جامعة الملك عبدالله
للعلوم والتقنية
King Abdullah University of
Science and Technology

Course Syllabus: Machine Learning Methods in Geoscience - ErSE 290C

Division	Physical Science and Engineering Division
Course Number	ErSE 290C
Course Title	Machine Learning Methods in Geoscience
Academic Semester	Fall
Academic Year	2019/2020
Semester Start Date	08/25/2019
Semester End Date	12/10/2019
Class Schedule (Days & Time)	10:30 AM - 12:00 PM | Sun Tue

Instructor(s)

Name	Email	Phone	Office Location	Office Hours
Gerard Thomas Schuster	gerard.schuster@kaust.edu.sa	+966128080296		Immediately after class hours

Teaching Assistant(s)

Name	Email
TBA	TBA

Course Information

Comprehensive Course Description	Learn fundamental concepts of machine learning and their applications in geosciences. The course concentrates on the theories and applications of neural networks, convolutional neural networks (CNN), autoencoders, VAEs, recurrent neural networks, support vector machines, principal component analysis, and cluster methods. Each method is accompanied by MATLAB or Pytorch exercises, most of which are applied to geophysical data.
Course Description from Program Guide	The course covers a number of Machine Learning methods and their applications in solving geoscience problems. The main focus is on using supervised learning methods to solve geoscience problems, with an emphasis on the practical use of convolutional neural networks. At the end of the course, the diligent student will know how to design the architecture of a convolutional network and employ it in solving a particular geoscience problem. Students are expected to have experience in programming a high-level language such as MATLAB and have a background in partial differential equations and linear algebra.
Goals and Objectives	Students will have mastered the theory and geoscience practice of neural networks, CNN, SVM, cluster analysis, Recurrent NNs, autoencoders, VAEs, and principle component analysis. They will have the ability to create their own codes in MATLAB and Pytorch.
Required Knowledge	Knowledge of calculus, linear algebra ad statistics is required.
Reference Texts	Text is "Machine Learning Methods in Geosciences" by G. Schuster, published by SEG, Tulsa.
Method of evaluation	**20.00**% - Midterm exam **20.00**% - Homework /Assignments **30.00**% - Final exam **30.00**% - Course Project(s)

Nature of the assignments	Homeworks are pencil and paper and computational labs Projects analyze data by ML methods
Course Policies	Students are expected to attend class on time and missed classes must be explained. Assignments handed in late will be penalized.
Additional Information	

Tentative Course Schedule

(Time, topic/emphasis & resources)

Week	Lectures	Topic
1	Sun 08/25/2019	Semester starts: Introduction
1	Tue 08/27/2019	Least squares inversion: linear and non-linear, iterative solution, convergence rate
2	Sun 09/01/2019	Gradient descent methods: Newton, quasi-Newton, CG, steepest descent, step length methods
2	Tue 09/03/2019	Gradient descent methods: Hessian, ill-conditioning, preconditioning, geometric interpretation, regularization
3	Sun 09/08/2019	Neural Networks: Perceptron, single node, activation functions, loss functions, Matlab
3	Tue 09/10/2019	Neural Networks: Multiple nodes, step length methods, regularization
4	Sun 09/15/2019	Neural Networks: Overfitting, training, testing, validation, normalization, demeaning.
4	Tue 09/17/2019	Neural Networks: General NN, MATLAB examples, Introduction to Pytorch
5	Sun 09/22/2019	University holiday
5	Tue 09/24/2019	Convolutional Neural Networks: Introduction
6	Sun 09/29/2019	CNN: Dropout, architectures, pooling, up-pooling, fully connected network, dropout, skip layers.
6	Tue 10/01/2019	CNN: SoftMax, feature maps, filters, deconvolution layers, MATLAB examples
7	Sun 10/06/2019	CNN: Geoscience examples and Pytorch codes
7	Tue 10/08/2019	CNN: Sparse inversion derivation of CNN
8	Sun 10/13/2019	CNN: Sparse inversion derivation of CNN (cont.)
8	Tue 10/15/2019	Sparse Coding
9	Sun 10/20/2019	Autoencoders and geoscience applications
9	Tue 10/22/2019	Variational autoencoders
10	Sun 10/27/2019	Mid-terms
10	Tue 10/29/2019	Recurrent neural networks
11	Sun 11/03/2019	Recurrent neural networks (cont.)
11	Tue 11/05/2019	Support Vector Machines
12	Sun 11/10/2019	Support Vector Machines (cont)
12	Tue 11/12/2019	Cluster Analysis
13	Sun 11/17/2019	Cluster Analysis (cont.)
13	Tue 11/19/2019	Principle Component Analysis
14	Sun 11/24/2019	Principle Component Analysis (cont.)
14	Tue 11/26/2019	GANS
15	Sun 12/01/2019	GANS
15	Tue 12/03/2019	Random Forest
16	Sun 12/08/2019	Exams
16	Tue 12/10/2019	Exams

Note

The instructor reserves the right to make changes to this syllabus as necessary.