BISTATIC SAR TOMOGRAPHY: METHOD ANALYSIS AND INDOOR EXPERIMENTAL RESULTS

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Introduction

- Multibaseline (MB) SAR techniques have appeared as evolution of InSAR.

- Their objective is to distinguish between different scatters in the same resolution cell and to retrieve their height.

- The MB techniques have been applied using monostatic geometries.
  ➔ Drawbacks of monostatic MB techniques:
    - Temporal decorrelation due to the time between the passes.
    - Irregular baseline sampling.
Introduction

- **Our Goal** → **Overcome** monostatic multibaseline **drawbacks**.

  ➔ **How to?** Using a **bistatic geometry** with **fixed receiver**.
  - Only **one pass** is needed → **no temporal decorrelation**.
  - Freedom placing the receivers → **baseline sampling as desired**.

  ➔ **Different algorithms will be tested**.

  ➔ **Results** over a **real controlled scenario** will be presented.
**Geometry and Acquisition System Description (RadLab)**

- $R \approx 7 \text{ m}$
- $B_v = 1 \text{ m}$
- $\theta = 50^\circ$

- $f_0 = 34.93 \text{ GHz}$ ($\lambda \approx 8.6 \text{ mm}$)
- $B_w = 2.5 \text{ GHz}$
- *Positioning precision better than 0.1 mm*
Tomographic processing techniques

- Raw data
- Back Projection
- Corregistration
- Preparation for APES processing
- APES Processing
- High resolution SLC image
Tomographic processing techniques

- **Parametric**
  
  ➔ Used in this work: MUSIC order 1 and MUSIC order 3 and Non Least Squares (NLS).
  
  ➔ They use a priori assumptions.
    - Born approximation.
    - MUSIC supposes the number of sources is known.
    - NLS assumes the maximum number of sources is known.
  
  ➔ **Expected behaviour:**
    - MUSIC will have a good resolution if the number of sources is correct.
    - NLS will be timing consuming but it should present high resolution for regular and irregular baseline dataset.
Tomographic processing techniques

- Non – parametric

  ➔ Used: Beamforming (BF), CAPON (CP) and CAPON with subapertures (CPs).

  ➔ They only use Born approximation.

  ➔ **Expected behaviour:**

    - **BF** will show low resolution. It presents high sidelobes when an irregular baseline set is used.
    - **CP** is a good spectral estimator able to retrieve the heights in a regular and irregular set of baselines.
    - **CPs** is similar to CAPON but uses the Baseline dimension to calculate the covariance matrix. Because of this it cannot be applied to irregular set of baselines.
Results. Scale model.
Results. Regular baseline set

- **Beam Forming (BF):** Ground cut

  - Corners
  - Trees
  - Building

- $B_v = 1m$
- $\Delta b = 0.1 m$
- $Nom \ h_{res} = 4.7cm$
- $H_{ambiguity} = 46.7\ cm$
Results. Regular baseline set.

- BF
- CP
- CPs
Results. Regular baseline set.

- **MUSIC**
  - Ns=1

- **MUSIC**
  - Ns=3

- **NLS**
Results. Irregular baseline set

- **CP. Ground cut**

Trees

Corners

Building

- $Bv = 1m$
- $E\{\Delta b\} = 16.7 \text{ cm}$
- $Nom \ h_{res} = 4.7 \text{ cm}$
- $H_{ambiguity} = 28.1 \text{ cm}$
Results. Irregular baseline set.

- BF
- CP

Height of ambiguity
Results. Differential Tomography.

- **Experiment Description**
  
  ➔ Three set of experiments were done moving the building between each acquisition set.
  
  ➔ The expected displacement is a ramp from 5 to 0 mm.
  
  ➔ Scheme:
Results. Differential Tomography.

- *Displacement horizontal cut @ 12 cm*

5 mm ramp displacement

Uncontrolled tree movement
Results. Differential Tomography.

- **Displacement vertical cut**

Aliasing from the ground  Uncontrolled tree displacement

Stable ground.  5 mm ramp displacement
Conclusions

- Bistatic tomographic **results** have been presented over **real data** obtained with an **indoor experimental setup**.

- Different algorithms have been used.
  - **MUSIC**: Works OK if the number of sources is the expected one. Creates artefacts when the number of sources is incorrect. It does not preserve the phase → It is not suitable for differential application.
  - **NLS**: Good results if the maximum number of sources can characterize the cell scattering. It presents some problems in non regular baseline sets. ?
  - **BF**: Works fine for regular baselines but with poor resolution. High sidelobes for a non regular baseline set.
  - **CP**: Shows pretty good results in a regular and irregular baseline set.
  - **CPs**: Works fine in a regular set but it is not applicable to an irregular set of data.

- **Differential Tomography** is useful for retrieving the **deformation in a 3D volume**.

- The next step is to apply the algorithms to real data obtained with SABRINA.