POLARIMETRIC TARGET DETECTOR BY THE USE OF THE POLARISATION FORK

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The contribution of synthetic aperture radar polarimetry and interferometry in target detection is described and found to add valuable information [1]. The aim of this study is target detection exploiting a particular aspect of the polarimetric target response, namely the (Huynen) polarimetric fork (PF) of the targets [2]. The detector is not based on a statistical technique, but rather a physical approach based on sensitivity of the complex coherence to changes in polarisation. The algorithm is based on the possibility to filter the target of interest in the target geometrical space. In some way, it acts not dissimilarly to a decomposition theorem [3]; however it is more aimed on the detection of a chosen single target type than the breakdown of the partial target in predefined components.

The target observed by a SAR system is not an idealised scattering target, but a combination of different targets which we refer to as a partial target. Decomposition theorems are able to represent the partial target as a combination of idealised single target components and the single target is always uniquely represented with a Sinclair (scattering) matrix or with the Huynen parameters. Moreover, the Huynen parameters (except absolute phase and generally amplitude) can be uniquely represented on the Poincare' sphere with the polarisation fork (PF). The latter is mainly (but not exclusively) composed by Cross-pol nulls (XPN) and Co-pol nulls (CoPN) [4]. The XPNs are polarisations that when transmitted do not have any return in the cross polarisation. The CoPNs are polarisations that when transmitted do not have any return, because all the power is backscattered in the cross-polarisations. Generally, any single target is characterised by two XPNs and two CoPNs, but there exist a family of targets that have infinite XPNs (e.g. multiple reflections), and others with degenerate eigen problem and just one XPN (e.g. oriented dipoles).

The matrix representation (Sinclair matrix) of the target can be modified as a vectorial one, defining a scattering vector $\underline{k}$ that in case of reciprocal medium and monostatic sensor is three dimensional complex. Starting from $\underline{k}$, it is possible to define the scattering mechanism $\underline{\omega} = \underline{k} / |\underline{k}|$, that represents an idealised target. Hence, this 3 dimensional complex vector encloses the information of the Huynen parameters (except amplitude and absolute phase). In other word any $\underline{\omega}$ can be obtained by the knowledge of the PF (or equivalently the Huynen parameters). The detector estimates the coherence between two complex targets (two different $\underline{\omega}$) one defined with the Huynen parameters of the target to detect and the second obtained from the first varying slightly the Huynen parameters. The coherence between the two elements will be high or low depending on the presence of the target of interest in the averaging window. All the process can be seen as a sensitivity analysis on the geometrical space of the polarisations.

The detector was validated on a full polarimetric L-band SAR dataset. The mathematical formulation shows that the detector is not directly dependent on the central frequency. The choice of the band is related to the particular target to detect. L-band presents an interesting setting, based on its foliage penetration (FOLPEN) capability. The dataset were acquired by the DLR (German Aerospace Agency) during the SARTOM campaign in 2006, with the E-SAR airborne system. One aim of the campaign was the target detection beneath foliage, hence a set of artificial targets where deployed in open field and inside the forest. For this reason, the dataset presents an ideal test scenario.

Although the detection can be aimed on any simple target (as long as it can be represented with the Huynen parameters) in this first test of the algorithm the selected targets are multiple reflections (odd and even-bounces) and oriented dipoles (horizontal and vertical ones). The preliminary choice of these targets is simply related with the possibility to have a relatively simple physical counterpart in the observed scene. The validation shows a significant agreement with the expected results based on the theoretical description.

Finally, a comparison with other detectors or target decomposition techniques is carried out showing the ability of the detector to outperform in some circumstances (e.g. foliage penetration) other techniques.

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