Machine Learning re-analysis of MINOS/MINOS+ neutrino oscillation data

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MINOS was the gold standard neutrino oscillation experiment which took data from 2006 to 2016. It had two identical detectors exposed to the Fermilab neutrino beam (NuMI), one detector positioned at Fermilab, near Chicago and one in Northern Minnesota. The neutrinos measured at the first detector produced the spectrum of neutrinos before oscillations had occurred, the second detector, 730km away, provided the spectrum of the neutrinos after oscillations had occurred. Comparing the two spectra gave not only evidence of neutrino oscillations, but a measurement of the mixing parameters which govern them. There is now a second generation of experiments which are nearing the end of their useful data taking period, but even with these experiments, we are largely still hampered by low statistics, owing to the very low rate of neutrino interactions. This project could make a significant impact on the parameter precision by applying machine learning to the MINOS data, something that has never been tried before, even though in the presently running experiments it is already exploited.

The first part of the project will be taking possession of the many monte carlo and data files and securing them at UCL. The first task will use the existing reduced data files to understand whether there is enough information stored in them to use in a machine learning analysis. If this is already the case then the machine learning aspect can start straight away. If not, then the raw data files will have to be copied and secured, and the analysis which reads them will have to be updated to run on modern machines. It is presently written in c++, so mostly should be portable. At this point, the machine learning algorithms will be run on the raw data and a scheme will be developed to get the best measurement of every neutrino event registered in the detector. There would be a lot of physics to learn encompassing neutrino production in the accelerator and how it pertains to the neutrino spectrum in the near detector, understanding the pion decay kinematics to make the prediction at the far detector and finally understanding the impact of systematic uncertainties on the machine learning process.

The outcome of this studentship should be a publication of improved parameters possibly in combination with the NOVA data, possibly as a MINOS standalone.