




Teaching methods	The class consists of lectures (30h) and exercise sessions (15h)
Content	<p>The course outline is as follows:</p> <ul style="list-style-type: none"> • Part I: <ul style="list-style-type: none"> • Basics of one-dimensional function optimization. Special case: the likelihood function. • Global vs local optima; numerical convergence and approximation errors. • Challenges of optimizing multi-dimensional functions. Special cases: linear and generalized linear models and computing the multivariate normal density (link with LSTAT2120, 2100, 2110, 2040). • Newton's method, Fisher scoring and IRLS. • Non-linear functions and numerical differentiation. • Case study: <code>?optim()</code>, <code>?nlm()</code>, <code>?deriv()</code> and friends. • The EM algorithm. Special cases: missing data, normal mixture models and linear mixed models (link with LSTAT2210). • Part II: <ul style="list-style-type: none"> • Setting up controlled simulation studies: competitor selection, performance metrics and reproducibility. • Sampling from distributions and DGPs. • Case study I: Sample mean (mean, median, trimmed mean from normal and skewed distributions); German tank problem (estimators from slide LSTAT 2040) - mean, bias, MSE, RE. • Case study II: t-test (size, power, coverage and length for CIs) and Binomial test (Tables from slides LSTAT 2040). • Case study III: GLM variable selection (TPR, FPR, FDR). • Parallel computing in R: <code>doParallel</code>, <code>foreach</code>, <code>mclapply</code> and friends to illustrate Case study I-III. • Part III: <ul style="list-style-type: none"> • Bootstrap and resampling methods. • Bias and variance approximation based on resampling. • Bootstrap confidence intervals and hypothesis testing. • Other techniques: Permutation tests and Jackknife
Inline resources	<p>Slides and notes on Moodle.</p> <p>Moodle website of the class :LSTAT2185 - Numerical Methods for Statistics: Optimization, Simulations and the Bootstrap</p> <p>https://moodle.uclouvain.be/course/view.php?id=5785</p>
Bibliography	<p>Givens, G.H. and Hoeting. J.A. (2013). Computational Statistics (2nd ed). Wiley.</p> <p>Rizzo, M.L. (2007). Statistical Computing with R (2nd ed). Chapman & Hall /CRC.</p> <p>Gentle, J.E. (2009). Computational Statistics. Springer.</p> <p>Lange, K. (2010). Numerical Analysis for Statisticians (2nd ed). Springer.</p> <p>Peng, R.D. (2020+). Advanced Statistical Computing. Available at https://bookdown.org/rdpeng/advstatcomp/</p> <p>Chernick, M.R. (2008). Bootstrap methods : a guide for practitioners and researchers, Wiley Series in Probability and Statistics.</p> <p>Davison, A.C. et Hinkley, D.V. (1997). Bootstrap Methods and their Applications, Cambridge University Press.</p> <p>Efron, B. et Tibshirani, R.J. (1993). An Introduction to the Bootstrap, Chapman and Hall.</p> <p>Hall, P. (1992). The Bootstrap and Edgeworth Expansion, Springer.</p> <p>Mammen, E. (1992). When does bootstrap work ? Springer.</p>
Other infos	Software: R
Faculty or entity in charge	LSBA

Programmes containing this learning unit (UE)				
Program title	Acronym	Credits	Prerequisite	Learning outcomes
Master [120] in Data Science : Statistic	DATS2M	5		
Master [120] in Statistics: Biostatistics	BSTA2M	5		
Master [120] in Statistics: General	STAT2M	5		
Certificat d'université : Statistique et science des données (15/30 crédits)	STAT2FC	5		