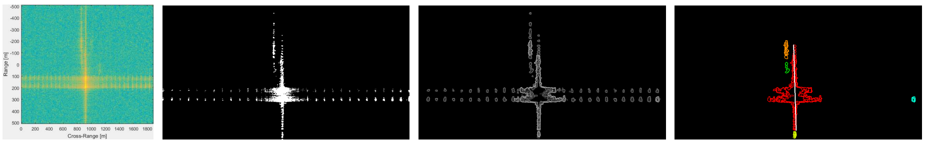
Feature-Based Target Detection and Classification in Passive ISAR Range-Crossrange Images

Levente Kovács and Andrea Manno-Kovacs
Machine Perception Research Lab., MTA SZTAKI, Budapest, Hungary
Email: {levente.kovacs, andrea.manno-kovacs}@sztaki.mta.hu



	A	B	C	D
A	0.43	0.50	0.07	0.00
B	0.00	1.00	0.00	0.00
C	0.27	0.20	0.53	0.00
D	0.09	0.55	0.00	0.36

Fig. 1: Left to right: input ISAR image; scaled and filtered; feature map; region blobs (red as primary); confusion matrix.

***Abstract*—We present a method for passive ISAR image analysis for target detection, feature extraction and shape-based classification without a priori target shape information. Results show that classification is possible with limited target samples.**

I. Introduction

In this work we analyzed ISAR images with 2D image processing tools for possibilities of augmenting pure signal-based processing. The goal is to detect targets and extract features that can be used for classification. When we know the possible targets' structures, our earlier works [1] provide solutions for detection using a Markovian approach. However, our goal here is to detect targets without having such information. The provided method produces a segmentation of the target, along with image features for classification.

The method is based on our previous results in saliency based feature map generation [2], [3], shape based recognition and retrieval [4]. Important steps are the generation of a feature points- and directional information-based feature map producing a direction selective edge map fused with a texture distinctiveness map [5] to produce a textural-directional feature map. From this map we extract target regions and use their shape information as a basis for classification and recognition.

II. The Proposed Method

The texture map is based on the statistical model of [5] using a sparse texture model. The Harris Based Feature Map and Salient Direction Feature Map emphasizes the structural information of the image based on [3] for efficient boundary detection. For local directions we analyze local gradient density around feature points, obtain the orientation histogram and correlate a series of Gaussians to find the main orientations. Then, we produce a Direction Selective Edge Map by applying Morphological Feature Contrast [6] to distinguish background texture and isolated salient features, with an extension to extract linear features in defined directions.

Then, we obtain the final Textural-Directional Feature Map, followed by the extraction of contiguous blobs by flood-filling regions and extracting their contours. Then, we order the blobs by size and take the largest as the target candidate (Fig. 1). For classification, the perimeter of the candidate is transformed into scale and rotation invariant tangent function representation [7], [4]. Using the representations, when we classify a detected target, we perform a retrieval step on the available index and take the best results as an indicator of the class. For evaluation we used a dataset containing 68 ISAR images of 4 cargo ships (classes denoted by A, B, C, D), provided by CNIT/RaSS[1]. As the normalized confusion matrix in Fig. 1 shows, targets from the classes B and C were in average correctly classified, with inputs from class B with 100% accuracy, while inputs from class A were mostly estimated to be class B marginally and inputs from class D remained estimated to be from class B. However, by increasing the number of labeled target samples and using a continuous estimation of the input target classes we can achieve a higher performance. The time required to produce a class estimate is an average of 0.19 s.

Acknowledgment

The work is part of the Multichannel passive ISAR imaging for military applications (MAPIS) R&T project of the EDA.

References

[1] C. Benedek and M. Martorella, "Moving target analysis in ISAR image sequences with a multiframe Marked Point Process Model," *IEEE Trans. Geosci. Remote Sens.*, vol. 52, no. 4, pp. 2234–2246, 2014.
[2] A. Manno-Kovacs, "Direction selective vector field convolution for contour detection," in *Proc. of IEEE ICIP*, 2014, pp. 4722–4726.
[3] A. Kovacs and T. Szirányi, "Harris function based active contour external force for image segmentation," *PRL*, vol. 33, no. 9, pp. 1180–1187, 2012.
[4] L. Kovács, A. Kovacs, A. Utasi, and T. Szirányi, "Flying target detection and recognition by feature fusion," *Opt. Eng.*, vol. 51, no. 11, p. 117002, 2012.
[5] C. Scharfenberger, A. Wong, K. Fergani, J. S. Zelek, and D. C. et al., "Statistical textural distinctiveness for salient region detection in natural images," in *Proc. of IEEE CVPR*, 2013, pp. 070–986.
[6] I. Zingman, D. Saupe, and K. Lambers, "A morphological approach for distinguishing texture and individual features in images," *PRL*, vol. 47, pp. 129–138, 2014.
[7] L. J. Latecki and R. Lakamper, "Application of planar shape comparison to object retrieval in image databases," *Intl. J. Info. Sci.*, vol. 35, no. 1, pp. 15–29, 2002.

[1] http://www.cnit.it/en/institutes/rass/