GSAW 2020 Tutorial D:

Demystifying Machine and Deep Learning

Length: Half day

Overview:
Operators and analysts are being overwhelmed with the amount of data available from both existing and new classes of sensors. Machine Learning has been proposed as a solution to "big data" problems which will enable analysts to evaluate and determine courses of action based on information. A lot of misinformation surrounds Machine Learning and its potential to solve SSA and related problems. This short course delves into Machine Learning and Deep Learning techniques to solve potential problems of interest to GSAW participants. This course presents both an overview of current technologies and software as well as crucial details on Machine Learning algorithms for aspiring or current users so that they can utilize Machine Learning and Deep Learning techniques in their exploitation of existing data. Due to the high interest in Deep Learning and Neural Networks, a large part of this course will be explaining these rapidly evolving technologies so that the audience can get a good overview of the breadth of these areas. We have found that there is a lot of misconceptions surrounding these topics so we want to demystify it for both folks that are new to the field as well as students that may have explored areas of these technology. Machine Learning, Deep Learning and Artificial Intelligence are all hot topics within the data science community for their potential to extract actionable information from the data.

Outline

- Introduction
  - What is Machine Learning (ML) vs Deep Learning (DL) vs Artificial Intelligence (AI)
  - Architectures for ML/AI
- Types of ML
  - Common usages
- Types of problems addressed by ML
- Feature extraction – how to formulate problems solvable with ML
- Sample problems used as themes in the course
  - Problem 1: Determine if satellites are stable or unstable
  - Problem 2: Determine if satellites remain in designated orbital regimes
- Unsupervised learning applied to the problems
  - Different unsupervised models
  - Advantages/Disadvantages. Is this the right solution to the problem?
  - Applicability of temporal unsupervised learning
- Supervised learning
  - Theory of learning types
  - How to evaluate supervised learning capabilities (ROC/CAP curves)
  - Overfitting/underfitting – what it means
- Time Series and data problems
  - ARIMA model
  - Real-world applications
  - Bias prediction and alerting
  - Metrics evaluation and prediction
- Deep learning
  - DL/Neural Networks
    - Hype versus reality
- Types
  - Recurrent Neural Networks, Convolutional Neural Networks, Restrictive Boltzmann

- Machines, Deep Belief Networks
  - How to build a Neural Network
    - Layers, activation functions, and optimizers
  - Neuromorphology
  - Reinforced Learning
    - Learning process and how to apply
  - Explainable AI
  - Other deep learning models
- Future of ML/AI
  - Future topics
  - On-board satellites
- Summary
  - Why use ML/AI
  - When not to use

Instructors: Rohit Mital, KBR and Joseph Coughlin, The Aerospace Corporation

Biographies:
Mr. Coughlin is a senior aerospace systems engineer at L3Harris working on projects to utilize commercial space sensors (optical, radar, and passive RF) for Space Situational Awareness (SSA) for the National Space Defense Center (NSDC) and other customers. He has been instrumental in bringing operational analytics and machine learning technologies to the analysis of data for the SSA mission and for monitoring system performance. He has spent over 30 years working science and systems engineering tasks for a wide variety of customers. He received a Master's degree in Astrophysical, Planetary and Atmospheric Physics from the University of Colorado.

Mr. Mital is the Chief Technologist at KBR. He has over 25 years of experience in developing and delivering high-performance, scalable, complex software systems and solutions. He currently leads KBR Innovations Labs, which is developing solutions in Agile/DevOps, Big Data, Machine Learning and Blockchain technologies. He has Master's degrees in Electrical Engineering and Mathematics.

Description of Intended Students and Prerequisites:
Short course is designed for a non-technical as well as a technical audience. Short course is for those interested in how Machine Learning and Deep Learning (especially Neural Networks) can be used for SSA and ground system applications and a desire to learn the details of how these technologies can be implemented for data exploitation. This course is designed to introduce the audience to many of the concepts of Machine and Deep Learning in a manner that will enable them to better understand the field. No prerequisites are needed.

What can Attendees Expect to Learn:
- What Machine Learning and Deep Learning really provide versus the hype.
- How to use Machine Learning for SSA and other applications and when not to use it
- Details on Machine and Deep Learning models to enable students to understand the benefits for using one versus another.
- What the bounds are of what Artificial Intelligence and Deep Learning can realistically do for data exploitation.
- A methodology to transform big data problems into solutions providing meaningful insights to analysts and decision makers.
- Architectural solutions for implementing operational analytics and machine learning
- Emerging topics in Deep Learning and Artificial Intelligence