Horizontal muon track identification with neural networks in HAWC

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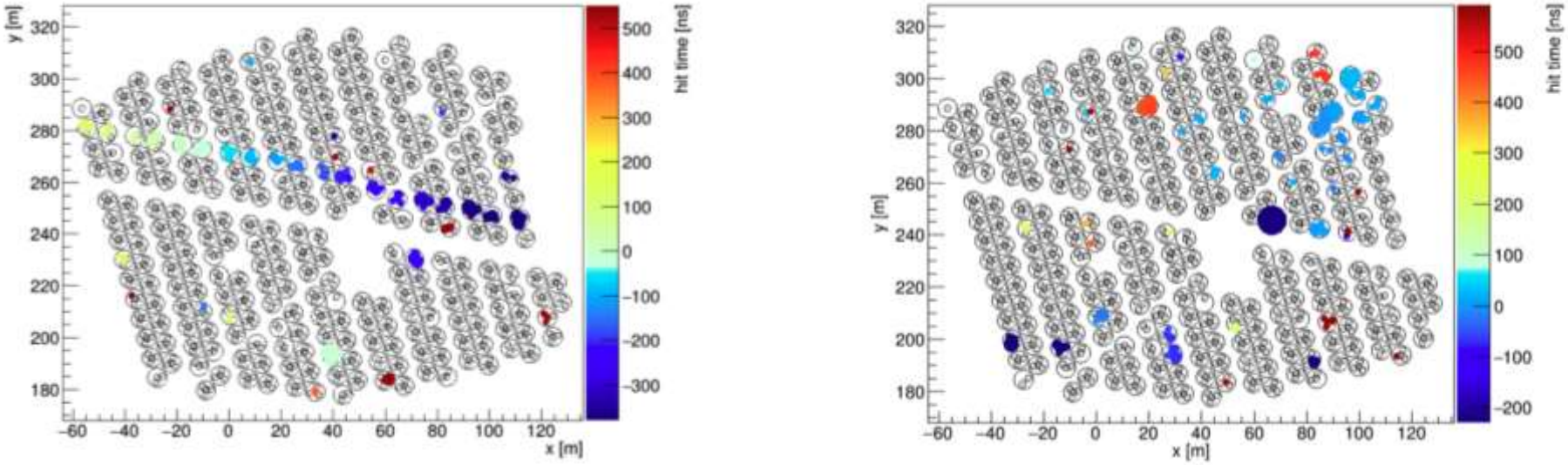
Introduction

The HAWC observatory consists of a large 22,000 m^2 area densely covered with 300 water Cherenkov detectors [1]. Nowadays there is an alternative line of research that proposes to use this observatory as an indirect neutrino detector [2, 3]. This idea is based on the Earth-skimming technique, here we want to get an interaction between a neutrino and a nucleon that form Pico de Orizaba mountain.

$$\bar{\nu}_\tau + N \rightarrow \tau^+ + X$$

Motivation

Figure 1 shows a visual comparison between a horizontal track and an air shower. As can be seen, each of these events has a characteristic shape that visually makes it easy to distinguish. Nowadays the use of artificial neural networks for image classification is widely optimized. For this reason, we analyze the possibility of applying these tools for track discrimination.



a) Horizontal track.

b) Air Shower.

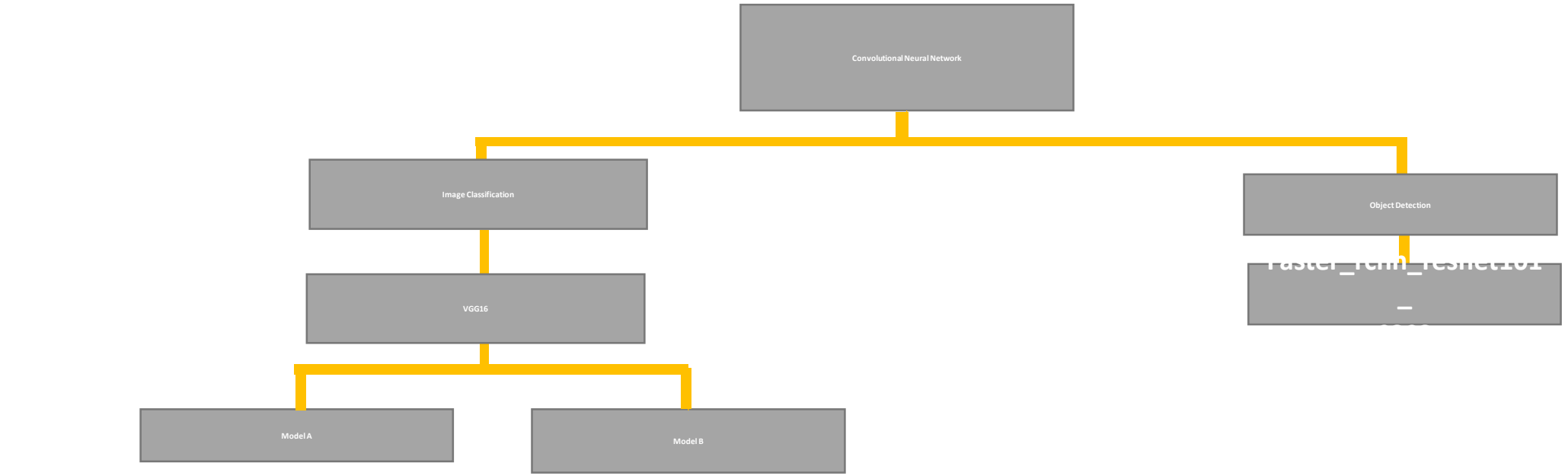
Figure 1

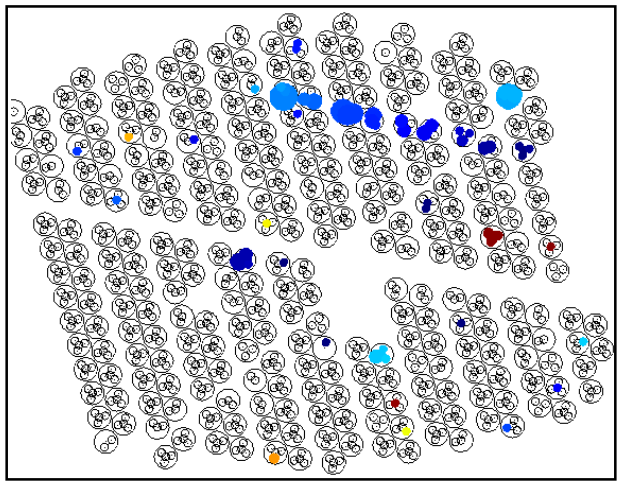
Actual horizontal track algorithm

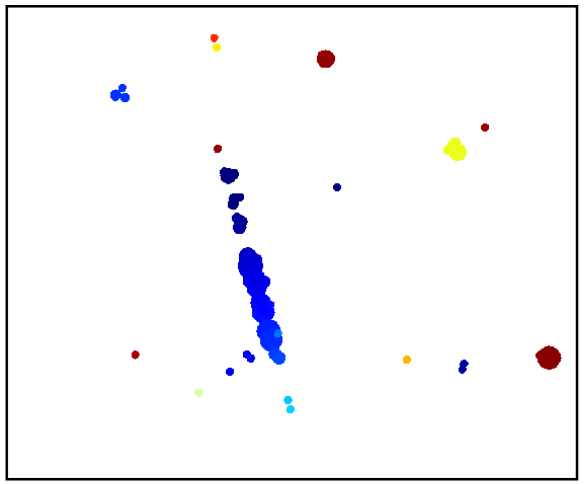
In [3] is described one of the method to detect horizontal tracks in HAWC. The phases of this method is:

1. Triggering of candidate signals using the HAWC shower data.
2. Tracking algorithm.
3. Filtering of candidate tracks

Three Models







Results

We analyze a real dataset consists of 118476 candidates with our three NNs. The results are shown in table 1.

Model	Tracks identified	False positives
A	103	3
B	125	5
Object detection	92	0
Filtering of candidate tracks	9	0

Table 1. Comparison of tracks identified by all models for the same dataset.

Conclusion

All our neural networks had an increase of an order of magnitude in the number of tracks identified, compared to the previous algorithm. Also, model B had the highest number of tracks identified, so in this case using a clearer image improves the detection process, but it had the highest number of false positives. However, the object detection network did not have false positives. The results of this study could be used in the future to improve the performance of the Earth-skimming technique for the indirect measurement of neutrinos with HAWC.

Reference

[1] A. U. Abeysekara et al. (HAWC Collaboration), Observation of the Crab Nebula with the HAWC Gamma-Ray Observatory, The Astrophysical Journal 843:39, (2017) [arXiv:1701.01778].

[2] H. León Vargas, A. Sandoval, E. Belmont and R. Alfaro, Capability of the HAWC Gamma-Ray Observatory for the Indirect Detection of Ultrahigh-Energy Neutrinos, Advances in Astronomy (2017) 1932413 [arXiv:1610.04820].

[3] H. León Vargas. Prospects of Earth-skimming neutrino detection with HAWC, in proceedings of 36th International Cosmic Ray Conference. (2019). [arXiv:1908.07622v1].