A Clutter Independent Novel Method for Target Detection

Authors: Pierluigi Falorni, Luca Bossi, Lorenzo Capineri

Affiliation: Università degli Studi di Firenze, Florence Italy

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The Global Landmine Crisis

Factors:

1. Landmines do their job
2. Landmines require little effort to deliver
3. Landmines lasts a lot longer than their operative lifecycle
4. Landmines require big effort to remove

⇒ The deployment of landmines significantly exceeds their clearance rate, leading to a consistent annual increase in the global landmine stockpile

THUS Productivity of detection is a key factor for success

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Our proposal

and why canonical methods can be unfeasible.

Proprietary Algorithm

Due to an ongoing patent request, at this time most of the information can't be disclosed.

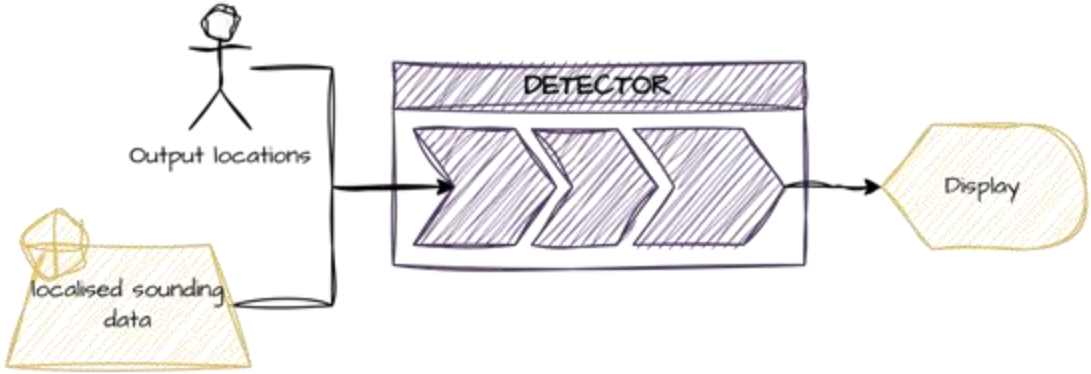
Still it is possible to analyse results via a black box, input/output model.

Two inputs are required:

1) the data from a sounding device and

2) the locations where the likelihood of detection must be calculated

On output, the algorithm effectively maps the likelihood of a scatterer presence.



Inversion from reconstruction

Invert (backpropagate) the field reconstructed from the samples

- Using RF signals frequencies of 2 - 4 GHz are recommended.
- ⇒ Wavelengths in air will be 7.5 - 15 cm.
- Due to weight constraints, both manual or robotized solutions must consider small inspection areas - e.g. 40 x 40 cm^2.
- ⇒ The inspection area will contain few wavelengths.
- ⇒ Reconstruction will contain artifacts and border effects.

Shannon-Nyquist methods will require tight sampling and extensive inspection areas, which means **LOW** productivity.

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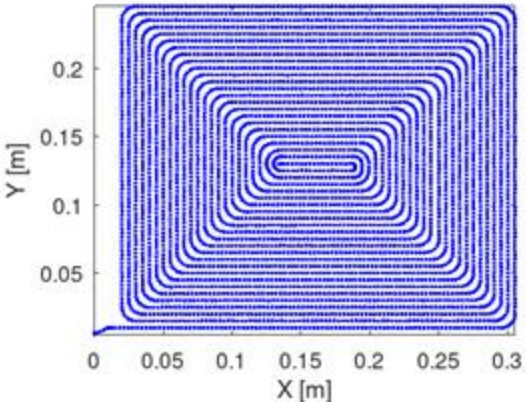
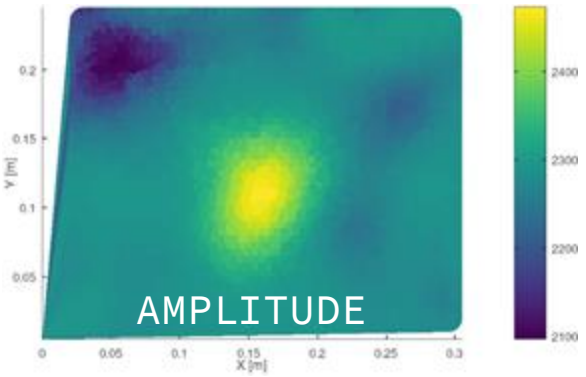
Use Cases

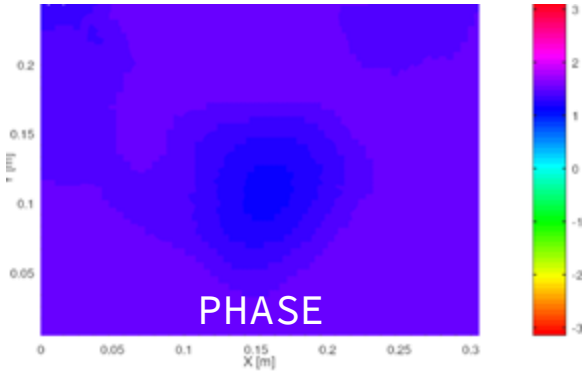
Some use cases enabled by the technology.

Basic data used to build all use cases

- Data acquired using a programmable microwave CW signal generator and a 3D-printed monostatic antenna.
- Antenna moved in a spiral trajectory over the designated area.
- About 4k samples acquired from the received signal.
- The target was a buried Chinese Type 72 anti-personnel mine simulant.







Robotic platform with triaxial scanner

Robotic platform

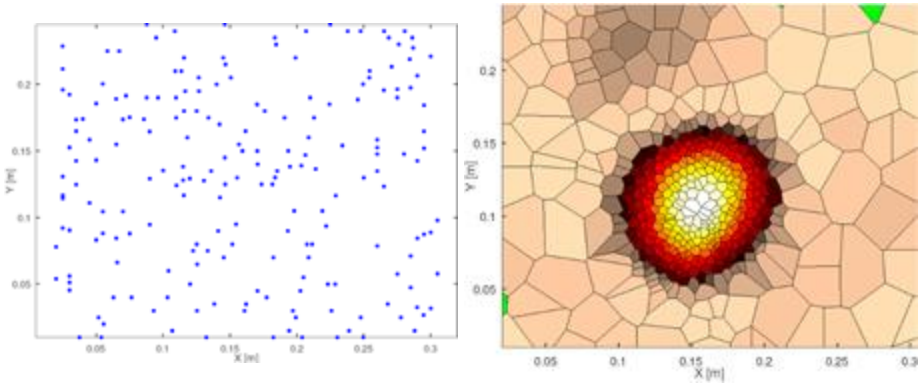
1. FESTO triaxial scanner.
2. 3D printed antenna.
3. Control unit.
4. GNSS positioning system.

All sensors are managed through the MUSIS network for configuration, acquisition, storage, data processing and visualization.

UC1: Drone hovering the area

200 random locations

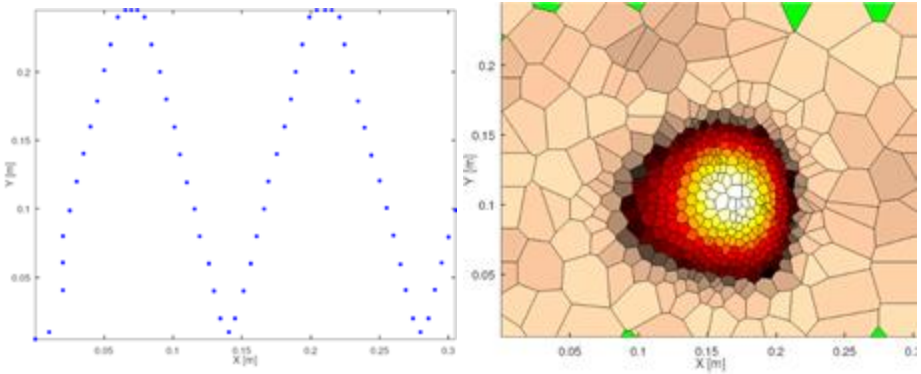
This case shows the ability of the method to be independent of the distribution of data points.



UC2: Manual “swipe” scan

Zig-Zag across motion

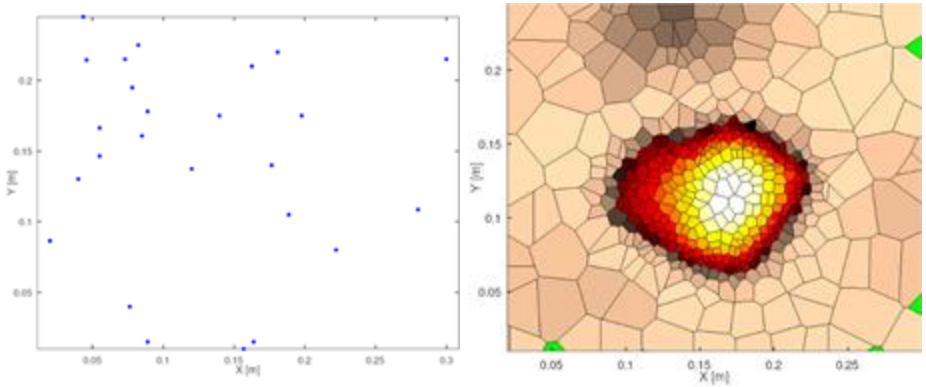
The method enables imaging with manual swipe of limited areas. FAST! Execution needs about 1 second on a average CPU.



UC3: Single shot image

25 random locations

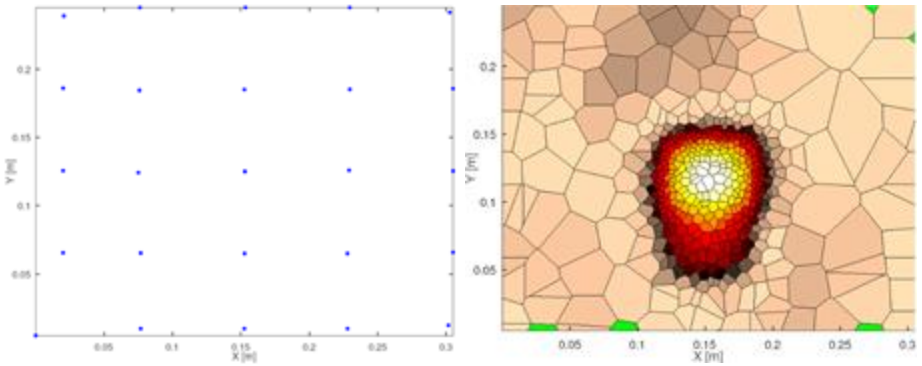
The shape is slightly altered in the direction where less data is available.



UC4: Single shot image

25 on grid locations

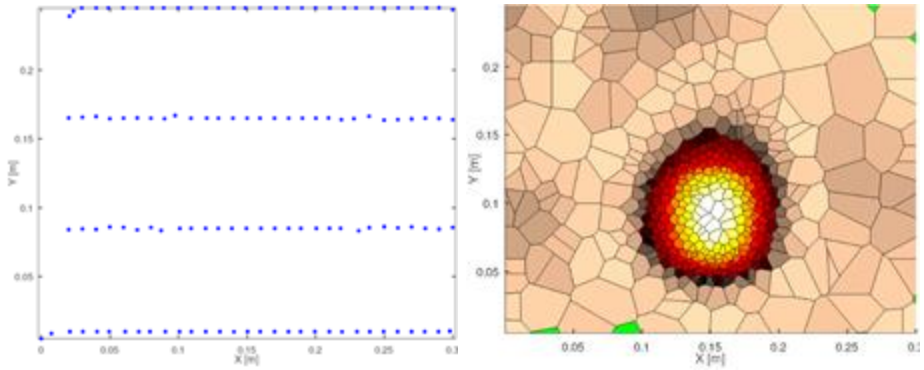
The shape is misrepresented due to some kind of aliasing.



UC5: Linear array

four stripes along motion

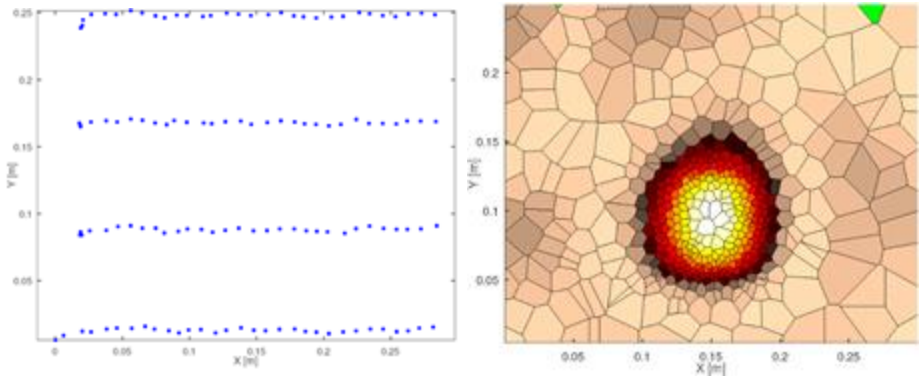
Target visible at correct position and clutter depressed



UC6: Linear array on UAV

four stripes with noise

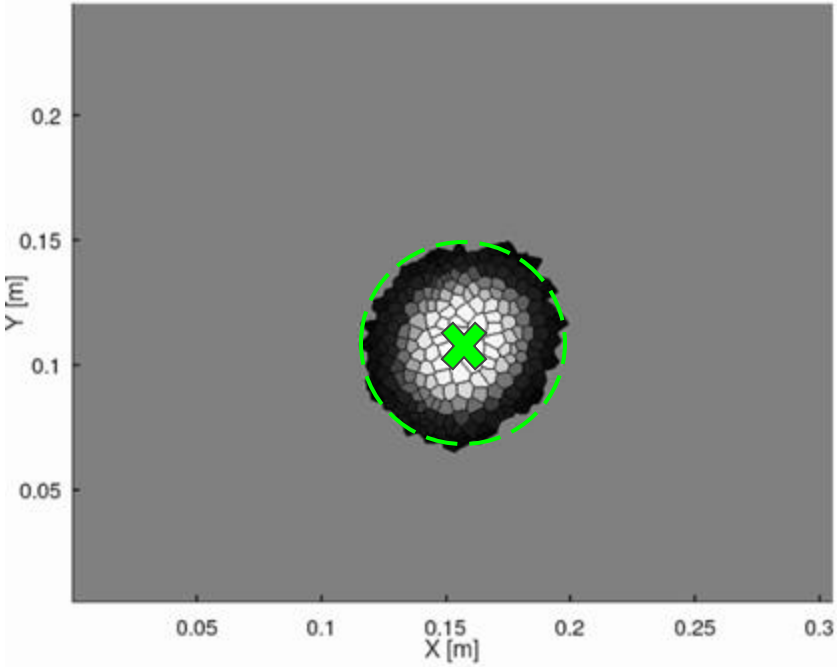
10% cumulative random error added on locations: this case enables the usage of low cost IMU for data location



Clutter removal and size estimation

UC7: Size and shape

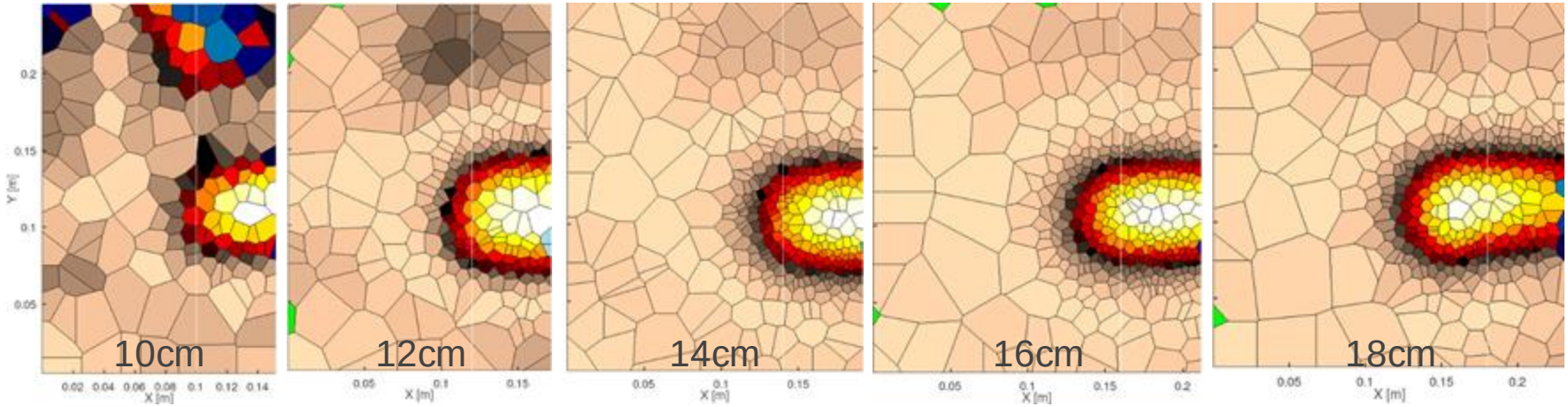
- The algorithm is able to estimate a valid threshold for clutter/target interface when a target is present in the area.
- The area of the cluster is 49.3 cm^2.
- The diameter of the cluster is 7.9 cm.



Forward looking

UC8: Forward looking

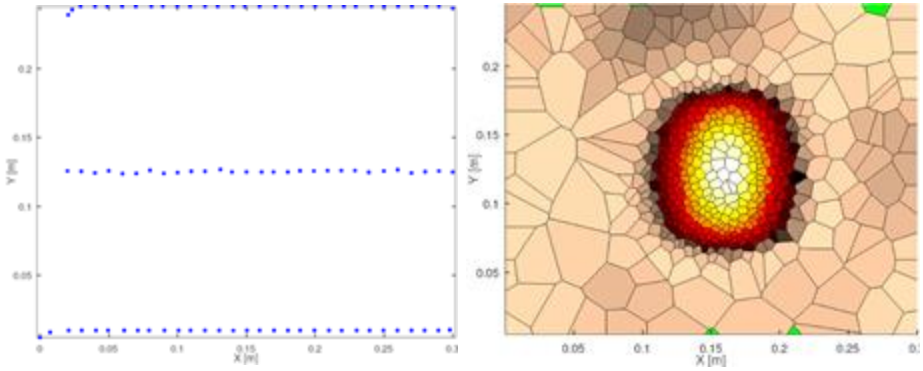
- The algorithm can extrapolate output values outside the convex hull of input locations.
- Forward looking is the imaging ahead of the input range along the motion (X) direction.
- A early alarm can be raised before the front array arrives above the target location.
- The cart can be stopped before the hazardous area.



UC9: Single swipe image

three stripes across motion

Shape slightly stretched along the direction of scarce locations. Enables solutions where cost or complexity or weight can be an issue.



CONCLUSIONS

The proposed method offers a robust solution for target detection with clutter.

It has the potential to significantly improve the efficiency and accuracy of landmine detection efforts.

Enables several use cases, including airborne, single shot, inline terrestrial and manual swipe.

Potential for near term field applications.

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Contacts:

- https://www.sensorsbot.com/about-us
- Filippo.bigi@sensorsbot.com
- Lorenzo.capineri@sensorsbot.com
- Pierluigi.falorni@sensorsbot.com
- Luca.bossi@sensorsbot.com