
MineDtect – UWBGPR
Ultra Wide Band (UWB) Ground Penetrating Radar (GPR)

Challenges

- Wide **variety of targets**: from small shallow-buried AP mines to AT mines and deeply-buried large UXO (devices that sink deep with time in soft soils)
- Wide **variety of environments/soils**, typically rural with overgrown vegetation
- Wide variety of **climatic conditions** (arid and humid regions) and **target status**
- Possibly **weak electromagnetic anomaly** due to:
  - Similar dielectric constant of the mine with the embedding soil
  - Soil compactness in post-conflict scenarios where targets have been lying for years
  - High electromagnetic absorption in moist/conductive soils
  - High clutter level in rocky/vegetated soils (stones, roots, etc.)

Requirements

Application:

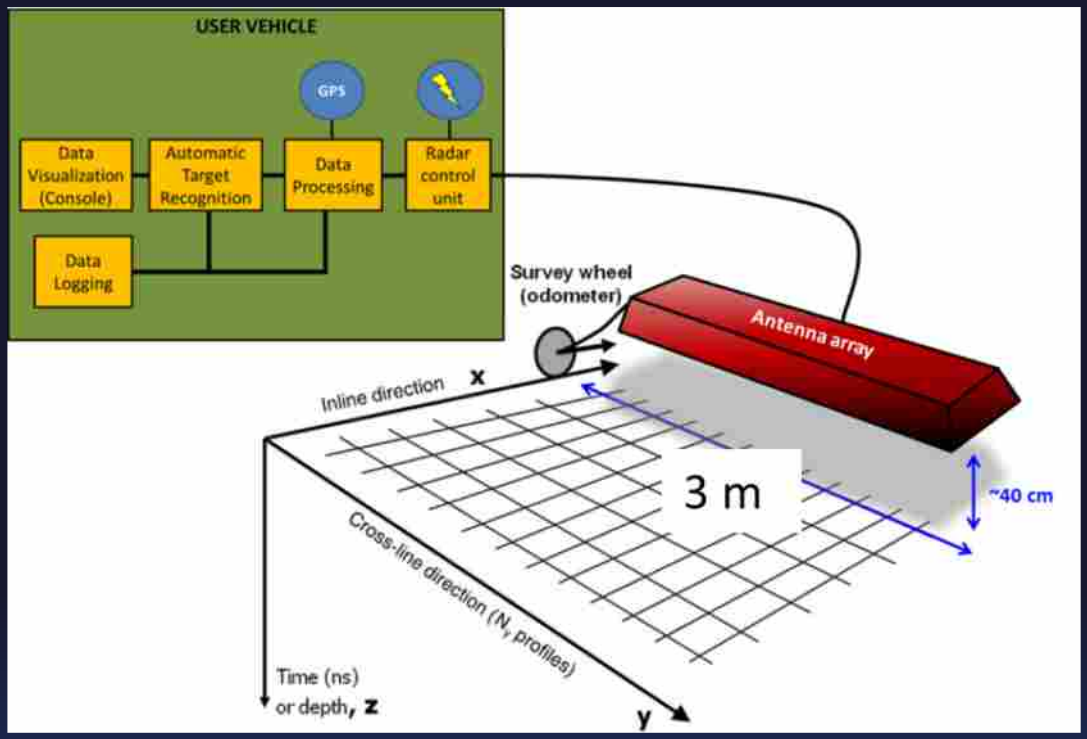
- **High probability of detection** is required for a wide range of environments and target types
- **Low false alarm rate** is desirable for efficiency, though moderate false alarm rate can be tolerated
- **Automatic target detection** is required for correct classification

Technical:

- **Air antenna** array is required since ground contact is problematic on rough soil
- Arrays (~3 m wide) shall be mounted on **vehicle**
- Vehicle movement shall be used to apply **synthetic aperture technique**
- GPR data recording and GNSS registration is essential for quality assurance and possible **data fusion** with other sensors

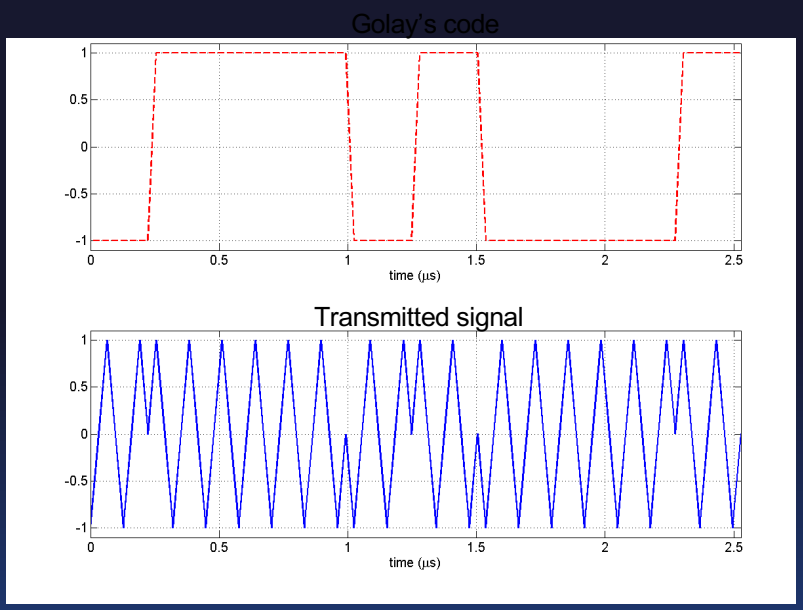
Antenna Array

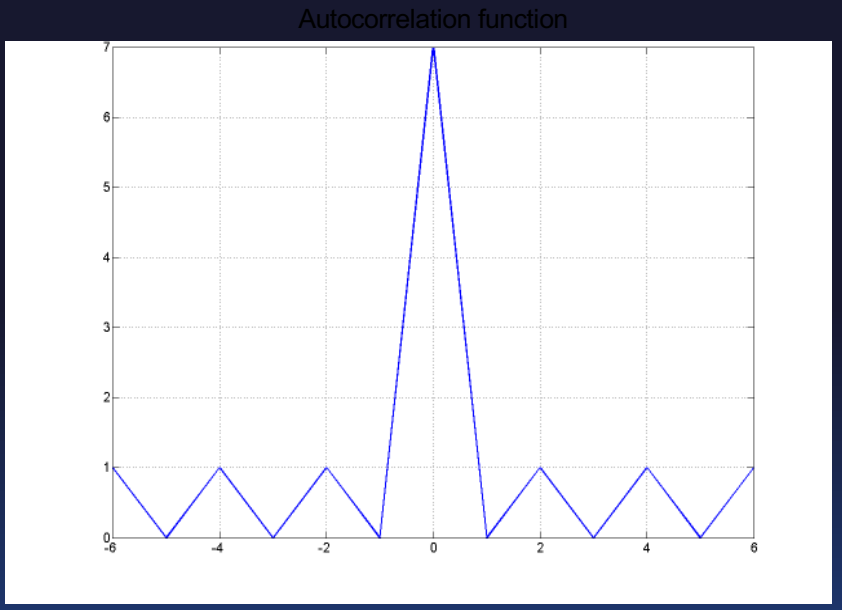
- Use of **air-coupled**, rather than ground-coupled, antennas to prevent activation of the mines and facilitate surveying on rough terrains
- **Small spatial sampling** along the array axis for detecting/resolving small objects
- Adoption of **synthetic aperture** technique along vehicle movement for detecting/resolving small objects



Radar Signal (TX)

- A **binary phase-modulated signal** is transmitted
- **Proprietary codes** are used to modulate a carrier frequency around 1 GHz
- The codes are characterized by extremely narrow and low side-lobes response function to **maximize detection/resolution**
- Long codes adopted to increase Signal to Noise Ratio (SNR) to **maximize depth**

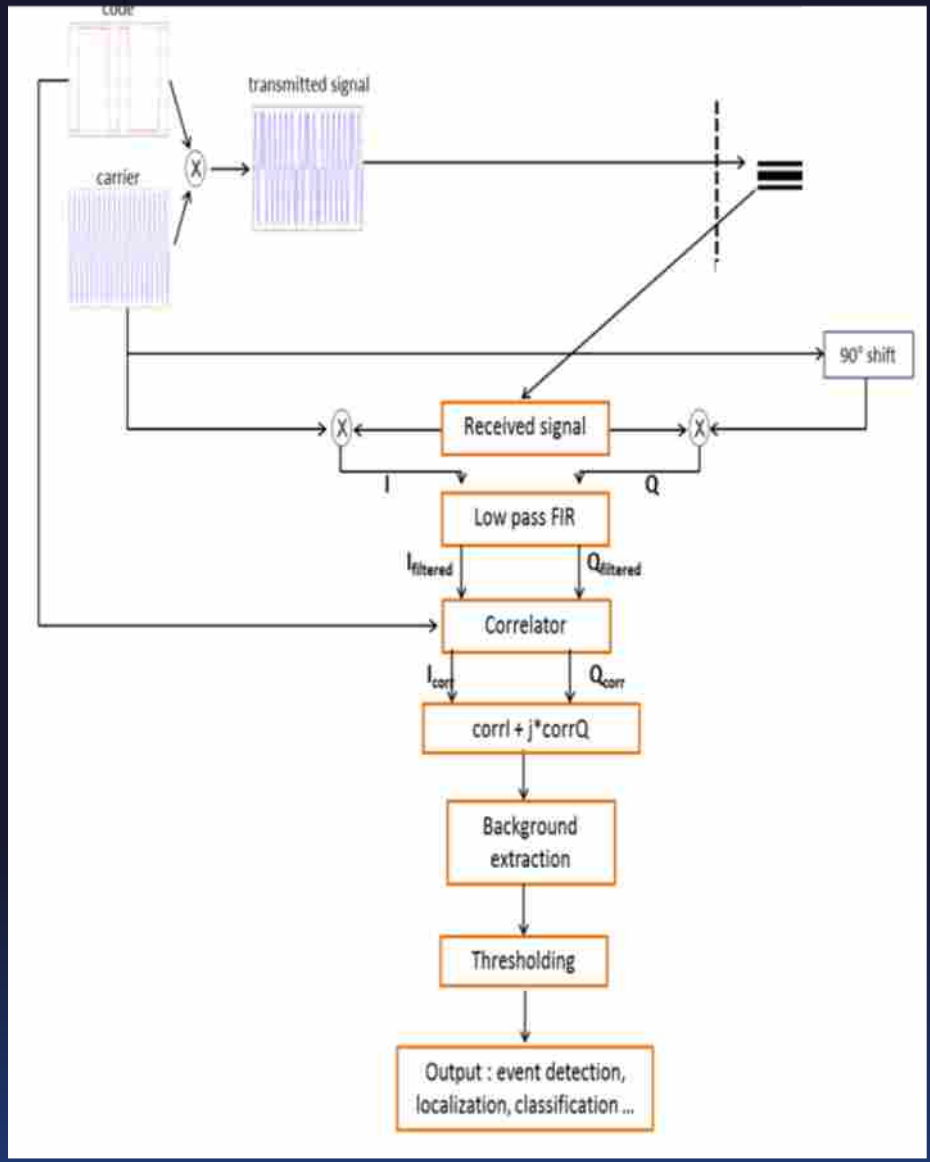




Radar Processing (RX)

The received signal is processed through:

- **Demodulation and filtering** to extract in-phase (I) and in-quadrature (Q) contributions
- **Correlation** of I and Q (filtered) signals with the modulating code and comparison with thresholds to determine if and where a target is present
- **Synthetic aperture technique** is applied exploiting vehicle movement



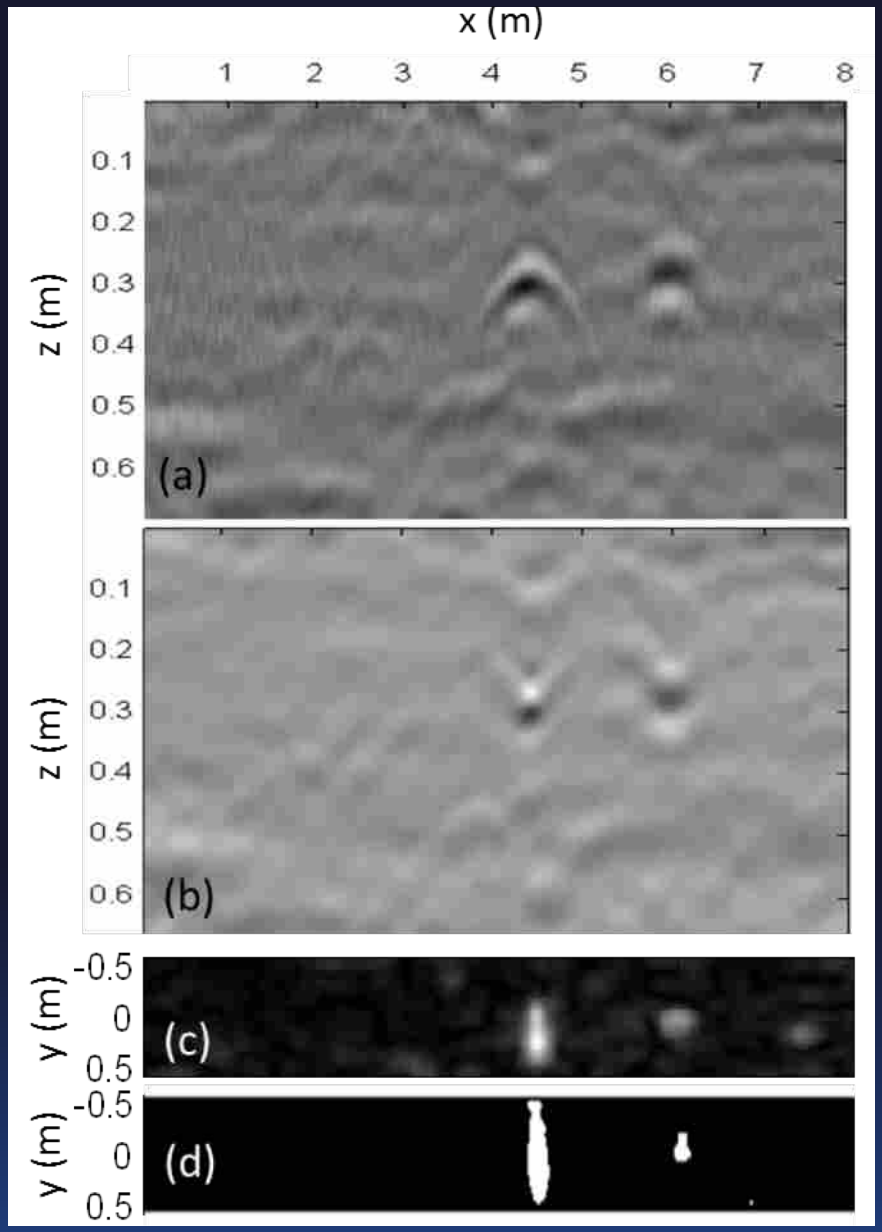
Example of Results

Depth-slice of transversal Ø 2 cm metal pipe and Ø 5 cm metal sphere buried at 30 cm depth in sandy soil

Depth-slice after array focusing

Top-view at a given depth after focusing

Top-view at a given depth after processing



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Deployment

- The System can be deployed in Tripod, ROV or Vehicle mount variants.
- The system requires the sensor to be stationary and the vibrometer to be deployed, which is non-disruptive to buried devices.
- The system scans the forward area, in $1m^2$ blocks as a matrix of inspection
- The system scans the matrix and marks each area as safe or hazard
- Each buried device is located, its size, shape and orientation provides the search team with essential knowledge of the threat which helps with determining how to deal with it -Deactivate, geo-tag or place surface markers

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