1. Description

DDrone is a teleoperated system based on an Unmanned Aerial Vehicle (UAV) aimed at localizing radioactive sources or materials in outdoor environments. This system allows the exploration of wide and potentially dangerous areas without or reducing the in-field exposure of the operator.
DDrone allows detection and localization of weak radioactive sources. It takes advantage from the UAV flying at low altitudes and reduced speed. Potential scenarios of application are the localization of radioactive materials in the security field like industrial plants, construction environments, recycling factories, landfills or places like harbors and border controls.
The DDrone was tested in a quasi-real live outdoor environment and in a real operational environment, a landfill, confirming the laboratory performance.

The S2D detection system is mounted on the drone shown in figure. The gamma detector is made of four steering strips of CdZnTe. The CdZnTe sensor was chosen for its spectroscopic response, from low energy gamma to the ^{60}Co energies, its low weight and a reduced power consumption.
During the flight, DDRone sends to the ground station the sensor spectra and the telemetric data in real time. The analysis algorithm allows to localize the presence of a weak source driving the user on the hot spot, flying in circle around the area under investigation.
The analyzed data are visualized on the screen of the operator using the developed graphical user interface which superimposes the radiometric and georeferentied acquired data on the images recorded by the on-board camera. This interface allows the user to interact with the system and quickly react.

2. Applications

- Monitoring of large public areas and public events
- Scan of waste environments and harsh working areas
- Prompt intervention
- Localization of low gamma radioactive materials of large areas

3. Typical Characteristics

Detector specifications

- Sensitivity by design: 1 mSv/y dose from 2 m distance sources (see Table 1)
- Energy range: 30 keV – 1.3 MeV
- Energy resolution: FWHM @ 662 keV (137Cs): 3%

Detection system

- 4 steering strips CdZnTe sensor of 2 cm^3
- Energy range: 10 keV to 1.3 MeV
- 1km Max communication range
- Embedded system for data management
- Battery pack for 8 h operations
- Onboard camera

Monitoring system

- Tablet Android
- Control software for mission planning
- Software for on-line mapping of the measurements
- Map of the identified radiation zones

Software features

- App for Android for planning the flight
- Real-time visualization of radiometric and geo-referenced data on the tablet
- integration of radiometric data with on board camera images
- Differential spectra saved on tablet for each georeferenced scanning area

Outputs

- Event list + energy spectra of the 4 channels
- Software displaying the energy spectra of the channels
- Flight report

UAV (*)

- Aircraft DJI Matrice 200/210
- 38 minutes max flight time
- IP43 level
- operation range in the order of km
- Battery on board
- obstacle avoidance (infrared, vision and ultrasonic sensors)
- on-board camera
- remote control + rugged tablet for navigation and data visualization

Figure 1

Example of a typical radiometric map

Table 1

Source	Dose (mSv/y)	Act. (MBq)	Counts/s
^{241}Am	1,010	12500,0	381,0
^{57}Co	1,017	3600,0	266,4
^{137}Cs	1,062	160,0	10,5

DDrone Sensitivity by design Table
(typical sensitivity at 2 meters height)