Master's Department of Engineering Sciences

MSc in Automation Engineering and Robotics

Name of the unit: Statistics for Evidence-Based Engineering

Lecturer: Stéphane Genet (stephane.genet@upmc.fr)
Course code:
Student workload: 12 h of lectures, 9 h of tutorials, 7 h of labs
Credits: 3 ECTS
Specialization tracks: ☒ ROBOT (elective) ☐ SI ☒ MeDH
Semester offered: ☐ S1 ☐ S2 ☒ S3 ☐ S4
Language of instruction: ☐ French ☒ English
Targeted audience: ☒ Engineering Sciences students ☐ Other (specify):
Localization : ☒ PMC Campus ☐ Other (specify):

Course Overview

In a world full of noise, statistical methods are indispensable, and drawing reliable conclusions without them is impossible. This course focuses on the creation of protocols and statistical analysis of results for small sample sizes in human-interactive systems. Students will learn to understand and manage variability, enabling them to evaluate intelligent systems effectively. Emphasis will be placed on designing robust experiments and applying appropriate statistical methods to analyze and interpret data. The course will also introduce Bayesian statistics, providing a comprehensive foundation for advanced statistical approaches in evidence-based human-interactive systems.
Keywords: Protocol Design, Statistical Analysis, Small Sample Sizes, Variability Management, Intelligent Systems Evaluation, Bayesian Statistics

Prerequisites

Students should have previously acquired the following prerequisites to follow this course:

- Analysis of a function of R in R, integration
- Basics of linear algebra (vector, matrix)
- Fundamentals of probability theory: - The two Bayes' formulas - Law of large numbers - Combinatorial analysis - Central limit theorem
- Discrete and continuous random variables
- Familiarity with the Laplace-Gauss law, Bernoulli law, binomial law, Poisson law
- Programming

Intended Learning Outcomes

By the end of this course, students will be able to:

1. 1. Understand and Manage Variability: • Take into account variability in result analysis. • Recognize that biological measurements often have a standard deviation of the same order as their mean. • Infer the effect size to select an appropriate sample size.
2. Apply Statistical Testing: • Identify the relevant statistical test based on the research question (number of random variables and factors). • Know and apply classical tests (Student's t-test, ANOVA, MANOVA, Chi-square, regressions). • Use generalized linear models to study repeated measures.
3. Formulate and Analyze Hypotheses: • Propose a protocol and corresponding analysis based on a hypothesis (experimental design, statistical methods). • Reason probabilistically about events. • Understand that proving a hypothesis as true is impossible due to the infinite population size; focus on proving a probability.

4. Implement Bayesian Statistics: • Understand Bayesian statistical tests corresponding to classical tests and their limitations. • Conduct Bayesian analysis using JASP in the final project

Indicative Teaching Sequence and Methods

Week	C/TD/TP*	Content	Preparation	Learn. outc.
S1	C1-C2	Introduction to Statistics and Variability (2 hours) • Understanding variability and its implications • Basics of statistical methods 2. Probability Theory and Event Analysis (2 hours) • Fundamental probability concepts • Applications in statistical reasoning		
S2	C3-C4	Experimental Design and Hypothesis Testing (2 hours) • Creating protocols and analyzing hypotheses • Experimental design principles Classical Statistical Tests (2 hours) • Overview of classical tests (Student, ANOVA, MANOVA, Chi-square, regressions) • Selection criteria based on research questions		
S3	C4-C6	Generalized Linear Models (2 hours) • Introduction to GLMs for repeated measures • Practical applications Introduction to Bayesian Statistics (2 hours) • Basics of Bayesian methods • Comparison with classical approaches		
S4	TD			
S5	TP			
S6	Project review			

* C/TD/TP respectively corresponds to lectures, tutorials and lab sessions.

Indicative Assessment of Intended Learning Outcomes (1st session)

Week	Individ./group	In-person/remote	Type of exam	Evaluated outcomes	Scale %
S15	Individual	Remote	Other	AAV1	100 %

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Session	Individ./group	In-person/remote	Type of exam	Evaluated outcomes	Scale %
2	Group	In-person	Written exam	AAV 1-10	50 %
1	Group	In-person	Quiz	AAV1-8	50 %

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