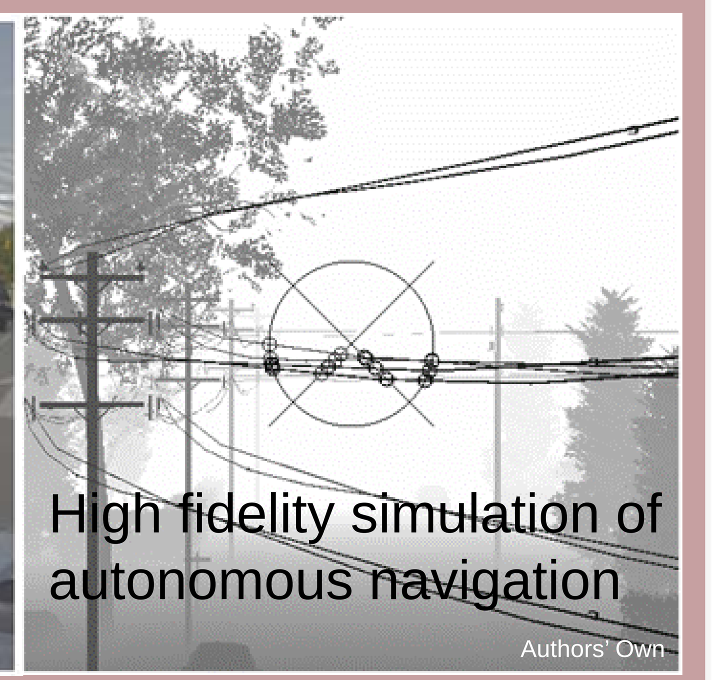
- Demonstrated frequency modulated continuous wave (FMCW) Phase 2 LIDAR with 5 cm resolution at 10 m range
- Conducted application specific demonstrations of AI-enabled, vision-cued random-access ranging payloads
  - Wires used as challenging obstacles (narrow cross section)
- Demonstrated precision, LOS stabilized pointing and real-time ranging from small unmanned ground vehicle (UGV) as surrogate platform prior to integration with small unmanned aircraft systems (sUAS)

Incremental capability enhancement: simulation ⇒ benchtop demonstrations ⇒ integration with platforms

AI enabled detection, high fidelity gaming simulations

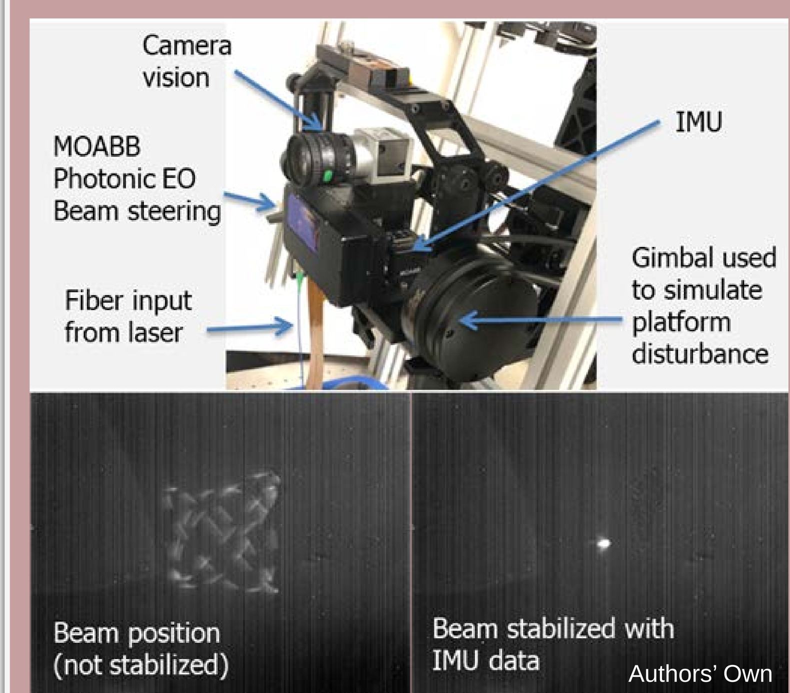


Fast algorithmic detection of overhead electrical wires by AI-enabled camera vision



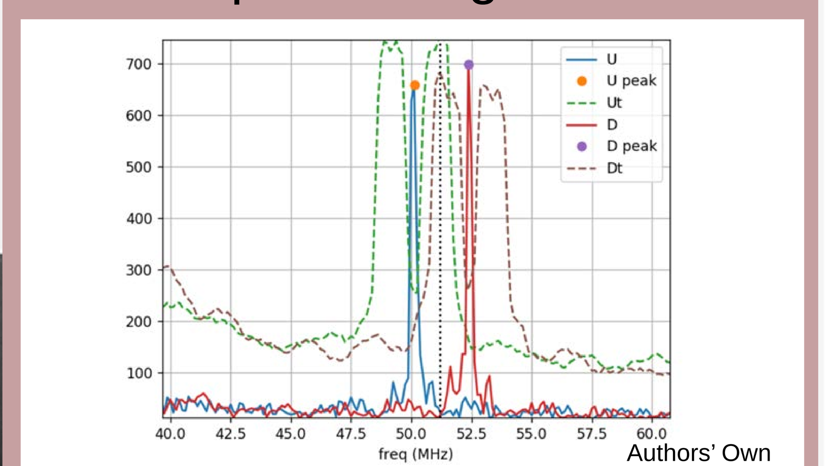
High fidelity simulation of autonomous navigation

Use of gimbal and motion table simulates platform jitter, IMU based LOS stabilization

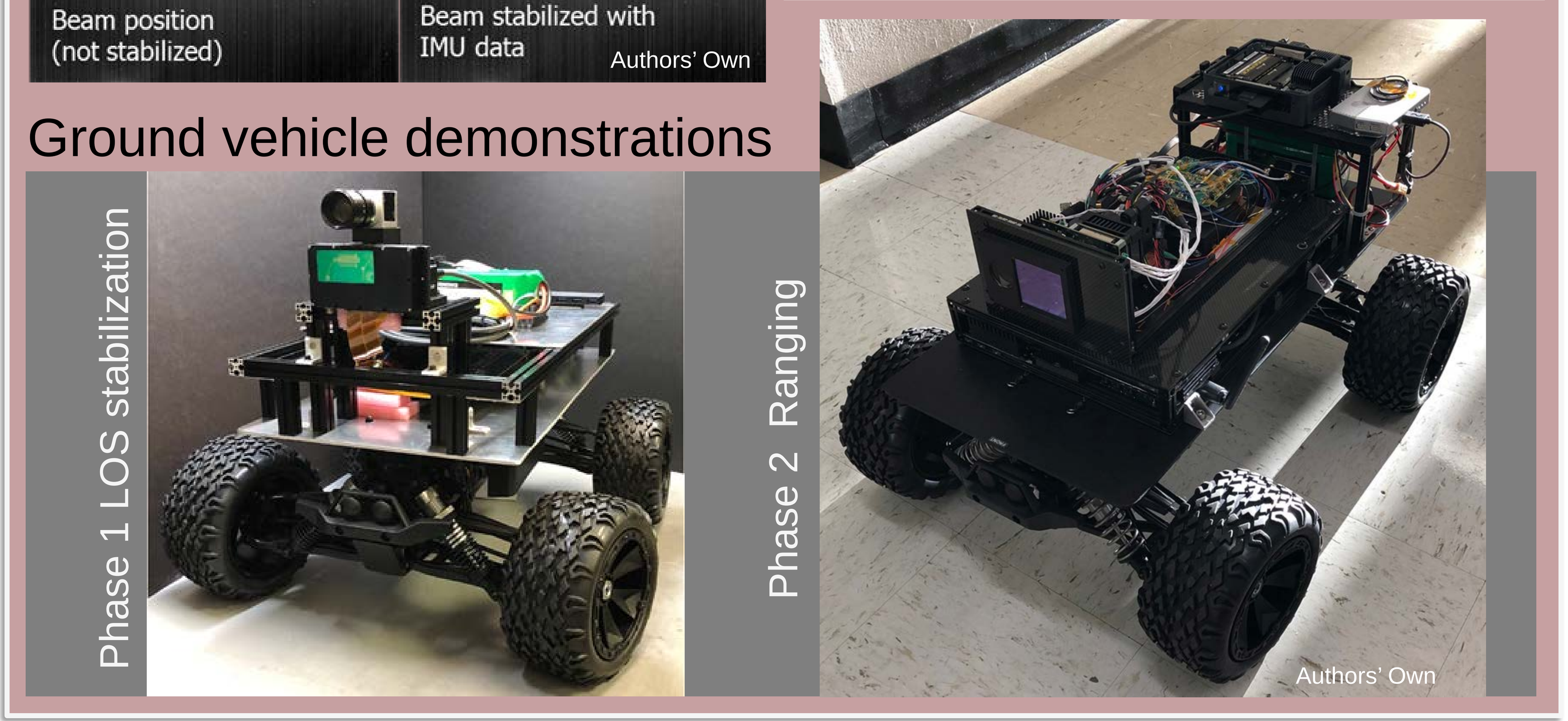


FMCW ranging with constant false alarm rate algorithms

Embedded controller for beam steering, LOS stabilization and LIDAR processing



Ground vehicle demonstrations



Phase 2 Final LIDAR Payload

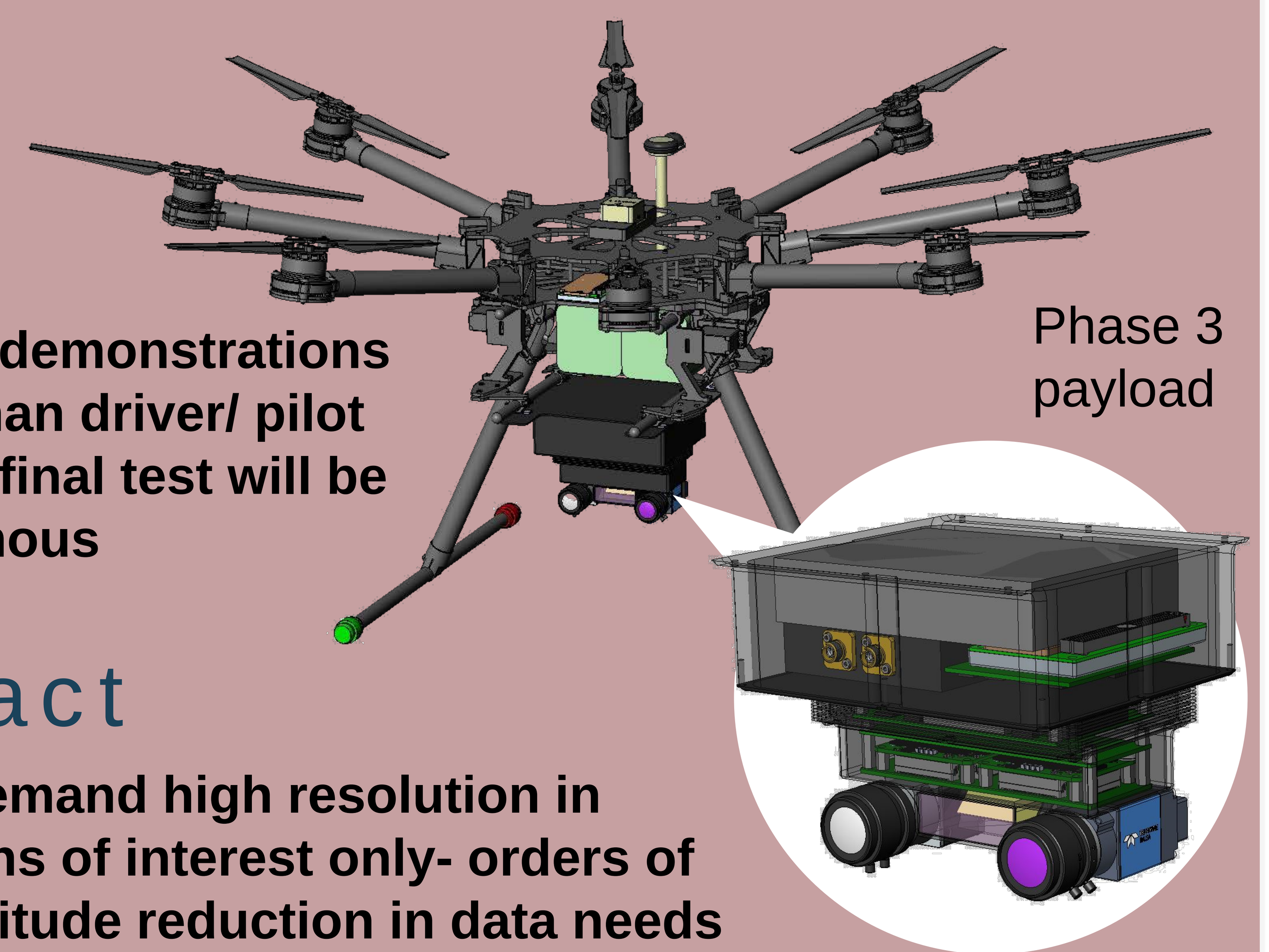
Phase 2 LIDAR payload integrated with a multirotor platform

Phase-3 Plans

A transition-oriented payload for sUAS (class I,II)

- **Laser upgrade: Narrow linewidth, broadly tunable**
- **Increased field of view (nominally 100° x 14°)**
- **Increased Range (From 10 m to 100+ m)**
- **Miniaturized drive electronics, aggressive size, weight and power reduction**
- **Miniaturized vision processor**

Phase 2 demonstrations had human driver/ pilot
Phase 3 final test will be autonomous



Impact

- **On-demand high resolution in regions of interest only- orders of magnitude reduction in data needs**
- **Gimbal-free operation**
- **Enable high speed autonomy in small air vehicles in presence of challenging clutter and platform disturbance**

TSC Contact:
Milind.Mahajan@Teledyne.com
805-373-4888

MTO PM: Dr. Gordon Keeler

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