Unmanned aerial vehicles are now widely employed for numerous applications including defense, search and rescue as well as within scientific fields such as high-altitude atmospheric sampling and remote sensing. However, their application to the high-resolution detection of radiation anomalies (specifically as part of the routine monitoring on nuclear sites) has been less well explained. In this work, we present the results of the radiation monitoring via a lightweight aerial platform on an active nuclear site (Sellafield Ltd.), having already deployed the device in the Fukushima-contaminated region. The system employed was able to detect regions of elevated radiation at the sub-meter scale as well as attributing the species responsible. Such a system presents as extremely powerful tool where it is not desirable, nor practical, to send human operators. Results presented show that the platform is easily capable of operating within the challenging and confined settings of a site such as Sellafield (or other similar worldwide).

Abstract

Introduction

While much of the world is currently experiencing a renaissance with the construction of fleets of new power generation facilities, challenges still exist at numerous other sites in the world, necessitating continual monitoring of radiation levels, and an increased radiation awareness.

Unmanned Aerial Vehicle (UAV)

The UAV consists of an X-form configuration with rotors and propellers mounted both above and below the platform’s four arms. Operating on Lithium Polymer (LiP) batteries, the system has a combined total mass of 15 kg, which supplies enough runtime for approximately 30 minutes. During typical survey flights, an altitude of between 50 m and 500 m was maintained, depending on topography and local obstructions. The maximum measurable speed of the system is 50 km/h, permitting the UAV to reach sites far from its initial position.

Detection Payload

The standard radiation monitoring platform consists of a lightweight gamma spectrometry (80 g) equipped with a single 1 cm³ crystal of cadmium-zinc-telluride (CZT) semiconductor material (GR1 from Kromek Ltd.), an unmanned aerial vehicle (UAV) and a ground control system (red). By employing gamma-ray spectroscopy, the system is able to identify the location, quantity and species of the radioactive material contributing to the radiation anomaly. This permits the detection of elevated activity over the entire surface of the site, thereby avoiding the need for manual human surveys.

Data Processing & Visualisation

Software was produced to interpret the new data, plotting the results as a colour coded overview map, a georeferenced base layer map. This new software was able to export the processed data to enable the results to be subsequently manipulated by third-party geographic information systems. Software was also able to import the raw data, plotting the results as a scaled coloured overlay onto a base layer map. Software was also able to enable the results to be transferred into a variety of GIS software platforms.

Isotopic Fingerprinting

By employing gamma-ray spectroscopy at Sellafield, the fingerprinting radionuclides can be identified by the overflight of the UAV.

Loc. 1

The radiation map of Loc. 1, the Iso-CZT scanner image is shown in Figure 3 (a). The time of the survey for the radionuclide containing buildings were located in the centre of the site with their location illustrated below. As can be seen within the figure the gamma-ray activity is localized in the exact position of the four containers. The location of the cloud would be emitted from the top of the containers which was detected to a depth of greater than 3 mm. From the container radar, a result of the potential radiation exposure.

Loc. 2

Figure 3 (b) is the radiation intensity map of Loc. 2 is shown in Figure 3 (b). As can be seen within the figure, the gamma-ray activity is localized in the exact position of the four containers. The location of the cloud would be emitted from the top of the containers which was detected to a depth of greater than 3 mm. From the container radar, a result of the potential radiation exposure.

Conclusions

The administration of an unmanned aerial vehicle for autonomous radiation mapping has shown:

- GPS positioning is not influenced by large buildings or structures on the site.
- Sub-meter level resolution and locations with logistical issues can be assessed in a rapid period of time.

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References