FSAB1105 Probability and statistics

[30h+30h exercises] 5 credits

This course is taught in the 2nd semester

Teacher(s): Bernadette Govaerts, Rainer von Sachs
Language: French
Level: First cycle

Aims

At the end of this course, the student will be able to:
-understand and know how to apply to various situations the basic concepts of probability and statistical inference,
-adopt an efficient methodological approach for setting-up a statistical experiment design,
-develop simple probabilistic or empirical models for given observed phenomena and integrate these models into simulations.

Main themes

Foundations of probability (10-8):
-Notion of and elementary calculus of probabilities; event, basic formulae for calculating probabilities, combinatorics, conditional probabilities, Bayes theorem, independence.
-Random variables: discrete and continuous random variables, probability distribution, distribution function, quantiles, expected values, variance, moments of k-th order, moment generating function.
-Classical probability laws: Bernoulli, uniform (discrete and continuous), binomial, Poisson, hypergeometric, normal, exponential, gamma, beta, Weibull.
-Bivariate random vectors: bivariate distribution, marginal and conditional distribution, conditional expectation and variance, independence of random variables, covariance and correlation, variance-covariance matrix., generalisation to the k-variate case.
-Transformation of random variables: linear and non-linear transformations of one variable, linear transformation of random vectors, expectation and variance of functions of random variables, linear combinations of common random variables.
Foundations of statistical inference (10-8):
-Point estimation and fitting of distributions: definition, quality of an estimator (bias, efficiency), method of moment estimation, maximum likelihood method, least-squares method.
-Limit theorems: Central Limit Theorem, Law of Large Numbers;
-Q-Q-plots; chi-square test of goodness-of-fit.
-Confidence intervals: definition, construction using the method of pivotal functions, asymptotic confidence intervals.
-Hypothesis tests: concepts of hypotheses, general development of a test statistic and a decision rule, type 1 and type 2 error, p-value, # Tests and confidence intervals for one or two samples in a normal population and for one or two proportions.
Statistical methods in engineering (8-10):
-Exploratory data analysis: mean, variance, standard deviation, median, interquartile range, correlation, #Graphical summary of data: histogram, box plot, point clouds, X-Y-graphical plots, scatter plot matrix, #Interpretation and efficient use of these methods with software such as MATLAB or R.
-Empirical modelling: linear regression (polynomial and multiple): model, least squares estimation, interpretation, tests and confidence intervals for the parameters, prediction, measures of goodness-of-fit, analysis of residuals.
-Introduction to the notion of design of experiments: factorial and composite plans, estimation of experimental variance, randomisation, calculation of sample size, etc.
-Analysis of Variance (one factor ANOVA): fixed model, as generalisation of a two-sample mean test; random model, for the estimation of the variance components.

Content and teaching methods

Content and teaching methods
This course presents first the fundamental concepts of probability and statistics useful to solve simple engineering problems and to be able to follow more advanced courses.
- Foundation in probability : notion of and elementary calculus of probabilities, random variables, classical probability laws, random vectors, transformation of random variables, limit theorems.
- Foundations of statistical inference : point estimation and fitting of distributions, estimation by confidence intervals, hypothesis testing, tests and confidence intervals for one or two samples in a normal population and for one or two proportions, sample size calculation.
The course presents also essential tools for the engineer which will be responsible to organise experiments or take decisions from data:
- Exploratory data analysis: position, dispersion and correlation indices, graphical summaries for quantitative variables.
- Empirical modelling: polynomial and multiple linear regression.
- Introduction to the notion of design of experiments.
- One factor analysis of variance.
The pedagogical approach encourages the student to work personally and have an active participation during the courses

Other information (prerequisite, evaluation (assessment methods), course materials recommended readings, ...)

Prerequisite
Linear algebra and basic calculus. Notions of Matlab or R
The course is made of several types of activities :
- oral presentations of the methodological concepts based on examples coming from the engineering world
- exercises sessions where the student will be able to apply systematically the concepts presented in the course on well chosen examples.
- case studies where the student will be able to apply the statistical tools to real world data using software like Matlab or R

Other credits in programs

FSA12BA	Deuxième année de bachelier en sciences de l'ingénieur, orientation ingénieur civil	(5 credits)	Mandatory
FSA13BA	Troisième année de bachelier en sciences de l'ingénieur, orientation ingénieur civil	(5 credits)	