Application of AI to IACTs and Dark Matter indirect direction

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High Energies Group (GAE)

TECHNICAL

SCIENTIFIC

TECHNICAL

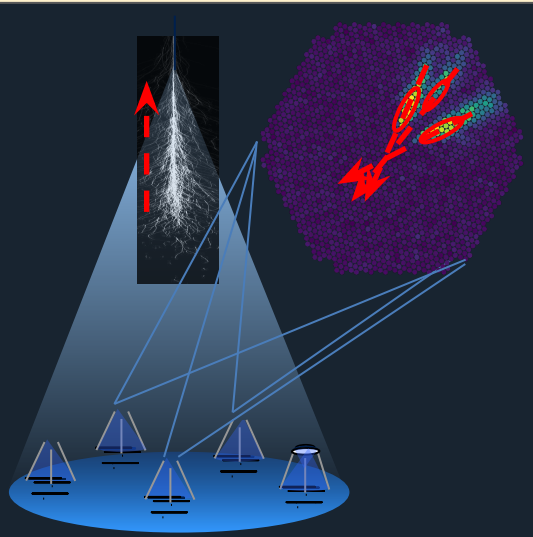
LST On-Site Analysis
Automatic system that process the LST-1 data

SCIENTIFIC

TECHNICAL

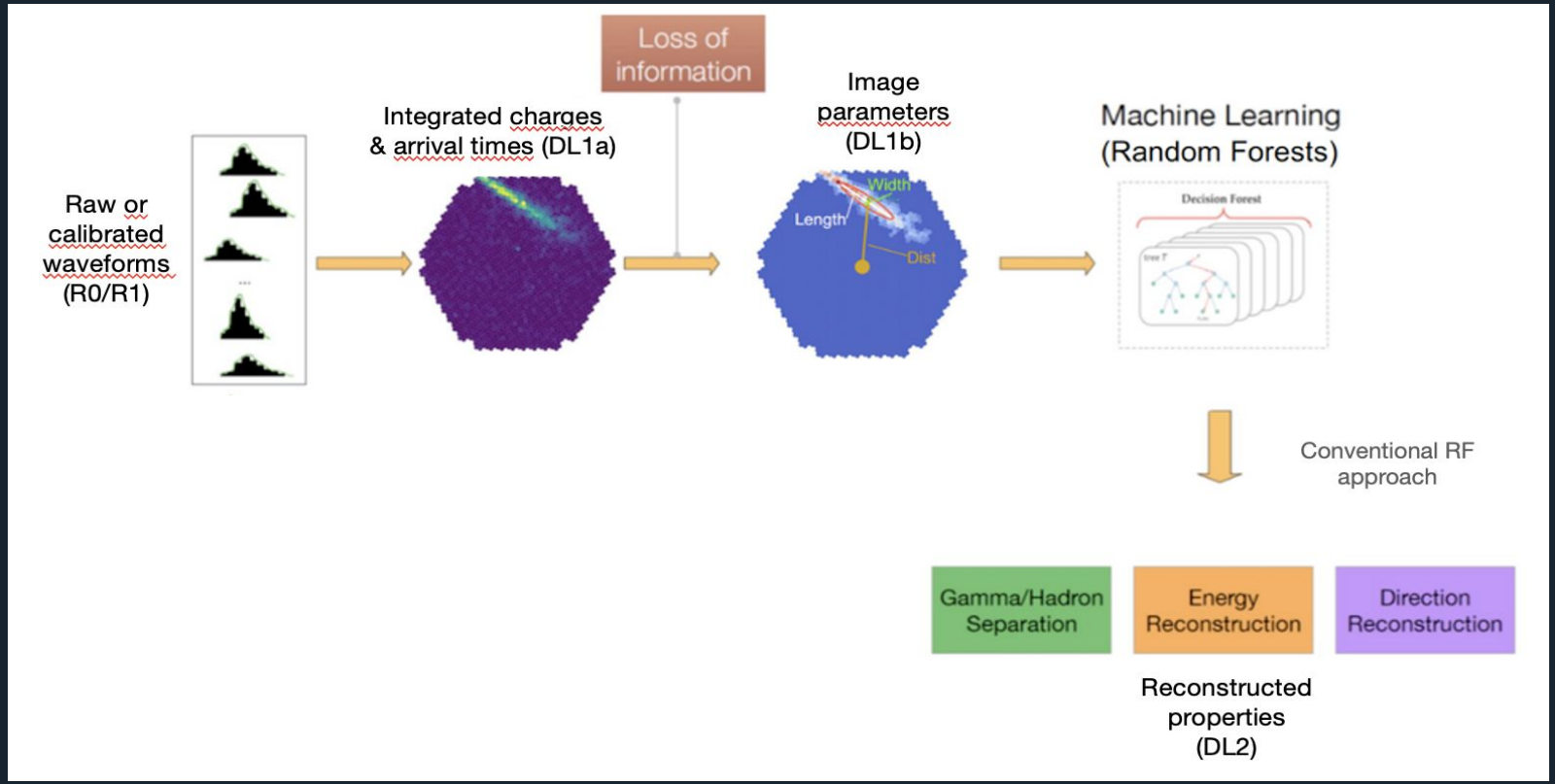
LST On-Site Analysis
Automatic system that process the LST-1 data

CNNs to IACTs

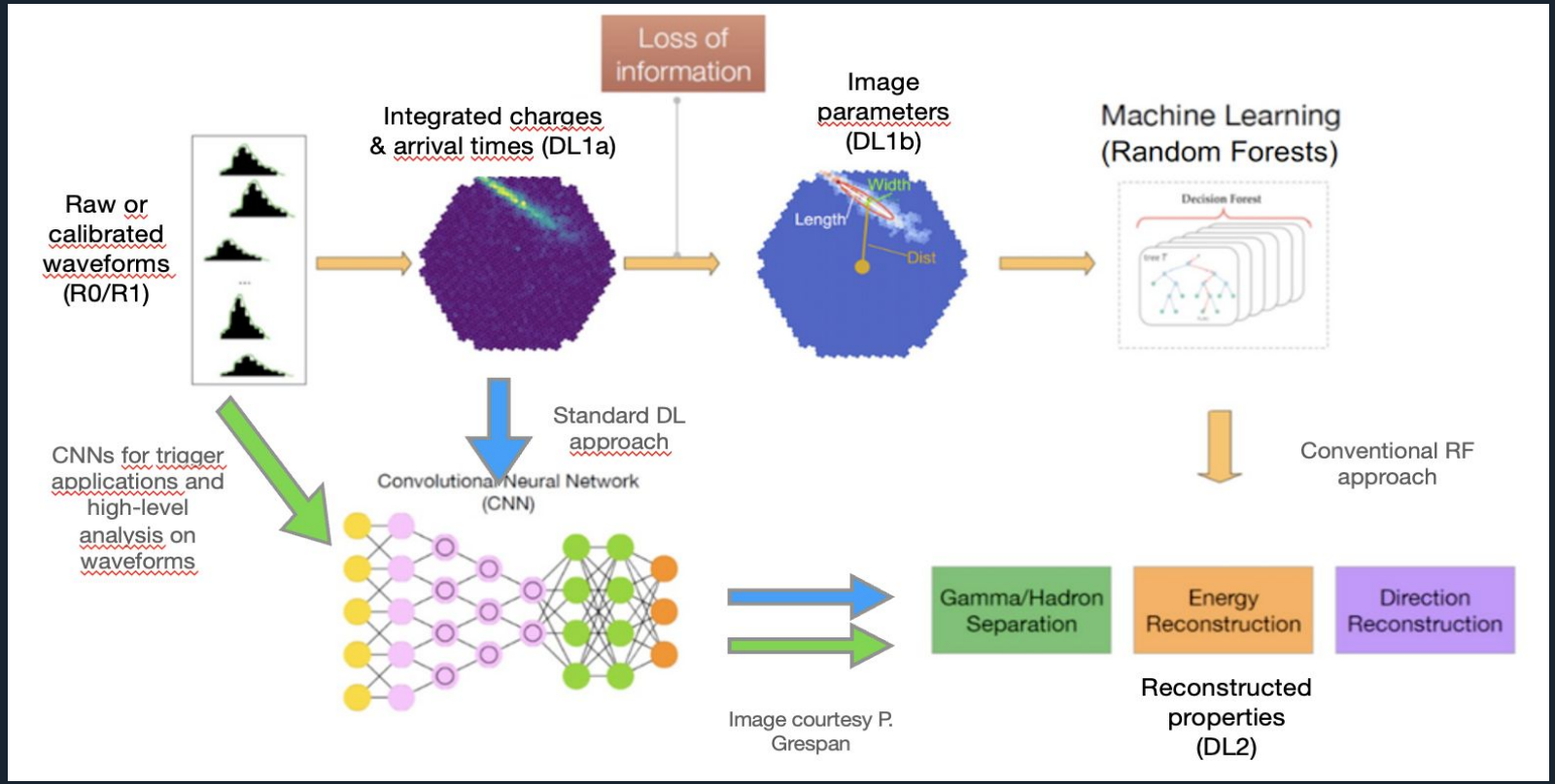


SCIENTIFIC

CURRENT STATUS

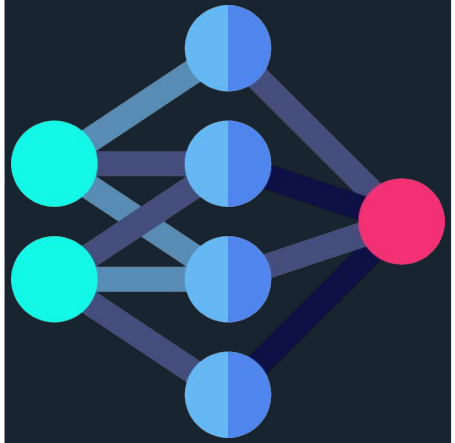


GOAL STATUS


Loss of information
Integrated charges & arrival times (DL1a)
Image parameters (DL1b)
Machine Learning (Random Forests)
Raw or calibrated waveforms (R0/R1)
Width
Length
Dist
Decision Forest
Standard DL approach
Conventional RF approach
CNNs for trigger applications and high-level analysis on waveforms
Convolutional Neural Network (CNN)
Gamma/Hadron Separation
Energy Reconstruction
Direction Reconstruction
Reconstructed properties (DL2)
Image courtesy P. Grespan

NEURAL NETWORKS

Like human neurons



Architecture

Parameters

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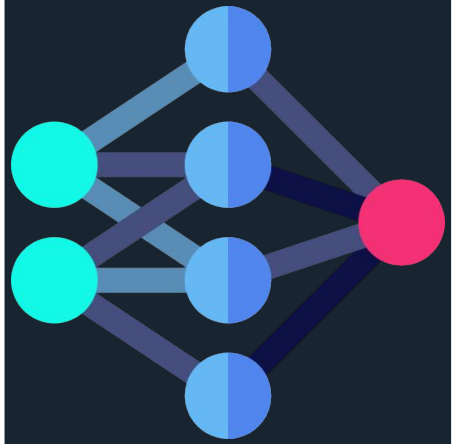
NEURAL NETWORKS
TRAINING



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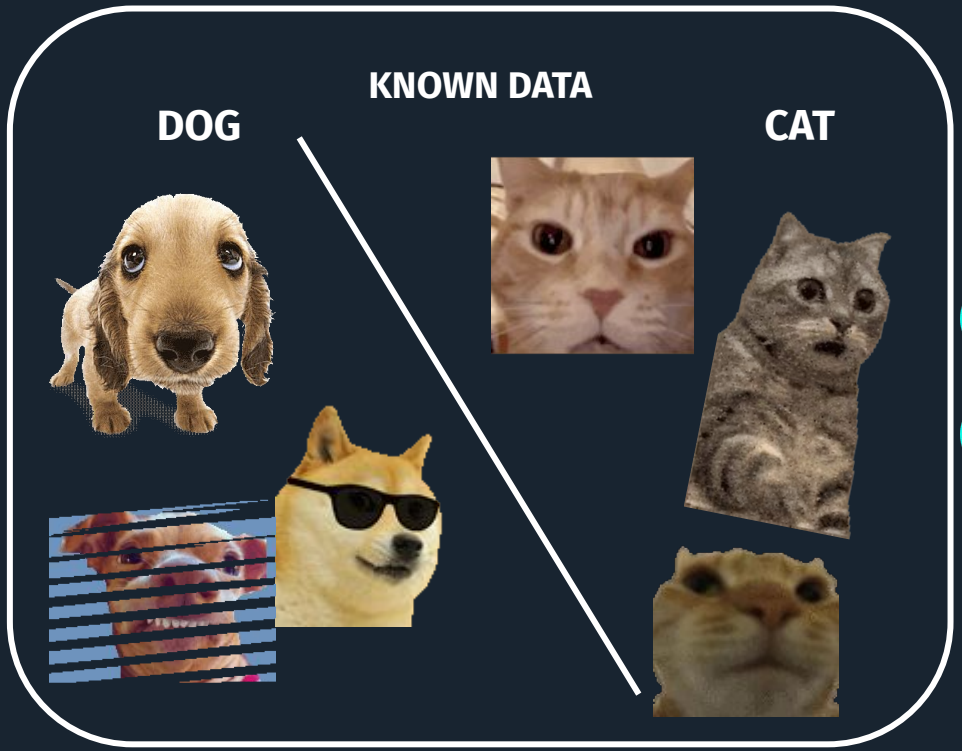
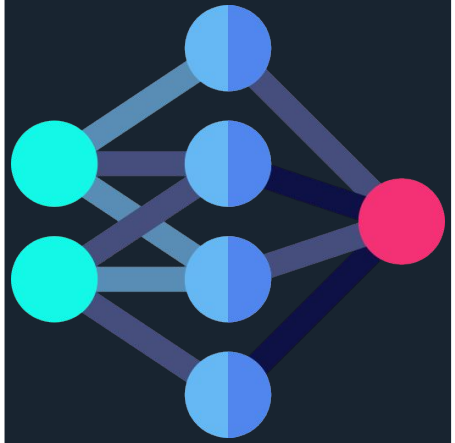
TRAINING





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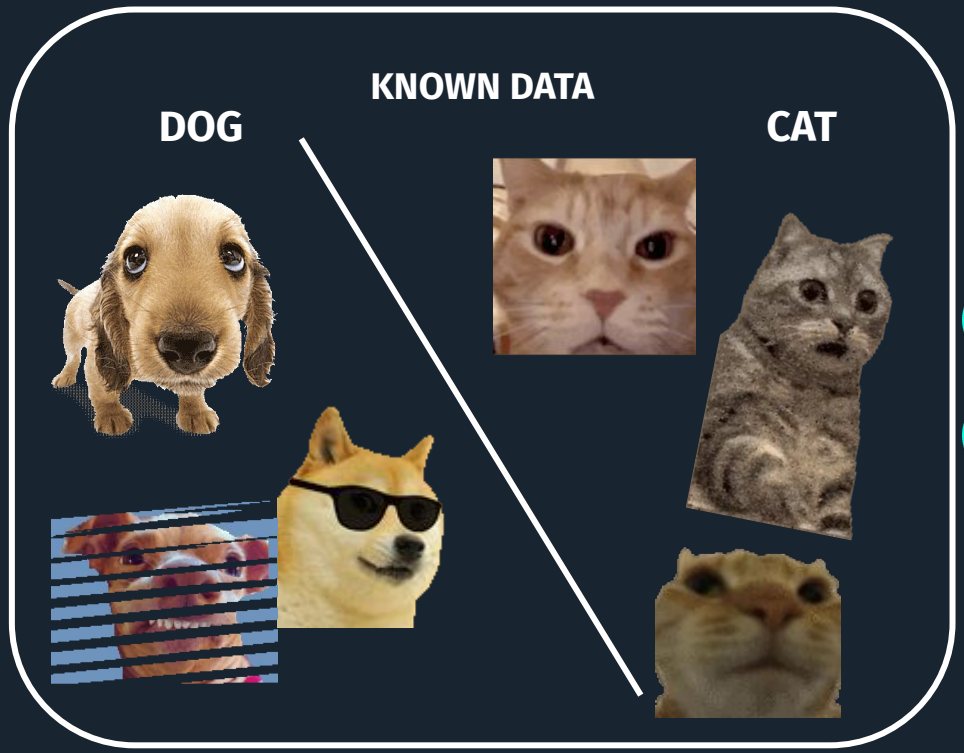
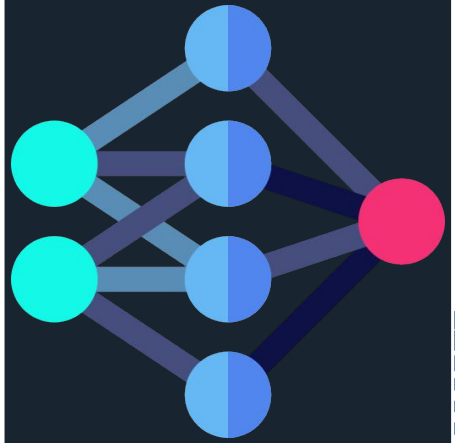
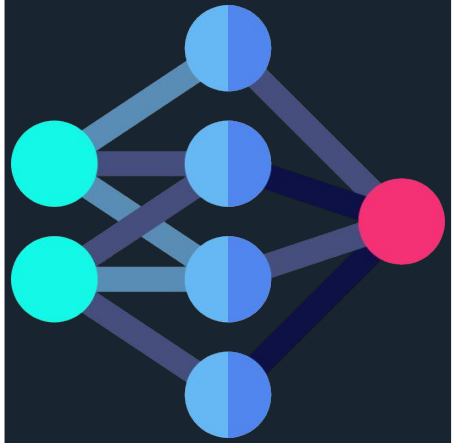




NEURAL NETWORKS
PREDICTION

NEW DATA

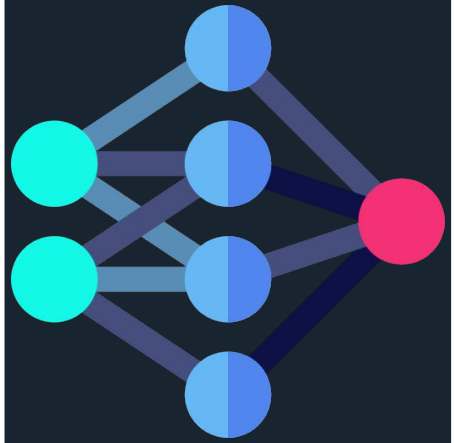


CAT

DOG

NEURAL NETWORKS
PREDICTION

NEW DATA



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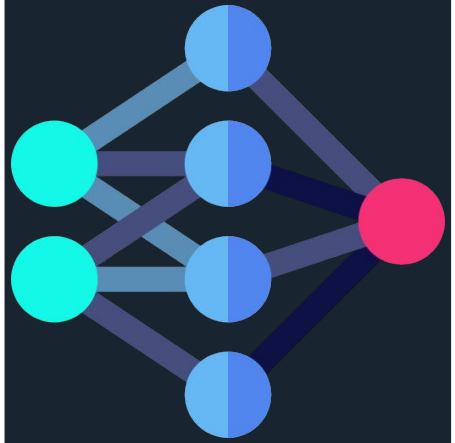
NEURAL NETWORKS
PREDICTION

NEW DATA



CAT

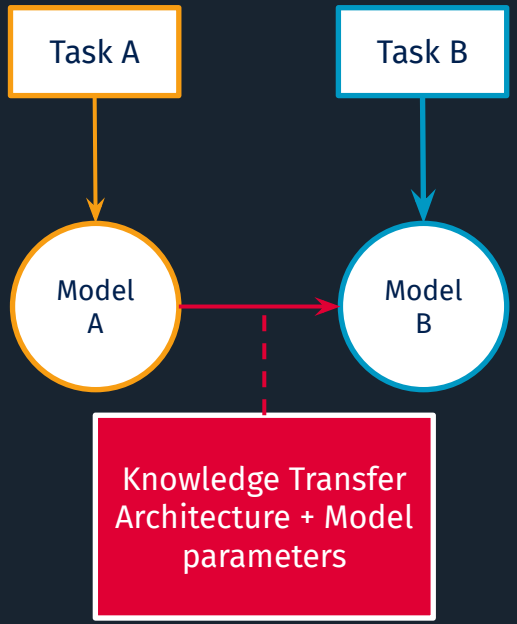
DOG

CTLEARN

- CTLearn is a high-level Python package for using **Deep Learning models for ground-based gamma-ray data analyses.**
- Developers and contributors from UCM, UniGe, IAA and U. of Torino
- Core functionality:
  - **Full-event reconstruction** of various imaging atmospheric Cherenkov telescopes in **monoscopic** and **stereoscopic** mode
  - **CNN-based analysis** on **waveforms** possible through the efficiently data management package **dl1-data-handler**
  - Application of an **AI-based Trigger system**, where neural networks are ported on FPGAs for real time processing.
- Latest release: v0.10.2 (21/03/2025)

https://github.com/ctlearn-project/ctlearn
https://ctlearn.readthedocs.io

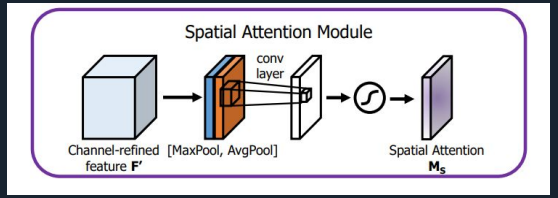
Transfer Learning

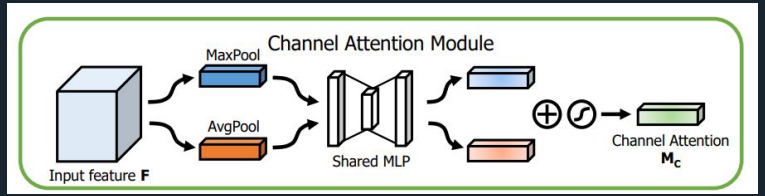


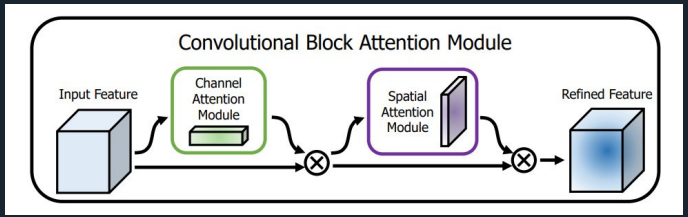
Can save up to 75% of training time

Good metrics with using less resources

Attention Experiments







Better understanding of the CNN Explainability

Cleaning step may be omitted

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CNNS for IACTs

Transfer Learning & Attention experiments

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SCIENTIFIC

Indirect search of DM

- Very early stage
- **WIMPS** (Weakly Interacting Massive Particles)
  - Gamma production when annihilation
- Possible sources: **Galactic center, dwarf spheroidal galaxies**...


THANK YOU