Course Type	Course Code	Name of the Course	L	T	P	Credits
DC	NGPC539	Artificial Intelligence and Machine Learning in Geosciences	3	0	0	3

Course Objective
The subject will provide the knowledge on AI and ML for time/space series data analysis. Knowledge on automatic nonlinear classification, regression and prediction of geo-records. Knowledge on application of AI and ML with deep network for big data processing. The subjects will allow to learn practical techniques for deriving ML-based relation from a set of teaching/learning examples.

Learning Outcomes
The primary objective of the course is to introduce fundamental and advanced aspects of Artificial intelligence and machine learning for geo-record analysis and processing. At the end of the course students will be able to build ML and AI models for solving complex nonlinear geoscience problems. Students will be exposed to Matlab/Python-based learning algorithms for geo-data processing and analysis.

Unit No.	Topics to be Covered	Lecture Hours	Learning Outcome
1.	Artificial Intelligence (AI) and Machine Learning (ML): Definition of Machine Learning (ML). The relation between AI and ML. ML classification algorithm: supervised, reinforcement and unsupervised learning: Principal component analysis (PCA), K-means, Fuzzy-C- means (FCM), Decision Tree (DT), Random Forest (RF), Logistic regression (LR), Self-organizing map (SOM).	7	Understanding of basic concept of Artificial Intelligence (AI) and Machine Learning (ML) and various supervised and un-supervised learning algorithm.
2.	Artificial neural networks: Introduction to artificial neural networks (ANNs). Multi-layer Perceptron (MLP) model, Pre-processing and dimension reduction techniques for time/space series modeling/classification. Back-propagation theory for ANNs.	4	Introduction to neural networks and processing techniques.
3.	Transfer Function: Types of transfer function, training, validation and test data set selection. Over-fitting, role of regularization, Calibration of model, cross-validation, early stopping techniques, bias-variance dilemma.	7	Non-linear activation functions and their role for classification/regression and model calibration.
4.	Optimization: ANNs optimization: local and global techniques. Adaptive neuro-fuzzy systems (ANFIS). Hybrid ML algorithm with ordinary kriging (OK), semi-variogram modeling, singular spectrum analysis (SSA) for de-noising, interpolation and missing value prediction techniques.	7	Neural networks and fuzzy-logy for hybrid data interpolation.
5.	Probabilistic methods: Probabilistic inference, Bayesian learning for artificial neural networks, evidence maximization (EA), hybrid Monte Carlo (HMC), Automatic relevance determination (ARD), Gaussian process (GP), Support vector machines (SVM).	7	Bayesian methods for machine learning
6.	Deep learning and Big data: Introduction to deep learning. Convolutional neural network (CNN), Long-Short Term Memory (LSTM) network, hybrid CNN-LSTM network, Encoder-Decoder network, Generative adversarial network (GAN): Theory and practices. Application of ML/DL algorithm for earth parameter estimation/inversion, reservoir properties, classification and prediction of rock-type/litho-logy/litho-facies/mineral boundary for analysis of space-time geophysical data. Application of deep learning to "Big Data" analysis of geophysics.	10	Deep learning and application to geosciences.
	Total	42	

Text Books

1. Aggarwal Charu C., (2018). Neural networks and deep learning. Springer International Publishing AG, part of Springer Nature 2018 https://doi.org/10.1007/978-3-319-94463-0
2. Bishop C M, (1995) Neural networks for pattern recognition. Oxford University Press.

References Books

1. Aggarwal Charu C., (2018). Neural networks and deep learning. Springer International Publishing AG, part of Springer Nature 2018 https://doi.org/10.1007/978-3-319-94463-0
2. Bishop C M, (1995) Neural networks for pattern recognition. Oxford University Press.
3. Haykin, S. (1999). Neural networks – a comprehensive foundation (2nd Ed.). Upper Saddle River, NJ: Prentice Hall.
4. MacKay, D.J.C., (1992). A practical Bayesian framework for back-propagation networks. Neural Comput, 4 (3), 448–472.
5. Poulton M, (2001) Computational Neural Networks for Geophysical Data Processing, Pergamon, Oxford, U.K.
6. Van der Baan M, and Jutten C, (2000) Neural networks in geophysical applications, Geophysics, 65: 1032–1047.
7. Wasserman, P.D. (1993) Advanced methods in neural computing. Van Nostrand Reinhold, New York, NY 10003