Smartphones come in handy for the rare cosmic particles search

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Credit: National Research University Higher School of Economics

Researchers from the Laboratory of Methods for Big Data Analysis (LAMBDA) at the Higher School of Economics have improved their method of analyzing ultra-high energy cosmic rays (UHECR) with the

use of mobile phones. The work has been carried out as part of the CRAYFIS experiment and the results were presented at the 22nd International Conference on Computing in High Energy and Nuclear Physics.

Cosmic rays are constantly entering the Earth's atmosphere. These include ultra-high energy cosmic rays (UHECR), which have an energy of more than 10^{18} eV). Their properties remain somewhat of a mystery to scientists. They emanate from supernovae and black holes, and, upon interacting with atmospheric particles, form cascades of secondary particles with lower energy. These are known as extended atmospheric showers (EAS). Scientists have calculated that with a detector with a surface area of 1 km^2, it would be possible to detect approximately one event every 100 years. For a full study, a surface area the size of a small European country would be required.

The CRAYFIS project proposes using a distributed mobile phone network to detect these UHECRs. To do this, researchers from HSE's LAMBDA have developed an algorithm for constructing convolutional neural networks that can be used with conventional mobile phones to record the muons making up these atmospheric showers.

Mobile phone cameras use technology similar to that in particle detectors, and hence are able to detect EAS. The particles interact with the CMOS camera and leave traces of weakly activated pixels, which can be difficult to distinguish from interference and random noise. Experiment volunteers installed the application on their smartphones and left them with the cameras facing down overnight, so that normal light wouldn't fall on them. Smartphones scan megapixel images at a speed of five to 15 frames per second and send the necessary information to the server.

Scientists expect signals from the interaction of cosmic rays to occur in

fewer than one out of 500 image frames. Due to the fact that millions of phones will potentially participate in the experiment, a problem arises in separating those images on which muon tracks are recorded from all the others. "A trigger algorithm is required to eliminate background data. We created a neural network for for the detection of muon signals, which can be used on any mobile phone fast enough to process a video stream. A special feature makes it possible to use the algorithm on something as simple as a mobile phone, meaning that they can now analyze responses to cosmic rays," says Andrei Ustyuzhanin, head of LAMBDA at HSE.

The network is divided into cascades. The first cascade works with a high resolution image, and each subsequent cascade works with an image four times smaller, working only on those parts that the previous cascade detected as interesting. If there are no interesting sites, the cascade can stop the network from analyzing a particular part of the image. The mathematical model is currently undergoing beta testing. Citizen scientists can participate as volunteers by registering on crayfis.io. Researchers hope that, if the project is successful, the information obtained will enable astrophysicists around the world to clarify where ultra-high energy cosmic rays come from, and to develop theories around their properties.

More information: M Borisyak et al, Muon Trigger for Mobile Phones, *Journal of Physics: Conference Series* (2017). DOI: 10.1088/1742-6596/898/3/032048

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