Course Description

This course will introduce the fundamentals of Distributed Fiber-optic Sensing (DFOS) technologies, including the measuring principles, calibration process, advantages and limitations. The students will be introduced to three major technologies of DFOS: distributed acoustic sensing (DAS), distributed temperature sensing (DTS), and distributed strain sensing (DSS). The course will explore the recent development of DFOS applications in geophysics, oil industry, smart city, and other fields.

Learning Outcomes

1. Students will learn the principle, advantage, and limitation of DFOS systems.
2. Students will review recent DFOS application development.
3. Students will be able to apply the theories to realistic DFOS applications.
4. Students will be able to learn how to handle, process, visualize DFOS data using Python programming language.
5. Students will be able to perform DFOS data analysis to obtain required results.

Assessments

1. Lab (40%): open source DAS and DTS data will be provided to the students for realistic data analysis. Some hands-up section will be arranged using the department instruments to demonstrate data acquisition and real-time visualization. The collected data will be used for the lab sections.
2. Literature review and discussion (30%): each student will present a recent DFOS application paper at least once during the semester. Every other week a paper will be presented and discussed during the class.
3. Final project (30%): the student will design a small data analysis project using open-source datasets or data recorded during the course.

Recommended Resources

- Hartog, A.H., 2017. *An introduction to distributed optical fibre sensors*. CRC press.
    - Recommended but optional

Course Outline

- Introduction to DFOS
    - Distributed measurement vs point measurement
    - DFOS performance criteria and trade-offs
- Optical fiber technology
    - Fiber structure and types
    - Key elements of an optical system
    - Elastic and inelastic back scatters
    - OTDR introduction
- Distributed Acoustic Sensing
    - Coherent Rayleigh backscatter
    - Amplitude-based DAS system

    - Phase-based DAS system
    - DAS applications
        - Geophysics
        - Smart city
- Distributed Temperature Sensing
    - Raman scattering
    - DTS system calibration
    - Single-ended and double-ended system
    - DTS applications
        - Reservoir monitoring
        - Hydrology applications
- Distributed Strain Sensing
    - Brillouin-based DSS
    - Rayleigh frequency shift based DSS
    - Applications
        - Well integrity monitoring
        - Civil engineer applications