Precise Palm Oil trees Detection By Polarimetry and Multi-Chromatic Analysis

Dr. Filippo Biondi
The expansion of oil palm plantations across the Earth is causing deforestation of natural forests.

Deforestation contributes to increasing CO2 emissions in the atmosphere.

This paper gives contribution in designing a new PolSAR classification scheme.

The method use additive information existing by the interference generated between two Doppler sub-apertures PolSAR (PolInSAR) + multi-chromatic analysis (MCA-PolInSAR).
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Multi Chromatic Analysis
Range-Doppler Sub-apertures

• **Range** → Interferometric SAR

• **Azimuth** → MTI-SAR, Absolute Height estimation with (Staring Spotlight)


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Doppler sub-aperture analysis → MTI-SAR
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State of the art of MCA: River velocity estimation.
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\[ \delta R = \frac{c}{2 \cdot \text{Chirp_band}} \]
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**Azimuth Chirp**

\[ \delta A = \frac{L}{2} \]
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**Volume Oriented Indetermination Problem**
Precise Palm Oil trees Detection By Polarimetry and Multi-Chromatic Analysis

MCA for solving polarimetric Oriented Volume miss-classification problem.

State of the art:

Polarometric Interferometric SAR (PolInSAR)

\[
P(p|\{T\}) = \frac{L^{L-p} |\{T\}|^{L-p} \exp(-LTr(\{T\}^{-1}\{T\}))}{\pi^{p(p-1)/2} \gamma(L) \cdots \gamma(L-p+1) |\{T\}^{-1}|^L}
\]

Wishart Classification
Precise Palm Oil trees Detection By Polarimetry and Multi-Chromatic Analysis

MCA for solving polarimetric Oriented Volume miss-classification problem.

State of the art:
- Polarometric Interferometric SAR (PolInSAR)

Master (Full-Pol)

Slave (Full-Pol)

\[
P\left(\langle [T]\rangle / [T_m]\right) = \frac{L^p L_{Tm}}{\pi^{p+1}} \exp -LT \left([T_m]^{-1}\langle [T]\rangle\right) \pi^{\frac{p}{2}} \gamma \cdot \gamma \cdot \gamma \cdot [T_m]_{L}^{L}
\]

L.Ferro-Famil, E. Pottier, J.S. LEE (2002)
PolInSAR Classification

Optimized Coherences (HH-HV-VV)
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State of the art:

Polarometric Interferometric SAR (PolInSAR)

\[
P(\langle |T| \rangle / |T_m|) = \frac{L^p \langle |T| \rangle^{L-p} \exp(-LT \text{Tr}(T_m^{-1} \langle |T| \rangle))}{\pi^{p|L-1|/2} \gamma(L) \cdots \gamma(L-p+1) |T_m|^L}
\]

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Solution:

Multi-Chromatic-Analysis-Polarometric-Interferometric-SAR

MCA-PolInSAR

Single image (Full-Pol)

F. Biondi Modified PolInSAR Classification

PolSAR
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Multi-Chromatic decomposition

Single image (Full-Pol)

RAW HH

RAW HV

RAW VV

F1 (Master) Full-Pol

F2 (Slave) Full-Pol
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MCA for solving polarimetric Oriented Volume miss-classification problem.

State of the art:
Polarometric Interferometric SAR (PolInSAR)

F1 (Master Full Pol)

\[ P\left(\frac{\langle [T]\rangle}{[T_m]}\right) = \frac{L^L P^{|[T]|^{L-p}} \exp(-LT \text{tr}([T_m]^{-1}<[T]>))}{\pi^p \frac{p-l}{2} \gamma(L) \cdots \gamma(L-p+1)[T_m]^L} \]

F2 (Slave Full Pol)

Optimized Intra-Chromatic-Coherences (HH-HV-VV)

24 classes:
(8 → HH)
(8 → HV)
(8 → VV)

F. Biondi (2017)
MCA-PolInSAR Classification
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Geospatial data exploitation for maritime surveillance

1. Single raw SAR image input
2. Band-pass filter 1
   - SAR focusing
   - Master-F1
3. Band-pass filter 2
   - SAR focusing
   - Master-F2
4. SLC master-F1
5. Infra chromatic $T_6$ matrix generation
6. MCA-PolInSAR coherency optimization
7. MCA-PolInSAR unsupervised ML Wishart classification
8. Classification output

MCA $\gamma_{opt}^{(1,2,3)}$
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(a) Double-bounce
(b) Volume
(c) Single-bounce
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![MCA-PollnSAR unsupervised classification map](image-url)
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Wishart supervised classification map

Range (pixel)

Azimuth (pixel)
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Precise Palm Oil trees Detection By Polarimetry and Multi-Chromatic Analysis

Detection probability

Wishart unsupervised = 0.7737
Wishart supervised = 0.3488
MCA-PolInSAR = 0.6846

False alarm

Wishart unsupervised = 0.1068
Wishart supervised = 0.2202
MCA-PolInSAR = 0.1040
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