CEC Continuing Education Center

DesignNews

Using Drone-Based LiDar

DAY 2 : LiDar and UAV Technology

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- Participate in ‘Group Chat’ by maximizing the chat widget in your dock.
- Submit questions for the lecturer using the Q&A widget. They will follow-up after the lecture portion concludes.

Louis W. Giokas

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Course Overview

During this program, attendees will learn how to convert data collected from a LiDAR mission into a point cloud comprised of over 6 million points, which will be used to create highly accurate digital surface models and contours. Watch the entire process and learn how you can start saving time and money by adding drone-based LiDAR to your workflow. In particular you will learn the components of UAV LiDAR; how to save time and money with drone-based LiDAR as part of workflows; evaluate the benefits of drone-based LiDAR; how to create a 3D point cloud with a visual data demonstration.

Class Overview

The two technologies we will use in this class to develop point clouds are Light Detection and Ranging (LiDar) and Unmanned Aerial Vehicles (UAV). In this class we will go into the details of each, especially in relation to our main topic.

Agenda

- LiDAR Basics
- LiDAR Data
- UAV Basics
- UAVs for LiDAR

LiDAR Basics

- LiDAR stands for Light Detection and Ranging.
  - Sometimes also called Active Laser Scanning
- Similar concept to RADAR but using light instead or radio waves.
- The laser pulses rapidly (strobed) impacting on objects and returning to a sensor where it is recorded.
- Information is the converted to both a distance from the sensor as well as other information.

LiDAR Basics

- Other system components
  - The system needs to process the pulses and the return data in reference to a known location
  - This can be done using GPS
  - Orientation of the sensor is typically provided by an Inertial Measurement Unit (IMU)
  - Knowing the exact location of the pulse is important, especially for mapping applications

LiDAR Basics

- Discrete Return LiDAR
  - In this type of system, a record is taken of the peaks of the waveform curve for each pulse of the laser
  - A point is recorded at each peak
  - Each peak is considered a discrete point in the point cloud
  - There are between one to four returns (sometimes more) per pulse depending on the makeup of the scene being recorded (e.g., vegetation)

LiDAR Basics

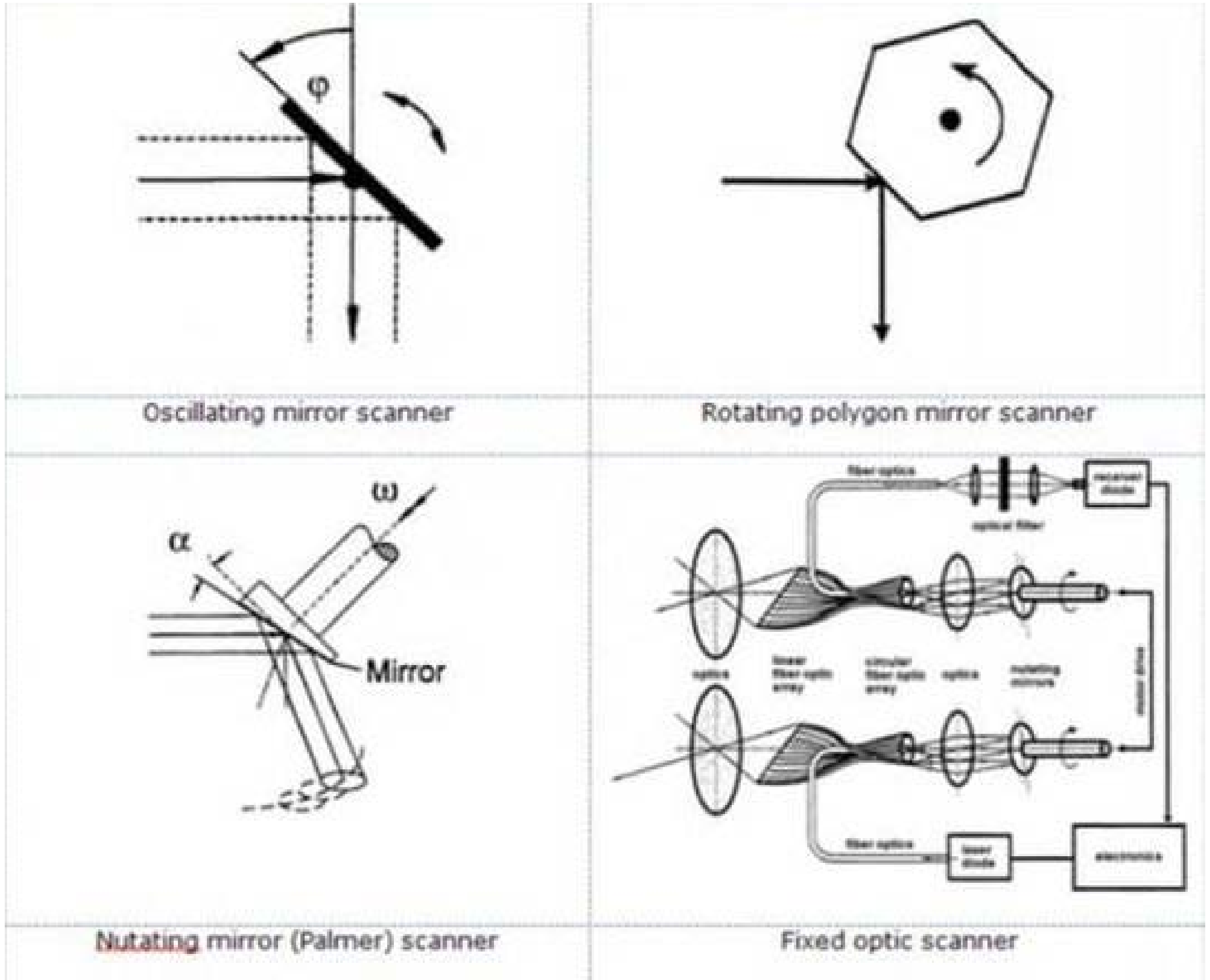
- Full Waveform LiDAR
  - This type of system records the full waveform of the returned pulse
  - This can give more detailed information about the nature of the scene being recorded
  - Requires more processing, but gives more detail (such as materials being observed)

LiDAR Basics

- Laser Types
  - Ground based LiDAR typically uses a laser in the 500 – 600 nm range
  - Airborne LiDAR typically uses a laser in the 1000 – 1600 nm range
  - The laser can be pulsed at various rates
  - In some systems the laser is steered, either by mechanical means or by electronic means
    - In mechanical systems, the laser/sensor is moved as a unit
    - In electronic systems the laser is steered and the system remains stationary

LiDAR Basics

Sensor Types



Oscillating mirror scanner | Rotating polygon mirror scanner | Nutating mirror (Palmer) scanner | Fixed optic scanner

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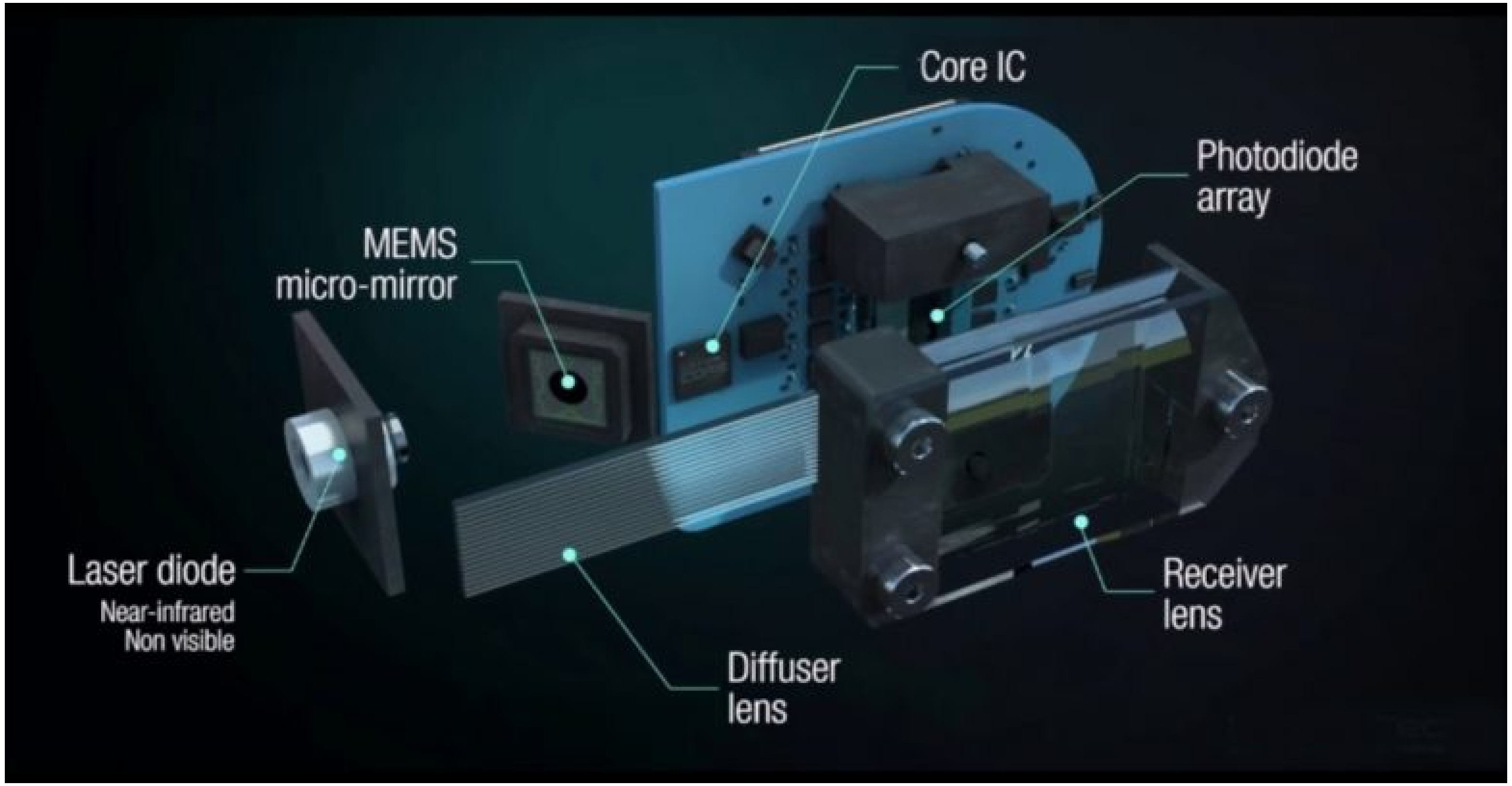
LiDAR Basics



LiDAR Basics

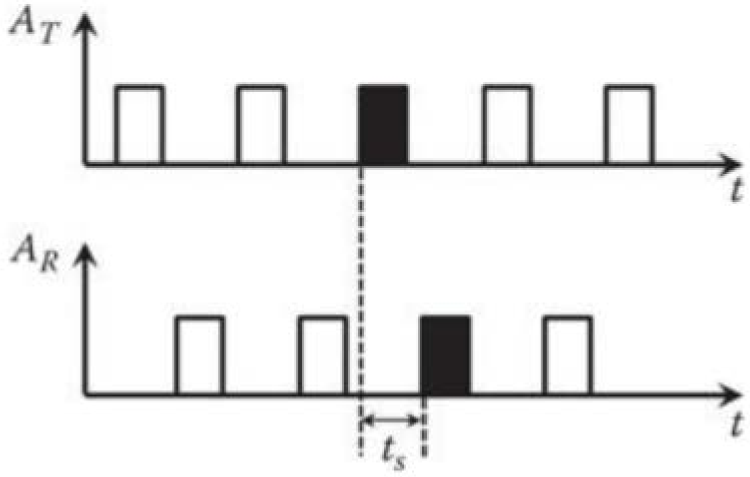
LiDAR Equation

Pr(t)=D24 π λ 2 ∫ 0H η sys η atmR4Pt(t−2R υ g) σ (R)dR(2.4)

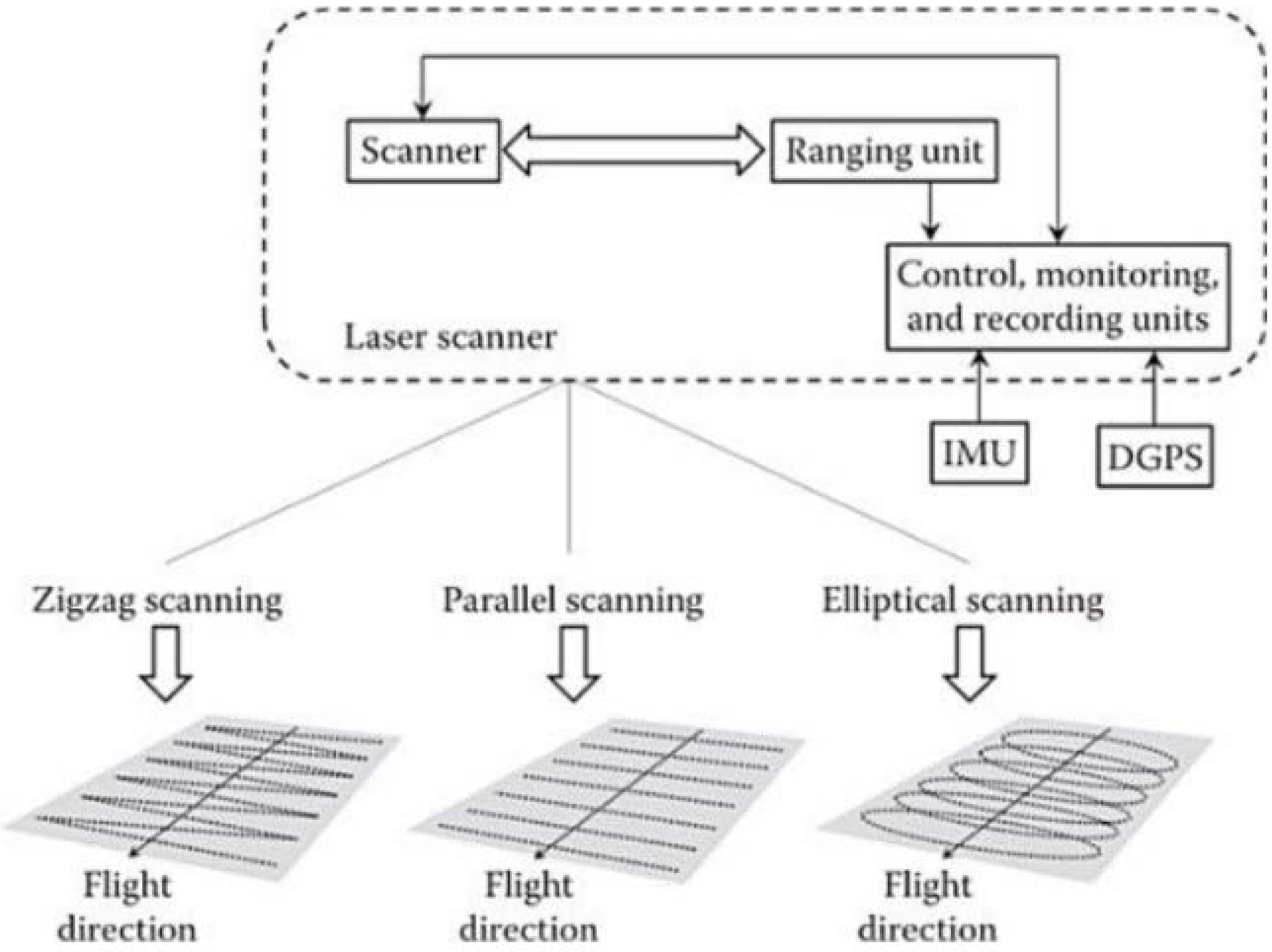
where t is the time; D is the aperture diameter of the receiver optics; P_r is the power of received signal; P_t is the power of transmitted signal; is the wavelength; H is the flying height; R is the distance from the system to the target; $_{sys}$ and $_{atm}$ are the system and atmospheric transmission factors, respectively; $_g$ is the group velocity of the laser pulse; and σ (R) dR is the apparent effective differential cross section.

LiDAR Basics

Amplitudes of the transmitted and received signals (ts is the traveling time of the laser pulse)



LiDAR Basics



LiDAR Data

- LiDAR data is typically stored in a format called LAS.
  - This is a binary format
  - LAS is a public standard used by applications that process LiDAR data
  - There are four basic components
    - Header - Required
    - Variable Length Records (VLRs) - Optional
    - Point Data Records - Required
    - Extended Variable Length Records (EVLRs) - Optional

LiDAR Data

- Header: Basic summary information such as number and boundary of the points
- VLR: Map projection and other metadata
- Point Data Records: (x,y,z), intensity, return number, number of returns, scan direction, classification, GPS time, etc.
- EVLR: Waveform data

LiDAR Data

- Many existing LiDAR data sets are available, especially from government agencies, for example:
  - USGS: https://viewer.nationalmap.gov/basic/
  - NSF: https://www.neonscience.org/plasio-view-pointclouds
- These data sets typically come with viewers, and can also be downloaded for use in various tools for analysis and visualization
- This data might be useful, when combined with your own scan, to create new products

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UAV Basics

- Unmanned Aerial Vehicle (UAV) can refer to any aerial vehicle that is remotely piloted
    - Sometimes called drones
- This can range from radio-controlled model planes to military observation and attack drones
- UAVs may use any number of propulsion systems
- Control systems can be direct user control to pre-programmed flight to adaptive navigation, or a combination of all of these
- We will be looking at the more contemporary drone types which are most popular, and used widely in remote sensing

UAV Basics

- The basic UAV used for LiDAR is a multirotor device that can hover, and that is stable, easy to control, and has a reasonable payload capacity
- They may have 4 to 8 rotors
- They have become popular as hobbyist devices
  - These are not the ones that are used for LiDAR point cloud collection
- UAV sizes can range from palm of your hand to a few feet in diameter
- Most UAVs are electrically powered, but some use gasoline engines

UAV Basics

Mini UAV with camera

Hobbyist drone

Gasoline powered UAV

UAVs for LiDAR

- For use as a host for LiDAR for point cloud production, there are some important attributes that a UAV should have
  - Stability
  - Accurate control
  - Automated control capability
  - Ability to host the LiDAR package
  - Long duration operation

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UAVs for LiDAR

- May organizations using LiDAR for mapping and point cloud development do not need the capability on an on-going basis
  - There are companies that provide the LiDAR drones and operate them to the customer's specification
  - This can be very useful, as these companies have broad experience in the area and can provide useful expertise in all aspects of UAV operation and project planning
  - They also can afford to keep up with the latest in technology for both the UAV and the LiDAR system attached

UAVs for LiDAR

Notice the LiDAR payload underneath and the GPS antenna on top

- Today we reviewed the two unique components addressed in this class, LiDAR and UAVs.
- Tomorrow we will look at processing the data collected.

Thank you for attending

Please consider the resources below:

- Introductory Courses:
  - https://coast.noaa.gov/digitalcoast/training/intro-lidar.html
  - https://www.esri.com/training/catalog/search/
- National Map Data
  - https://catalog.data.gov/dataset/lidar-point-cloud-usgs-national-map

Thank You