The 5th IML Machine Learning Workshop

Closing session

The 2022 Workshop Organizers:
Simon Akar, Anja Butter, Fabio Catalano, Gian Michele Innocenti, Michael Kagan, Lorenzo Moneta, David Rousseau, Riccardo Torre, Pietro Vischia, Andrea Wulzer

UCLouvain
Institut de recherche
en mathématique et physique

5th IML Machine Learning Workshop

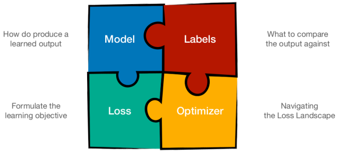
The Workshop

- *“Each spring IML organizes an annual workshop typically comprised of **roughly 300 participants**, which includes invited data scientists’ talks, submitted talks, and tutorials.”*
- The previos edition, 4th, was in 2020...
- ...but here we are
  - 600 registered participants from many continents!
  - 73 contributions (tutorials, plenary, workshop)
- For this edition we finally are back in person (in hybdrid form
- All talks have been recorded will be (mostly already are) linked in the agenda
- Upon request, we provide registration certificates (write us an email iml.coordinators@cern.ch if you need one)
  - Participants online: please provide the details (e.g. email address) you used to connect to zoom (80% attendance threshold)

- Moved to our next IML monthly meeting, be sure you connect!
  - We hope to spark a discussion on the scope and requirements for ML resources at CERN

Image from Flickr (wingedwolf/5471047557)

The Ingredients of a (Deep) Learning system

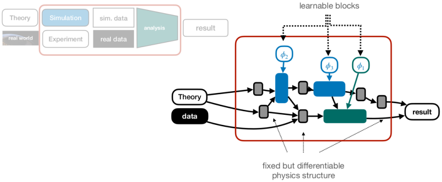


We want to put physics into each of these!

This talk: one weird trick to do it

Mix & Match

Broader view of differentiable programming allows us to enforce physics structure where we need it to but also jointly optimise all "neural" blocks



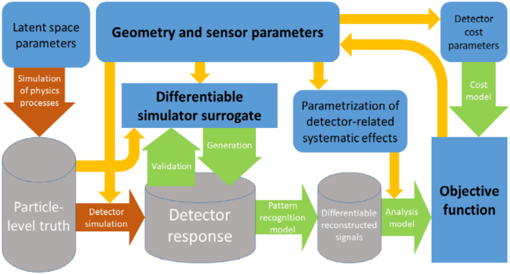
Differentiable Programming is the main topic of today's tutorial

Realigning design choices and ultimate goals

The target of **MODE** is to design a scalable, versatile architecture that can provide end-to-end optimization of particle detectors, proving it on a number of different applications across different domains.

The key observation is that while the detectors of HEP, astro-HEP etc. are quite varied and their purposes are diverse, the inference extraction process, and therefore its modeling, share marked similarities across the board

✉ If we "solve" a few problems we may construct a library of solutions and exploit the universality of the architecture and its modularity, re-using modeling efforts



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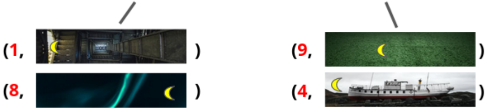
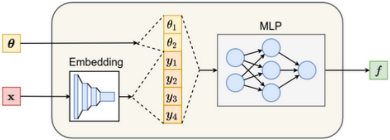
Neural ratio estimation (NRE) in a nutshell

Strategy: Learning to distinguish between **matching (parameter, data) pairs** and **random pairs**.



Loss function: Binary cross entropy

$$\ell[f_\phi]_{\mathrm{NRE}} = -\int d\boldsymbol{x}\, d\boldsymbol{\theta}\, \left[p(\boldsymbol{x}, \boldsymbol{\theta}) \ln \sigma(f_\phi(\boldsymbol{x}, \boldsymbol{\theta})) + p(\boldsymbol{x})p(\boldsymbol{\theta}) \ln\left(1 - \sigma(f_\phi(\boldsymbol{x}, \boldsymbol{\theta}))\right)\right]$$



Minimizing network approximates posteriors

$$f_\phi(\boldsymbol{\theta}, \boldsymbol{x}) \approx \ln \frac{p(\boldsymbol{x}, \boldsymbol{\theta})}{p(\boldsymbol{x})p(\boldsymbol{\theta})} = \ln \frac{p(\boldsymbol{\theta}|\boldsymbol{x})}{p(\boldsymbol{\theta})}$$

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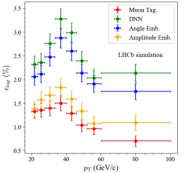
Hermans+ 1903.04057, Miller+ 2107.01214, Cole+ 2111.08030

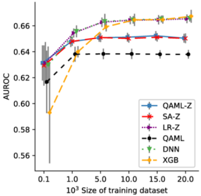
Quantum ML in HEP: Sofia Vallecorsa

QML in High Energy Physics

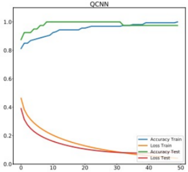


Alexander Zlokapa, Alex Mott, Joshua Job, Jean-Roch Vlimant, Daniel Lidar, and Maria Spiropulu. **Quantum adiabatic machine learning by zooming into a region of the energy surface.** Physical Review A, 102:062405, 2020. DOI:10.1103/PhysRevA.102.062405.

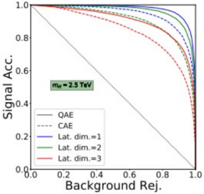
Alessio Gianelle, Patrick Koppenburg, Donatella Lucchesi, Davide Nicotra, Eduardo Rodrigues, Lorenzo Sestini, Jacco de Vries, and Davide Zuliani. **Quantum Machine Learning for *b*-jet identification.** arXiv:2202.13943, 2022.



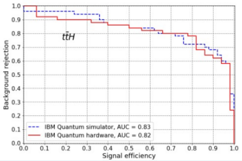
Samuel Yen-Chi Chen, Tzu-Chieh Wei, Chao Zhang, Haiwang Yu, and Shinjae Yoo. **Quantum convolutional neural networks for high energy physics data analysis.** arXiv preprint: 2012.12177, 2020.



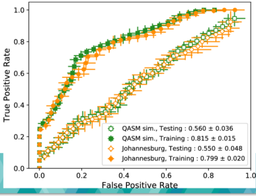
Vishal S Ngairangbam, Michael Spannowsky, and Michihisa Takeuchi. **Anomaly detection in high-energy physics using a quantum autoencoder**. arXiv preprint arXiv:2112.04958, 2021.

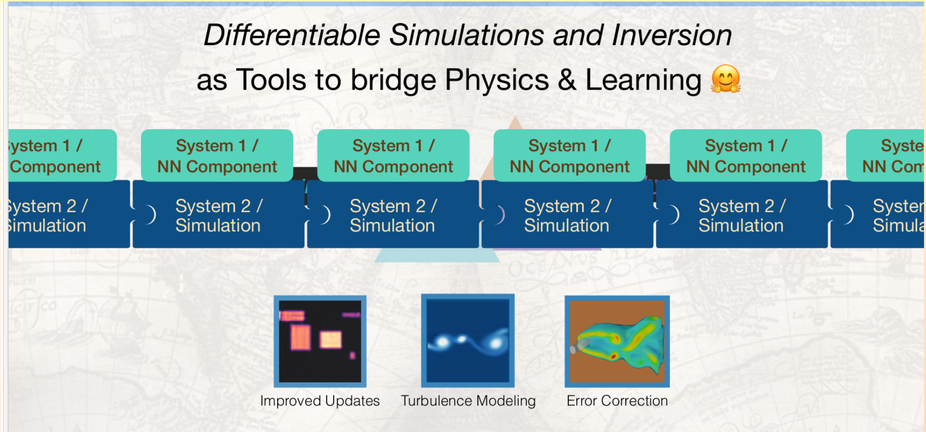


Sau Lan Wu, Jay Chan, Wen Guan, Shaojun Sun, Alex Wang, Chen Zhou, Miron Livny, Federico Carminati, Alberto Di Meglio, Andy C Y Li, and et al. **Application of quantum machine learning using the quantum variational classifier method to high energy physics analysis at the lhc on ibm quantum computer simulator and hardware with 10 qubits**. Journal of Physics G: Nuclear and Particle Physics, 48(12):125003, Oct 2021



Koji Terashi, Michiru Kaneda, Tomoe Kishimoto, Masahiko Saito, Ryu Sawada, and Junichi Tanaka. **Event classification with quantum machine learning in 20 high-energy physics**. Computing and Software for Big Science, 5(1), January 2021.




Differentiable Simulations and Inversion
as Tools to bridge Physics & Learning
System 1 / NN Component
System 2 / Simulation
Improved Updates
Turbulence Modeling
Error Correction


scikit learn
scikit-learn the origin in 2010
Really started with Inria funding in
2010 in PARIETAL team

Optical Processing Unit technology

Lig

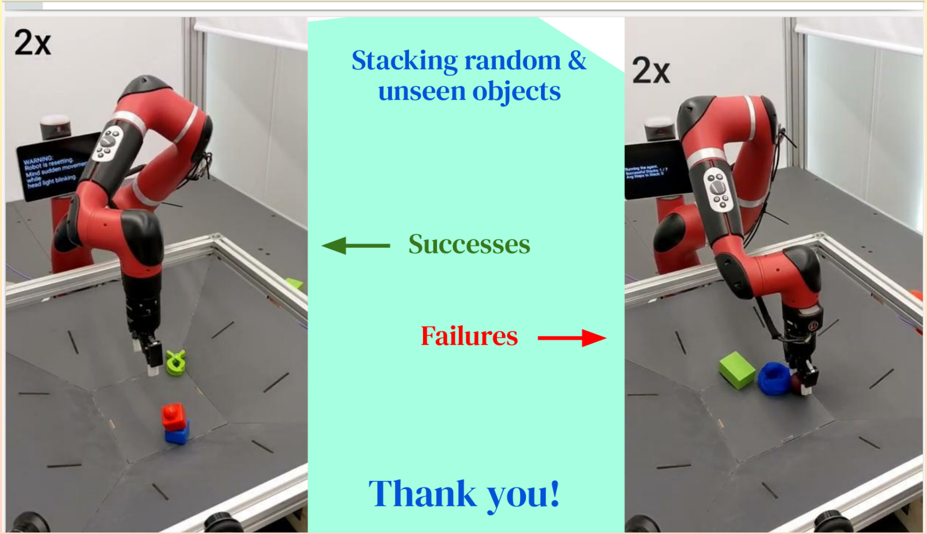
LightOn Appliance: the world's first photonic AI co-processor publicly available, since March 7th, 2021

2200 TOPS
In a single photonic core

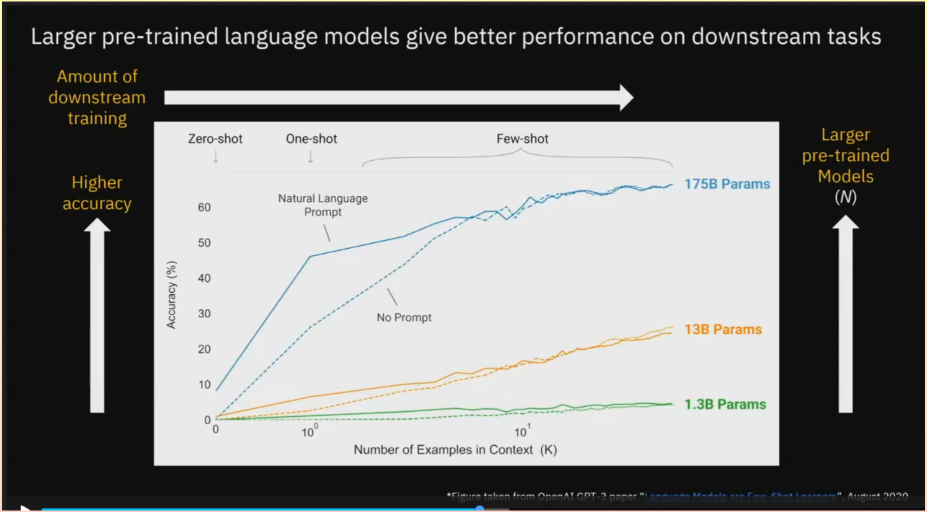
With only 30 W TDP
200 times better in #OPS/W than NVIDIA top-range GPU boards

Used by AI experts worldwide through our "LightOn Cloud for research" program

Beyond pick-and-place: reinforcement learning in robotics: Coline Devin



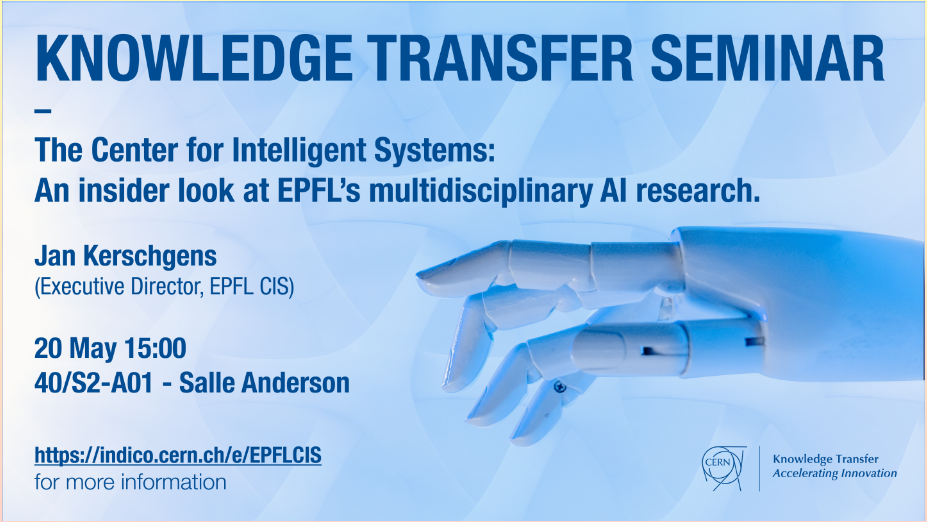
Foundation Models: John R. Smith



Many other topics: you!!!

- Several high-quality talks (all recorded!!!)
  - 32 “long” contributions
  - 11 “short” contributions
  - 17 “lightning” contributions
- Several areas of interest, e.g.:
  - Uncertainty quantification
  - Structure our data using graph networks
  - Anomaly detection
  - ML aware of physical constraints / invariant laws

Advertisement: CERN Knowledge Transfer Event



Advertisement: PhyStat Anomalies

24–25 May 2022
Europe/Madrid timezone

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- Overview
- Timetable
- Contribution List
- Registration
- Participant List
- Videoconference
- Reading Material
- Introduction to Particle Physics for Statisticians

A workshop on model independent searches, bringing together physicists and statisticians

With higher accelerator energies and beam intensities, searches for New Physics (NP) have been a very active area. While there is motivation for NP, so far model-driven searches have successfully excluded increasing volumes of parameter space, but not yielded evidence for new particles. This has led, over the last few years, to the development of model-independent searches. By now, they have become a useful complement to traditional approaches targeting some specific form of NP. In many of the new searches, Machine Learning has played an important role. The aim of this meeting is to compare and contrast the assumptions and performance on these approaches, and to see what can be learned from Goodness of Fit methodology. This meeting will bring together physicists who are active in this field, those who want to be involved in the future, and Statisticians, to discuss the relevant issues.

The meeting is on 24th and 25th May 2022, and will be remote. The PHYSTAT Seminar on 27th April by Mikael Kuusela (CMU) on "Model-Independent Detection of New Physics Signals Using Interpretable Semi-Supervised Classifier Tests" is also part of the PHYSTAT-Anomalies meeting. See https://indico.cern.ch/event/1148820/

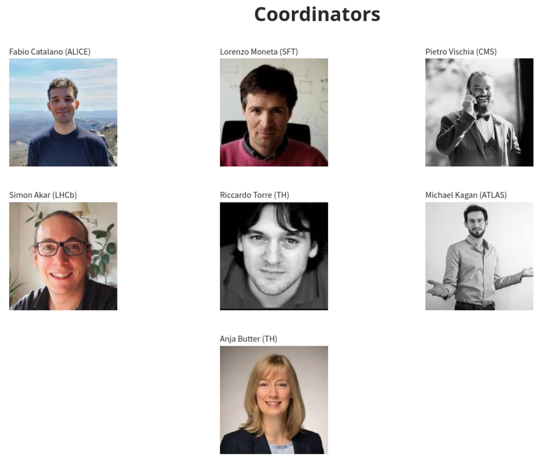
Advertisement: The 2nd MODE Workshop on Differentiable Programming

- Information at https://indico.cern.ch/event/1145124/
  - Registration and abstract submission will open on May 20th
  - First confirmed keynote: **Adam Paszke** (Google Brain)

12–16 September 2022, Kolumbari (Crete)

You can contact us at iml.coordinators@cern.ch

if you wish to present at one of our meetings



WE HOPE YOU HAD FUN!!!

We will circulate a survey in the next few days: please fill it up to help us improving this workshop series!!!