SE 167GS – Signal Processing and Spectral Analysis
Under the UC San Diego Global Seminar:
How Shaky Structures Become the Safest Structures in Taiwan

Summer Session II
Course Syllabus

Instructor: Prof. Chin-Hsiung Loh
cloh@ucsd.edu

Dates: Instruction begins Monday, August 5, 2024
Instruction ends Friday, September 6, 2024

Format: SE 167GS will be taught in Taiwan – at the National Taiwan University (NTU) and the National Center for Research on Earthquake Engineering (NCREE) in Taipei – to allow students to see and gain hands-on experiences in relevant course topics.

Office hours: Available anytime by e-mail appointment
In-person office hours TBD
Instructor: Prof. C.H. Loh, kenloh@ucsd.edu

Course Description:

The field of signal processing is a well-developed discipline with solid theoretical and methodological foundations. In the analysis, design, and assessment of large and complex systems, the effective utilization of the capabilities provided by recent developments in digital technology and signal processing become very important. This course involved basic theoretical discussions of different signal processing methods Besides, this course will equip students with the knowledgebase on how to manage digital data and how to extract features from signal measurements using MATLAB tools. MATLAB code for each signal analysis will be introduced and applied to each lecture topic. This course also discusses techniques to analyze signals (or data), particularly related to structural dynamic response data focusing on time/frequency domain data analyses (Fourier transform, digital filtering, and time-frequency analysis), and included hands-on computer programming lab exercises and assignments to enhance learning.

Learning Objectives:

1. Students will understand and apply signal processing techniques in both time and frequency domains.
2. Students will know how to treat and process data collected from sensors (dynamic systems) and be able to extract features (physical meaning) from data.
3. Students will utilize signal processing techniques to explain and enhance the quality of measured data.
4. Students will use experimental data to identify the features contained in the data (for example: the dynamic characteristic of a building).

Course Requirements:

- Regular attendance in lectures
- Homework assignments
- Matlab coding assignments
- Final project

Academic Integrity:

Academic dishonesty and plagiarism are taken very seriously, and any <u>suspicions</u> of these activities will be immediately and directly reported to Academic Integrity Office.

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Course Topics

1. Introduction of random data, basic concept of Fourier Transform (FT)
2. Concept of Signal Convolution & Correlation, Sampling theorem,
3. Discrete Fourier Transform, Fast Fourier Transform (FFT), Short-Time Fourier transform (Homework)
4. Power spectral density, Input-output relationships in frequency domain (Homework),
5. Frequency Domain Decomposition (Homework)
6. Low-pass filter: time domain data analysis (Homework)
7. (Integration technique algorithm)
8. Time-domain signal decomposition: Singular spectrum analysis (Homework)
9. EMD and Hilbert Transform: Instantaneous frequency (Homework)
10. Time-Frequency Analysis: Continuous Wavelet Transform (CWT), (Homework)
11. Time-Frequency Analysis: Wavelet Packet Transform (WPT), (Homework)
12. Concept of Digital filter (Application of ARX model on structural system identification)
13. Online structural system Identification (Recursive ARX model) (Homework)
14. Damage assessment of structure using vibration-based signals
15. Covariance-driven Stochastic Subspace Identification (Output-only measurement)
16. Subspace Identification using input/output response data