High-Dimensional Data Analytics (HDDA)

ESI 6617
Class Periods: MWF (9:35 AM - 10:25 AM)
Location:
Academic Term: Spring 2023

Instructor:
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(352) 294-6896
Office Hours: TBD

Teaching Assistants
None

Course Description
Covers techniques in high-dimensional data analytics that are particularly beneficial to industrial applications, including manufacturing, agricultural, and healthcare systems. It focuses on nonparametric modeling approaches (e.g., polynomial regression, splines, Kernels, etc.), multi-channel data analysis, regularization techniques for high-dimensional data, and various optimization algorithms.

Course Pre-Requisites
ESI 6325 and ESI 6420 or instructor permission.
Knowledge in Linear Algebra, Probability, and Statistics, and proficiency in Matlab programming is strongly recommended.

Course Objectives
The objective of this course is to introduce students to high-dimensional data analytics that is at the core of modern data-rich complex systems. At the end of this course, students should be able to

- understand the opportunities and challenges of high-dimensional data,
- analyze complex high-dimensional data,
- formulate and solve optimization problems to model high-dimensional data
- design dimensionality reduction and regularization methods to exploit HD data structures,
- understand several ISE applications of high-dimensional data.

Materials and Supply Fees
none

Required Textbooks and Software
Lecture notes and papers provided by the instructor. Lecture notes are intended to be self-contained. Interested students can review the recommended materials.

Matlab will be used for implementation purposes.

Recommended Materials

- Multilinear Subspace Learning: Dimensionality Reduction of Multidimensional Data, by Haiping Lu, Konstantinos N. Plataniotis, Anastasios Venetsanopoulos, CRC press, 2013, ISBN 9781439857243

- Analysis of Multivariate and High-Dimensional Data by Inge Koch, Cambridge University Press, 2013, ISBN 9781139025805
- Applied Matrix and Tensor Variate Data Analysis, by Toshio Sakata, Springer Japan. 2016, ISBN 9784431553878
- Elements of statistical learning by Hastie, Tibshirani and Friedman, Springer-Verlag. 2009. Available here: https://web.stanford.edu/~hastie/ElemStatLearn/
- Convex Optimization by Boyd, S., & Vandenberghe, L. (2004). Cambridge: Cambridge University Press. doi:10.1017/CBO9780511804441

Course Schedule

Dates	Topic	Recommended References
Week 1	Intro to HD data; Review of regression, polynomial regression, and kernel.	Multilinear Subspace Learning Analysis of Multivariate and High-Dimensional Data: Chapter 1; Elements of statistical learning Chapters 3 and 6; Instructor's notes.
Week 2-6	Intro to nonparametric data analysis (Splines, B-splines, cubic splines, natural splines, local regression, kernel regression, PCA, and functional PCA, etc.) with examples in agriculture and healthcare data.	Elements of statistical learning: Chapter 5 and 6; Analysis of Multivariate and High-Dimensional Data: Part III; Instructor's notes. Multiple sessions will be allocated to in-class activities to complete a hands-on problem.
Week 7-9	Review of dimensionality reduction using PCA and PLS. Intro to multidimensional data analysis for multi-channel and Spatio-temporal data. Topics include higher order PCA, tensor decomposition, and regression.	Multilinear Subspace Learning Analysis of Multivariate and High-Dimensional Data: Parts III and V. Instructor's notes from literature. Multiple sessions will be allocated to in-class activities to complete a hands-on problem.
Week 10-11	Introduction to large-scale optimization algorithms for data analysis (topics include first and second-order methods such as GD, PGD, ADMM, Newton, Quasi-Newton, etc.)	Instructor's notes and codes. Convex Optimization: part III-algorithms Multiple sessions will be allocated to in-class activities to complete a hands-on problem.
Week 12	Exam: Take-home	
Week 12-13	Regularization techniques for HD data (Ridge, lasso, adaptive lasso, group lasso, non-negative garrote, group non-negative garrote, and rank penalties)	Elements of statistical learning: Chapter 3 and 5.8. Instructor's notes from literature.
Week 14	Applications of regularization techniques in prognostics, fault detection, and systems modeling and monitoring.	Instructor's notes based on the existing literature.
Week 15	*Project Presentations*	

Attendance Policy, Class Expectations, and Make-Up Policy

Attendance is not required; however, it is strongly recommended. It will be to your benefit to attend all lectures. Students will be responsible for all material covered in class. Requirements for class attendance and make-up exams, assignments, and other work in this course are consistent with university policies that can be found at Attendance Policies.

Evaluation of Grades

Assignment	Total Points	Percentage of Final Grade
Homework Sets (4)	100 each	25%
Project	100 each	25%
In-class Activities (3 or 4)	100 each	25%
Exam [Take-home]	100	25%

HW policy

To receive full credit, HWs must be submitted by the deadline. For each day of delay 15 points penalty will be considered. Seven days of delay will translate to a score of zero for that HW. The following is a tentative schedule of HWs.

	Topic	Estimated Due date
HW1	Regression and nonparametric methods	Last week of January (Jan 27th)
HW2	Tensor Data analysis and Optimizations	Second week of March (Feb 27th)
HW3	Optimization algorithms and regularizations	Last week of March (March 31st)
HW4	More on regularizations	Second week of April (April 14th)

Project policy

The project will be assigned by the instructor. All students will work on the project topic individually. Students can also introduce their own project but should be approved by the instructor. The project will have an implementation component based on the materials learned in the class. Students will present their projects in the last week of the semester.

Grading Policy

Percent	Grade	Grade Points
90.0 - 100.0	A	4.00
87.0 - 89.9	A-	3.67
84.0 - 86.9	B+	3.33
81.0 – 83.9	B	3.00
78.0 - 80.9	B-	2.67
75.0 - 77.9	C+	2.33
72.0 – 74.9	C	2.00
69.0 - 71.9	C-	1.67
66.0 - 68.9	D+	1.33
63.0 - 65.9	D	1.00
60.0 - 62.9	D-	0.67
0 - 59.9	E	0.00

More information on UF grading policy may be found at:
UF Graduate Catalog
Grades and Grading Policies

Students Requiring Accommodations

Students with disabilities requesting accommodations should first register with the Disability Resource Center (352-392-8565, https://www.dso.ufl.edu/drc) by providing appropriate documentation. Once registered, students will receive an accommodation letter which must be

presented to the instructor when requesting accommodation. Students with disabilities should follow this procedure as early as possible in the semester.

Course Evaluation

Students are expected to provide professional and respectful feedback on the quality of instruction in this course by completing course evaluations online via GatorEvals. Guidance on how to give feedback in a professional and respectful manner is available at https://gatorevals.aa.ufl.edu/students/. Students will be notified when the evaluation period opens, and can complete evaluations through the email they receive from GatorEvals, in their Canvas course menu under GatorEvals, or via https://ufl.bluera.com/ufl/. Summaries of course evaluation results are available to students at https://gatorevals.aa.ufl.edu/public-results/.

In-Class Recording

Students are allowed to record video or audio of class lectures. However, the purposes for which these recordings may be used are strictly controlled. The only allowable purposes are (1) for personal educational use, (2) in connection with a complaint to the university, or (3) as evidence in, or in preparation for, a criminal or civil proceeding. All other purposes are prohibited. Specifically, students may not publish recorded lectures without the written consent of the instructor.

A "class lecture" is an educational presentation intended to inform or teach enrolled students about a particular subject, including any instructor-led discussions that form part of the presentation, and delivered by any instructor hired or appointed by the University, or by a guest instructor, as part of a University of Florida course. A class lecture does not include lab sessions, student presentations, clinical presentations such as patient history, academic exercises involving solely student participation, assessments (quizzes, tests, exams), field trips, private conversations between students in the class or between a student and the faculty or lecturer during a class session.

Publication without permission of the instructor is prohibited. To "publish" means to share, transmit, circulate, distribute, or provide access to a recording, regardless of format or medium, to another person (or persons), including but not limited to another student within the same class section. Additionally, a recording, or transcript of a recording, is considered published if it is posted on or uploaded to, in whole or in part, any media platform, including but not limited to social media, book, magazine, newspaper, leaflet, or third party note/tutoring services. A student who publishes a recording without written consent may be subject to a civil cause of action instituted by a person injured by the publication and/or discipline under UF Regulation 4.040 Student Honor Code and Student Conduct Code.

University Honesty Policy

UF students are bound by The Honor Pledge which states, "We, the members of the University of Florida community, pledge to hold ourselves and our peers to the highest standards of honor and integrity by abiding by the Honor Code. On all work submitted for credit by students at the University of Florida, the following pledge is either required or implied: "On my honor, I have neither given nor received unauthorized aid in doing this assignment." The Honor Code (https://www.dso.ufl.edu/sccr/process/student-conduct-honor-code/) specifies a number of behaviors that are in violation of this code and the possible sanctions. Furthermore, you are obligated to report any condition that facilitates academic misconduct to appropriate personnel. If you have any questions or concerns, please consult with the instructor or TAs in this class.

Commitment to a Safe and Inclusive Learning Environment

The Herbert Wertheim College of Engineering values broad diversity within our community and is committed to individual and group empowerment, inclusion, and the elimination of discrimination. It is expected that every person in this class will treat one another with dignity and respect regardless of gender, sexuality, disability, age, socioeconomic status, ethnicity, race, and culture.

If you feel like your performance in class is being impacted by discrimination or harassment of any kind, please contact your instructor or any of the following:
• Your academic advisor or Graduate Program Coordinator
• Robin Bielling, Director of Human Resources, 352-392-0903, rbielling@eng.ufl.edu
• Curtis Taylor, Associate Dean of Student Affairs, 352-392-2177, taylor@eng.ufl.edu
• Toshikazu Nishida, Associate Dean of Academic Affairs, 352-392-0943, nishida@eng.ufl.edu

Software Use
All faculty, staff, and students of the University are required and expected to obey the laws and legal agreements governing software use. Failure to do so can lead to monetary damages and/or criminal penalties for the individual violator. Because such violations are also against University policies and rules, disciplinary action will be taken as appropriate. We, the members of the University of Florida community, pledge to uphold ourselves and our peers to the highest standards of honesty and integrity.

Student Privacy
There are federal laws protecting your privacy with regards to grades earned in courses and on individual assignments. For more information, please see: http://registrar.ufl.edu/catalog0910/policies/regulationferpa.html

Campus Resources:
Health and Wellness

U Matter, We Care:
If you or a friend is in distress, please contact umatter@ufl.edu or 352 392-1575 so that a team member can reach out to the student.

Counseling and Wellness Center: http://www.counseling.ufl.edu/cwc, and 392-1575; and the University Police Department: 392-1111 or 9-1-1 for emergencies.

Sexual Assault Recovery Services (SARS)
Student Health Care Center, 392-1161.

University Police Department at 392-1111 (or 9-1-1 for emergencies), or http://www.police.ufl.edu/.

Academic Resources

E-learning technical suppor*t*, 352-392-4357 (select option 2) or e-mail to Learning-support@ufl.edu. https://lss.at.ufl.edu/help.shtml.

Career Resource Center, Reitz Union, 392-1601. Career assistance and counseling. https://www.crc.ufl.edu/.

Library Support, http://cms.uflib.ufl.edu/ask. Various ways to receive assistance with respect to using the libraries or finding resources.

Teaching Center, Broward Hall, 392-2010 or 392-6420. General study skills and tutoring. https://teachingcenter.ufl.edu/.

Writing Studio, 302 Tigert Hall, 846-1138. Help brainstorming, formatting, and writing papers. https://writing.ufl.edu/writing-studio/.

Student Complaints Campus*:* https://www.dso.ufl.edu/documents/UF_Complaints_policy.pdf.

On-Line Students Complaints*:* http://www.distance.ufl.edu/student-complaint-process.