Automatic target recognition in SAR images using multilinear analysis

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***Abstract*— In this paper, we investigate an approach based on multilinear analysis for synthetic aperture radar automatic target recognition (SAR/ATR). High resolution SAR images are the composite consequences of multiple factors : bearing angle, grazing angle, number of views and polarisation. Linear methods like principal component analysis (PCA) require to reshape images into a high dimensional vector. This vectorisation processing breaks natural structure and correlation in the original data set. Moreover the PCA, based on a matrix singular value decomposition (SVD), allows only one factor to vary in the image database. Multilinear analysis provides a powerful mathematical framework to analyse ensembles of images resulting from the interaction of underlying factors and preserves their original shapes. In this paper, we propose a method based on multilinear principal component analysis (MPCA) to classify unlabeled targets. We form a tensor with the images of the training set and use the higher order singular value decomposition (HOSVD) to reveal interesting patterns and dependencies between images. HOSVD is also used to compress the data and remove all information belonging to the background. A multilinear projection algorithm projects the unknown target into multiple basis which characterize learned classes. Tests using real SAR images database show that the multilinear approach provides very good recognition performance with a very high compression rate.**

I. Introduction

SAR images are very noisy due to speckle noise. Moreover, unlike optical images, SAR images of a same target observed from different view directions can be characterized by great variations in appearance of the target which makes the target classification problem non trivial. Usually in classification, the test images are expected to belong to predefined training classes. In practical situations, especially for security and military applications, some test images do not belong to learned classes. In face recognition for biometric authentication, classification algorithms must be able to prevent from intruder. In military target recognition, classification algorithms must prevent users from unlearned threatening targets and must be able to discriminate military and civilian vehicles. Two classes must be added to the learned classes : the rejecting class and the confusion class. Unlearned targets are labeled into the rejecting class while the confusion class allows the classifier not to decide between different classes. A classifier must be able to classify targets as well as variants, to reject unknown targets, to have a reasonable level of confusion with a classification error rate as low as possible

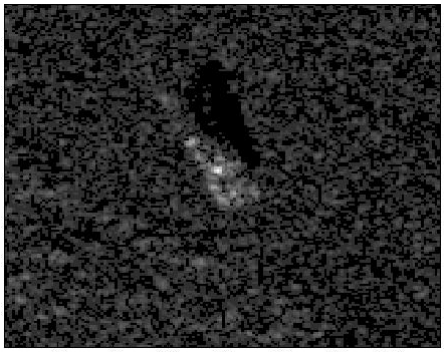

Fig. 1. SAR image of a target from the MSTAR database

There are several approaches to solve a pattern recognition problem : principal component analysis (PCA), independent component analysis (ICA), linear discriminant analysis (LDA), support vector machines (SVM), nearest neighbours, statistical modelling, neural networks... Recognition can also be accomplished using a multilinear analysis based on a tensor representation of an image ensemble. Such multilinear approaches can be viewed as high order generalizations of linear methods, among which one can cite multilinear principal component analysis (MPCA), multilinear independent component analysis (MICA) and multilinear discriminant analysis (MDA). Various algorithms based on MPCA, MICA or MDA have been recently proposed in the litterature for face recognition ([4], [5]), handwritten digit classification ([3]) or gait recognition ([6], [7]). A SAR image database is composed of an ensemble of images, each one containing a target viewed from different directions, and sometimes with different polarisations. Multilinear methods like MPCA combine all those underlying factors to find the best representation of the training set. Moreover application of PCA to ensembles of matrix images requires their reshaping into vectors with high dimensionality which breaks the natural structure and correlation in the original data