GSAW 2024 Tutorial J: Half Day

Demystifying Machine Learning and Artificial Intelligence: From unsupervised learning through deep learning, explainable AI and ChatGPT

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, Neural Networks and Explainable AI, 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 folks that are new to the field as well as for those who may have explored areas of these technologies. The determination of features in the data is critically important to successfully building a model, and we present ways to determine the most useful features and how to measure the performance and accuracy of the chosen approaches. Machine Learning, Deep Learning and Artificial Intelligence are all hot topics due to their potential to extract actionable information from the data. However, 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
- 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 of the different approaches
- Ethical AI
- 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
- Advances in Machine Learning and where it is going in the future
    - Chat GPT

- o Spiking neural networks
- o On-board satellite processing

Instructors:
Joseph Coughlin, John Chauvin, and Tiffany Lam, The Aerospace Corporation

Biographies:
Joe 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.

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.

Tiffany Lam is a Senior Project Lead at the Aerospace Corporation. She has over 15 years of experience with developing advanced concepts and prototype systems in the areas of radar, electronic warfare, situation awareness, and advanced signal/image processing. She has led CRADs/IRADs in cognitive systems and machine learning/AI. She received her B.S, M.S, and Ph.D. all in Electrical Engineering from Rensselaer Polytechnic Institute.

Description of Intended Audience and Recommended Prerequisites:
Tutorial is designed for a non-technical as well as a technical audience. Tutorial is for those interested in learning more about different aspects of Machine Learning and Artificial intelligence, especially as it can apply to ground system and satellite applications. 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 and Space Systems 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 their components.
- Ethical AI and biases in AI applications and how to consider them in your model.
- Explainable AI tools and processes and why they are important for building trusted ML system.
- New areas of AI, such as ChatGPT, and its ramifications for use in government systems.