Spring 2003

CE 200: Engineering Data Analysis

Instructor: Henri Gavin, 122 Hudson Hall, Henri.Gavin@Duke.edu
Class Time: Tu, Th, 12:40–1:55, Room 115A Hudson, ACES Call # 13335
Office Hours: We 1:30 – 2:30 and by appointment

T.A.: Cenk Alhan, 053 Engineering Annex, Cenk.Alhan@Duke.edu
Website: http://www.duke.edu/~hpgavin/ce200/
Prerequisite: Graduate standing or permission of instructor.
Computers: Many assignments will require computations using MATLAB.
Students are responsible for familiarizing themselves with MATLAB.
Grading: Homeworks(6) 30%; Exams(2): 30%; Final Project(1): 30%; Presentation: 10%

Bulletin Description:


Course Schedule:

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<td>Time series analysis: ensembles, auto-correlation and cross-correlation</td>
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<td>Feb.3–Feb.7</td>
<td>Spectral analysis: Fourier transforms, spectra and transfer function estimates</td>
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<td>Linear regressions for polynomial, power-law, and ARMA models, RLS</td>
<td>[6, 7, 30, 37]</td>
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<td>Error propagation, estimation of parameter uncertainty, confidence bands</td>
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<td>Condition number, null spaces, and introduction to singular value decomposition</td>
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<td>Scaling and orthogonal polynomials in linear least squares</td>
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<td>Constrained nonlinear least squares using Nedler-Mead simplex and BFGS methods</td>
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<td>Linear and nonlinear estimation of dynamic systems in engineering</td>
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<td>Project presentations</td>
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DETAILED OUTLINE

1. **Review of engineering statistics:**
   accuracy and precision of measured quantities; statistical description of data; random variables; discrete
   and continuous probability density functions; samples, sets and populations; common probability density
   functions and their properties; functions of independent random variables; the central limit theorem; 
   joint probability density functions; marginals; covariance and correlation; functions of correlated random 
   variables. 
   MATLAB: `normpdf`, `lognpdf`, `normcdf`, `normplot`, `cdfplot`, `norminv`, `rand`, `randn`, `disttool`, `polytool`

2. **Sample covariance and correlation matrices:**
   Chebyshev’s theorem and Chauvenet’s Criterion for out-lying data. Computation of covariance and cor-
   relation from repeated samples and from known a priori sensor knowledge. Resampling statistics. Defi-
   niteness and convergence.

3. **Time series analysis:**
   ensembles, stationarity and ergodicity; auto-correlation and cross-correlation.

4. **Spectral analysis:**
   the Fourier transform and the fast Fourier transform (FFT); leakage and resolution; signal processing 
   using the FFT, filtering and integration; power spectrum estimation, windows and averaging; effects of 
   noise on inputs and outputs; $H_1$, $H_2$, $H_6$ transfer function estimates; coherence estimates.

5. **Time–frequency analysis:**
   the analytic signal; Hilbert transforms and Kramer-Leadbetter envelopes; phase velocity; time-frequency 
   distributions, Choi-Williams kernels; wavelets

6. **Linear least squares:**
   $\chi^2$ and other goodness of fit criteria; dependent and independent variables; interpolating, smoothing, and 
   de-trending data; linearity in the parameters, nonlinear models and linear least squares formulations.

7. **Linear regressions:**
   power polynomials and power-laws; auto-regressive, moving average models, $z$-transform, poles & zeros, 
   linear prediction and recursive least squares; forgetting factors; linear prediction and system identi-
   fication.

8. **Error propagation:**
   data covariance and parameter covariance; Student-$t$ confidence intervals, confidence ellipsoids and confidence 
   bands.

9. **Condition number, null spaces, and introduction to singular value decomposition:**
   random and bias errors; null spaces; regularization and series truncation.

10. **Scaling and orthogonal polynomials:**
    re-scaling relationships for power polynomial curve-fits; minimization of the condition number; continuous 
    and discrete Chebyshev, Legendre and Forsythe polynomials; interpolation points; recurrence relation-
    ships.

11. **Constrained nonlinear least squares using Nedler-Mead simplex and BFGS:**
    the simplex; Nedler-Mead rules for simplex evolution; annealing; penalty function for constraints; Lagrange 
    multipliers; Gradient calculation and Hessian update formula; examples.

12. **Linear and nonlinear estimation of dynamic systems in engineering:**
    static and dynamic models; models for hysteresis, chatter and dynamic buckling; curve-fitting frequency 
    response functions; parameter estimation from curve-fitting; nonlinear dynamic systems and identification.

13. **Individual projects:**
    identification of project topic; preliminary analysis incorporating equilibrium, continuity, balance laws and 
    material characteristics; interactions between test specimens, sensors, and test hardware; development of 
    simulations; calibration and data collection; parameter estimation and error analysis; oral presentation 
    and written report.
REFERENCES


Chapter 5, 160 6.5.3 Extension of the ROS Method for Multiple NDs in Various Positions, 163 6.5.4 Cohen’s Adjustment, 165 6.6
The Kaplan – Meier Method (Nonparametric Approach) for Analysis of Laboratory Data with Nondetects, 170 References, 174 7
CALIBRATION BIAS 177 7.1 Error, 177 7.1.1 Types of Error, 179 7.2 Uncertainty
Thus, in statistics, we deal with the sample that we collect and make our decisions. Again, if Introduction to Statistical Analysis of Laboratory Data, First Edition. Alfred A. Bartolucci, Karan P. Singh, and Sejong Bae. It comprises methods of numerical data analysis and graphical representation as well as many example programs and solutions to programming problems. The book is conceived both as an introduction and as a work of reference. In particular it addresses itself to students, scientists and practitioners in science and engineering as a help in the analysis of their data in laboratory courses, in working for bachelor or master degrees, in thesis work, and in research and professional work. Show all. About the authors. *immediately available upon purchase as print book shipments may be delayed due to the COVID-19 crisis. ebook access is temporary and does not include ownership of the ebook. Only valid for books with an ebook version. Springer Reference Works are not included. Many statistical modelling and data analysis techniques can be difficult to grasp and apply, and it is often necessary to use computer software to aid the implementation of large data sets and to obtain useful results. S-Plus is recognised as one of the most powerful and flexible statistical software packages, and it enables the user to apply a number of statistical methods, ranging from simple regression to time series or multivariate analysis. This text offers extensive coverage of many basic and more advanced statistical methods, concentrating on graphical inspection, and features step-by-s