Fusion of Multistatic Synthetic Aperture Radar Data to obtain a Superresolution Image

Ali Mohammad-Djafari[1], Sha Zhu[1],
Franck Daout[1] and Philippe Fargette[3]

[1] Laboratoire des Signaux et Systèmes
(UMR 8506 CNRS - SUPELEC - Univ Paris Sud 11)
Supélec, Plateau de Moulon, 91192 Gif-sur-Yvette, FRANCE.
{djafari,zhu}@lss.supelec.fr

[2] SATIE, ENS Cachan, Université Paris 10, France
fdaout@u-paris10.fr

[3] DEMR, ONERA, Palaiseau, France
philippe.fargette@onera.fr

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Summary

- Introduction to SAR imaging
- Monostatic, Bistatic and Multistatic SAR imaging
- Forward modeling as a Fourier Synthesis inverse problem
- Classical inversion methods
  - Inverse Fourier Transform
  - Gerchberg-Papoulis
  - Least square and deterministic regularization
- Bayesian estimation approach
- Proposed method of joint data fusion and super-resolution reconstruction
- Simulation and experimental data results
- Conclusions and Discussions

Synthetic Aperture Radar (SAR) imaging

- Point sources:

$$s(t) = \sum_m \sum_n f(m,n)\, p(t - \tau_{m,n})$$

- Continuous case:

$$s(t) = \iint f(x,y)\, p(t - \tau(x,y))\, \mathrm{d}x\, \mathrm{d}y$$

- SAR imaging with a set of transmitter/receivers along the axis u:

$$s(t,u) = \iint f(x,y)\, p(t - \tau(x,y,u))\, \mathrm{d}x\, \mathrm{d}y$$

$$\boldsymbol{k} = \begin{bmatrix} k_x \\ k_y \end{bmatrix} = \begin{bmatrix} k\cos(\theta) \\ k\sin(\theta) \end{bmatrix} \qquad |\boldsymbol{k}| = k = \omega/c$$

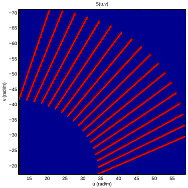
$$s(\omega,u,\theta(u)) = P(\omega) \iint f(x,y)\, \exp\left\{-j\omega\tau(x,y,\theta(u))\right\}\, \mathrm{d}x\, \mathrm{d}y$$

Monostatic, Bistatic and Multstatic cases

- Mono-static case (same transmitter-receivers)

$$s(t, u(\theta)) = \iint f(x,y)\, p(t - \tau(x,y,u(\theta)))\, \mathrm{d}x\ \mathrm{d}y$$

$$\tau(x,y,u(\theta)) = \frac{2}{c}\sqrt{x^2 + (y-u)^2} = \frac{2}{\omega}(k_x x + k_y(y-u))$$



$$k_x = k\ \cos(\theta)$$
$$k_y = k\ \sin(\theta)$$

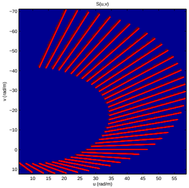
$$\begin{aligned} s(\omega, u, \theta(u)) &= P(\omega) \iint f(x,y)\ \exp\{-j\omega\tau(x,y,\theta(u))\}\ \mathrm{d}x\ \mathrm{d}y \\ &= P(\omega) \iint f(x,y)\ \exp\{-j(k_x x + k_y y)\}\ \mathrm{d}x\ \mathrm{d}y \end{aligned}$$

Bistatic and Multstatic cases

- Bistatic case (one transmitter, many receivers)
- Multistatic case (one transmitter, many receivers)

$$s(t,u) = \iint f(x,y)\, p(t - \tau_{tc}(x,y) - \tau_{rc}(x,y,u(\theta)))\ \mathrm{d}x\ \mathrm{d}y$$

$$\tau_{tc} + \tau_{cr} = \frac{2}{\omega}(k_x x + k_y(y-u))$$

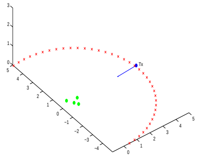


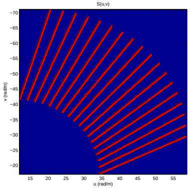
$$\begin{aligned} k_x &= k\left(\cos(\theta_{tc}) + \cos(\theta_{cr})\right) \\ k_y &= k\left(\sin(\theta_{tc}) + \sin(\theta_{cr})\right) \end{aligned}$$

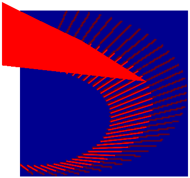
$$s(\omega, u, \theta(u)) = P(\omega) \iint f(x,y)\ \exp\left\{-j(k_x x + k_y y)\right\}\ \mathrm{d}x\ \mathrm{d}y$$

Monostatic, Bistatic and Multstatic cases

$$s(\omega, u, \theta(u)) = P(\omega) \iint f(x,y)\, \exp\{-j(k_x x + k_y y)\}\ \mathrm{d}x\ \mathrm{d}y$$





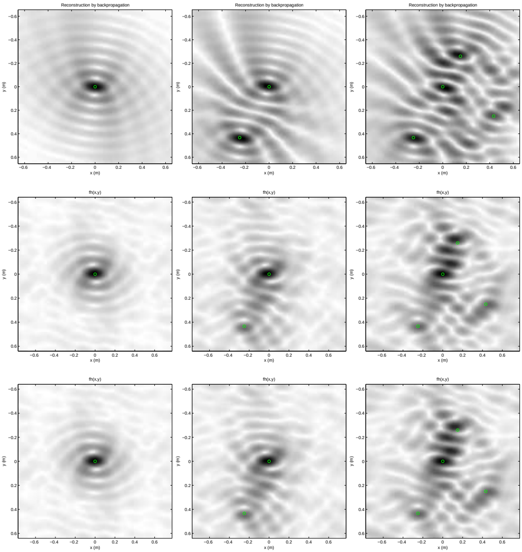


Results on experimental data (2 bands fusion)

BF1 band

BF2 band

BF1 & BF2



Conclusions and Perspectives

- Bayesian estimation framework is an appropriate one for handeling inverse problems and in particular Fusion and inversion of SAR imaging data
- Proposed method shows good results both on simulated and experimental data
- For experimental data, we still need to account for polarisation information
- Present forward modeling assumes a scene with point sources
- More accurate forward models are needed for accounting for real sources