AUTOMATIC TARGET RECOGNITION OF AIRCRAFT MODELS BASED ON ISAR IMAGES

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1. INTRODUCTION

Recently, Inverse Synthetic Aperture Radar (ISAR) imagery has been widely used in Automatic Target Recognition (ATR) applications. This paper presents a system for aircraft target recognition which consists in four stages: data acquisition, preparation, classification and interpretation/evaluation (see figure 1). We focus in this work on the data preparation and classification stages.

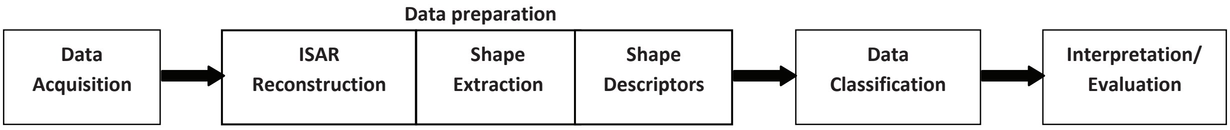

Fig. 1. Process for radar ATR system

Extracting the object shape from ISAR images is a difficult task in our ATR system because of the presence of Speckle noise and the poor quality of ISAR images. We propose a new approach based on a combination of the SUSAN (Smallest Univalue Segment Assimilating Nucleus) method and active curves evolution via level set. We then compute the shape descriptors using two methods: the Fast Fourier Transform (FFT) and Invariant Moments (IM). We use each of these feature vectors for classification, as well as their fusion. The classification stage is finally performed using Support Vector Machine (SVM) and K-Nearest Neighbor (K-NN).
Experiments are carried out on synthetic data simulated in an anechoic chamber of ENSIETA (Brest, France). We used five targets in our experimentation (F4, F16, Mig29, Rafale, and Harrier), placed on tunable support, and controlled remotely by a computer (Pentium IV). These targets represent aircraft scale reduced models (1/48). For each target we have 162 ISAR images of 256×256 grayscale pixels, and each image has a different angle of rotation.

2. METHODS AND EXPERIMENTAL RESULTS

2.1. Shape Extraction

We tested several classical shape extractors proposed in the literature such as filtering, watershed, snakes and gradient vector flow. All these methods did not yield satisfactory results. The best results, from both visual and classification perspectives, were obtained by the method we propose in this paper, that is, SUSAN [1] followed by active curves evolution via Level Set [2]. SUSAN uses a circular mask (Nucleus) for each pixel in the input image, then it computes the sum of grayscale comparison between a mask center and the others pixels in the local mask area (named also USAN). Usually, there are three cases:

- If the pixel is located in a homogeneous area, the sum of comparison will be low, because all grayscale levels of USAN pixels will be close to a nucleus gray level.
- If the pixel is located on a boundary, half of pixels of the mask area will have a gray level different from nucleus; therefore one obtains a large sum of comparison.
- Finally, when the pixel is located on a corner, ¾ of pixels in the mask area will have a different gray level, thus, a very large sum of comparison.

In our approach we view SUSAN as a pre-processing technique and modify it in order to segment the image into two regions, the target region and the background region. In the following step, we apply a variational formulation of the Level Set method [2] to recover the target closed shape. This formulation is more convenient and more natural to incorporate additional information than traditional Level Set methods. An example of shape extraction is shown on Figure 2.

a) b) c)

Fig. 2. Results of shape extraction, a) F16 model scale reduced (1/48), b) ISAR image of Mig. 29, c) SUSAN modified, d) The final shape extracted by Level Set

2.2. Shape Descriptors

After extracting the target shape, we use three types of shape descriptors:

- Fourier Descriptors (FD): we normalize the shape size and apply FFT. Then, Principle Components Analysis (PCA) is applied to reduce the dimension.
- Invariant Moments (IM): we use invariants based on the Hu moments [3] of the coefficients up to third order. FD and IM are both invariant to geometrical transformation such as translation, scaling and rotation.
- Fused descriptors: we concatenate the FD and IM feature vectors (Early Integration fusion).

2.3. Experimental results

Table 1 and 2 show the classification scores obtained using SVM and K-NN, respectively. CV=2 means a cross-validation of order 2. That is, a random half of the database is taken for training and the other for test, then roles are exchanged and the average score is taken. CV=3 means a cross validation of order 3. That is, the database is randomly split in 3 parts. Each part is taken for test and the 2 others for training, then the average score is taken. Three conclusions can be drawn from these results. First, for both classifiers, the IM descriptors seem to be more accurate than the FD. Second, the SVM classifier yields good results and significantly outperforms the K-NN one. Finally, the (Early Integration) fusion of the two descriptors significantly improves the classification accuracy. We will also present results using a fusion of the classifiers (Late Integration fusion).

Table I. Classification accuracies by RBF kernel based SVM classifier

Shape Descriptors	**Classification Accuracy**	
	CV=2	**CV=3**
Fourier Descriptors	**78.64%**	**80.37%**
Invariant Moments	**81.85%**	**82.83%**
Fusion of both	**88.89%**	**89.32%**

Tale II. Classification accuracies by K-NN

Shape Descriptors	**Classification Accuracy**	
	CV=2	**CV=3**
Fourier Descriptors	**74.91%**	**75.98%**
Invariant Moments	**77.82%**	**76.94%**
Fusion of both	**85.69%**	**80.61%**

3. REFERENCES

[1] Smith S. M. and J. M. Brady, “SUSAN . A new approach to low level imageprocessing,” *International Journal of Computer Vision*, vol.23, no.1, pp.4578, 1997.

[2] C. M. Li, C. Y. Xu and C. F. Gui, “Level set evolution without re-initialization: A new variational formulation,” IEEE International Conference on Computer Vision and Pattern Recognition, (San Diego, CA, USA), June 20-25, 2005.

[3] J. Flusser and T. Suk, "Rotation Moment Invariants for Recognition of Symmetric Objects", *IEEE Trans. Image Proc*essing, vol. 15, pp. 3784-3790, 2006.