GSAW 2022 Tutorial L:

Demystifying Machine and Deep Learning

Overview:
Last year's GSAW tutorial on Demystifying Machine Learning was very well received. The students were engaged and very interested in the topics and methodology covered. We presented details on applications of Machine Learning and Deep Learning and the students were clearly interested in learning more about this subject since they are beginning to encounter it regularly in their work. This year, in a condensed format, we plan to expound on these topics and present more detailed information on the algorithms and examples of the different aspects of Machine Learning, especially Deep Learning and Neural Networks, which is becoming more popular but equally misunderstood. We have found that there is a lot of misconceptions surrounding these topics so we want to further demystify it for both folks that are new to the field as well as students that may have explored areas of these technology. The determination of the features in the data is critically important to successfully building a model and we present ways to determine the correct features and how to measure the performance and accuracy of the chosen approaches. Machine Learning, Deep Learning and Artificial Intelligence are all hot topics for their potential to extract actionable information from the data. Biases in the data can lead to incorrect models and results, so we present ways to be aware of these potential problems and how to mitigate them.

Course outline:
- What is Machine Learning
    - Types of Machine Learning
    - Hype versus reality
    - Languages and technologies
- Machine Learning
    - Supervised Learning
    - Unsupervised Learning
    - Projections and forecasting – lessons learned
- Deep Learning
    - What is it?
    - Neural networks and their different flavors
        - Recurrent neural networks
        - Convolutional neural networks
    - Building a neural network
    - Reinforcement Learning
    - Pros and cons
- Advances in Machine Learning and where it is going in the future
    - Spiking neural networks
    - On-board satellite processing
- Biases in Machine Learning and how to try and prevent them

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

Biographies:

Mr. Coughlin is a Senior Engineer Specialist at Aerospace Corporation working on projects to improve the utilization of sensors and their data for Space Domain Awareness (SDA) application and working for the USSF and SpOC Chief Data Offices to define data usage and standards across the enterprise. He has been instrumental in bringing operational analytics and machine learning technologies to the analysis of data for the SDA mission. 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 Technology Officer 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:

Tutorial is designed for a non-technical as well as a technical audience. Tutorial is for those interested in how Machine Learning and Deep Learning, especially Neural Networks, can be used for ground system applications and Space Domain Awareness. Students should have a desire to learn the details of how Artificial Intelligence can be implemented for data exploitation. No prerequisites are needed.

What can Attendees Expect to Learn:
- What Machine Learning and Artificial Intelligence can really provide versus the hype.
- How to use Machine Learning and AI for Ground Systems and Space Domain Awareness applications and when not to use it.
- How to properly identify data features for correctly building models
- Details on Machine Learning algorithms, such as supervised and unsupervised learning and neural networks, to enable students to understand the benefits for using one approach versus another.
- How to determine the performance and accuracy of the chosen ML approach
- What the bounds are of what Artificial Intelligence and Deep Learning can realistically do for data exploitation.
- What is Deep Learning and Neural Networks and how would you build one
- Emerging topics in Artificial Intelligence, such as Reinforcement Learning and applications for space-based sensors
- Ethical AI and Biases in AI applications of which to be aware