Course Information	
Course title	Modern Spectral Analysis
Semester	110-2
Designated for	COLLEGE OF ELECTRICAL ENGINEERING AND COMPUTER SCIENCE GRADUATE INSTITUTE OF COMMUNICATION ENGINEERING
Instructor	CHUN-LIN LIU
Curriculum Number	EE5147
Curriculum Identity Number	921 U9640
Credits	3.0

Course Syllabus	
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Course Description	The heart of signal processing resides in analyzing signals from various perspectives. A common, yet important approach is to study the frequency components or the spectra of signals. This approach finds applications in communication, radar, sensor array processing, acoustics, and image processing. This course aims to cover some advanced methods that were developed to infer the spectral information of signals. This course contains two parts. The first part concentrates on recovering the power spectral density of wide-sense stationary processes. They can be divided into nonparametric methods and parametric methods. The second part covers some recent advances in the spectral analysis of signals. The topics include sub-Nyquist sampling, compressed sensing, and sparse recovery algorithms. Part 1: Spectral analysis for WSS random processes - Signal representation: Random processes - Nonparametric methods: Periodogram and its extensions - Parametric methods for line spectra: MUSIC, ESPRIT, etc. - Performance analysis: Estimation theory, MSE, CRB, etc. - Applications in array signal processing Part 2: Spectral analysis with sub-Nyquist sampling and compressed sensing

	- Sparse sampling: random sampling, etc. - Recoverability of sparse vectors: Kruskal's rank, spark, etc. - Sparse recovery algorithms: \ell_0, matching pursuit, orthogonal matching pursuit, basis pursuit, LASSO, and their extensions - Performance analysis - Applications
Course Objective	Analysis of the spectral information of signals using modern methods.
Course Requirement	This is an advanced course in signal processing. The following background courses (or background keywords) are suggested for this course. Linear Algebra: Orthogonality, eigen-decomposition, Hermitian matrices, norm, dual norm, and matrix norms. Adaptive Signal Processing: Stochastic models (AR, MA, ARMA), Wiener filters, linear prediction, and adaptive beamforming. Convex Optimization: Convex functions, convex problems, dual problems, and semidefinite programming. This following course is optional: Detection and Estimation Theory: Parameter estimation, (un)biasness, mean-square-error (MSE), and maximum likelihood estimation (MLE).
References	[1] P. Stoica and R. Moses, Spectral Analysis of Signals, Upper Saddle River, N.J. : Pearson/Prentice Hall, 2005. [2] D. G. Manolakis, V. K. Ingle, and S. M. Kogon, Statistical and Adaptive Signal Processing Spectral Estimation, Signal Modeling, Adaptive Filtering, and Array Processing, Artech House, 2005. [3] S. Foucart and H. Rauhut, A Mathematical Introduction to Compressive Sensing, New York, NY : Springer, 2013. [4] D. H. Johnson and D. E. Dudgeon, Array Signal Processing: Concepts and Techniques. Addison Wesley Pub. Co. Inc., pp. 1, 1993. [5] H. L. Van Trees, Optimum Array Processing: Part IV of Detection, Estimation, and Modulation Theory. Hoboken, NJ, USA: Wiley, 2002.