1. Course Number and Course Title:

MLR 570 – Advanced Machine Learning

2. Credits Hours: 3 – 0 – 3

3. Prerequisites and/or Co-requisites:

Prerequisite: Approval of the CSE Head of Department
Co-requisites: None
Competencies: Undergraduate-level knowledge of statistics and programming

4. Name and Contact Information of Instructor:

Name: Dr. Mohamed AlHajri
Email: mialhajri@aus.edu
Office: ESB-2066
Phone: 06-515-4987

Office Hours: 10:00 am – 12:00 pm (Tuesday)
11:00 am – 1:00 pm (Wednesday)

5. Course Description (Catalog Information)

Introduces machine learning concepts and data pre-processing techniques including aggregation, dimensionality reduction, feature selection, and measures of data similarity and dissimilarity. Covers supervised learning methods including Naïve Bayes, SVM, Feedforward, Convolutional and LSTM neural networks. Examines semi-supervised learning including GANs and consistency regularization algorithms, as well as unsupervised learning methods including K-Medoids, Gaussian Mixtures Methods, and Autoencoders. Covers ensemble learning methods including bagging and boosting, and model evaluation techniques.

6. Textbook and other Supplemental Material:

Primary:
Readings, excerpts from book chapters, and notes.

Secondary:

- Alpaydin E., *Introduction to Machine Learning,* MIT Press, 4th ed., 2020.
- Goodfellow, I., Bengio, Y, Courville, A., *Deep Learning,* MIT Press, 2016.
- Chollet, F., *Deep Learning with Python,* Manning Publications, 2021.
- Raschka, S., Mirjalili, V., *Python Machine Learning: Machine Learning and Deep Learning with Python, Scikit-Learn, and TensorFlow,* 3rd ed., 2019.

7. Course Learning Outcomes:

Upon completion of the course, students will be able to:

1. Apply data pre-processing techniques such as aggregation, dimensionality reduction, and feature selection for various types of data.
2. Demonstrate a strong understanding of the measures of data similarity and dissimilarity.
3. Evaluate different machine learning models.
4. Apply supervised learning methods.
5. Apply semi-supervised learning methods.
6. Compare unsupervised learning methods.
7. Apply appropriate ensemble methods.

8. Teaching and Learning Methodologies:

Different teaching and learning methods will be adopted in class to help students achieve the course's learning outcomes and to encourage student participation, creativity, and interaction with each other. Methods include formal lectures, class discussion, case studies, and a term project.

9. Course Topics and Schedule:

Topic	Weeks
Introduction to Machine Learning	Week #1
Data Preprocessing – aggregation, sampling, normalization, encoding, discretization	Week #2
Data Preprocessing – dimensionality reduction, feature selection, feature creation	Week #3
Measures of data similarity and dissimilarity	Week #4
Model Evaluation	Week #5
Supervised Learning – K-Neighbors, logistic regression, SVM	Week #6
Supervised Learning – Bayes, Decision Trees	Week #7
Supervised Learning – Feedforward and Convolutional Neural Networks	Week #8
Supervised Learning – LSTM, Transformers	Week #9
Unsupervised Learning - K-Means, K-Medoids	Week #10
Unsupervised Learning - DBSCAN, Gaussian Mixtures	Week #11
Unsupervised Learning - Autoencoders, VAE, AAE	Week #12
Semi-supervised Learning – Consistency Regularization Algorithms	Week #13
Semi-Supervised Learning – Label Propagation, SGAN	Week #14
Ensemble Learning - AdaBoost, Gradient Boosting, Isolation Forest	Week #15
Final Exam	Week #16

10. Schedule of Laboratory and other Non-Lecture Sessions:

The course has no laboratory. Homework assignments will be done in teams of two students each. The final project and report will be done in teams of three students. In the final project, students will be required to apply the techniques to a non-trivial large dataset and evaluate the results or the project will include an algorithmic contribution to one of the algorithms proposed in the course. The individual class survey report will be done individually where each student will select a topic area and write a detailed survey paper based on literature review.

11. Out-of-Class Assignments with Due Dates:

Each homework will consist of some theoretical questions and hands-on application of the techniques learned to different datasets.

Assignment	Due Date (tentative)
HW-1 Data pre-processing and feature engineering	Week #4
HW-2 Supervised Learning (SVM, Decision Trees, and K-Neighbors)	Week #7
HW-3 Supervised Learning (Neural Networks)	Week #10
HW-4 Semi- and Unsupervised Learning	Week #14
HW-5 Ensemble Learning Methods	Week #15

12. Student Evaluation:

Assessment	Weight	Due Date
Homework Assignments	20%	Cf. Section 11
Individual Survey Report	20%	Week #10
Final Project Report	30%	Week #15
Final Exam	30%	Week #16

13. Assessment Instruments:

Assessment	Course Learning Outcomes
Homework	O1–O8
Individual Survey Report	O1-O8
Class project	O1-O8
Final Exam	O1–O8

14. Contribution of Course to Program Outcomes:

MSML Program Outcomes	Emphasis in this course	Course Learning Outcomes
1. Perform research emphasizing creativity, independent learning, and scientific methods in the field of Machine Learning.	○	O1
2. Apply advanced mathematics, computer science knowledge, and software tools in identifying, formulating, and solving real world problems.		
3. Demonstrate an in-depth understanding of modern Machine Learning approaches, algorithms, and tools.	●	O3-O8
4. Select and use techniques, skills, and modern tools necessary for research or professional practice.	◑	O2
5. Communicate effectively through technical presentations and reports.		
6. Recognize the need for, and engage in, lifelong learning in professional areas.	◑	O1
7. Attend to professional and ethical responsibilities within global and societal contexts.		

Emphasis: ● High; ◑ Medium; ○ Low; Blank – Nothing Specific Expected

15. Letter Grade Policy:

Total (T)	Letter Grade
$93 \leq T$	A
$90 \leq T < 93$	A-
$85 \leq T < 90$	B+
$80 \leq T < 85$	B
$75 \leq T < 80$	B-
$70 \leq T < 75$	C+
$65 \leq T < 70$	C
$T < 65$	F