ASEN 6365. Lidar Remote Sensing

Syllabus, Spring 2023

Lecture: 2:40−3:30 pm on Monday and Wednesday, and
11:45am—12:35pm on Friday
@ AERO 232 (Available for distance learning)

Canvas course: ASEN 6365-001, 001B at https://canvas.colorado.edu/

Instructor

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Office Hours: Monday and Wednesday 4—5pm over Zoom

Course Objective

LIDAR stands for "Light Detection and Ranging", commonly known as Laser Radar. It is not only replacing conventional sensors, but also creating new methods with unique properties that could not be achieved before. Lidar is extremely useful in atmospheric and environmental research as well as space exploration. It also has wide applications in industry, defense, and military.

For example, recent lidar observations made at McMurdo, Antarctica by the University of Colorado Boulder researchers and students have led to new science discoveries on thermosphere-ionosphere neutral metal layers and persistent gravity waves, which opens a new door to study the complex space-atmosphere interactions and coupled atmospheric processes that govern our planetary atmosphere and are essential to sustaining life. The new development in wind lidars, including both direct-detection and coherent-detection Doppler lidars, has enabled the applications of lidar for wind energy industry, aviation control, spacecraft positioning, and space monitoring of wind fields, etc. The spectroscopic methods applied in lidar systems are enabling identification of dangerous or pollutant species, easily finding wide applications in military, industry, environmental monitoring, and air quality control, etc.

Our class objectives are to provide:

1. Comprehensive, yet easily understandable, up-to-date understandings of lidar principles, technologies, and applications;
2. Approaches for quantitative lidar simulation, lidar sensitivity and error analysis, lidar data retrieval, lidar system design and performance analysis;
3. Opportunities to connect with lidar experts in the nation and world.

This class is based on the "Lidar Remote Sensing" classes offered in the past decade. In light of the new development of lidar technologies and applications through worldwide research, the course contents are updated to include new developments and directions, more sophisticated lidar simulation and sensitivity analysis, and possible new applications. Guest speakers will be invited from the world to present the lidar research in breadth. The class format will be interactive, engaging students in discussions.

Course Content

1. INTRODUCTION

A. Concept and classification of remote sensing

B. Overview of lidar remote sensing

2. FUNDAMENTALS OF LIDAR REMOTE SENSING

A. General picture of lidar remote sensing

B. General lidar equation

C. Physical processes involved in different lidars

D. General lidar architecture

E. General solutions of lidar equation

F. Laser Basics

3. LIDAR EQUATION, DATA INVERSION AND ERROR ANALYSIS

A. From photon counts to physical parameters using lidar equation

B. General data inversion procedure

C. General error analysis procedure

4. TOPICAL LIDARS AND THEIR APPLICATIONS

A. Lidars for Aerosol/Cloud Measurements

B. Lidars for Constituent Measurements

C. Lidars for Temperature Measurements

D. Lidars for Wind Measurements

E. Lidars for Solid Target Detection

F. Laser Range Finding / Laser Altimeter

G. CW-Laser Imaging Lidars

5. LIDAR DESIGN AND PERFORMANCE ANALYSIS

A. Overall Considerations

B. Transmitter Considerations

C. Receiver and Data Acquisition Considerations

D. Lidar Performance Analysis and Simulation

6. LIDAR FUTURE OUTLOOK

Where will we go from here? Open discussions with students and experts will provide an overview for possible future development and application of laser remote sensing technologies.

Texts

Required Textbook:

- Laser Remote Sensing, Edited by Takshi Fujii and Tetsuo Fukuchi, Published by CRC Press, Taylor & Francis Group, ISBN: 0-8247-4256-7, 2005. The eBook version of Laser Remote Sensing is available through the University library.

This text was chosen for its frontier descriptions of modern lidars and applications. During the course of the semester chapters will be assigned for reading requirements. Supplementary material will also be provided during the course to provide more clarity or depth to a topic. There are some books on lidars that you can access through the Engineering Library to provide a different point of view on the material we will cover in class. Several recommended books are

- Atmospheric Lidar Fundamentals: Laser Light Scattering from Atoms and Linear Molecules, by Chiao-Yao She and Jonathan S. Friedman, Cambridge University Press, ISBN 978-1-316-51823-6, 2022.
- Lidar: Range-resolved optical remote sensing of the atmosphere, edited by Claus Weitkamp, published by Springer, ISBN: 0-387-40075-3, 2005.
- Laser Remote Sensing: Fundamentals and Applications, by Raymond M. Measures, Wiley-Interscience, New York, ISBN: 0-89464-619-2, 1984.
- Solid-State Laser Engineering, by Walter Koechner, Springer, e-ISBN: 0-387-29338-8, 2006.

Course Grading

10	HW Reports
40	HW Projects
20	Midterm Exam
30	Final Projects
100	Total