NATIONAL UNIVERSITY OF SAN MARCOS

FACULTY OF MATHEMATICAL SCIENCES

SYLLABUS

1. GENERAL INFORMATION

1.1 Course name	:	Statistical Learning Theory
1.2 Code	:	MA355
1.3 Academic Program	:	Scientific Computing
1.4 Credits	:	4
1.5 Prerrequisites	:	• MA352. Stochastic processes. (8^{th} Sem) • MA372. Functional analysis II. (8^{th} Sem)
1.6 Type of Course	:	Elective
1.7 Area of Studies	:	Estudios Generales
1.8 Number of Weeks	:	16
1.9 Hours per week	:	2 HT; 4 HP;
1.10 Cycle	:	I
1.11 Learning modality	:	Face to face
1.12 Academic Period	:	2026-I
1.13 Semester Start Date	:	
1.14 Semester End Date	:	

2. PROFESSORS

Meetings after coordination with the professor

3. INTRODUCTION TO THE COURSE

This course provides the theoretical foundations of statistical learning, covering the mathematical principles that support machine learning algorithms. It focuses on the theoretical analysis of generalization capability, model complexity, and performance guarantees for various learning methods. The course connects theory with practice through the study of generalization bounds, bias-variance tradeoff, and foundations of computational learning theory.

4. GOALS

- Understand the fundamentals of statistical learning theory and its probabilistic foundations.
- Analyze the bias-variance tradeoff in the selection and evaluation of machine learning models.
- Apply Vapnik-Chervonenkis (VC) theory to analyze model complexity and generalization capability.
- Develop and demonstrate generalization bounds for different learning algorithms.
- Connect theoretical principles with the practical implementation of statistical learning algorithms.

5. COMPETENCES

ABET-1) An ability to identify, formulate, and solve broadly defined technical or scientific problems by applying knowledge of mathematics and science and/or technical topics to areas relevant to the discipline. (Usage)

ABET-3) An ability to develop and conduct experiments or test hypotheses, analyze and interpret data, and use scientific judgment to draw conclusions. (Usage)

6. TOPICS

Unit 1: Foundations of Statistical Learning (20 hours)	
Competences Expected: ABET-1,ABET-3	
Topics	**Learning Outcomes**
• Bias-variance tradeoff • Vapnik-Chervonenkis (VC) theory • Empirical risk minimization • Generalization bounds • Learning theory fundamentals	• Analyze the bias-variance tradeoff in model selection [Assessment] • Apply VC theory to analyze model complexity [Usage] • Implement empirical risk minimization [Usage] • Interpret generalization bounds [Familiarity]
Readings : [**Vapnik1998**], [**Hastie2009**]	

Unit 2: Supervised Learning Methods (20 hours)	
Competences Expected: ABET-1,ABET-3	
Topics	**Learning Outcomes**
• Linear models and extensions • Support Vector Machines (SVM) • Decision trees and ensemble methods • Kernel methods • Probabilistic supervised learning	• Implement and analyze linear models [Usage] • Apply SVM for classification and regression [Usage] • Construct ensemble methods (bagging, boosting) [Usage] • Use kernel methods for nonlinear problems [Usage]
Readings : [**Hastie2009**], [**James2013**]	

Unit 3: Unsupervised Learning Methods (20 hours)	
Competences Expected: ABET-1,ABET-3	
Topics	**Learning Outcomes**
• Clustering algorithms (k-means, hierarchical) • Dimensionality reduction (PCA, t-SNE) • Density estimation • Manifold learning • Autoencoders and deep unsupervised learning	• Apply clustering algorithms to data exploration [Usage] • Implement PCA and other dimensionality reduction methods [Usage] • Use density estimation for unsupervised learning [Usage] • Analyze manifold learning techniques [Assessment]
Readings : [**Murphy2012**], [**Bishop2006**]	

Unit 4: Model Evaluation and Selection (20 hours)	
Competences Expected: ABET-1,ABET-3	
Topics	**Learning Outcomes**
• Cross-validation strategies • Performance metrics for classification and regression • Model comparison and statistical tests • Hyperparameter optimization • Learning curves and diagnostic tools	• Implement cross-validation for model assessment [Usage] • Select appropriate performance metrics [Assessment] • Compare models using statistical tests [Usage] • Optimize hyperparameters using systematic methods [Usage]
Readings : [**Hastie2009**], [**James2013**]	

7. WORKPLAN

7.1 Methodology

Individual and team participation is encouraged to present their ideas, motivating them with additional points in the different stages of the course evaluation.

7.2 Theory Sessions

The theory sessions are held in master classes with activities including active learning and roleplay to allow students to internalize the concepts.

7.3 Practical Sessions

The practical sessions are held in class where a series of exercises and/or practical concepts are developed through problem solving, problem solving, specific exercises and/or in application contexts.

8. EVALUATION SYSTEM

********* EVALUATION MISSING ********

9. BASIC BIBLIOGRAPHY