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#9-161 Gamma ray monitors for Multimod'Air, a mobile environmental monitoring platform

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Multimod'Air is a CEA internal project aiming at developing a demonstrator of a mobile platform for environmental measurement in any place of interest from cities, rural or industrial outdoor areas.

The platform comprises a dozen of detectors including gas sensors (NO2, O3, NH3, N3, CL2, Ox, H2S, SO2), fine particle sensors (PM1, PM2.5, PM10) for pollution monitoring, as well as a complete weather station (rain fall intensity, wind speed, atmospheric pressure, relative humidity, temperature, ⋯) and gamma-ray monitors. The platform is engineered to receive any type of additional sensor which can be hot plugged and operated independently and autonomously while their data can be combined for analysis. All sensors are connected via RS485, Ethernet or Lora protocols to a central node computer. Detectors can be deployed up to 20 meters away from their central node offering flexibility to fit any local installation constraints.

The central node computer is equipped with a full custom board based on NXP i.MX8 Cortex A-53 processor units, that processes and combines the data in real time, involving conventional or AI algorithms. The raw data, the preprocessed data and the alerts are sent to a cloud server database accessed from anywhere by authorized users by means of a dedicated GUI application for online monitoring or for further offline finer data analysis, verifications, validations and AI model training aim at data corrections and predictions.

The paper is specifically devoted to the gamma ray detectors for radiation monitoring. Their architecture, real time and offline data analysis process and performance are presented. Two different gamma ray monitors have been developed in the project by a collaborative team involving CEA DRF/Irfu, DRT/List and DES/Iresne: One gamma ray monitor is based on a KROMEK GR1+ (1 cm3 CZT, coplanar grid single channel) coupled to a local ODROID XU4 microcomputer for data acquisition, management and communication. The other sensor is based on Caliste-O detectors (0.4 cm3 CdTe, 256 independent spectrometry channels) initially developed at CEA/Irfu with 3D PLUS for space science and used for gamma ray cameras. The latter is readout by a full custom data acquisition system involving a Zynq SoC, routed to an ODROID XU4 computer as well, for data preprocessing such as energy calibration and histogramming, and data management. While GR1+ detector sends an integrated spectrum every minute, Caliste-O both sends accumulated spectra over all channels every minute and photon event list on demand.
Both detectors are fully autonomous. They can be configured, operated and reset remotely. The different detector geometries are fit into specific 3D printed carriers attached to a common housing enabling a standard detector packaging definition.

Regarding the data analysis, the central node computer collects the gamma ray monitors raw data and runs real time algorithm for data reduction and analysis on the fly: 10-minutes, 1-hour and 1-day accumulated spectra are processed every minute, 10-minutes and hours respectively, to search for possible spectral anomalies with respect to a prerecorded gamma-ray background reference spectrum. In addition to a simple overall-count-rate monitoring, in case of an anomaly detection, the algorithm attempts an isotope identification and reports an alert. An anomaly detection confidence level is provided as well.

Both gamma ray monitors are complementary and may work together or independently. GR1+ is well suited for measurement from 60 to 2000 keV while Caliste-O shows high spectral response from 10 to 900 keV. Both detectors nicely cover the energy range where most of natural radioactivity lines are expected such as Uranium decay chain, Thorium decay chain and Potassium 40.

Currently the detectors are deployed outdoor on two monitoring stations for evaluation in real conditions in Paris (AIRPARIF station) and at CEA LSCE lab station in a suburban area. Thanks to this instrumentation,

natural radioactivity is monitored in real time. Detector architecture and performance, as well as data analysis results will be presented, including Radon daily fluctuations measurements, natural radioactivity fluctuations with rain falls, atmospheric muons rate dependency with atmospheric pressure for instance.

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