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UAS radiation hot-spot detection and refinement

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Unoccupied Aerial Systems (UAS) are ideal tools for responding to nuclear incidents where large outdoor areas have become contaminated with a radiological hazard. They are advantageous because rapid response radiation surveys can be conducted while the human operator remains at a safe distance and avoids direct contamination of the platform. During fieldwork within the Chernobyl Exclusion Zone (Ukraine), an airborne platform was equipped with a GNSS enabled gamma spectrometer and used to survey an area surrounding a known highly contaminated building (a ‘hot-spot’), resulting in a radiation intensity map. The detected radiation pattern, however, was ‘blurred’ since the intensity recorded at any point counted nadir emissions, but also emissions from all sources within line-of-sight; The ‘hot-spot’ had an influence far outside its ground footprint. Methods exist to correct for errors introduced by varying terrain altitude, however, they do not remove the unwanted blurring. Hence, small point sources appear as broad regions of contamination which is entirely an artefact of the measurement process. The effect is further accentuated with increasing height above ground hence understanding and correcting for this phenomenon is particularly relevant to data collected using UAS. Here, we present a novel algorithm to refine the detected pattern to more accurately recover the ground-truth.

A forward model of the system is created which describes the relationship between the unknown ground-truth and the aerial measurements. Gamma ray emissions from a point source obey the inverse square law of spatial dilution and have an exponential attenuation in air. To model both effects, geometric information of the scene is required and is provided by the geotagged spectrometer data and photogrammetrically processed DEMs of the surveyed terrain. The resulting model is hyper-cube of linear equations, where every aerial measurement point is assumed to be influenced by every ground sample point. By finding the inverse solution of this system, the ground-truth radiation pattern is estimated in more detail. The Kaczmarz method is advantageous because a large system of equations can be broken down into smaller sub-routines and solved iteratively. A caveat is that the solution might settle to false positive. The refinement algorithm will be presented with simulated results, controlled laboratory experiments using robotic arms and sealed radioactive sources, and finally applied to a real-world data set collected in the Chernobyl Exclusion Zone.