Investigation of Variations in the Equivalent Number of Looks for Polarimetric Channels

Dingsheng Hu, Stian Normann Anfinsen, Ding Tao, Xiaolan Qiu

Department of Physics and Technology, University of Tromsø
Institute of Electronics, Chinese Academy of Science
Overview

• Current methods and the corresponding limitation
• Variation in ENL of each channel
• Methodology
• Experiment results
• Conclusion and Future Work
Current methods

• Based on single channel data
  • Coefficient of Variation Estimator (CoV)
    \[ L_{\text{cov}} = \frac{E\{I\}^2}{\text{Var}\{I\}} \] (1)

• Based on full sample matrix-variate statistic
  • Log-Determinant Moment-Based Estimator (ML)

\[ g\left[ \hat{L}_{\text{ML}} \right] = \langle \ln |C| \rangle - \ln \langle C \rangle - d^{-1} \sum_{i=0}^{d-1} \Psi^{(0)} \left[ \hat{L}_{\text{ML}} - i \right] + d \ln \hat{L}_{\text{ML}} = 0 \] (2)

• Development of Trace Moments Estimator (DTM)

\[ \hat{L}_{\text{DTM}} = \frac{E\{\text{tr}^2(C)\} \text{tr}^2(E\{C\}) - E\{\text{tr}(C\cdot C)\} \text{tr}(E^2\{C\})}{E\{\text{tr}(C\cdot C)\} \text{tr}^2(E\{C\}) - E\{\text{tr}^2(C)\} \text{tr}(E^2\{C\})} \] (3)
Current methods

- Unsupervised estimation

Limitation of Current Methods

SAR scenes

Minor mixture

Medium mixture

High mixture

ENL distribution
Variation in ENL of each channel

- Difference of ENL statistics in each channel
  - Texture: scalar parameter
  - Mixture: 1. visually observable
    2. mixture in small scale
Methodology

HH data

Cross data

VV data

Full-polarimetric data

Unsupervised Matrix-variate ENL estimation (ML or DTM)

ENL in HH channel

Threshold selection

ENL in cross-pol channel

Threshold selection

ENL in VV channel

Threshold selection

Combined Mask

ENL output

ENL based on full-polarimetric information
Experiment results

- Generated Data
Experiment results

• Generated Data

Mask of each channel on the ENL estimation maps
Experiment results

• Generated Data

<table>
<thead>
<tr>
<th>Strategies</th>
<th>Pd</th>
</tr>
</thead>
<tbody>
<tr>
<td>Based on the combination of individual channels</td>
<td>13848(64.53%)</td>
</tr>
<tr>
<td>Based on the covariance matrix</td>
<td>9773(45.55%)</td>
</tr>
</tbody>
</table>
Experiment results

• Real Data
Experiment results

• Real Data
Experiment results

• Real Data

M.-A. N. Moen, et.al "Comparison of feature based segmentation of full polarimetric SAR satellite sea ice images with manually drawn ice charts", 2013
Experiment results

Looks = 25, Comparing Different Estimators

- ENLMoML
- Mode of ENLMoML
- ENLML
- Mode of ENLML
Conclusion and future work

• Performance improvement
  • Generated Data:
    Get more completed mixture position in PolSAR images
  • Real Data
    Estimate the ENL value more precisely
    Improve the applicability of the unsupervised estimators for complex SAR scene.

• Future Work
  • Adaptive approaches to determine the threshold for each channels based on the SAR scenes
Thank you!

Thanks to:
Methodology

This mixture may not be reflected by ENL result of matrix-variate ML estimator

\[ C' = \begin{bmatrix} C'_{11} & * \ \\ *^H & C'_{33} \end{bmatrix} \]

\[ C'' = \begin{bmatrix} C''_{11} & * \\ *^H & C''_{33} \end{bmatrix} \]

\[ |C'| \approx |C''| \]
The statistic of the two classes would differ at least in one channel.
Experiment results

• Real Data
Experiment results

- Real Data

![Image of data analysis results]
Experiment results

- Real Data
Improvement measures

• Purpose: discard the contribution of the windows which contain the mixture to the ENL estimation distribution.

• Methodology: Set threshold for each channel to filter the pixels with low ENL value.

• Reason: Since the statistics properties of two classes will differ at least in one channel, then the mixture can be detected in that channel. Combining the discarded pixels in three channels, all the mixture part in that image will be located.
Current method

• Based on single channel data
  • Coefficient of Variation Estimator
  • Fractional Moment-Based Estimator

• Based on full sample matrix-variate statistic
  • Trace Moment-Based Estimator
  • Log-Determinant Moment-Based Estimator
  • Development of Trace Moments Estimator

• Unsupervised estimation based on above estimators
Experiment results

Looks = 25, Comparing Different Estimators

- ENLMoML
- Mode of ENLMoML
- ENLMoDTM
- Mode of ENLMoDTM
- ENLML
- Mode of ENLML
- ENLDTM
- Mode of ENLDTM