https://eic.ai/

C. Fanelli, T. Horn

**Report from
Artificial Intelligence WG**

EICUG Annual Meeting, 23-31/July/2023

What is "AI4EIC"?

EIC has the unique opportunity to start incorporating AI from the very beginning and to systematically leverage on it during all phases of the project.

AI will be an integral part of the EIC software (ePIC and beyond) and we will take advantage of intelligent decisions in all aspects of data processing from detector readout and control to analysis.

The AI4EIC initiative originated as a consortium, which was integrated, as a sector, into the SWG of the EICUG in December 2021. Within the EICUG, the AI WG serves as an accessible entry point for AI applications, orchestrating workshops, tutorials, hackathons and Kaggle-like challenges.

The AI4EIC initiative continues evolving to date following two successful workshops (each with 200+ participants), an international hackathon, with a forthcoming workshop and hackathon in 2023, the publication of ten proceedings, and a community paper.

https://eic.ai

AI4EIC 2nd Workshop: Oct 10-14 2022, William & Mary

https://indico.bnl.gov/e/AI4EIC

- We had a total of 220 registered participants with a very good attendance in person

- Workshop: 6 sessions (15 conveners, 40+ speakers)

  - Design
  - Intersection Theory/Experiment (morning + afternoon sessions)
  - Reconstruction & PID
  - Infrastructure and Frontiers** (+ Panel Discussion)
  - Streaming Readout

- Community:

  - 4 Tutorials

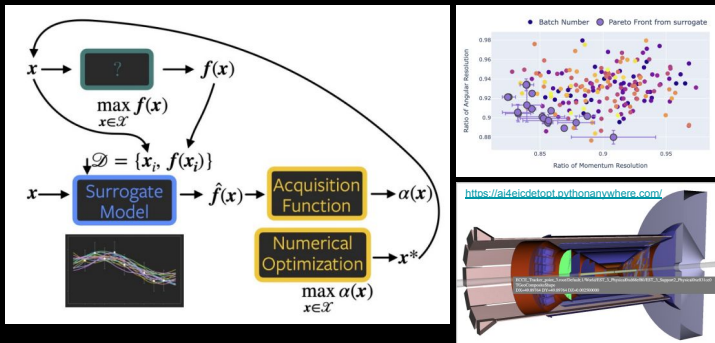 - Hackathon (10 teams from North, South America, Asia, Europe)
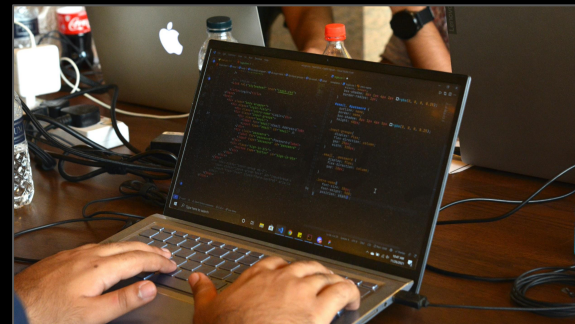
300+ users in ai4eic slack sign-up here

https://eic.ai/workshops

AI4EIC Tutorials

Provided by experts from industry and national labs and research centers

M. Balandat,
Meta AI

Multi-objective Optimization

F. Torales Acosta (LBNL)

V. Mikuni (NERSC)
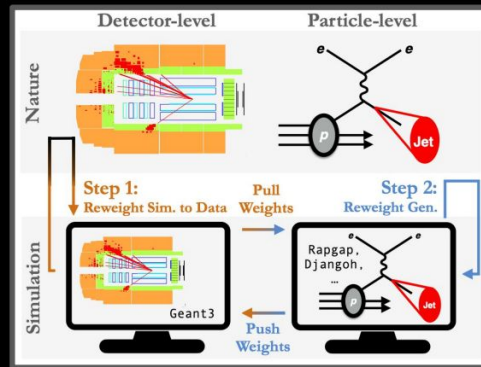
Unfolding

OmniFold

K. Rajput
JLab/DS

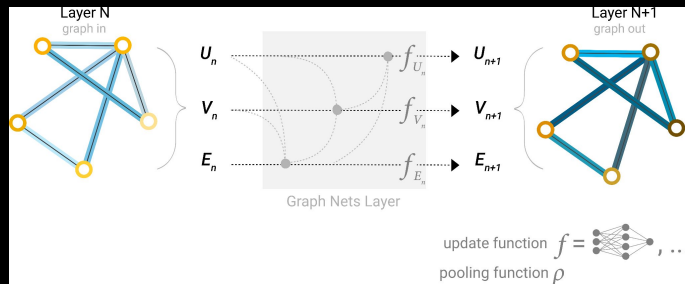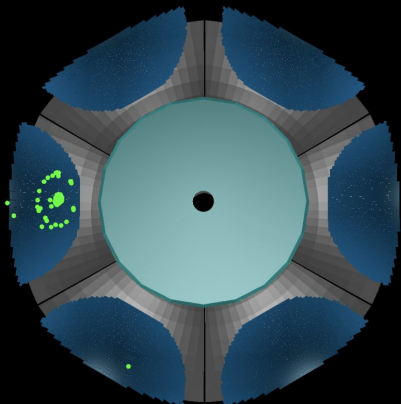| Tracking	Projects	Models
Record and query experiments: code, data, config, results	Packaging format for reproducible runs on any platform	General format for sending models to diverse deploy tools

MLflow — ML lifecycle
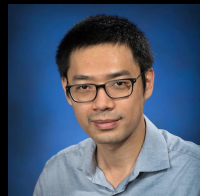
Y. (Ray) Ren (BNL)

Graph Neural Network

Hackathon

π, K datasets

Organizers: Cris Fanelli (William & Mary/JLab), Diana McSpadden (JLab/Data Science), Kishan Rajput (JLab/Data Science)

Advisory and problem definition: Evaristo Cisbani (INFN), Wouter Deconinck (U. Manitoba)

Computing resources: Eric Walter (William & Mary, IT)

Data generation, Documentation, Validation: James Giroux (U. Regina), Karthik Suresh (U. Regina)

Technical Assistance: Eric Walter (William & Mary, IT), James Giroux (U. Regina), Karthik Suresh (U. Regina)

CF, DMcS,KR, EC,WD,EW,KS,JG

https://zenodo.org/record/7197023

AI4EIC Hackathon

Congrats Team JINR!!!!!!!! (submission on 10-14-2022)

Hackathon Leaderboard

RANK	TEAM	SCORE	QUESTIONS ATTEMPED
🥇 1	Jets	295.502	Q 1, Q 3, Q 2
🥈 2	JINR	294.508	Q 1, Q 3, Q 2
🥉 3	JB and EC	262.313	Q 1, Q 3, Q 2

Problem Number	Threshold Accuracy
Problem 1	94%
Problem 2	86%
Problem 3	80%

Solutions:
- JINR: CatBoost, https://catboost.ai/
- Jets: 2D CNN

Training Events	1.5 Million Events	With Magnetic Field ($\sim$ 1.5T)
Momentum	15 GeV/c	at Interaction Point (0, 0, 0)
Theta θ	20°	at Interaction Point (0, 0, 0)
Phi ϕ	0°	at Interaction Point (0, 0, 0)

Problem 1

Training Events	3 Million Events	With Magnetic Field ($\sim$ 1.5T)
Momentum	$15 - 20 GeV/c$	at Interaction Point (0, 0, 0)
Theta θ	$15 - 16°$	at Interaction Point (0, 0, 0)
Phi ϕ	$0 - 5°$	at Interaction Point (0, 0, 0)

Problem 2,3*

*Problem 3: addition of noisy hits

The best solutions were all Machine Learning/Deep Learning-based, they were quite original, and they outperformed solutions based on classical approaches (followed by some teams). While this is only a first step towards deeply learning the identification of particles reconstructed with the dual-RICH, these exploratory studies clearly indicates the potential of ML/DL approaches for reconstruction and PID.

https://eic.ai/hackathons

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AI4EIC Paper

Artificial Intelligence for the Electron Ion Collider (AI4EIC)

C. Allaire, R. Ammendola, E.-C. Aschenauer, M. Balandat, M. Battaglieri, J. Bernauer, M. Bondì, N. Branson, T. Britton, A. Butter, I. Chahrour, P. Chatagnon, E. Cisbani, E. W. Cline, S. Dash, C. Dean, W. Deconinck, A. Deshpande, M. Diefenthaler, R. Ent, C. Fanelli, M. Finger, M. Finger Jr., E. Fol, S. Furletov, Y. Gao, J. Giroux, N. C. Gunawardhana Waduge, R. Harish, O. Hassan, P. L. Hegde, R. J. Hernández-Pinto, A. Hiller Blin, T. Horn, J. Huang, D. Jayakodige, B. Joo, M. Junaid, P. Karande, B. Kriesten, R. Kunnawalkam Elayavalli, M. Lin, F. Liu, S. Liuti, G. Matousek, M. McEneaney, D. McSpadden, T. Menzo, T. Miceli, V. Mikuni, R. Montgomery, B. Nachman, R. R. Nair, J. Niestroy, S. A. Ochoa Oregon, J. Oleniacz, J. D. Osborn, C. Paudel, C. Pecar, C. Peng, G. N. Perdue, W. Phelps, M. L. Purschke, K. Rajput, Y. Ren, D. F. Renteria-Estrada, D. Richford, B. J. Roy, D. Roy, N. Sato, T. Satogata, G. Sborlini, M. Schram, D. Shih, J. Singh, R. Singh, A. Siodmok, P. Stone, J. Stevens, L. Suarez, K. Suresh, A.-N. Tawfik, F. Torales Acosta, N. Tran, R. Trotta, F. J. Twagirayezu, R. Tyson, S. Volkova, A. Vossen, E. Walter, D. Whiteson, M. Williams, S. Wu, N. Zachariou, P. Zurita

The Electron-Ion Collider (EIC), a state-of-the-art facility for studying the strong force, is expected to begin commissioning its first experiments in 2028. This is an opportune time for artificial intelligence (AI) to be included from the start at this facility and in all phases that lead up to the experiments. The second annual workshop organized by the AI4EIC working group, which recently took place, centered on exploring all current and prospective application areas of AI for the EIC. This workshop is not only beneficial for the EIC, but also provides valuable insights for the newly established ePIC collaboration at EIC. This paper summarizes the different activities and R&D projects covered across the sessions of the workshop and provides an overview of the goals, approaches and strategies regarding AI/ML in the EIC community, as well as cutting-edge techniques currently studied in other experiments.
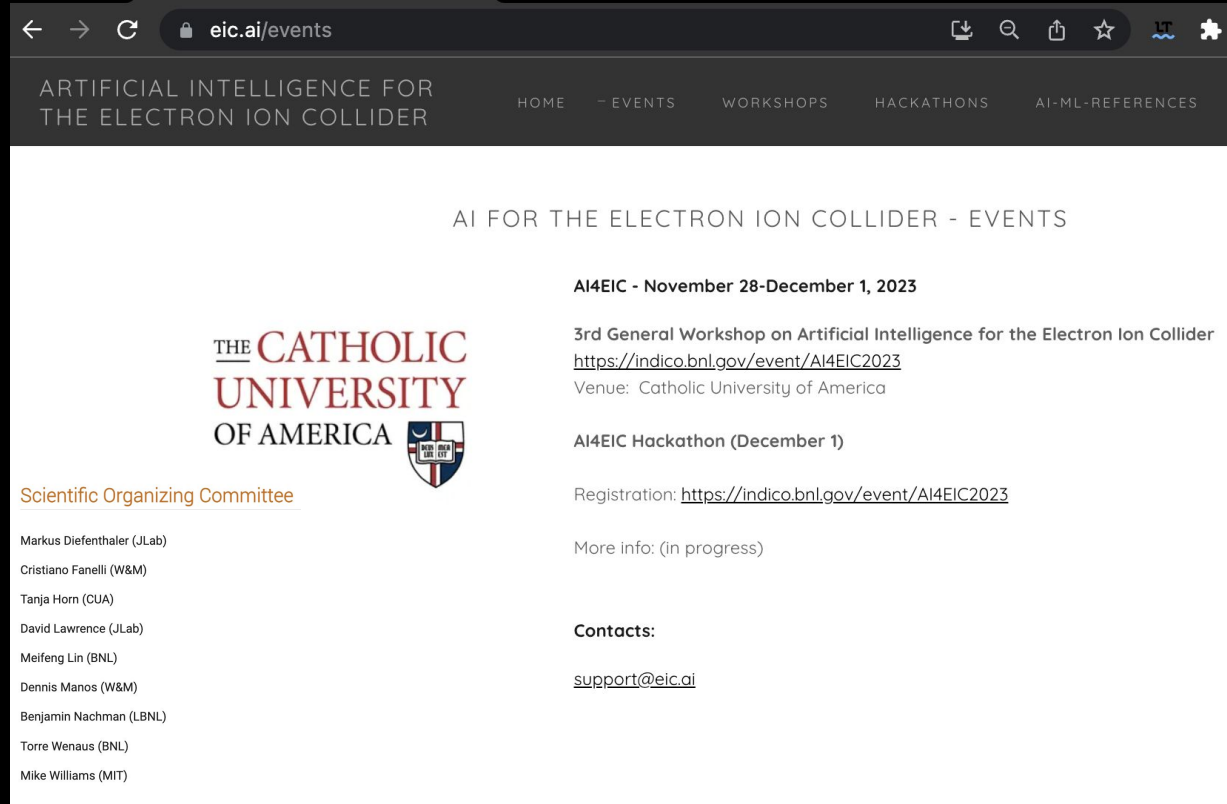
- Design
- Intersection theory/experiment
- Reconstruction and PID
- Infrastructure and Frontiers
- Streaming
- Community efforts:
  - Tutorials
  - Hackathon

https://arxiv.org/abs/2307.08593
(July 17 - submitted to Computing and Software for Big Science)

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Upcoming Events

- Forthcoming workshop +hackathon at CUA in Washington D.C. November 28 - 30, 2023

- Hackathon (Dec 1, 2023)

- Hybrid format (in-person + virtual)

- Contributions
  - Abstract submission
  - By invitation
  - JINST Proceedings

https://indico.bnl.gov/event/AI4EIC2023

A Pathway to Collaboration & Funding Opportunities

- During the recent AI4EIC workshop, we explored the concept of a multi-university AI/ML Center for the EIC Science. This platform aims to serve as a collaborative venue, bringing together diverse minds to exchange ideas, knowledge, and resources, while fostering partnerships among various universities.

- Challenges / motivating factors:

  - The current landscape of AI/ML activities tends to be fragmented, leading to unnecessary duplication of similar efforts despite their sparsity.

  - To implement AI/ML applications at scale and in production (particularly for streaming readout), the EIC requires significant collaborative action. Development of novel approaches/solutions may sometimes be necessary.

  - Current funding mechanisms for AI/ML can pose a challenge especially for universities with more limited resources.

  - Multidisciplinary efforts: the aim is to foster synergies among physics, data science, and computer science.

- The timing of AI4EIC is apt, considering the ongoing expansion and focus on data science. A significant educational component is entailed, necessary for nurturing the next generation of scientists active in EIC.

AI4EIC at W&M:
Fostering AI/ML Research for the EIC

This is what AI4EIC looks like at the university of William & Mary

- A dedicated physical space

- Strategically positioned near Jefferson Lab

- A dynamic hub for Data Science

space in Applied Science at W&M and plan to migrate in newly built ISC3/4 building in the next years

- University students

- Postdocs

- Visiting Researchers

- Fellows

The center will address the challenges of scattered efforts, amplify collaborative AI/ML initiatives for the EIC, assist in securing funding, and encourage cross-disciplinary collaboration.

Outlook

We will have the third annual workshop and hackathon on Nov 28-Dec 1, 2023 in Washington DC — https://indico.bnl.gov/event/AI4EIC2023

People interested in the AI4EIC activities and/or in proposing new ideas can email support@eic.ai

More info on https://eic.ai