UAS Radiation Hot-spot Detection and Refinement

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Motivation – Chornobyl UAS Survey April 2019

Connor et. Al, 2020 “Radiological Mapping of Post-Disaster Nuclear Environments Using Fixed-Wing Unmanned Aerial Systems: A Study From Chornobyl”, Front. Robot. AI

Large scale fixed-wing UAS mapping reveals ‘hot-spot’ of radiation separated from main plume.

Cause determined to be residual contamination from abandoned facility.

However, the survey at 50m altitude resolves to a region 100s meters wide using interpolation methods.

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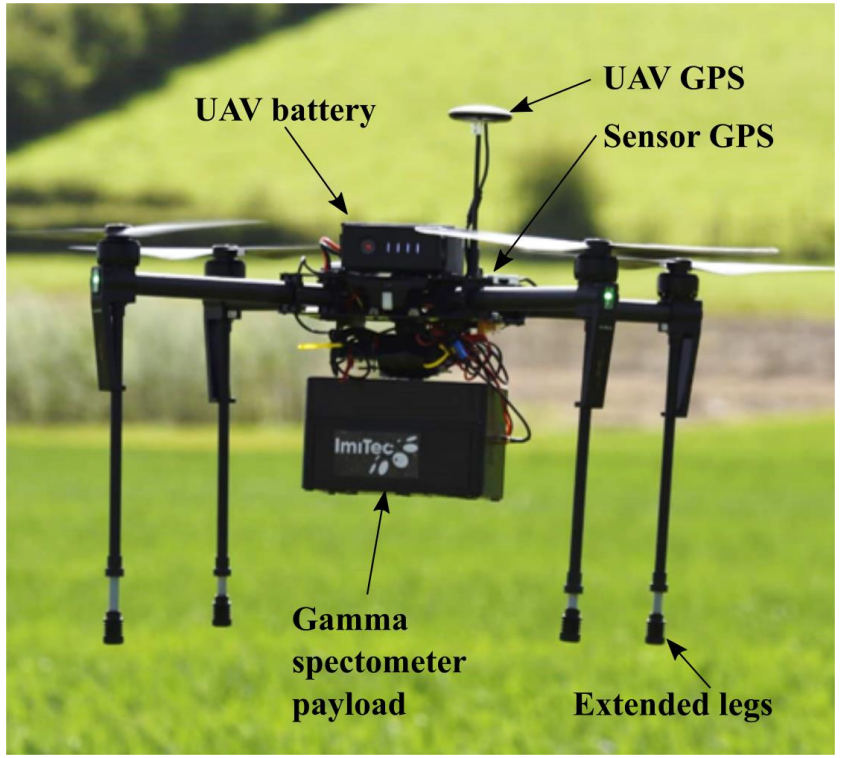
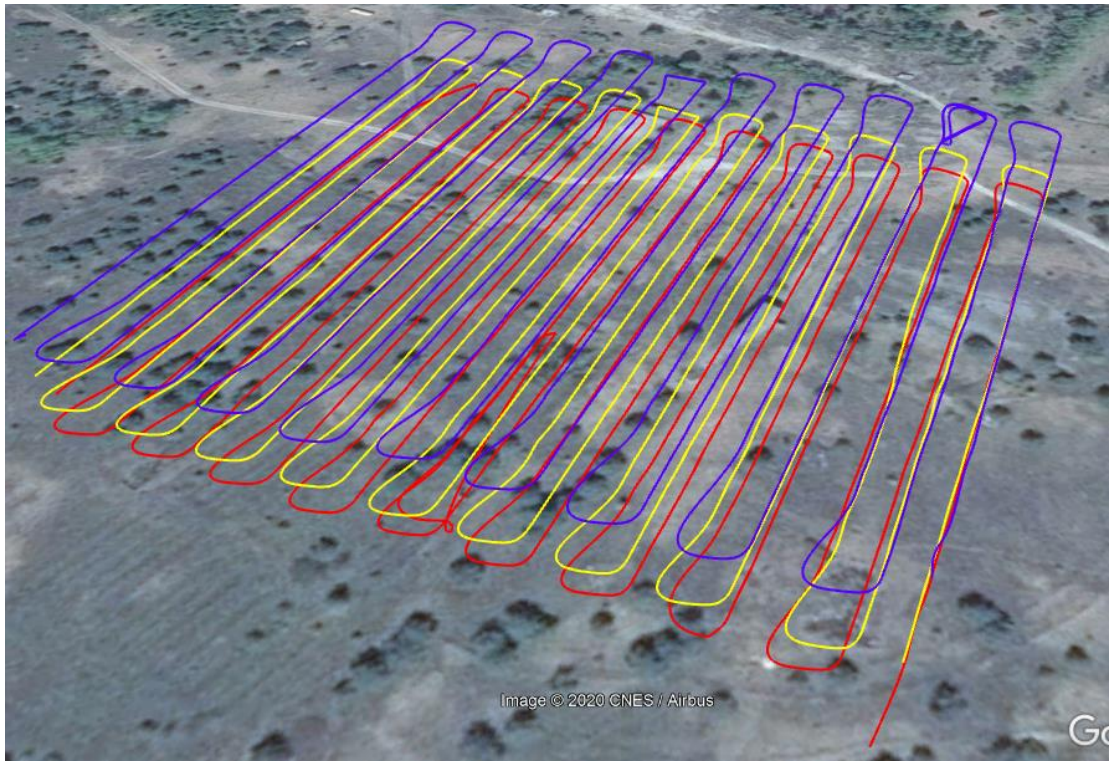
Repeated Detailed Survey October 2019



M100 quadrotor equipped with gamma spectrometer payload.



Multi-altitude detailed survey above ‘hotspot’.

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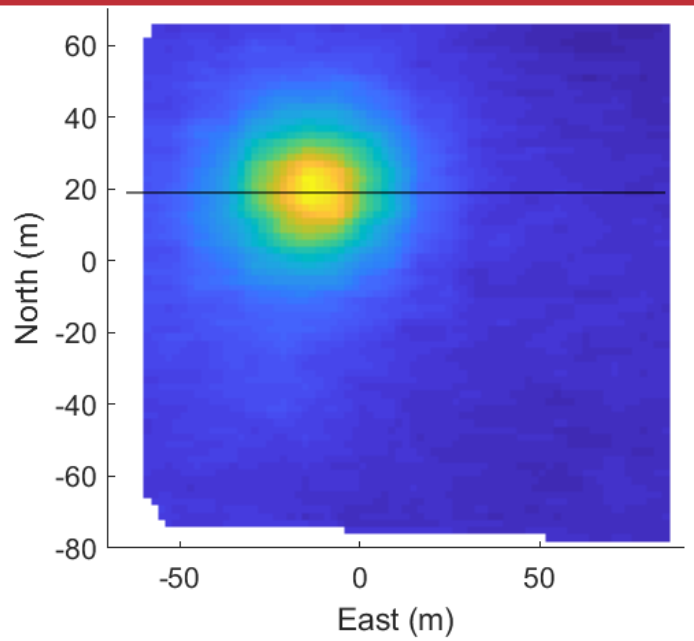
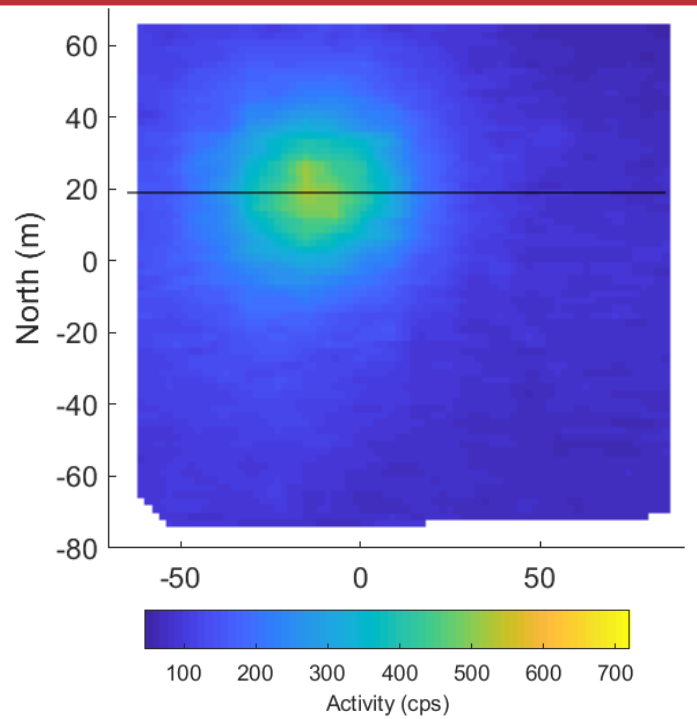
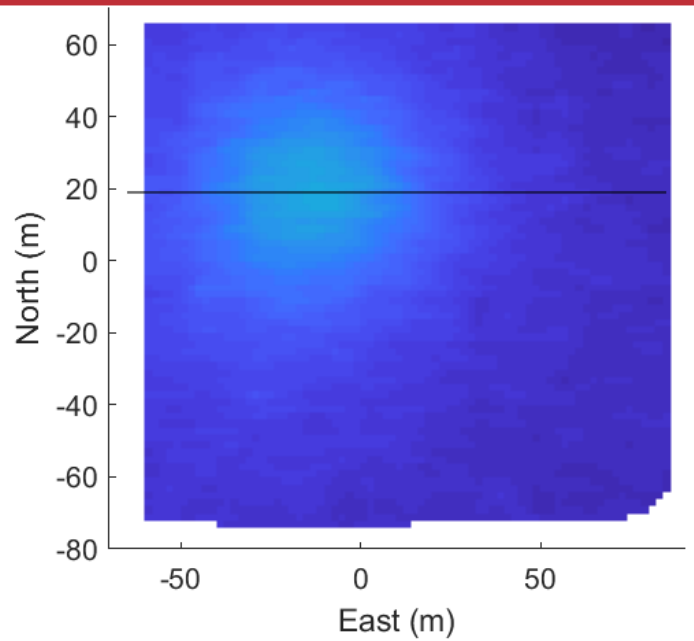
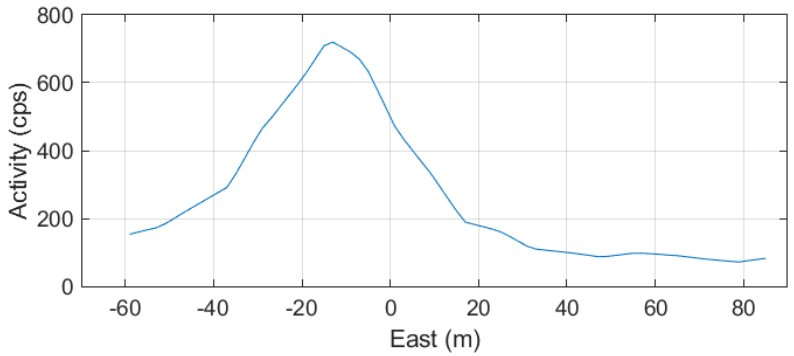
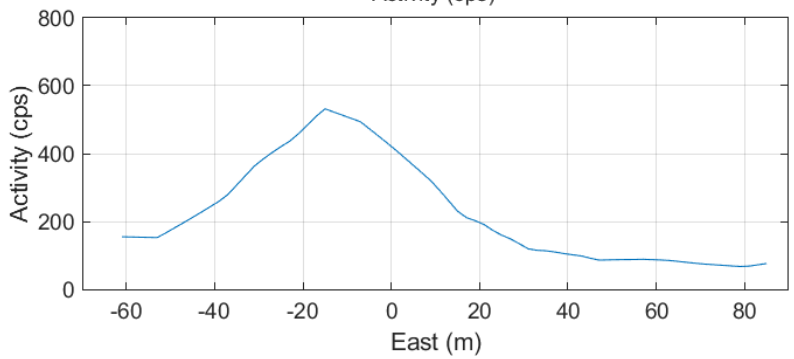
Interpolation of aerial data – broad hotspot

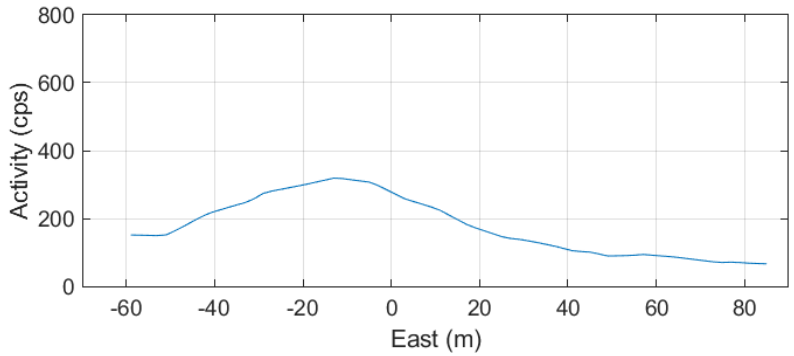












15 m

20 m

30 m

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Inversion algorithm

‘blurring’ matrix relating every measurement to every surface point

$$\mathbf{A}x = b$$

known measured gamma spectrum from aerial surveys

unknown gamma spectrum emitted from contaminated surface

$$a_{i,j} = f(\|p_m - p_s\|, \gamma_f)$$

each element of $\mathbf{A}$ is a function of the geometric distance between the surface point, p_s, and measurement point, p_m, and the gamma frequency.

Kaczmarz method

- Iterative solver for linear equations. (a.k.a ART)
- Adapted to ensure non-negativity constraint
- Computational advantage for sparse systems

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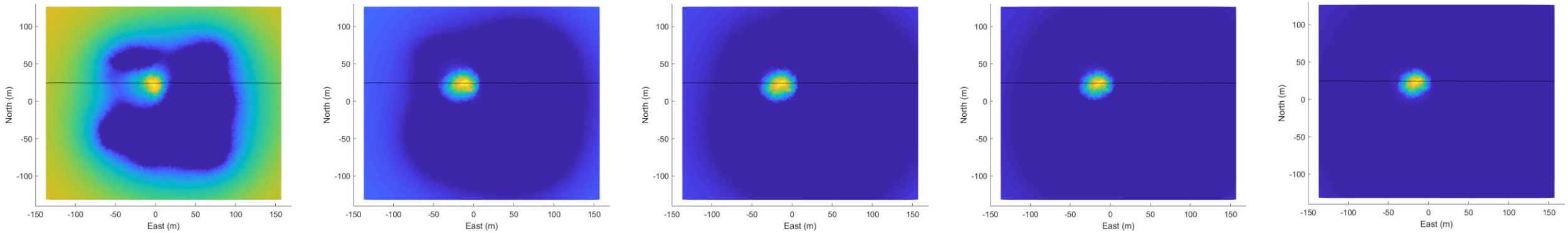
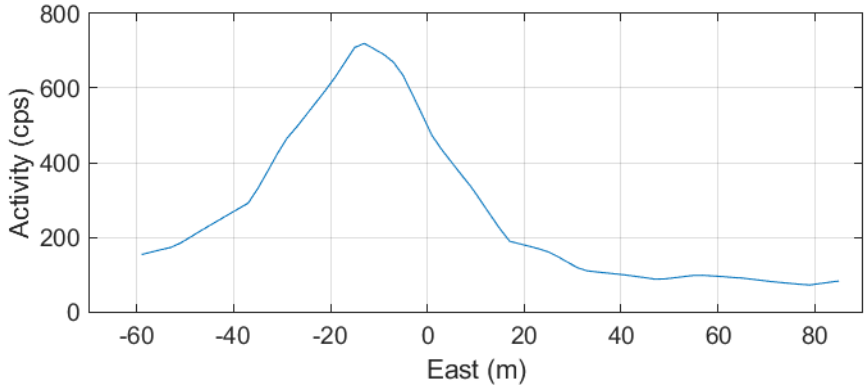
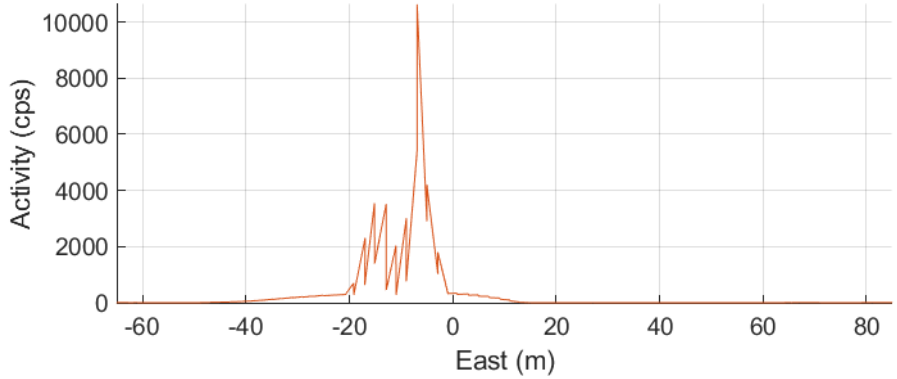
Results – more refined hotspot localisation



Initial solution iteration progression



Interpolation from single altitude. ~70m wide hotspot with low peak activity.



Inversion results. Peak activity significantly higher and in a more confined region.

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Conclusions

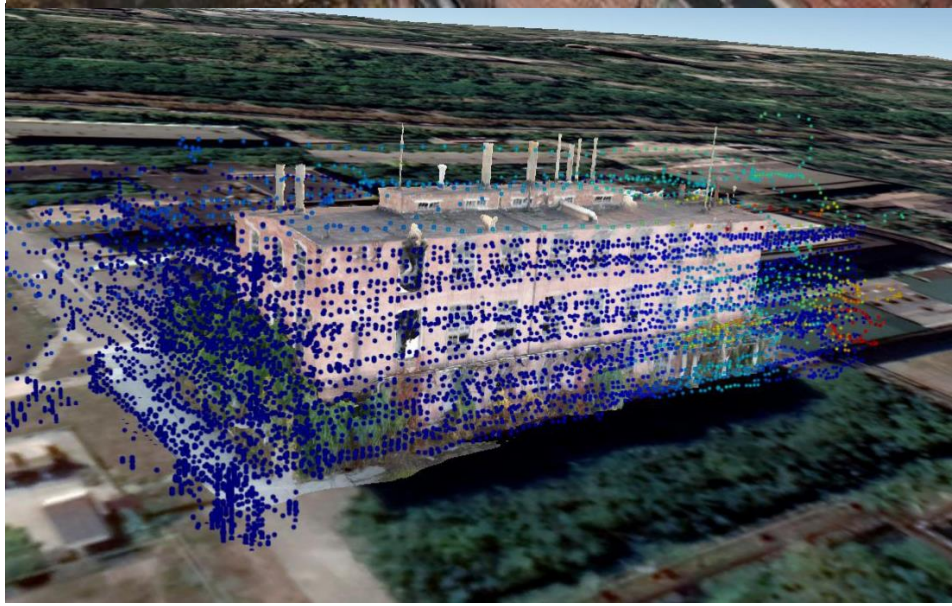
Applying numerical inversion to UAS radiometric data removes the ‘blurring’ effect caused by the sensor having a wide field of view to the contaminated surfaces below.

The location and strength of contamination can be more accurately determined.

Tested using UAS and ground truthing experimental data collected within the Chornobyl Exclusion Zone.

Assumptions of a non-zero far field background radiation and zero occlusion. i.e perfect line of site between measurement and solution points.

Future work includes expanding the complexity of the system formulation (**A** matrix) to allow vertical faces, occlusion, and multiple attenuation mediums.



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