Man Made Target Detection in a Forest with a Subspace SAR Processor

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To detect Man Made Targets (MMT) embedded in noise, clutter or speckle with a SAR system is a current issue which involves both the signal processing and the SAR community. Most techniques used for target detection are post-processing treatments on SAR images (eg polarimetry...) but very few focus on a preprocessing treatment, operating directly on the received signal. SAR images can be formed with many algorithms, which generally are based on the isotropic point model. This model assumes that any target is a single or a set of isotropic points. This assumption is true if the element to image can be considered as a random volume. The MMT SAR detection issue is to discriminate its scatterering elements from others. Scattering properties of an element generally depend on parameters such as its size, orientation and form. If we consider a model suited to MMT, we will certainly be able to improve detection. For this purpose, we propose to develope a new SAR imaging algorithm by considering an MMT as a set of canonical elements: as an example, an MMT can be seen as set of plates. To develope such an algorithm, a first idea could be to implement a filter bank matched to different configuration of the chosen model (for example, filters matched to any orientation of plate). This kind of algorithm suffers from several drawbacks. First, many filters are required to cover all existing configurations. Then it would not be robust enough to configurations which have not been forseen... However, we show in this paper that these problems can be overcome when the set of signals scattered by the chosen model, whatever its configuration (orientation), belongs to a low dimensional subspace.The resulting imaging algorithm is based on a subspace detector. Each represented pixel of the final image is based on an evaluation of an appropriate Generalized Likelihood Ratio (GLR). This algorithm has the advantage of taking the scattering properties of the target into account while using a low number of filters.

The paper will be organized as follows. First, we present the new Subspace Detector SAR (SDSAR) algorithm. We show that it generalizes classical SAR processors (as Backprojection or Time Domain Correlation Algorithms), which only concider the isotropic point model, to any kind of model. However, as said before, the SDSAR algorithm will be efficient if the set responses of the chosen model whatever its orientation belongs to a low dimensional subspace. It is the case of most of canonical elements (as plate, cylinder, dipole or dihedral). In a second part, we consider that an MMT is a set of metallic plates and we particularize the SDSAR algorithm to that case. We compare the ability of SDSAR and classical algorithms for detection of metallic plates of different orientations and sizes in a white Gaussian noise. Then we test these two algorithms on a more complex plate made target. In simulations, the SDSAR algorithm shows important improvement in terms of probability of detection compared to CSAR. Moreover interesting robustness properties to plate orientation and size are obtained. The final part of the paper will concern target detection under foliage and the capability of the SDSAR algorithm to discriminate a man made target from trees. This study relies on the use of a SAR simulator of a forest containing an hidden target. SDSAR provides in simulation improvements in term of detection compare to a classical algorithm.