

# LIDAR Technology and Its Diverse Applications

HI-TEC 2020 Transformed

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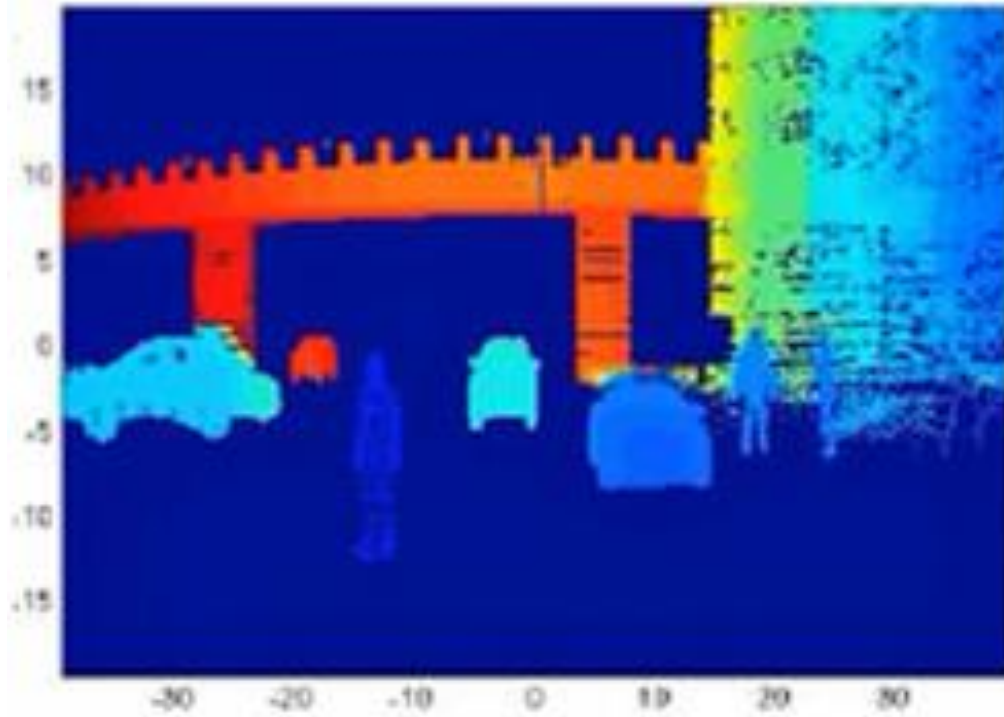


# Outline

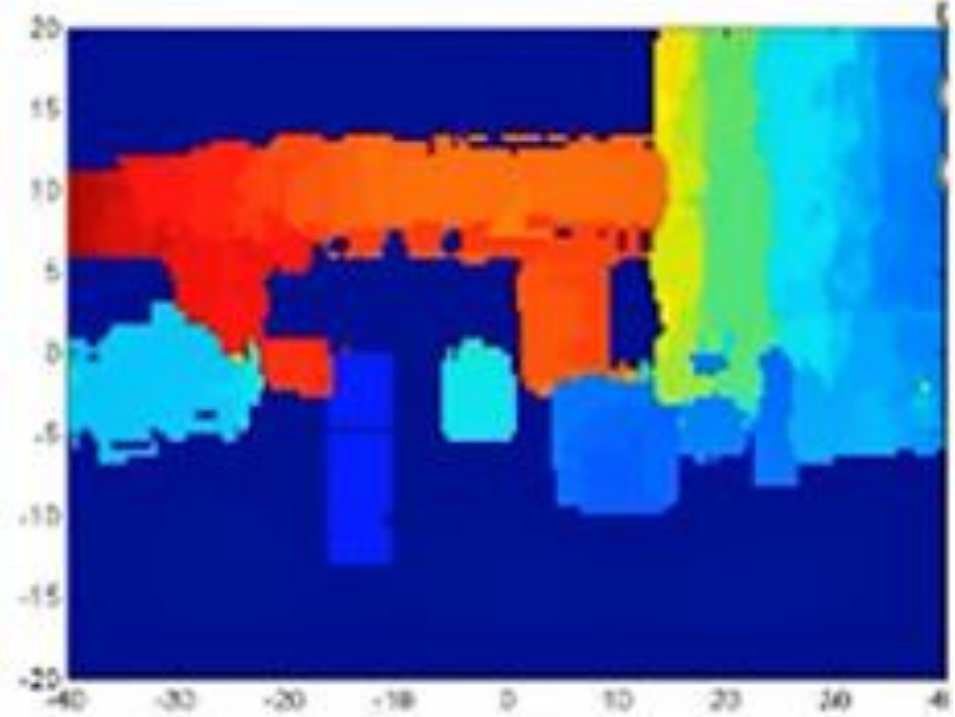
- I. What is LIDAR?
- II. LIDAR Basics
- III. Components and Types
- IV. Performance
- V. Applications
- VI. Lidar in ATE
- VII. Student Projects Using Lidar
- VIII. Resources

# I. What is LIDAR?

- Light Detection and Ranging
- Analogous to Radar, but based on light waves instead of microwaves
- Technology that uses a laser beam and its reflections from surrounding objects to determine the distance between the laser source and the objects
- Using light waves allows for higher resolution than radar
- Can create high resolution, 3D maps of the environment
- Technology is becoming ubiquitous, with growing number of applications



**Lidar**



**High Resolution Radar**

## Lidar vs Radar comparison

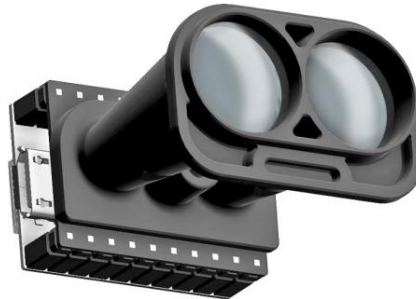
- Lidar has better resolution and produces a much clearer picture
- Lidar is worse than radar in bad weather conditions like fog, snow

## II. LIDAR Basics

- Lidar has been around for 50+ years
- The technology was invented soon after the invention of the laser in 1960
- Initially developed for use by the military, in applications such as rangefinders and weapons guidance systems
- One early application was mapping the surface of the Moon by Apollo 15 astronauts in 1971
- Since then Lidar applications have multiplied
- A highly anticipated, high volume commercial application is in self-driving vehicles

# III. Components and Types

- Basic components of Lidar
  - Laser source - transmitter
  - Photodetector - receiver
  - Electronics - for synchronization and data processing
  - Motion control equipment or components for precise laser steering
- Types of lidar
  - Mechanical scanning – rotating, covering 360° or smaller field of view
  - Solid state – no moving parts – based on MEMS or optical phased array
  - Flash – emits a single pulse of light, spread over large area



# Laser Source

- Plays a large role in device performance
  - Beam divergence impacts the lateral resolution, in the x, y axes
  - Power impacts the range of the device – big range requires high power, on the order of Watts or more. High power is also needed if the target has low reflectivity.
  - Pulse duration impacts the longitudinal resolution, in the z axis
  - Pulse repetition impacts the data throughput, how much data is generated per second
- Different types of lasers were used historically – ruby, Nd:YAG, CO<sub>2</sub>, fiber
- Diode lasers and VCSELs are now the most common

# Laser Source

- Laser wavelength depends on the application
  - 355 nm (UV) for atmospheric applications
  - 532 nm (visible, green) used in water applications
  - 830 nm - 940 nm are common in many Lidars
  - 1.55  $\mu\text{m}$  (IR) works well for detecting solid bodies and is better for eye safety
- Safety considerations for commercial applications – the 355 nm and 1.55  $\mu\text{m}$  wavelengths are safer



## IV. LIDAR Performance

- Resolution: on the order of cm
- Range: <1m - 300 m
- Size: varies from table top size to compact electronic device
- Cost: from \$ tens of thousands to < \$100, depending on performance
- Evolution has been towards smaller size, higher reliability and smaller cost
- Last decade has seen intense competition for producing an inexpensive, high performance Lidar for self-driving vehicles
- Hundreds of companies are developing Lidar for automotive and other industries

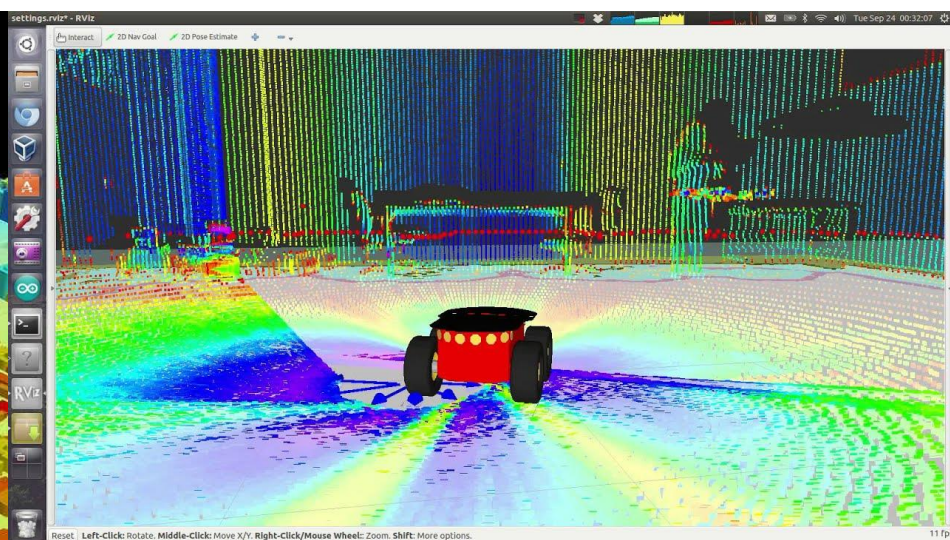
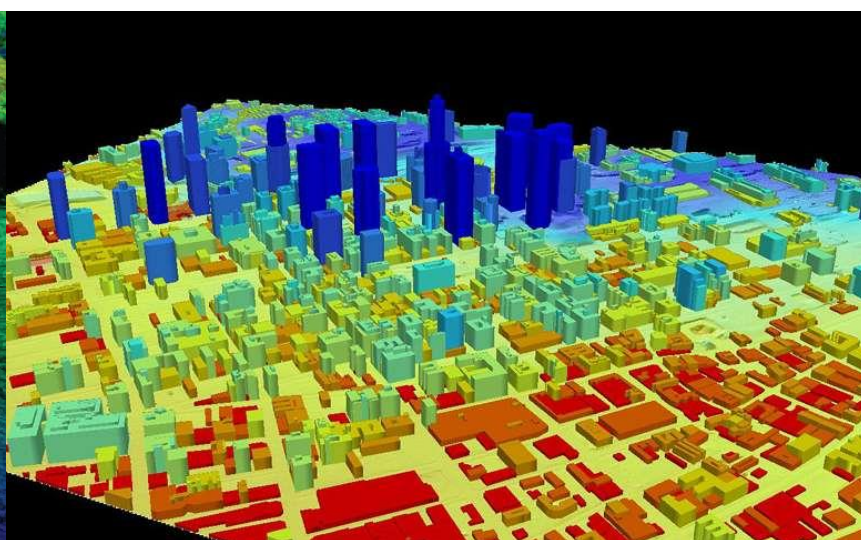
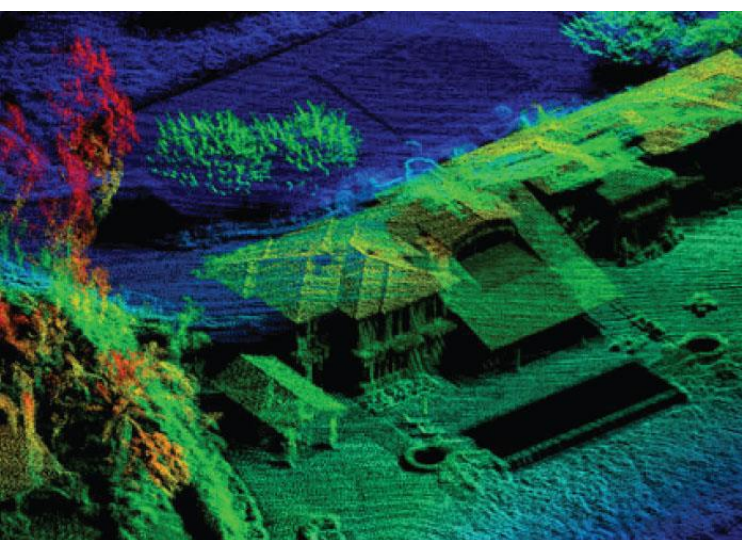
# V. Applications

- Agriculture
  - map terrain, monitor health of crops, determine use of fertilizer and pesticides
- Airborne applications
  - obstacle detection, terrain following, wind sensing
- Archeology
  - mapping of ancient sites
- Autonomous vehicles
  - self-driving cars, trucks, boats and planes
- Environmental
  - determine composition of atmosphere and oceans, detect pollution, monitor deforestation

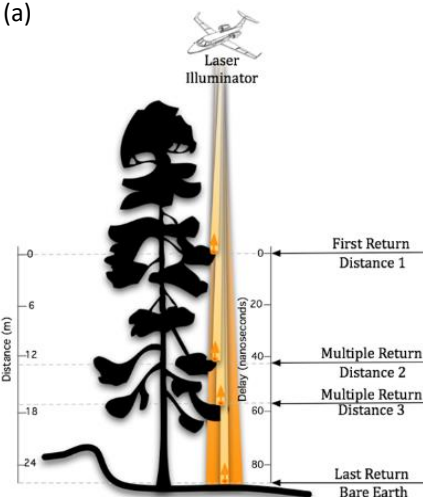
# Applications

- Industrial robots
- Mapping
  - shorelines, rivers, lakes
- Medicine
  - analyze content of drugs, eye investigation
- Military
  - identify targets, weapons guidance
- Mining industry
  - map excavated areas, determine volume of material removed
- Unmanned aerial vehicles (UAV), drones
  - geospatial measurements, ...

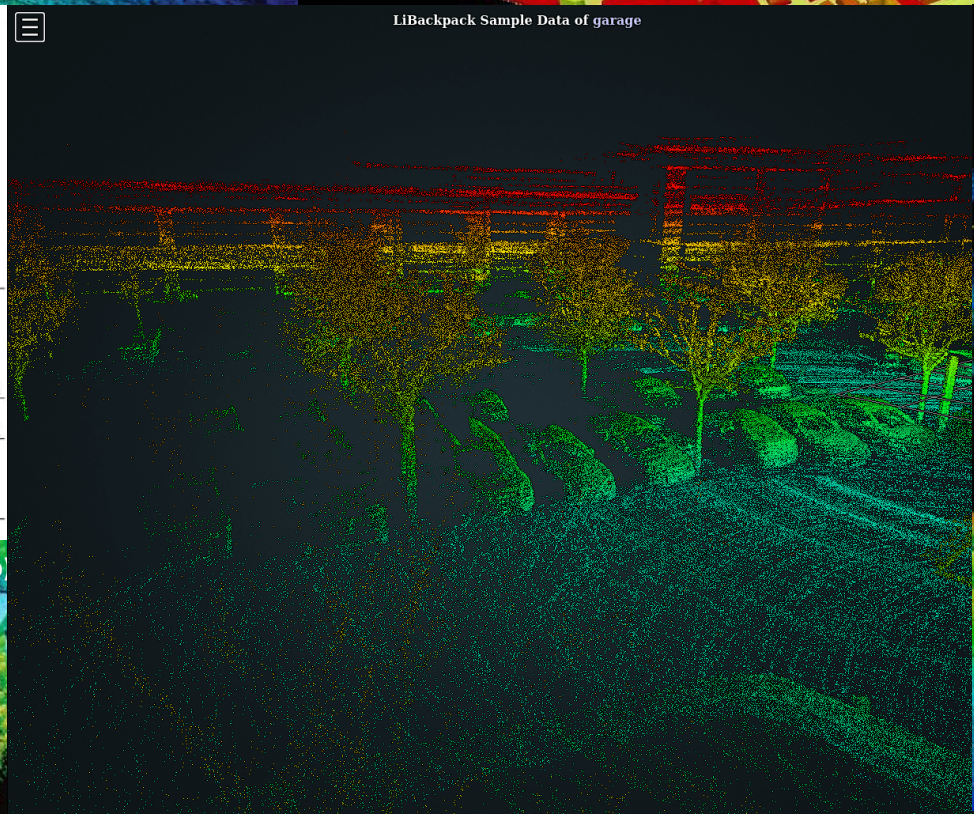




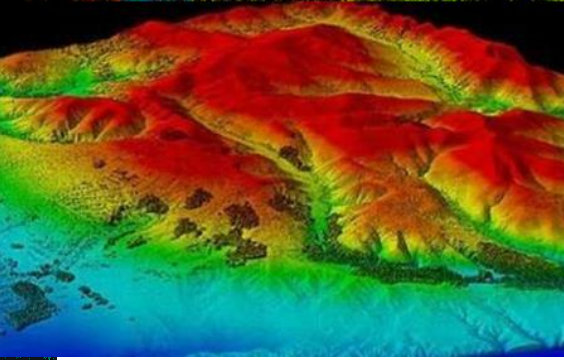
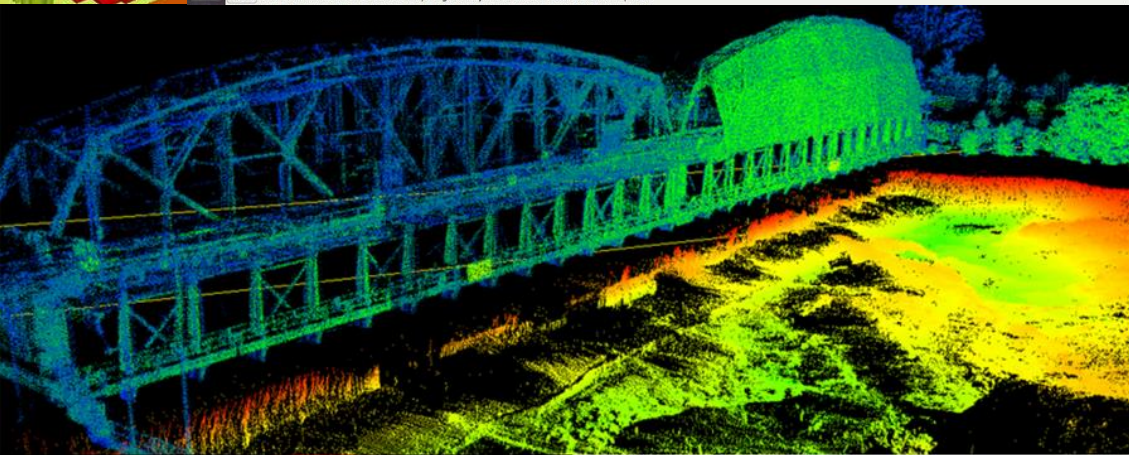
(a)



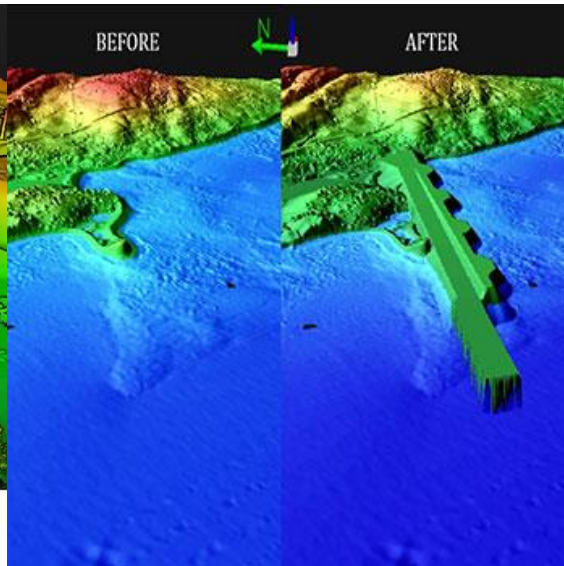
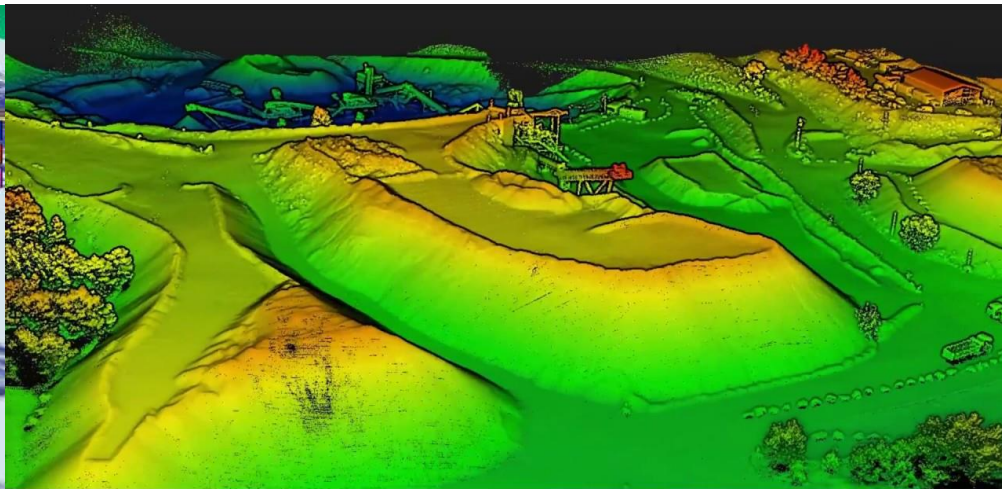
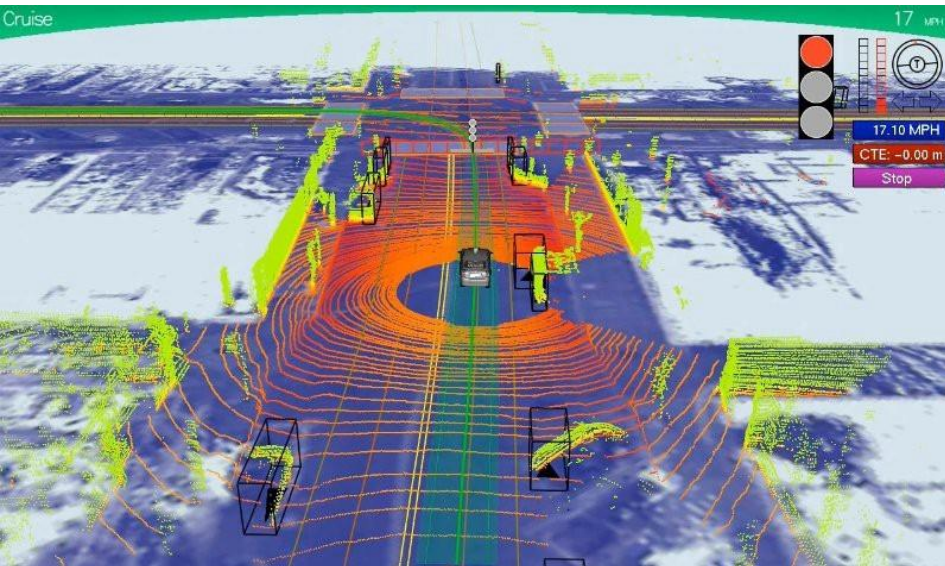
(b)



LiBackpack Sample Data of garage



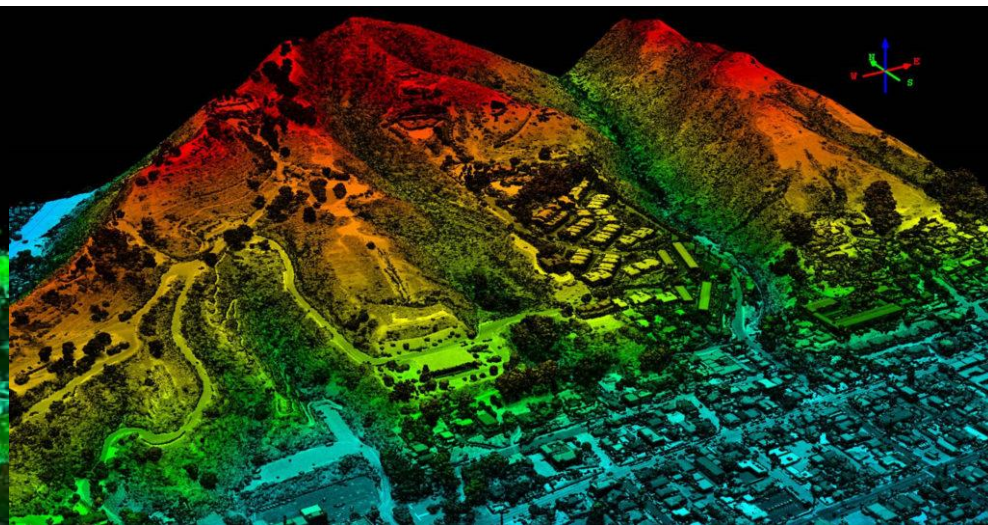




Flight site.  
Poussan, France

LiDAR system.  
YellowScan Surveyor

UAV.  
Onyxtar





# VI. Lidar in ATE

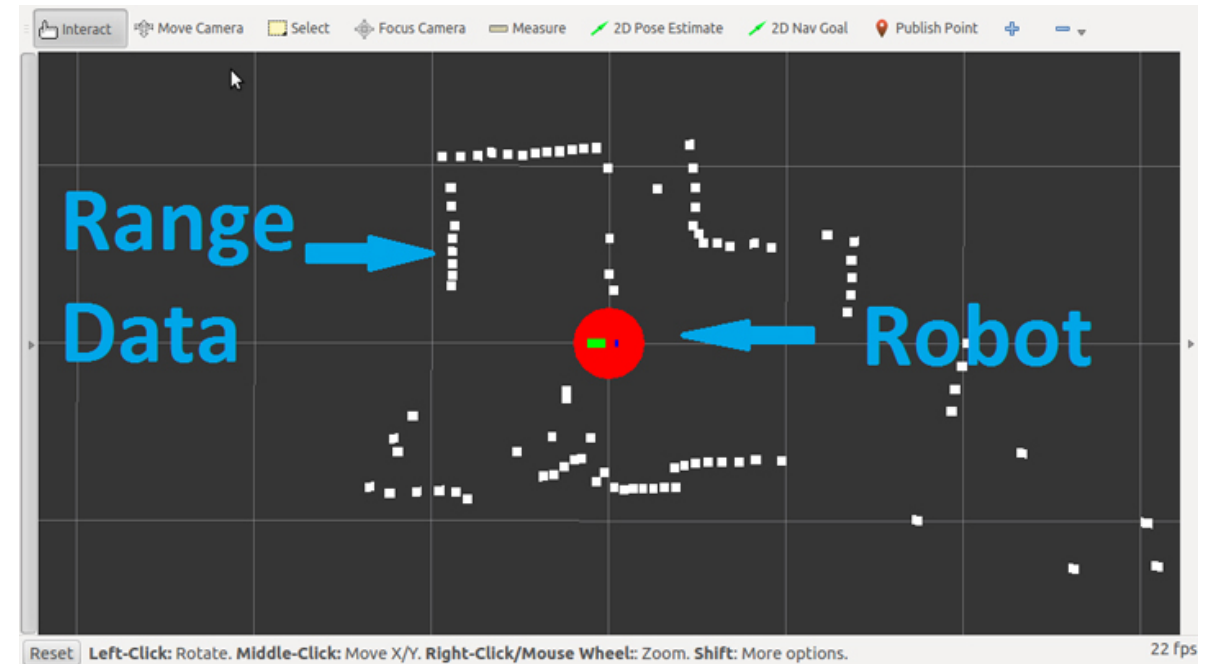
- Lidar is an Advanced Technology that combines optics and lasers, electronics, motion control, computing, data analysis and interpretation
- Its applications cover a wide range of industries
- Lidar projects can be embedded in numerous ATE programs
  - Automotive technology
  - Agricultural and environmental technologies
  - Engineering technologies including optics, electronics, mechatronics, robotics
  - Information and communications technologies
  - Geospatial technology
  - And others

# VII. Student Projects Using LIDAR

- Obstacle Avoidance
- Map Generation
- Self Driving Car
- Path Planning Robot
- Websites
  - [Best Lidar projects for students](#)
  - [Best Ros projects for students](#)
  - [37 Lidar projects](#)
  - [More Lidar projects](#)
  - [Lidar-based self-driving car](#)

# Student Projects Using LIDAR

- [Home made Lidar sensor](#)
- [Arduino based Lidar scanner](#)
  - [www.qcontinuum.org/lidar](http://www.qcontinuum.org/lidar)
- [Autonomous robot using Lidar](#)
- [DIY Roomba](#)





## VIII. Resources

- RPLidar A1M8 - 360 Degree Laser Scanner Development Kit, \$99, available from [robotshop.com](http://robotshop.com)
- TFMini - Micro LiDAR Module, \$49.94, available from [mouser.com](http://mouser.com)
- Garmin LIDAR-Lite, \$ 59.95, available from [adafruit.com](http://adafruit.com)
- [Getting started with Lidar](#)
- [Best Lidar sensors for makers](#)
- [What are the top 5 uses of Lidar](#)
- [Drone + Lidar](#)
- [Basics of Airborne Lidar](#)

# Contact Information

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Thank You!