SMARTHEP

REAL-TIME ANALYSIS FOR SCIENCE AND INDUSTRY

ESR12: Accelerated Anomaly Detection

Pratik Jawahar

Supervisors:
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Maurizio Pierini

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About Me

- Name: Pratik Jawahar; DOB: 24 Jan 1997 (India), Raised: NJ, USA
- Host: University of Manchester, CERN - ATLAS Experiment; Start: Oct 2022
- Education
  - Undergraduate: National Institute of Technology Trichy, India (2015-2019)
    - Mechanical Engineering (Research Focus: Control Systems)
      - Minor: Humanitarian and Cognitive Science
    - Theses:
      - Automated Control of Industrial Manipulators in Dynamic Environments
      - Reading as a Cognitive Learning Process [Minor]
  - Masters: Worcester Polytechnic institute, MA, USA (2019-2022)
    - Robotics Engineering (Research Focus: Deep Learning, Anomaly Detection)
      - Thesis: Fault Detection in Robot Swarms with Lying Agents using Unsupervised Deep Learning
  - PhD: Manchester, UK (Oct 2022-Present)
    - Particle Physics [ATLAS Experiment]
- Relevant Experience
  - Summer Student at CERN (EP-CMX) [May-Aug 2018]
    - Automation of QC testing for GEM Detectors
  - Technical Student/External at CERN (EP-CMG) [June 2020 - Feb 2022]
    - Deep Learning algorithms as Trigger-Level Anomaly Detectors for New Physics Searches
- Research Experience:
  - Control Algorithms, Micro-Robots, Swarm Robots, ML, CV, Audio Analytics

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Project A: Heterogenous Architectures for improved Track Reconstruction

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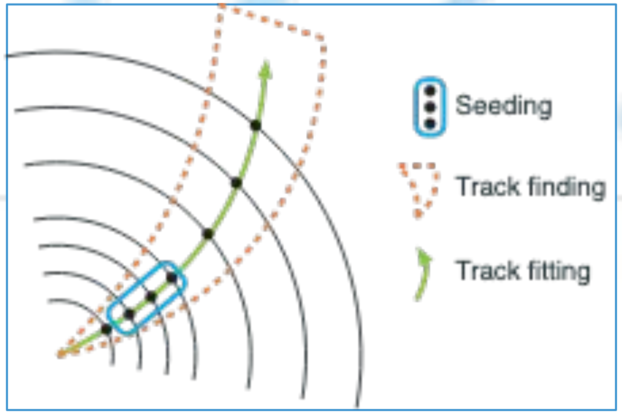
Tracking - ACTS

- Track Reconstruction:
  - Recover information about charged particles
    - how? - study their interactions with highly sensitive detectors arranged in a defined detector geometry
- High pileup (planned future upgrades to the LHC) requires faster computation of tracks
- Potential solution: Heterogenous Architectures (CPU, GPU, FPGA etc.)
  - Study if a heterogenous solution is feasible
    - Measure current runtime overheads, latencies etc.
  - If feasible, prototype and test potential solutions and measure speedup vs costs incurred
  - Implementation in the context of ATLAS tracking SW



CPU: Intel i5-10600 @ 4.10Ghz, GPU: Nvidia RTX 3090 24GBs, CUDA 11.7, Nvidia driver: 515.43.04, CC. 8.6

	64 THD/BLK					512 THD/BLK				
Function Name	**Cycles [cycle]**	**Duration [ms]**	**Compute Throughput [%]**	**Memory Throughput [%]**	**# Registers [register/thread]**	**Cycles [cycle]**	**Duration [ms]**	**Compute Throughput [%]**	**Memory Throughput [%]**	**# Registers [register/thread]**
find_clusters	3,895,811	2.79	0.31	2.35	48	5,127,261	3.72	0.24	1.72	48
count_cluster_cells	26,657	0.02	8.29	41.49	16	23,836	0.02	9.27	46.46	16
connect_components	690,531	0.5	0.78	8.54	32	669,326	0.48	0.81	20.62	32
create_measurements	752,744	0.54	2.76	19.11	70	675,834	0.51	3.08	15.95	70
form_spacepoints	35,335	0.03	8.39	39.41	38	40,254	0.03	7.36	37.96	38
count_grid_capacities	19,986	0.02	11.52	40.69	32	20,221	0.02	11.38	40.33	32
populate_grid	30,586	0.02	8.48	39.53	34	30,812	0.02	8.42	39.25	34
count_doublets	353,799	0.26	25	12.07	40	359,410	0.26	24.63	11.85	40
find_doublets	1,488,936	1.07	11.82	27.7	104	1,491,983	1.07	11.8	27.66	104
count_triplets	223,972	0.16	42.39	20.53	45	221,584	0.16	42.7	20.69	45
find_triplets	124,189	0.09	6.29	6.84	82	126,959	0.09	6.13	6.72	82
update_triplet_weights	10,552	0.01	5.34	25.08	32	10,431	0.01	5.39	25.32	32
select_seeds	142,334	0.1	14.14	14.14	74	142,188	0.1	14.24	14.24	74
estimate_track_params	35,710	0.03	3.89	49.83	47	35,298	0.03	3.94	50.33	47
Execution time		5.64					6.52			

Results from Minsi Chen (University of Huddersfield)

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Project B: Real-time Anomaly Detection at Trigger Level using Machine Learning

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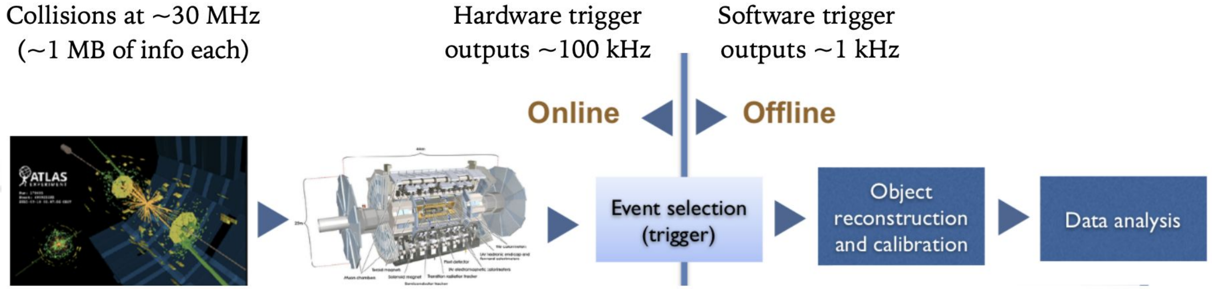
Anomaly Detection

- Collisions at very high frequency
  - Not all events can be stored to later analyze
  - Trigger: Selects 'interesting' events
    - Selection:
      - Specific Model-based Searches
      - Anomaly Detection
    - Online trigger - Real Time
- Experience
  - Darkmachines Anomaly Detection Challenge: https://scipost.org/SciPostPhys.12.1.043
  - Normalizing Flow to improve VAEs as Anomaly Detectors: https://www.frontiersin.org/articles/10.3389/fdata.2022.803685/full
- Data Storage Issues
  - Compressed data => More data can be stored
    - Autoencoders for Data Compression



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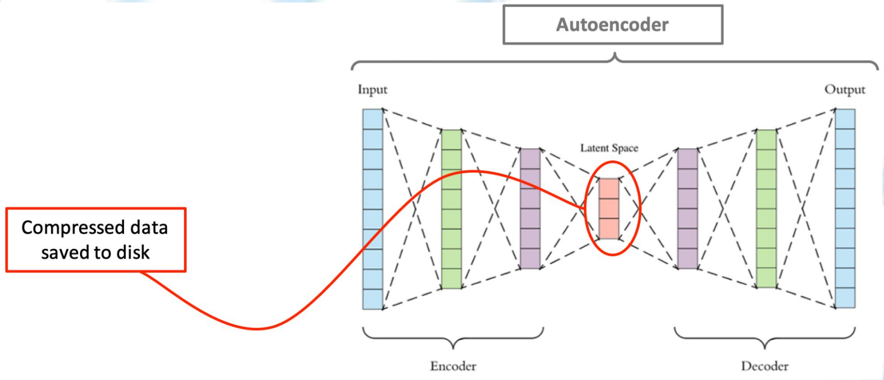
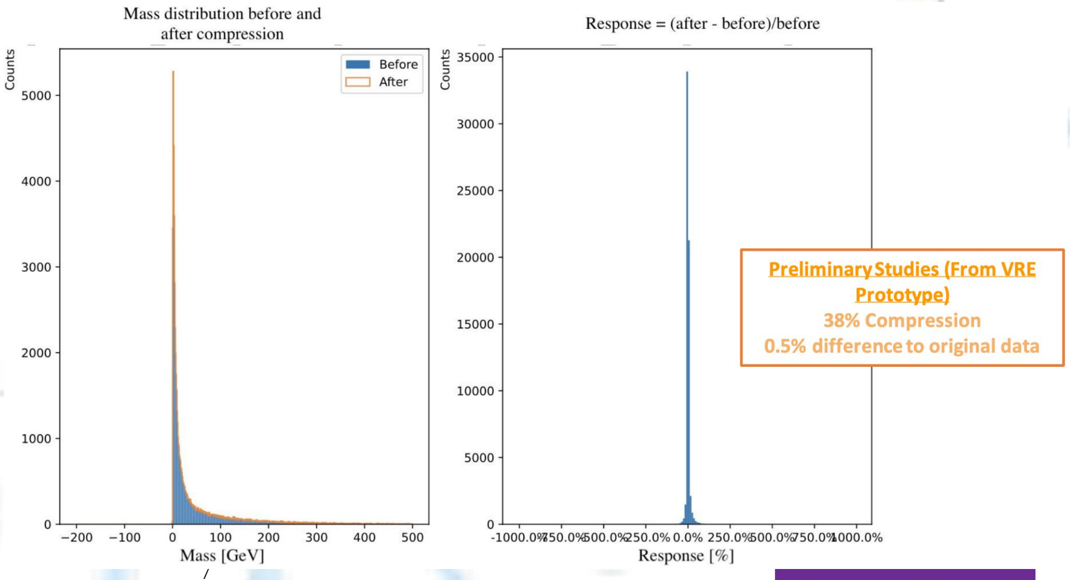
Data Compression using Autoencoders

- Autoencoders (lossy compression):
  - Compression
    - Encoder - Neural network that compresses input data to lower dimensional latent representation (abstract features)
  - Decompression
    - Decoder - Neural network that decompresses latent data points back to the reconstructed input
- AE compression is useful to the scientific community beyond just particle physics
  - AE compression has existed for a while
    - However, no package/tool available tailored to scientific data
  - Currently collaborating with researchers from Lund University and University of Manchester to package this methodology into a plug-and-play software tool
  - Currently testing tool on
    - Particle Physics Data
    - Computational Fluid Dynamics Data
- Poster accepted at CHEP 2022





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Trainings/Outreach

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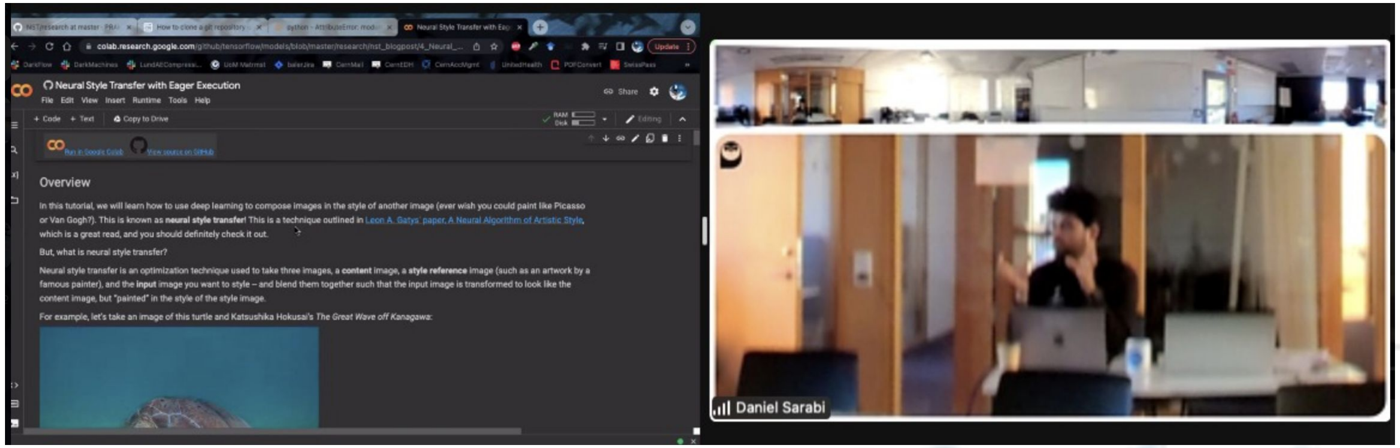
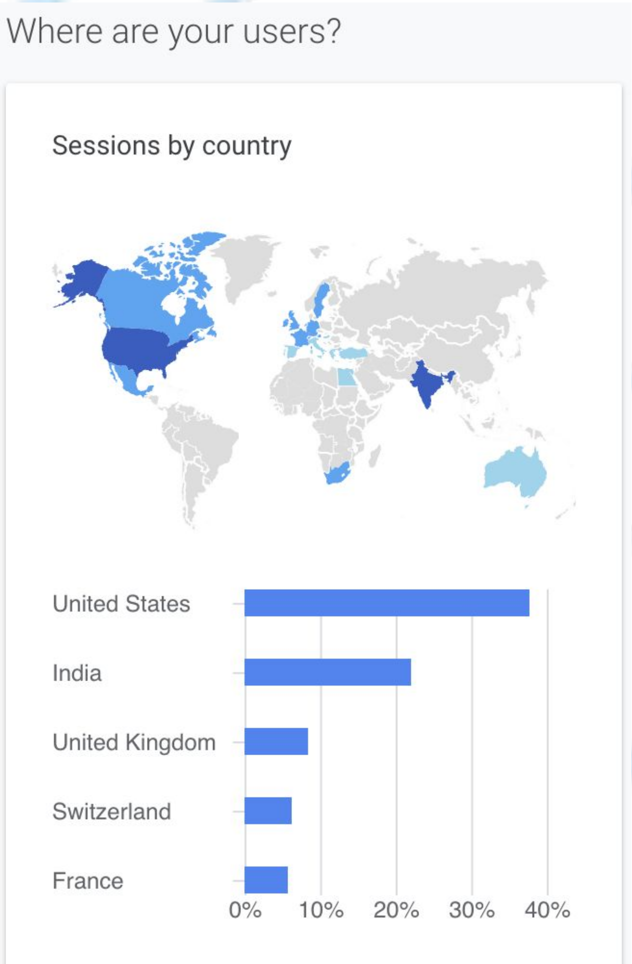
- Assisted in teaching the *"Reproducible and Interactive Data Analysis and Modelling using Jypyter Notebooks"* course to graduate researchers as part of the COMPUTE school at Lund, Sweden (December 2022)
  - Demonstrated the uses of Jupyter notebooks for scientific presentations
  - Presenting a walkthrough of *"Neural Style Transfer"* in an interactive manner and provided a summary of techniques used
- Personal website: [https://www.pratikjawahar.com/]
  - Last 12 months:
    - </Research> Views: 753
    - Query forms answered: 319





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Career Expectations

- Stay acquianted with state-of-art RTA and Machine Learning techniques
  - Continue research contributions preferably within the context of Particle Physics
- Get an idea of how different/similar research in academia and industry are
- Network with experts to identify gaps for potential contributions and for guidance to navigate the field

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Thank You!

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