课程大纲

COURSE SYLLABUS

1.	课程名称(中英文) **Course Title(Chinese and English)**	Detection and Estimation Theory 信号检测与估计
2.	课程类别 **Course Type**	专业课
3.	授课院系 **Originating Department**	电子与电气工程系
4.	可选课学生所属院系 **Open to Which Majors**	本专业
5.	课程学时 **Credit Hours**	48
6.	课程学分 **Credit Value**	3
7.	授课语言 **Teaching Language**	中文授课
8.	授课教师 **Instructor(s)** （如果是一个课题组共同讲授的，请标明 MI 以及其他构成成员。）	唐晓颖
9.	先修课程、其它学习要求 **Pre-requisites or Other Academic Requirements**	Digital Signal Processing, Random Processes
10.	教学目标 **Course Objectives**	

Parameter estimation. Least-square, mean-square, and minimum-variance estimators. Maximum A Posteriori (MAP) and Maximum-Likelihood (ML) estimators. Bayes estimation. Cramer-Rao lower bound. Continuous and discrete time detection and estimation.

Students are expected to be able to :
1. Determine if a minimum variance unbiased estimator (MVUE) exists & compute it
2. Determine if an efficient estimator exists and compute it
3. Compute the Cramer-Rao lower bound for scalar and vector cases
4. Compute MVUE for linear models
5. Compute maximum likelihood estimator
6. Compute the linear least-squares estimator
7. Compute various Bayesian estimators including the minimum mean square error estimator and the maximum aposteriori estimator
8. Apply theory and estimation algorithms learned in class to real-world examples

11.	教学方法及授课创新点 **Teaching Methods and Innovations**

Considering that I have many years of industry experience in designing adaptive equalizers and carrier and symbol timing recovery tracking algorithms at the receiver, and building the nonlinear polynomial model (or Volterra series) of the power amplifiers at the transmitter, I present a proposal to this course by adding some practical algorithms that are used and developed in modern digital communications, especially in Chapters 7 & 10 of *maximum likelihood* and *least squares estimations*. The purpose for adding these practical algorithms is to tell students why and how the ML and LS estimation methods are used in modern digital communication systems in order to enhance their interest in this course. The contents of the proposal for these two Chapters are described as follows:

1. Maximum Likelihood (ML) Estimation (Ch.7)

A typical application of ML estimation is the optimum detector in digital communications. A new teaching method that I would plan in this chapter is to apply the ML estimation to the optimum detector at the receiver of digital communication systems.

The maximum of likelihood function over the transmitted *n*th signal symbol is equivalent to minimize the Euclidean distance when the transmitted *M* signal symbols are equally probably a priori probability. Euclidean means to find one of the transmitted signal symbols, which is closest in distance to the currently received signal symbols. Furthermore, the minimum of the Euclidean distance is equivalent to the largest correlation metric at the receiver, called the correlation based optimum receiver that is widely used in digital communications.

Next content would be added in this Chapter is carrier frequency offset (CFO) estimation in OFDM systems by using ML estimation based on training symbols in the received frame. This ML based estimation is widely used in the IEEE 802.11 Wi-Fi OFDM signal reception to achieve the fast and accurate CFO estimation.

2. Least Squares (LS) Estimation (Ch. 8)

Besides teaching the content required in this topic, I also plan to add one practical design example by using the LS estimation to solve the practical problem of the nonlinear behavioral modelling for the power amplifier. This practical example is to extract the coefficients of the Volterra series that is used to approximate to the power amplifier's characteristics from the measured (or collected) data at the input and output of the power amplifier. This behavioral model is widely used for linearizing power amplifier in order to compensate for the power amplifier's nonlinear property by inserting a predistorter prior to the power amplifier. Thus, students could obtain the latest knowledge how to model a nonlinear device in practice by using LS algorithm. Actually, Chapter 5 of my book describes the LS algorithm in more detail.

Note: Teaching new contents above in these two Chapters will be limited within the required time period or the total of 3 weeks if extra time is not allowed.

12.	教学内容及学时分配 **Course Contents and Course Schedule**

1. Minimum Variance Unbiased Estimation (MVU) (Ch.2) : ~ 1 week
2. Cramer-Rao Lower Bound (scalar & vector cases) (Ch.3) : ~ 2 weeks
3. Linear Models (Ch.4) : ~ 1 week
4. Sufficient Statistics, Neyman-Fisher Factorization Theorem (Ch.5) : ~1 week
5. Best Linear Unbiased Estimators (BLUE) (Ch.6) : ~ 1 week
6. Maximum Likelihood Estimation (Ch.7) : ~ 2 weeks
7. Least Squares Estimation – Geometrical Interpretations (Ch.8) : ~ 1 week
8. Bayesian Estimation (Ch.10) : ~ 1 week
9. Maximum Aposteriori (MAP) Estimation (Ch.11) : ~ 1 week
10. Linear Minimum Mean Square Error (LMMSE) Estimation (Ch.12) : ~ 2 weeks
11. Overview of Detection Techniques : ~ 1 week

13.	课程考核 **Course Assessment**

	20% Homework 20% Midterm 20% Project 40% Final Exam
14.	教材及其它参考资料 **Textbook and Supplementary Readings**
	Fundamentals of Statistical Signal Processing : Estimation Theory by Steven Kay. Volume I, Prentice Hall, 1993 I suggest one another reference textbook to this course, which was revised a few years ago. “Detection, Estimation, and Modulation Theory”, Part 1- detection, estimation, and filtering theory. Harry L. Van Trees, Wiley, 2013