New frontiers in multimessenger neutrino astronomy with machine learning imaging

Supervisors: Dr Matteo Agostini, Prof Nikos Konstantinidis

Overview

The most exci t ng chapter in the history of mul t -messenger neutrino astronomy is about to unfold. The recent IceCube's discovery of neutrinos from supermassive black holes has opened a new window on our cosmos. These neutrinos coming from the edge of the observable universe are revolu t onising our understanding of astrophysical systems at the ul t mate energy and gravita t onal fron t ers. This mo t vated the construc t on of several new neutrino telescopes that will soon get online, increasing our detec t on sensi t vity to the level needed to discover mul t ple new neutrino sources per year. The data analysis of these massive par t cle-physics detectors will be extraordinarily challenging. S t ll, it will rely on the rapidly growing f eld of machine learning techniques for image recogni t on and processing, which is becoming increasingly crucial for high-energy physics.

Aims

This project will focus on algorithms and sta t s t cal analysis methods for image recogni t on in par t cle-physics experiments. While the analysis techniques will be developed for generic applica t ons as part of a cross-disciplinary e f ort carried out within the CDT, the student will have the opportunity to apply them to extract physics results from P-ONE, one of the most promising future neutrino telescope experiments.

Work summary

The project will develop machine-learning methods to simulate and reconstruct events in par t cle-physics detectors, exploi t ng image recogni t on techniques such as convolu t onal or graph networks. The development of these techniques will be ini t ally driven by the data and simula t ons of events in the large neutrino-telescope Cherenkov detectors. These detectors provide an ideal case study, as they behave as a colossal camera sensi t ve only to Cherenkov light. Depending on the interest and skills of the student, the work can then develop towards implemen t ng these techniques on FPGAs or TPU for in-situ triggering and fast data reduc t on or on their o f ine applica t on to op t mise the design of P-ONE. In both cases, broad physics analysis is expected with connec t ons to elementary neutrino proper t es and astrophysics. This project will bolster connec t ons within the CDT, and we hope it will ul t mately create a long-las t ng cross-experiment group of experts on this emerging f eld of machine learning. Although the work will focus on P-ONE and its physics case, our f ndings will be valuable for several CDT ac t vi t es and facilitate the ini t a t on of similar analysis within ATLAS and other research groups at UCL.