Dark Machines

http://darkmachines.org/

♥ @dark_machines

Bob Stienen ATLAS Machine Learning Workshop November 11th, 2019



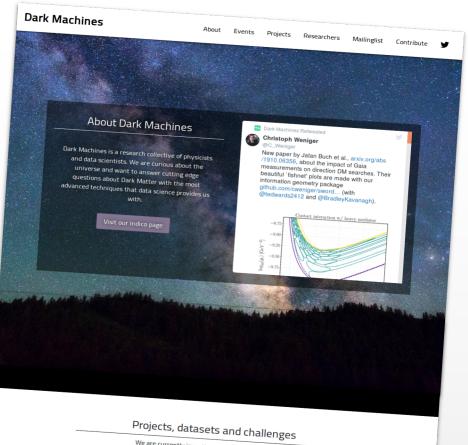
The goal of Dark Machines

Exploit recent advances in Machine Learning to help in the search for Dark Matter

Who is Dark Machines

Online research collective with scientists from range of fields

Many are ML experts, all are ML enthusiasts

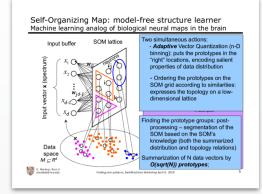


We are currently investigating the following projects. Click the project name for information on how to join.

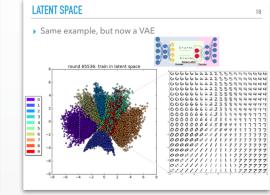
Collider searches and unsupervised: or supervised or not-yet-thought-off learning

Eventeers

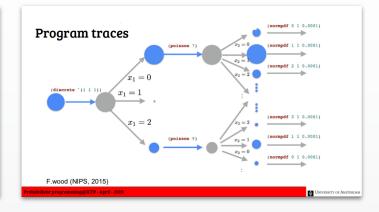
Flashes from our previous workshop



Self-organising maps



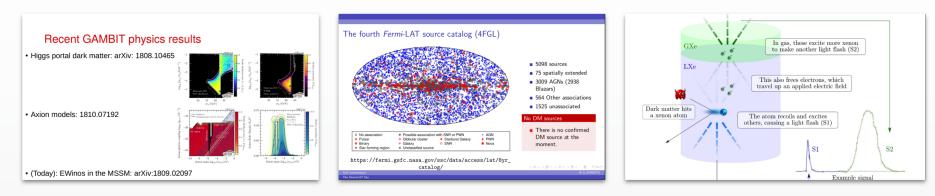
Variational Auto-encoders



Probabilistic Programming

http://indico.ictp.it/event/8674/session/155/contribution/1120/material/slides/ http://indico.ictp.it/event/8674/session/155/contribution/1121/material/slides/ http://indico.ictp.it/event/8674/session/153/contribution/1109/material/slides/

Flashes from our previous workshop



Gambit

Fermi-LAT

XENON

http://indico.ictp.it/event/8674/session/155/contribution/1123/material/slides/ http://indico.ictp.it/event/8674/session/153/contribution/1110/material/slides/ http://indico.ictp.it/event/8674/session/158/contribution/1141/material/slides/

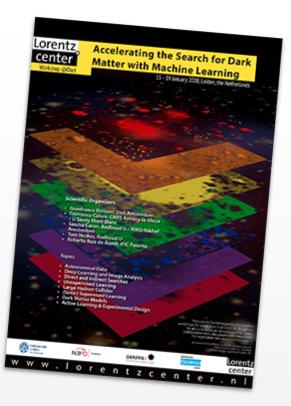
What does Dark Machines do

Yearly workshop 2018 @ Lorentz Center, Leiden, The Netherlands 2019 @ ICTP, Trieste, Italy 2020 @ CERN (April 27th - May 1st)

Network of 216 members

Regular meetings

Currently 8 research lines (a.k.a. challenges)



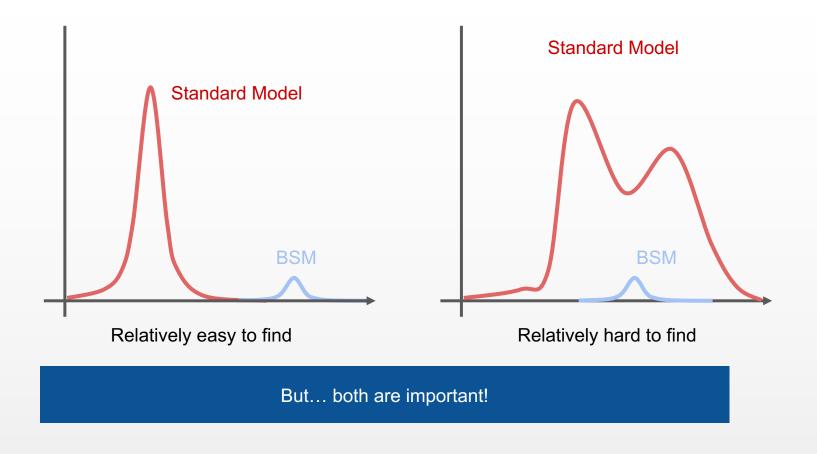
Examples of challenges

Particle track reconstruction with ML Sydney Otten, Michela Negro and Fabian Gieseke Exploring high dimensional parameter spaces Martin White and Joaquin Vanschoren

Unsupervised collider searches Andrea de Simone, Maurizio Pierini and Amir Farbin

Inclusive analysis of Fermi-LAT point sources Luc Hendriks and Gabrijela Zaharijas Library of trained models Sanmay Ganguly and Bob Stienen

Unsupersived Collider Searches



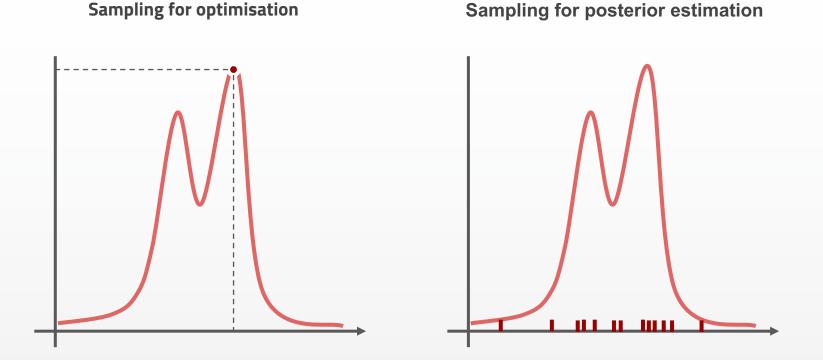
Unsupersived Collider Searches

Generated Standard Model events and events from BSM models

O(10⁹) events generated in order to archieve 10 fb⁻¹

Challenge: "Find the BSM physics"

Open to community, everyone can participate. Join with your favourite algorithm!



Naive approach of random sampling is flawed:

- Concentrates points near the edge of the parameter space for high dimensional problems, leading to biased inference
- Easily misses high-likelihood regions in strongly peaked spaces

So more sophisticated algorithms are needed! But...

Sampling for optimisation	Sampling for posterior estimation				
Random sampling	Rejection sampling				
Stochastic gradient descent	MCMC				
Genetic algorithms	PyBAMBI				
Particle swarm optimisation	MultiNest				

Which one should you choose?

Systematic investigation of sampling algorithms to find which algorithms work best in which situations

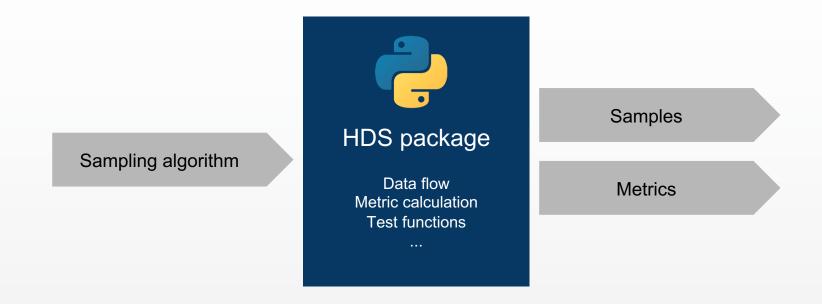
Python package written to do this (found on github, Travis CI and unit tests available, additions more than welcome)

Structure of package

Package is finished developing, algorithms are being added

Results will be available hopefully soon

Systematic investigation of sampling algorithms to find which algorithms work best in which situations



In other words: Join us! You w

Systematic investigation of sampling algorithms to find which algorithms work best in which situations

Open source code

Development through GitHub and pull requests

Travis CI integration

Unit tests with almost 100% coverage

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high_dimensional_sampling	Update changelog				4 months ago
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gitignore					14 days ago
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) .travis.yml					2 months ago
CHANGELOG.md	Move coverall installation				7 months ago
CODE_OF_CONDUCT.rst	Complete unit tests for entire package				23 days ago
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Move coverall installation

BE README.md

Systematic investigation of sampling algorithms to find which algorithms work best in which situations

Core of the package is finished

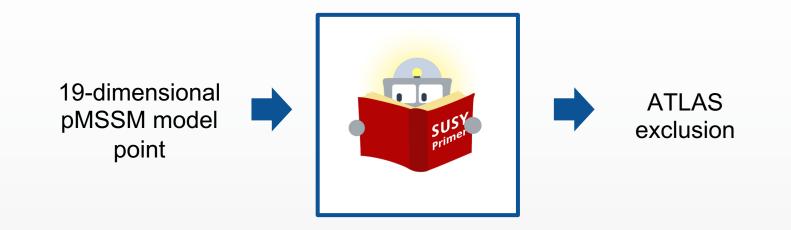
Algorithms are being added to the package

Stay tuned for results!

https://github.com/DarkMachines/high-dimensional-sampling

<> Code (1) Issues 2 (1)	Pull requests	🕮 Wiki 🕕 Securi		O Unwatch -	4 ★ Star 0 ♀Fork
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high_dimensional_sampling	Update changelog				4 months ago
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in tests	Add optimisation function	ns			12 days ago
editorconfig	Make PEP8 compliant				2 months ago
.gitignore	Template project				14 days ago
.prospector.yml	Create results submodule				7 months ago
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LICENSE	Template project				7 months ago
MANIFEST.in	Template project				7 months ago
NOTICE	Template project				7 months ago
README.md	Template project				7 months ago
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Example of a trained model made public



DOI: 10.1140/epjc/s10052-017-4814-9

Communicating trained models is not standard yet, even though they become more and more integral part of analyses in experiment and theory

Reasons

Using the models requires understanding machine learning (or ML libraries)

Model might be library dependent

Each model needs its own manual

Easy mistakes easy to make e.g. querying a prediction outside of training box

Facilitate easy communication of models, so that trained models can be used by external researchers

Easy to use for both implementer and end-user

Consistent interface for all trained models, reducing learning curve

Collection of trained models in a searchable library



Handles post- and preprocessing of data following rules of implementer

Server-client structure to allow easy implementation in HEP workflows

Understandable warnings and errors

Facilitate easy communication of models, so that trained models can be used by external researchers

Currently in the pipeline

Electroweak cross-section in pMSSM19

W' and Z' cross-sections

Doublet Higgs model

Loop integrals (input momenta, masses)

Higgs model with many nuisance parameters

Example relic density trained on observables

Reconstruction efficiencies of LLSps

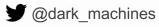
+ your model?

Global fits Gambit Zenodo data

Dark Machines

Exploit recent advances in Machine Learning to help in the search for Dark Matter

ttp://darkmachines.org/



Workshops

Network

Exciting challenges

Infrastructure for collaboration

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