University of Tehran
School of Electrical and Computer Engineering

<table>
<tr><td>Course:</td><td>Machine Learning</td></tr>
<tr><td>Course type:</td><td>
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<tr><td></td><td colspan="6">EE*</td><td colspan="4">CE*</td><td rowspan="2">Credit:

3</td></tr>
<tr><td></td><td>Com</td><td>E</td><td>P</td><td>B</td><td>Con</td><td>D</td><td>SW</td><td>HW</td><td>IT</td><td>MI</td></tr>
<tr><td>Required</td><td>☐</td><td>☐</td><td>☐</td><td>☐</td><td>☒</td><td>☐</td><td>☐</td><td>☐</td><td>☐</td><td>☒</td></tr>
<tr><td>Elective</td><td>☒</td><td>☒</td><td>☒</td><td>☒</td><td>☐</td><td>☒</td><td>☒</td><td>☒</td><td>☒</td><td>☐</td></tr>
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<tr><td>Level:</td><td>Undergraduate ☐
Graduate ☒</td></tr>
<tr><td>Co-requisite(s):</td><td>None.</td></tr>
<tr><td>Prerequisite(s):</td><td>None.</td></tr>
<tr><td>Prerequisite by topic:</td><td>• Probability
• Random Variables, Expectations, Distributions
• Statistical inference
• Estimation Theory
• Hypothesis Testing
• Linear Algebra & Multivariate/Matrix Calculus
• Eigenvalue/vector
• Optimization
• Gradient descent and Newton–Raphson algorithm
• Lagrange multiplier
• Basic computer science principles
• Complexity of algorithm</td></tr>
<tr><td>Textbook(s):</td><td>[1] C. M. Bishop, Pattern recognition and machine learning. Springer Verlag, 2006.
[2] R. O. Duda, P. E. Hart, and G. David, Stork - Pattern classification. Wiley, 2001.
[3] T. Hastie, J. Friedman, and R. Tibshirani, The elements of statistical learning. New York, NY: Springer New York, 2001.
[4] S. Theodoridis and K. Koutroumbas, Pattern recognition. Elsevier, 2006.</td></tr>
<tr><td>Coordinator(s):</td><td>Babak Nadjar Araabi, Professor, School of ECE.
Mohammadreza A. Dehaqani, Assistant Professor, School of ECE.</td></tr>
<tr><td>Goals:</td><td>In this course, the concepts of machine learning are introduced and acquaintance with different branches of this field is done and important practical and theoretical aspects are introduced. Important techniques and algorithms are discussed in various disciplines. In the field of observer learning, regression and classification problems will be examined and methods for solving these problems and evaluating models will be introduced. Relevant perspectives and algorithms are proposed for the classification problem. In the unsupervised learning section, we will talk about density estimation, unsupervised dimension reduction, and clustering. Finally, there will be a brief introduction to the branch of reinforcement learning.</td></tr>
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Topics:

Module	Material Covered	HW	Hands on
Introduction and Basic Concepts	1. What is learning 2. Bias variance trade-off 3. Training/Testing 4. Decision Theory 5. Generalization 6. Overfitting/Underfitting 7. Classification 8. Evaluation 9. Linear regression (LMS algorithm and gradient descent) 10. Regularized Least Squares Regression	HW1	HO1. Linear Regression
Bayesian Decision Theory and linear models	1. Cost/Risk 2. Bayes Optimal Classifier 3. Neyman-Pearson 4. Decision Boundary 5. Minimum Distance Classifier 6. Discriminability 7. logistic regression (Discriminative vs. Generative models)	HW2	HO2. Classification HO3. Logistic Regression
Parametric Models	1. Maximum Likelihood 2. Bayesian Density Estimation 3. Expectation Maximization 4. Hidden Markov Models 5. Bayesian Networks	HW3	HO4. Parametric Density Estimation
Non-parametric Models	1. Non-parametric Density Estimation 2. Parzen 3. K-Nearest Neighbor 4. Decision trees 5. Boosting	HW4	HO5. Non-Parametric Density Estimation
Dimensionality	1. Feature Conditioning 2. Feature Selection 3. Principle Component Analysis 4. Linear Discriminant Analysis 5. Independent Component Analysis		HO6. PCA & LDA
Margin-based approaches	1. Linear Discriminant Functions 2. SVM 3. Kernel Trick 4. Nonlinear and Kernel Regression	HW5	HO7. SVM
Clustering	1. K-Means 2. Hierarchical Clustering 3. Density-Based Clustering 4. Clustering Evaluation	HW6	HO8. Clustering
Neural Nets	1. Intro to Neural Nets 2. Learning 3. Convolutional Neural Networks	HW7	HO9. CNN
Learning Theory	1. PAC learning 2. Probably Approximately Correct 3. Error Bounds 4. Vapnik-Chervonenkis dimension	HW8	
Learning to make decisions	1. Markov decision processes 2. Reinforcement learning	HW9	HO10. RL

Computer usage: You can use Python and MATLAB (preferably Python)

Assignments:

- 9 homework
  - One homework per each course module.
- Homework assignments will include analytical questions and computing exercises.

Projects:

- Give you a chance to exercise what you learned in the course in some real-world problem and data.
- Students get involved in
  - Data Gathering
  - Problem Solving
  - Implementation
  - Documentation

Grading:	Assignments: 40% Review Quiz: 10% Final exam: 30% Project: 20%
Prepared by:	Babak Nadjar Araabi, Professor, School of ECE. Mohammadreza A. Dehaqani, Assistant Professor, School of ECE.
Date:	September 12, 2021

*EE: Electrical Engineering		*CE: Computer Engineering	
Com	Communications	SW	Software
E	Electronics	HW	Hardware
P	Power	IT	Information Technology
B	Bioelectronics	MI	Machine Intelligence and Robotics
Con	Control		