课程大纲
COURSE SYLLABUS

1.	**课程代码/名称** **Course Code/Title**	**统计前沿选讲 III / Selected Topics in Frontiers of Statistics III** **STA5103**
2.	**课程性质** **Compulsory/Elective**	专业选修课 Major Elective Courses
3.	**开课单位** **Offering Dept.**	**统计与数据科学系** Department of Statistics and Data Science
4.	**课程学分/学时** **Course Credit/Hours**	48
5.	**授课语言** **Teaching Language**	英文 English
6.	**授课教师** **Instructor(s)**	王超 WANG Chao
7.	**开课学期** **Semester**	秋季 Fall Semester
8.	**是否面向本科生开放** **Open to undergraduates or not**	是
9.	**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.） 运筹与优化（STA201）或者 最优化理论与方法（MA433） Operational Research and Optimization (STA201) OR Optimization Theory and Method (MA433)

10. 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.）

本课程旨在使研究生学习和掌握图像处理中常用的统计与数学方法，包括傅立叶变换，凸优化，贝叶斯估计，机器学习等，使其能够应用这些数学方法解决实际图像处理问题，并具备开展相关研究的能力。基本目标是教会学生掌握图像处理中的各类统计与数学方法，培养学生的统计学思维和数学分析能力，并为后续关于图像应用方面的研究打下良好的基础。

This course aims to enable graduate students to learn and master commonly used statistical and mathematical methods in image processing, including Fourier transform, convex optimization, Bayesian estimation, machine learning, etc., so that they can apply these mathematical methods to solve practical image processing problems and have the ability to conduct related research. The basic goal is to teach students to master various statistical and mathematical methods in image processing, cultivate students' statistical thinking and mathematical analysis ability, and lay a good foundation for subsequent research on image applications.

11. 教学方法
Teaching Methods

本课程将采用讲授、案例分析等多种教学方法相结合，旨在让学生通过课堂讲解和案例实践，更好地理解和掌握所学知识。特别是，在学习本课程后，学生应该能够

1.掌握基本知识，深入理解和掌握图像处理中的各种概念和统计数学方法的本质。学生应该能够不仅记住概念，也要学会模型与算法， 同时能深刻理解如何利用这些工具解决问题。

2.掌握基本技能，并能正确的进行图像重建与图像分析。培养思维能力，提高对数据的分析能力，乃至概括的能力。

3.提高解决实际问题的能力。学习本课程后,学生应该能够使用学到的知识对实际问题建立合理模型，从而解决相关的图像处理问题。

This course will use a combination of teaching methods, including lectures, and case studies. The aim is to help students better understand and master the knowledge through classroom teaching and case practice. After studying this course, students should be able to

1. Master the basic knowledge, deeply understand and master the various concepts and statistical or mathematical approaches. Students should be able to remember not only concepts, but also basic models and algorithms, while also having a deep understanding of how to use these techniques to solve problems.

2. Master basic skills and perform image reconstruction and classification analysis correctly. Develop thinking skills, improve the ability to analyse data, and even generalize.

3. Improve the ability to solve practical problems. After studying this course, students should be able to use their acquired knowledge to develop a reasonable model of the actual problem to solve the relevant image processing problems.

12. 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	1 介绍 （2 hours） 1. Introduction (2 hours)
Section 2	2 数学预备知识 （4 hours） 1.1 傅立叶变换与滤波 1.2 去卷积 1.3 线性方程与反问题 2 Math Prerequisite（4 hours） 2.1 Fourier Transform and Filtering 2.2 Deconvolution 2.3 Linear System and Inverse Problems
Section 3	3 图像解卷积(8 hours) 3.1 逆/维纳滤波器 3.2 逆问题的贝叶斯视角 3.3 全变分 3.4 半二次分裂法 3.5 交替方向乘子法 3 Image Deconvolution（8 hours） 3.1 Inverse/Wiener filtering 3.2 A Bayesian perspective of inverse problems 3.3 Total variation 3.4 The half-quadratic splitting (HQS) method 3.5 Alternating Direction Method of Multipliers
Section 4	4 图像恢复的变分方法（16 小时） 4.1 凸分析

	4.2 图像去模糊 4.3 正则化 4.4 解决变分模型 4.5 基于块的方法 4 Variational Methods for Image Restoration（16 hours） 4.1 Convex analysis 4.2 Image deblurring 4.3 Regularization 4.4 Solving variational models 4.5 Patch-based methods
Section 5	5 图像处理中的数据驱动方法（12 小时） 5.1 神经网络的介绍 5.2 半监督学习与图像分类 5.3 自编码与图像去噪 5.4 基于物理驱动的神经网络 5 Data-driven Methods in Image Processing (12 hours) 5.1 Introduction to neural networks 5.2 Semi-supervised learning and image classification. 5.3 Autoencoders and image denoising 5.4 Physics-driven neural networks
Section 6	6. 节选额外内容（6 小时） 6.1 CT 图像重建的展开动力学 6.2 目标检测的张量分解方法 6. Selection of Additional Topics (6 hours) 6.1 Unrolling dynamics for CT Image reconstruction 6.2 Tensor decomposition for object detection

13. 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.）

平时成绩 General assessment（小测验以及作业, Quiz & Homework） 50%
期末项目 Final project 50%

14. 教材及其它参考资料
Textbook and Supplementary Readings

1. Image processing: the fundamentals by Maria Petrou and Costas Petrou
2. Fundamentals of Digital Image Processing: A Practical Approach with Examples in Matlab by Chris Solomon and Toby Breckon
3. Digital Image Processing (3rd ed.) by Rafael C. Gonzalez and Richard E. Woods