LOG-POLAR AND POLAR IMAGE FOR RECOGNITION TARGETS

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ABSTRACT

We describe in this abstract, data processing algorithms applied on radar image in order to extract feature descriptors and then to perform recognition task. Several kinds of descriptors can be used to acquire information about target characteristics from radar images such as ISAR (Inverse Synthetic Aperture Radar) images. We present in this abstract two types of vector descriptors extracted from two minds of transformed images so-called *polar* and *log-polar* images obtained respectively via the *polar* and *log-polar* mapping. In order to guarantee the invariance of some geometrical transformation, additional processing are proposed. In this paper, we present our approach to extract feature vectors obtained on the both transformed images. In the classification step, the Support Vector machine will be used in the field of radar experimentation.

Index Terms— Target recognition, Image processing, Classification.

1. INTRODUCTION

The radar signatures are exploited to perform and produce an efficient strategy for recognition. However several kinds of radar signatures can be employed to acquire information about the target characteristics. The main kinds deal with ISAR image of the target such that the information about the geometry of the target revealed. Therefore. these informations deal usually with characteristics that can be done in one radar reflection, two or $n-$reflections ($n > 2$) in range. The one radar reflection is called a radar *range profile*. Under certain circumstances, the information on the targets motion perpendicular to the line-of-sight can be extracted from a bidimensional image. That is why several techniques have been investigated in this context and several researches have particularly focused on ISAR techniques and automatic target recognition (ATR).

For recognition targets field, several techniques of Data Mining (DM) can be used. DM uses machine learning, statistical and visualization techniques to discover knowledge and make interpretation and comprehension easy to human operator. Classification task is one of the major tasks of data mining used in order to recognize the unknown target. The goal of classification is to assign a new target (unknown target) to a class from a given set of classes (known targets). This process used a feature vectors obtained from radar images. The main problem to extract feature vectors is to obtain descriptors that have the invariance property relative to scaling and rotation of the ISAR image. In this paper, a semi-automatic/automatic recognition scheme is proposed as an alternative to overcome operator limitations resulting from target recognition difficulties and provide a useful tool for decision making.

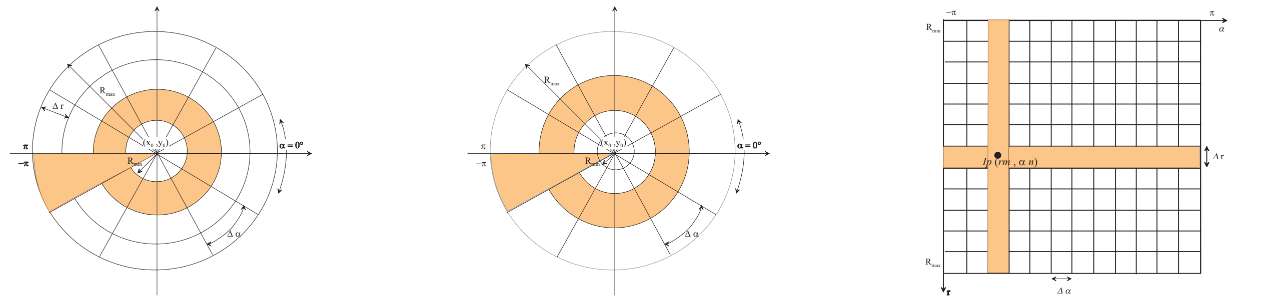
2. EXPERIMENTATION DATA

A radar data acquisition system is being studied, based on results obtained during tests conducted in ENSIETA's anechoic chamber. It facilitates the taking of real measurements and allows good control of the target-radar configuration. Thus, the human operator's interpretation and control are made easier. To construct our simulation ISAR image database, we used 11 scale reduced $(1/48)$ aircraft models: F-104, F-117, Tornado, Harrier, A-10, F-14, F-15, F-16, Mig-29, F-18, and F-4. Each target is illuminated in the acquisition level with a frequency stepped signal between $11.65GHz$ and $18GHz$ which is the B bandwidth. So, a sequence of $N+1$ pulses is emitted at linearly increasing frequencies $f_n = f_0 + n\Delta f$ at time moments t_n, where n runs form 0 to N. The frequency increment in our case is $\triangle f = 50MHz$ (128 frequency samples). To obtain the resolutions against full-scale targets, equivalent effective center frequency and bandwidth can be used as $308.85MHz$ and $132.29MHz$, respectively. Afterward, the processing algorithms are started in order to transform images and achieve classification task. In the next section we describe the preparation step.

3. DATA PREPARATION

3.1. Tranformed images

In this step, we are interested to study and to compare the both transformed images called, polar and log-polar images using Polar (MP) and Log-polar Mapping (LPM) [1, 2]. We can note that the PM has a finer grid than a similar grid as LPM [1] because of its sampling interval in *r-direction* and the same irrespective of the *radius* but the both mapping can give interesting advantage for image analysis. PM is so proposed in the radar field for target recognition and all details can be found in [3]. For instance, we will demonstrate that the problem of 2D translation motion estimation observed on ISAR images can be reduced on to two 1D translation motion estimation by using projections. The MP and LPM are adequate for guarantying scale and rotation invariant in pattern recognition [4, 2].



(a) Polaire grid (b) Log-polaire grid (c) Geometry of corrependante image

Fig. 1. Geometry of polar and log-polar image.

3.2. Polar image

If we applied a polar mapping on the initial image $I(x_i, y_j)$, we obtained an image called polar image $I_p(r_m, \alpha_n)$ with $m = 1, .., N_r, n = 1, ..., N_\alpha$, where N_r is the number of sampling points in *r-direction* and N_α is in α-direction (azimuth aspect) as is shown in figure 1. Therefore, we obtain a polar image using polar mapping illustrated by the polar algorithm given in [3]. To complete the feature vectors and to reduce the polar image dimensionality, we calculate the r-projected vector $I_r(r)$ and α-projected vector $I_\alpha(\alpha)$ by:

$$I_r(r) = \int_{-\pi}^{\pi} I_P(r,\alpha) d\alpha \approx \sum_{n=1}^{N_\alpha} I_P(r_m, \alpha_n) \;\; ; \;\; I_\alpha(\alpha) = \int_{R_{min}}^{R_{max}} I_P(r,\alpha) dr \approx \sum_{m=1}^{N_r} I_P(r_m, \alpha_n) \qquad (1)$$

(a) Original ISAR image with polar grid everlapped (b) Polar image and the both prejected vectors

Fig. 2. Polar mapping principle of an ISAR image with $N_r = 50$ and $N_\alpha = 50$.

As wil be shown in the final version of this paper, the scale invariance in polar image is achieved and the translation variance is transformed into translation toward the α-direction. Therefore, to guarantee this invariance in translation and rotation, the Fourier descriptors FD_n are computed by applying Fourier transform on the $I_\alpha(\alpha)$ [5]. Thus, sophisticated classification methods can be applied for automatic target recognition based only on vectors I_r and df_α. As result, each ISAR image I_i is represented by a template that contains the both vectors I_r and df_α extracted from the corresponding polar image. Finally, to validate this feature vectors we have used a hierarchical scheme to achieve automatic recognition. In the experimental simulation, the correct recognition rate will be presented on the simulation database.

3.3. Log-polar image

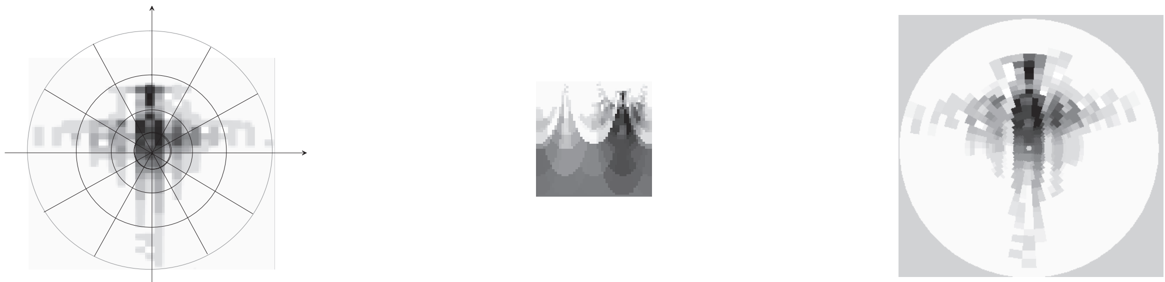
There are several models of log-polar imaging (see [6] for a review). The LPM model used here defines the log-polar coordinates:

$$(\xi, \eta) \approx \left(\log_a(\frac{\rho}{\rho_0}), q.\alpha\right) \tag{2}$$

with (ρ, α) defined from Cartisian coordinates (x, y) as usual, i,e.

$$(\rho, \alpha) \approx \left(\sqrt{x^2+y^2}, \arctan\frac{y}{x}\right) \tag{3}$$

Because of the discretization, the continuous coordinates (ξ, η) become the discrete one $(r, \alpha) = (\lfloor\xi\rfloor, \lfloor\eta\rfloor)$, $1 \leq r \leq N_r, 1 \leq \alpha \leq N_\alpha$ with N_r and N_α being the number of rings and sectors of the discrete log-polar image. The dimension of the log-polar result is denoted by $N_\alpha \times N_r$ points. all user parameters such as $N_r, \rho_0, \rho_{max}, N_\alpha, a$ and q used for implementing the log-polar image will be discussed in the final paper. So that, the log-polar transformation of a ISAR image I is denotes as $l(I)$ and the inverse operation can be achieved *i.e* the reconstruction of initial ISAR image from a log-polar image L is obtained using the inverse log-polar mapping noted $l^{-1}(L)$. An example of this process transformation is illustrated in figure 3.



(a) Original ISAR image (b) Log-polar image L (c) Retinal image $l^{-1}(L)$

Fig. 3. Log-polar mapping principle of an ISAR image with $N_r = 50$ and $N_\alpha = 50$.

To accomplish feature vectors from the log-polar image, we compute 1D projection toward r and α axes (see eq.1). However, the invariance in translation and rotation in these 1D projection is not guaranteed. In this purpose, we have improved this invariance by additional processing which we present in the final paper.

4. EXPERIMENTATION RESULTS

In simulation results, each target is represented by 162 ISAR images of 256×256 grayscale pixels. The initial database is divided into test and training databases. From each ISAR image, we compute polar and log-polar templates. To evaluate the robustness of our approach used in recognition process, we have used 11 aircraft targets. For recognition step, we propose an hierarchical approach for each LP and LPM template. In the present work, using the polar template, the correct recognition rate is close to 100%. When we used a only 231 images in training set and 1551 images in test set, the correct recognition rate is 99.78% for polar template. The comparative results using log-polar template will be presented and discussed in the final paper.

To evaluate the robustness of our recognition scheme and feature vectors, all ISAR images from the whole database are arbitrarily rotated and down-scaled from a uniform distribution between 0 and 2π, and between 1 and $1/\sqrt{2}$ respectively before computing a polar and log-polar templates. In the first results, we obtain 86.07% as a correct recognition rate using polar template.

In the final paper, we improve that the target recognition based on polar and log-polar templates (signatures) gives a satisfactory result. Then, all results will be compared and discussed.

5. REFERENCES

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