





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

Programmes containing this learning unit (UE)				
Program title	Acronym	Credits	Prerequisite	Learning outcomes
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		