School of Computing and Information Sciences

Course Title: Applied Linear Structures for Computing **Date:** 10/08/2020

Course Number: COT-3510

Number of Credits: 3

Subject Area: Foundations	**Subject Area Coordinator:** Xudong He **email:** hex@cs.fiu.edu
Catalog Description: This course is designed to prepare computer science/IT students with the applied knowledge of linear structures for computing and data analytics.	
Textbooks: Boyd, Stephen, and Lieven Vandenberghe. Introduction to applied linear algebra: vectors, matrices, and least squares. Cambridge university press, 2018. ISBN: I978-1-316-51896-0	
References (for further reading): [1] Heller, Don. "A survey of parallel algorithms in numerical linear algebra." *Siam Review* 20.4 (1978): 740-777. [2] Xiao, Han. "Towards parallel and distributed computing in large-scale data mining: A survey." *Technical University of Munich, Tech. Rep* (2010). [3] Davis, Ernest. *Linear algebra and probability for computer science applications*. CRC Press, 2012.	
Prerequisites Courses: MAC-XXXX and COP-XXXX (passed at least one college level math course and one basic college level programming course)	
Corequisite Courses: COT 3100 or MAD 2104	

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Type: Elective for CS and IT Majors.

Prerequisites Topics:

1. Solve basic algebraic equations
2. Systems of linear equations
3. Functions
4. Radical Expressions and Equations

Applied linear structures course requires that students must have completed some introductory math (any MAC-XXXX) and some introductory programming experience (any COP-XXXX) as prerequisite/corequisite. Additionally, the students need university level discrete structures knowledge by previously/simultaneously taking COT3100.

Course Outcomes:

1. Be familiar with basic definitions of vectors, matrices, linear functions, norm, and linear structures
2. Master the computing applications of linear structures, including those in data analytics
3. Be exposed to computing tools (e.g., clustering, regression, and least squares) using applied linear structure tools
4. Be familiar with application of linear structures in distributed computing and distributed optimization.
5. Be exposed to future application of linear structures in computing, including distributed machine learning and quantum computing

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Relationship between Course Outcomes and Program Outcomes

BS in CS: Program Outcomes	Course Outcomes
a) Demonstrate proficiency in the foundation areas of Computer Science including mathematics, discrete structures, logic and the theory of algorithms	1, 2, 3, 4, 5
b) Demonstrate proficiency in various areas of Computer Science including data structures and algorithms, concepts of programming languages and computer systems.	
c) Demonstrate proficiency in problem solving and application of software engineering techniques	
d) Demonstrate mastery of at least one modern programming language and proficiency in at least one other.	
e) Demonstrate understanding of the social and ethical concerns of the practicing computer scientist.	
f) Demonstrate the ability to work cooperatively in teams.	
g) Demonstrate effective communication skills.	

Assessment Plan for the Course & how Data in the Course are used to assess Program Outcomes

Student and Instructor Course Outcome Surveys are administered at the conclusion of each offering, and are evaluated as described in the School's Assessment Plan: http://www.cis.fiu.edu/programs/undergrad/cs/assessment/

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Outline

Topic	Number of Lecture Hours (Total: 37.5 hours = 15 weeks * 2 lectures/week * 1.25 hrs/lecture)	Outcome
1. Introduction to Applied Linear Structures 1.1. Vector Operation, inner product, and addition 1.2. Linear functions and their application in computing 1.3. Norm, Distance, and Matrix Algebra	8.75	1, 2, 5
2. Clustering, and Least Squares for Data Analytics 3.1. Data Clustering Objectives 3.2. k-means Algorithm 3.3. Least squares data fitting 3.4. Least squares classification 3.5. Linear Regression Using Least Squares 3.6. Iteratively Reweighted Least Squares	10	2, 3,5
3. Computing and Data Analytics Applications of Linear Structures 3.1. Data analytics using matrix decomposition 3.2. Eigenvalue decomposition for distributed computing 3.3. Linear Computing Algorithms, e.g., Simplex algorithm 3.4. Future Linear Computing Applications, e.g., quantum computing	8.75	2, 3, 5
4. Distributed Linear Computing 4.1. Linear dependence 4.2. Distributed Linear optimization 4.3. Distributed Processing	10	4,5

Learning Outcomes: (Familiarity → Usage → Assessment)

Introduction to Applied Linear Structures

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1. Explain with examples the basic terminology of vectors, norm, distance, and linearity. [Familiarity]
2. Perform the operations associated with vectors and linear functions. [Usage]
3. Relate practical examples to the appropriate vector, linear function, or norm/distance, and interpret the associated operations and terminology in context. [Assessment]
4. Describe how constructs of these concepts can be used in computer science applications. [Assessment]
5. Describe how matrices and matrix algebra can be used to model real-life situations or applications, including those arising in computing contexts such as clustering and distributed algorithms. [Usage]

<u>Clustering and Least Squares for Data Analytics</u>

1. Identify the definitions of clustering techniques, and least squares. [Familiarity]
2. Outline the preliminaries needed to understand these techniques. [Familiarity]
3. Apply each of the clustering and least squares methods to practical applications, e.g., data analytics for a small dataset. [Usage]
4. Explain various instances of least squares for data analytics, including linear regression using least squares and least squares classification [Familiarity]
5. Apply Iteratively Reweighted Least Squares in presence of outlier data [Usage]
6. Explain the k-means algorithms and provide computer science applications that benefit of this method. [Assessment]

<u>Computing and Data Analytics Applications of Linear Structures</u>

1. Identify the fundamental definitions for various matrix decomposition techniques. [Familiarity]
2. Apply decomposition techniques to solve linear computing problems. [Usage]
3. Solve a group of computer science-related problems using matrix factorization, especially data analytics problems. [Usage]
4. Describe how a computing problem can be represented in terms of matrices, and how matrices can be used and implemented to analyze a real-world dataset. [Assessment]

<u>Distributed Linear Computing</u>

1. Describe how to use linear equations to formulate a decision-making problem [Usage]
2. Model a variety of real-world problems in computer science, e.g., data fitting, using appropriate forms of linear systems. [Usage]
3. Show how concepts from linear systems can be leveraged for distributed computing. [Usage]
4. Apply linear programming to a hands-on example. [Usage]

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Oral and Written Communication

No significant coverage

Written Reports		**Oral Presentations**	
Number Required	Approx. Number of pages	Number Required	Approx. Time for each
0	0	0	0

Social and Ethical Implications of Computing Topics

No significant coverage

Topic	**Class time**	**student performance measures**

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Approximate number of credit hours devoted to fundamental CS topics

Fundamental CS Area	Core Hours	Advanced Hours
Algorithms:	0.6	
Software Design:		
Computer Organization and Architecture:		
Data Structures:	0.4	
Concepts of Programming Languages		

Theoretical Contents

Topic	Class time
Algorithms and Complexity (AL)	22.5 hours
Parallel and Distributed Computing (PD)	15 hours

Problem Analysis Experiences

Solution Design Experiences

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The Coverage of Knowledge Units within Computer Science Body of Knowledge[1]

Knowledge Unit	Topic	Type	Lecture Hours
AL1. Introduction to Applied Linear Structures	1	Tier 1	8.75
AL3. Clustering and Least Squares for Data Analytics	2	Tier 1	10
PD4. Computing and Data Analytics Applications of Linear Structures	3	Tier 1	8.75
PD5. Distributed Linear Computing	4	Tier 1	10

[1]See Appendix A in Computer Science Curricula 2013. Final Report of the IEEE and ACM Joint Task Force on Computing Curricula, available at: http://www.acm.org/education/CS2013-final-report.pdf