

GSAW 2023 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, we plan to expound on these topics and present more information on 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 those 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. With the need to build trust in the results of an AI model, we spend time on how to implement Explainable AI to understand the results of the models.

Course outline:

- What is Machine Learning
 - Types of Machine Learning
 - Hype versus reality
- 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
- Explainable AI and how to develop trust in the models.
 - Tools and metrics
 - Fairness in AI
 - When to use and how

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

Biographies:

Mr. Coughlin is an Associate Director 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. He has been instrumental in bringing operational analytics and machine learning technologies to data analysis for SDA missions. He received a Master's 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.

John Chauvin is a Senior Engineering Specialist at The Aerospace Corporation where he has led several projects with the goal of improving tracking performance for Missile Warning and Missile Defense. He has over 10 years of experience both as a developer and as a manager on deep/machine projects for national defense. He received his Ph.D. in Electrical Engineering from the University of North Dakota.

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 and the benefits and pitfalls of the different approaches. This year there will be an added emphasis on how to build trust in the models. No prerequisites are needed.

What can Attendees Expect to Learn:

- What Machine Learning and Artificial Intelligence can 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 the different types of Neural Networks and the components of them
- Ethical AI and biases in AI applications and how to consider them in your model
- Explainable AI tools and processes and why it is important for trusting ML systems