AI/ML for Accelerators Roadmap Discussion

ICFA ML Workshop
April 10, 2025

Designing, building and operating the next generation particle accelerators and colliders will require new approaches due to the unprecedented scale and complexity, and the constraint of remaining affordable while becoming sustainable. AI will be an enabler in all of these aspects. AI will also transform how we design, build and operate particle accelerators.

How to get from R&D to AI at scale as fast as possible? What is our vision of AI for particle accelerators? Which building blocks do we need? What needs to be prepared within the community and when to be ready with design choices of AI building blocks for decision making on the next projects?

Overall control system challenges and requirements for AI-ready accelerators?

What are the open AI/ML technical challenges that need to be solved (as distinct from practical challenges)?

What is required to integrate AI-enhanced equipment?

What should the place of LLMs be?

How can we best foster/leverage community engagement and development for common needs (e.g. software infrastructure for deployment, in-depth deployment practicalities that are often not addressed in the academic literature)?

How can we ensure efforts for real-world deployment are recognized / encouraged especially for junior scientists/engineers (academic literature can skew toward simpler conceptual demos vs. real world deployment)

How to include robotics?

A few of the responses so far and further prompts

- **Comments on Needs**
  - AI-based Accelerators need to be able to stream and archive various types of data and their descriptors and make to data searchable to assist in creating data sets for learning.
  - Coordinated and balanced responses to funding calls (e.g. EU calls in the frame of Horizon programs)
  - Should activities towards AI/ML driven accelerators get their own panel within ICFA? For improved representation, improve the visibility of the community, shape the actual future of accelerators (for which the F in ICFA stands for :))? *International Committee for Future Accelerators*

- **LLMs / Agentic Interfaces**
  - Further prompts
    - What is needed to allow LLMs to be the Operators interface to control the Accelerator?
    - What kind of components/agents can you imagine to help to improve autonomy / connecting together different controls components (e.g. BO/anomaly detection)
    - When you have unlimited resources, what kind of subsystems would you like to know about/visualize/have accessible?
    - What kind of questions would you like to ask?
    - What kind of AI would increase the autonomy of the entire system?
  - Comments
    - LLMs can be used to search logbooks and also find undiscovered connections between events/actions and outcomes.
    - Could be used for future EIC design for example: LLMs can be used expert that collect all related design information, and provide feedback for all design groups. It likes a information pool that can be accessed by everyone, keep all information update and accessible for everyone.

- **AI-ready hardware**
  - Are there any plans to develop chip architectures to train Machine Learning algorithms more efficiently? Is anyone working on new electronics to improve the efficiency and energy impact of the actual architectures? (Gpu, tpu, fpga….)

Let’s Discuss!

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