课程大纲
COURSE SYLLABUS

1.	**课程代码/名称** **Course Code/Title**	**现代信号处理** **Modern signal processing**
2.	**课程性质** **Compulsory/Elective**	专业核心课
3.	**课程学分/学时** **Course Credit/Hours**	3/48
4.	**授课语言** **Teaching Language**	英文
5.	**授课教师** **Instructor(s)**	唐晓颖
6.	**是否面向本科生开放** **Open to undergraduates or not**	否
7.	**先修要求** **Pre-requisites**	（如面向本科生开放，请注明区分内容。 If the course is open to undergraduates, please indicate the difference.） 研究生先修要求：Digital Signal Processing，Random Processes

8. **教学目标**
Course Objectives

（如面向本科生开放，请注明区分内容。 If the course is open to undergraduates, please indicate the difference.）

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

9. **教学方法**
Teaching Methods

（如面向本科生开放，请注明区分内容。 If the course is open to undergraduates, please indicate the difference.）

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 nth 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.

10. 教学内容
Course Contents
（如面向本科生开放，请注明区分内容。 If the course is open to undergraduates, please indicate the difference.）

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

		weeks
	Section 11	Overview of Detection Techniques : ~ 1 week
11.	课程考核 **Course Assessment**	
	（①考核形式 Form of examination；②.分数构成 grading policy；③如面向本科生开放，请注明区分内容。If the course is open to undergraduates, please indicate the difference.） 20% Homework 20% Midterm 20% Project 40% Final Exam	
12.	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	