CS 4783: Machine Learning

Required Course: Elective
Course Number: CS 4783
Course Name: Machine Learning
Credit Hours: 3
Lecture Hours: 3
Lab Hours: 0
Instructors: Dr.Christopher Crick

Book Title 1: The Elements of Statistical Learning: Data Mining, Inference and Prediction
Book Author(s): Trevor Hastie, Robert Tibshirani and Jerome Friedman
Book Year(s): 2009

Book Title 2: Pattern Recognition and Machine Learning
Book Author(s): Christopher M Bishop
Book Year(s): 2019

Course Description: A probabilistic, statistical approach to automated pattern discovery applied to large datasets. Constructing computational models with this information and assessing their behavior and reliability. Representing data and devising tools for discovering these models. Class focuses on the development and analysis of learning algorithms as well as the mathematical formulations underlying statistical processing.

Course Prerequisites: CS 3353 (Data Structures and Algorithm Analysis I), and MATH 3013 (Linear Algebra (A)), each with a grade of 'C' or better

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Course Goals: Students should be able to

- Understand the strengths and weaknesses of a wide variety of supervised and unsupervised learning algorithms
- Devise data structures to support efficient implementation of machine learning techniques
- Create useful and informative visualizations of data and pattern recognition outputs
- Design, use, and characterize the advantages and limitations of various deep learning architectures
- Apply the principles of probabilistic analysis and Bayesian reasoning to understand the behavior of various learning approaches
- Transform raw data from a wide variety of real-world contexts into a form usable by machine learning algorithms
- Recognize the various failure modes of machine learning approaches, such as the curse of dimensionality, overfitting and local minima

Student Outcomes:

Student Outcome	Course Outcome
1	• Choose appropriate machine learning algorithms for specific dataset characteristics, constraints, and desired outcomes • Characterize algorithm behaviors and tradeoffs using probabilistic reasoning and Bayesian inference
2	• Implement machine learning algorithms and supporting data structures • Design effective visualizations for data and machine learning outputs
3	• Produce elegant, well-documented implementations of algorithms for machine learning, visualization and data handling • Perform and document scientific data analysis on algorithm performance • Produce and deliver research presentations for peers
4	• Understand and characterize shortcomings, errors and vulnerabilities in deployed machine learning applications
6	• Use libraries for large-scale parallel GPU processing of deep learning architectures

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Course Topics:

Knowledge Area	Total Hours of Coverage
Algorithms and Complexity (AL)	4
Architecture and Organization (AR)	1
Computational Science (CN)	8
Discrete Structures	4
Graphics and Visualization (GV)	1
Information Management (IM)	2
Intelligent Systems (IS)	16
Networking and Communication (NC)	1
Social Issues and Professional Practice (SP)	5

Knowledge Area	Knowledge Unit	Topics Covered	Hours
AL	Algorithmic Strategies	Brute-force, greedy, branch-and-bound, heuristics	1
AL	Fundamental Data Structures and Algorithms	Pattern matching and string/text algorithms	1
AL	Advanced Data Structures and Algorithms	Advanced data structures, stochastic algorithms, probabilistic analysis	2
AR	Performance Enhancements	Vector processors and GPUs, hardware support for multithreading, scalability	1
CN	Processing	Numerical methods	2
CN	Interactive Visualization	All	2
CN	Data, Information and Knowledge	Content structure/managment, processing and pattern recognition, modeling, design, logical and physical implementation	2
CN	Numerical Analysis	Error, stability, convergence, function approximation, numerical differentiation and integration	2
DS	Graphs and Trees	All	1
DS	Discrete Probability	All	3
GV	Visualization	Visualization of 2D/3D scalar fields, color mapping, isosurfaces, visualization of high-dimensional data, visualization design	1

IM	Data Mining	All	2
IS	Basic Machine Learning	All	2
IS	Reasoning Under Uncertainty	All	2
IS	Agents	Rationality, game theory, learning agents	1
IS	Natural Language Processing	N-grams and HMMs, text classification, categorization	3
IS	Advanced Machine Learning	All except for inductive logic and reinforcement learning	6
IS	Robotics	Localization and mapping	1
IS	Perception and Computer Vision	Computer vision, audio and speech recognition, approaches to pattern recognition	1
NC	Social Networking	Social network analysis	1
SP	Professional Communication	Dynamics of oral, written, and electronic team and group communication	4
SP	History	History of computer hardware, software, networking, pioneers of computing	1