FIVE QUESTIONS WITH DR. SALVADOR SOSA

Machine learning: a tool for improving the performance of particle accelerators

Machine learning (**ML**) is a branch of Artificial Intelligence (**AI**) that looks for correlations on known data and "learns" about them so that it knows how to react in an optimal way when processing new, previously unseen data. Particle accelerators are complex machines with many independent components (vacuum, rf, magnets, etc.), making them suitable for data-driven controllers [1,2]. **AI**-assisted operation of particle accelerators has the potential to enhance performance and reduce operation costs.

Could you introduce yourself?

My name is *Salvador Sosa Güitrón*, I studied Physics in the University of Puebla (BUAP) and in Old Dominion University in the state of Virginia. My PhD research was developed at Jefferson Lab, a nuclear science facility driven by a superconducting electron linear accelerator; this was a great place to learn from leading experts in accelerator science and technology. I now have Physics PhD and I'm currently working as a Postdoc at the University of New Mexico in Albuquerque.

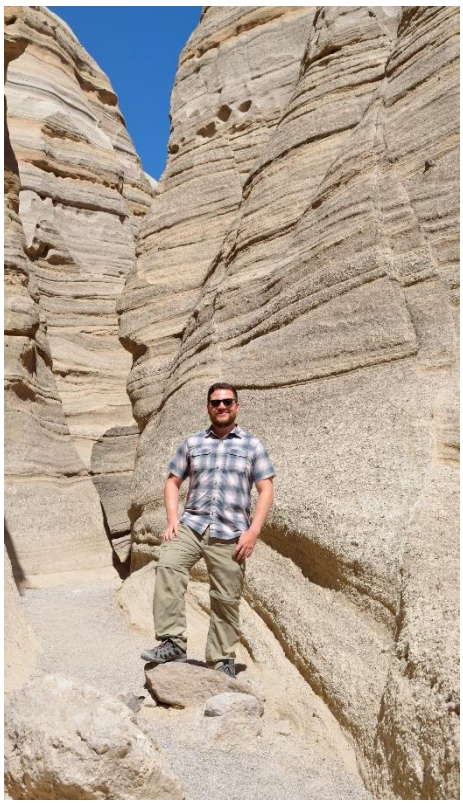

Figure 1. Dr. Salvador Sosa in Kasha-Katuwe Tent Rocks National Monument, New Mexico.

Could you tell me about your institute and research topic?

I am doing research at the department of Electrical and Computer Engineering, in the University of New Mexico. My research is on advanced controllers for particle accelerators: the application of **ML** and **AI** for optimized control of particle accelerators and their sub-components.

Our research group has a collaboration with Ion Linac Systems, a start-up company in Albuquerque developing compact, low-energy, high-current proton accelerators for cancer therapy based on Boron Neutron Capture (BNC). In this therapy, cancerous cells are tagged with Boron and

subsequently radiated with a neutron beam. BNC releases alpha particles, which decay within micrometers, making this therapy very localized, virtually removing damage to healthy tissue.

My goal is to provide advanced controllers based on **ML** and **AI** for this proton Linac in order to achieve higher beam throughput and optimized efficiency, which will result in reduced Linac costs. My current work consists on performing simulations of the machine operation [3] using leadership computing systems to generate training data for a **ML** controller.

How or why did you choose that topic?

After I graduated, I wanted to learn more about **AI** since it has a very wide range of applications and is in general very popular these days. I believe it is an important skill to have that makes you more competitive in the job market. I was lucky enough to find a research group applying **AI** to the field of particle accelerators, this lets me learn about **AI** while still working with particle accelerators, which I am already passionate about.

Right now, what is the biggest challenge of your work?

AI is driven by data, lots of data. The biggest challenge on my project is adapting already existing particle accelerators for data-driven operation, much like fitting a self-driving car with cameras and sensors that feed information about its surroundings. Since most of the accelerators are not properly fitted with diagnostics and data acquisition systems that accurately log the state of the accelerator at any given time, whereas the experimental end stations tend to be fully instrumented. For this reason, and with limited available experimental data, I am simulating Linac operation as accurately as possible using electromagnetic and particle-in-cell codes.

What did you think that will be the future of you research area?

Recent applications of **AI** to the control of particle accelerators have shown promising results [4], to name a few: reducing the beam emittance of the Advanced Light Source for better quality of synchrotron light [5]; predicting SRF accelerating cavity-trips at JLab, which results in longer experimental physics runs; advanced controls for medical proton therapy machines, making them cheaper and easier to use. I think **AI** is a relatively new tool being applied to accelerators that has already shown enhanced performance of accelerators, it is already getting a lot of attention and I think we can expect this trend to keep growing in the following years, particularly in machines that are currently being designed with **AI** in mind.

[1] S.G Biedron, “Adding data science and more intelligence to our accelerator toolbox” in Proc. of IPAC 2019, TUZPLM1. Melbourne, Australia.

[2] A. Edelen, et al. “Opportunities in Machine Learning for Particle Accelerators”, arXiv:1811.03172 (https://arxiv.org/abs/1811.03172).
[3] S.J. Smith, et al. “3D Electromagnetic-PIC simulations for a novel RFQ/RFI Linac design” in Proc. of IPAC 2019, MOPTS118, Melbourne, Australia.
[4] https://www.symmetrymagazine.org/article/the-future-of-particle-accelerators-may-be-autonomous?fbclid=IwAR1LEB0gmEEj8FmM6r0zglDmg-p5vFFnBDZwkewCITObRLR9H1Orw6PyQhE
[5] https://newscenter.lbl.gov/2019/11/08/machine-learning-enhances-light-beam-performance-at-the-advanced-light-source/?fbclid=IwAR2xlM5Cze9Euk_SQ0xHTC5oBv0sI9Y1S0fFiZNeQDv06l7CB2lyYTpYWUo