Detection and Analysis for Synthetic Aperture Radar Image of Airport
Xiao-rui SUN, Wen-bang SUN and De-jun LI
Aviation University of Air Force, China Changchun

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Abstract. A method of airport target detection and analysis of Synthetic Aperture Radar image is suggested in this article based on the facts. The airport detection processing steps are presented and the target shape analysis method is suggested. The airport target is automatically detected and the parameters of target are calculated. Experimental results show that the method is efficient.

Introduction

Synthetic Aperture Radar (SAR) is an imaging radar operating in microwave band. Because of its all-weather, all-day and penetrating ability to the surface, it makes up for the shortcomings of visible and infrared imaging. It has become the research object of universal attention and development in the world. With the continuous improvement of SAR image resolution, SAR has been widely used in geological exploration, ground monitoring, military reconnaissance and other fields. Target detection in SAR images has become a hot issue of general concern at home and abroad, and it has special significance for airport target detection and research from both military and civil. In this paper, computer automatic airport detection method based on SAR image is proposed to assist remote sensing image interpreters to complete the detection task.

Characteristics of Airport Target

Airport is a place for taking off, landing and parking of aircraft, usually composed of runway, taxiway, apron, command facilities, weather station and oil depot etc. There are terminal buildings in civil airports and barrack in military airports. Runway is the main object for airport detection as the most obvious feature of airport.

The runway is a paving area with a certain length and width for aircraft takeoff, landing and taxiing. The runway is the main part of the flight area. It has a large area and regular shape. In SAR images, the reflected wave is weak because of the smooth surface of the runway, which is shown as a dark strip. It is easy to detect and recognize. The other targets are difficult to detect because of their small area and different shapes, as well as the limited resolution of SAR images. Fig. 1 is an airport SAR image with a resolution of 1 m.

Flow Chart and Method of Airport Detection and Analysis

The flow of airport detection and analysis in SAR images includes three stages: image preprocessing, target detection and target analysis. Fig. 2 shows the flow chart of Airport Detection and Analysis.
Image Preprocessing

Histogram equalization is used to transform the image with known gray probability distribution into a new image with uniform gray probability distribution. Through this step, we can get a clear image display effect and prepare for the following target segmentation. The specific steps are as follows. Fist the gray histogram of the original image $f(x, y)$ is obtained and expressed using $h(r)$ representation.

Secondly, we should calculate the gray distribution probability of the original image using $p_r$ representation, it is recorded as Eq. 1.

$$p_r = \frac{1}{N_f} h_r(r), \quad r = 0, 1, 2 \cdots 255$$  

(1)

$N_f$ is the total number of pixels in the image. Thirdly, histogram equalization is computed. And the pixel value $g(x, y)$ of the processed image is obtained as Eq. 2.

$$g(x, y) = 255 \cdot \sum_{k=0}^{255} p_f(k), \quad r = 1, 2 \cdots 255$$  

(2)

Airport Target Detection

Because of the unique features of the airport runway in SAR images, this paper uses the detection method of the airport runway to achieve the detection of the airport target. The detection includes two steps and one check: Canny edge detection, threshold segmentation and model checking.

(1) Canny edge detection

In this paper, the image edge information is extracted by Canny operator to determine the airport runway area. The basic principle of Canny edge detection is that the first-order directional derivative of two-dimensional Gauss function in any direction is used as noise filter, and the image is filtered by convolution with $F(x, y)$. Then the filtered image is searched for the local maximum of the image gradient to determine the image edge.

(2) Model checking

The airport area of the image after edge detection is determined by establishing the runway model and according to the five descriptive features of the runway. These five characteristics are as follows:

The shape of the runway is similar to that of a slender rectangle.

The length of the runway is within a certain range, that is: $L_1 < L < L_2$ (3).
The width of the runway is within a certain range, that is: \( WL_1 < W < W_2 \) (4).
The length of the runway is much larger than the width of the runway.
When the number of runways is more than one, they may intersect or parallel.

(3) Threshold segmentation

After model checking, we can roughly determine the area of the airport runway. Then, the region corresponding to the histogram equalized image is segmented by local threshold.
Firstly, the total number of pixels \( N \) in the region is calculated \(^{[3]}\), and then the average gray value of the region is calculated by Eq. 3.

\[
\overline{T} = \frac{1}{N} \sum \sum f(x,y)
\]  

(3)

A threshold range is determined according to the requirement, and the histogram equalized image is binarized according to this range. That is, all the pixel values in this range are 1, and the rest are 0 as Eq. 4.

\[
g(i, j) = \begin{cases} 
1, & f(i, j) \in (\overline{T} - \Delta t, \overline{T} + \Delta t) \\
0, & f(i, j) \notin (\overline{T} - \Delta t, \overline{T} + \Delta t)
\end{cases}
\]  

(4)

So far, we have successfully detected the runway of the airport, thus separating the airport from the image. Next, we will analyze the target detection results.

Airport Target Analysis

The purpose of airport target detection is to carry out target analysis. Here we use the method of feature extraction for analysis. The so-called feature extraction is based on some formulas to extract the feature parameters of the target, including: the area of the airport runway, the direction angle of the principal axis, the length and width of the runway and other useful information. Because the airport runway is rectangular, its features are easy to extract.

(1) Airport area
In this paper, the method of counting the area of the runway target area \( R_i \) is used. The area \( A_i \) of the runway target area is the sum of 1 pixels in the interior (including on the boundary) of the \( R_i \). The calculation formula is as Eq. 5.

\[
S = \sum_{x=1}^{N} \sum_{y=1}^{M} f(x,y)
\]

(5)

The actual area of the runway can be obtained through multiplying \( S \) by the pixel spacing of the SAR image.

(2) Directional angle of spindle
To determine the orientation of the airport, the longest axis of the axis passing through the center of gravity of the target is called the main axis of the target. Because the airport runway is long strip, its long side is the spindle. The angle between the target principal axis and the Y axis is the principal axis direction angle. The calculation formula is as Eq. 6.

\[
\theta = \frac{1}{2} \cdot \arctan \left[ \frac{2\mu_1}{\mu_{20} - \mu_{02}} \right]
\]

(6)

(3) Length and width
The length and width of runway are important parameters of airport target. Through it and eye surface area, important information such as airport size and airload can be analyzed.
Because the target is rectangular, its main axis is the target length, and the axis direction perpendicular to the main axis is the target width direction. The number of pixels on these two axes is
calculated, and then multiplied by the interval of pixels, the length and width of the runway can be obtained.

**Experimental Results**

The experiment takes Figure 3 as the data source; Figure 4 is the image obtained after histogram uniform transformation; Figure 5 is the image obtained after Canny detection; Figure 6 is the image after threshold segmentation; Figure 7 is the segmented runway; Table 1 is the parameter values obtained by analysis.

![Figure 3. Original image.](image)

![Figure 4. Histogram transformed image.](image)

![Figure 5. Canny transform image.](image)

![Figure 6. Threshold Segmentation image.](image)

![Figure 7. Segmented runway image.](image)

<table>
<thead>
<tr>
<th>Airport area</th>
<th>Directional angle of spindle</th>
<th>The length of runway</th>
<th>The width of runway</th>
</tr>
</thead>
<tbody>
<tr>
<td>9750</td>
<td>4.3°</td>
<td>650</td>
<td>15</td>
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**Summary**

Airport targets are clearly visible on synthetic aperture radar images. It has wide application prospects to further extract effective information by detecting Airport targets. Because of the large amount of data, it is necessary to realize automatic detection by computer. In this paper, the steps of automatic airport target detection are established, and the method of obtaining airport parameters is given, which lays a foundation for subsequent target classification and recognition.

**References**

