DISTRIBUTED TARGETS DETECTION BASED ON LOCAL SPECTRAL HISTOGRAMS AND AGENTS

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1. INTRODUCTION

Detection of distributed targets, such as ship wakes, oil slicks and internal waves, is an important and challenging problem in SAR image processing of sea surface. In this paper, an agent-based detecting method using local spectral histograms is proposed.

Spatial relativity and statistics features are important characteristics of distributed targets. Because of randomness and complexity of the sea surface, it is very difficult to estimate probability models exactly, and most of the existing models are approximate. Histograms give a good statistical expression, and a filter bank can catch the structure and scale information. So the local spectral histograms (LSH) are quite suitable for distributed targets. Sometimes distributed targets are blurred, diffusing and of low contrast, for example at the end of a ship wake, or at the edge of an oil slick blown by the wind. They are so weak that a global algorithm can not get a satisfying result, thus an autonomous agent-based method is used. And it is long time consumed to get the LSH pixel by pixel, while the agents system can reduce the computation times. Experimental results show that our method is quite effective.

2. THEORIES

2.1. Local Spectral Histograms [1]

W is a window, $\left\{F^{(\alpha)}, \alpha = 1, 2...k\right\}$ is a filter bank. And $W^{(\alpha)}$ is the sub-image passing through the filter $F^{(\alpha)}$. For $W^{(\alpha)}$, a bin of its histogram is defined by

$$H_W^{(\alpha)}(z_1, z_2) = \sum_{v \in W} \int_{z_1}^{z_2} \delta(z - W^{(\alpha)}(v)) dz$$

$[z_1, z_2]$ is the gray level range. So the spectral histogram with respect to the filter bank is given

$$H_W = \frac{1}{W}\left(H_W^{(1)}, H_W^{(2)}, ..., H_W^{(\alpha)}\right)$$

And the difference value of two spectral histograms is

$$\chi^2(H_{W1}, H_{W2}) = \frac{1}{|W|} \sum_{\alpha=1}^{K} \sum_{z} \frac{\left(H_{W1}^{(\alpha)}(z) - H_{W2}^{(\alpha)}(z)\right)^2}{H_{W1}^{(\alpha)}(z) + H_{W2}^{(\alpha)}(z)}$$

The LM filter banks have a mix of edge, bar and spot filters at multiple scales and orientations: 36 Gaussian derivative filters at 6 orientations and 3 scales, 8 Laplacian of Gaussian filters and 4 Gaussian filters[2]. The intensity filter and some filters of the LM filter bank are used in the algorithm.

From lots of experiments, a conclusion is drawn that the LSH difference value of the same kind of sea surface images varies in a certain range, and the difference distribution is Gaussian like. Given a probability P, we can get a threshold Th which will be used for the agent judgment behavior.

$$P = \int_{Th}^{\infty} f(x) dx$$

When detecting images, if the LSH difference of the neighborhood around an agent is larger than Th, it is probably a part of an unknown target. Otherwise the agent will regard this pixel the same as the ordinary sea surfaces.

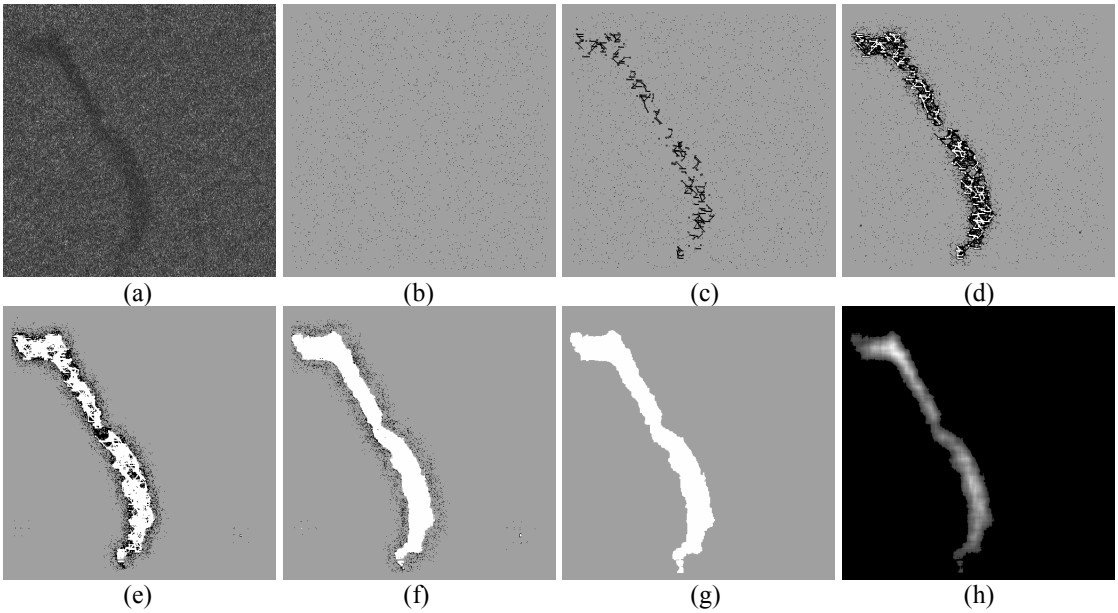

Fig1. Serial images in Agents detecting process

(a) An oil slick. (b) ~ (f) the first to the fifth iterative results. The black dots stand for the active Agents, while the white ones stand for the location of the detected targets. (g) Detection result. (d) LSH difference image.

2.2. Autonomous Agents System

The input image is regarded as an environment in which many autonomous agents live in. They collect information from their neighborhoods. Given by some criterion the agents will select and execute their behaviors, for example labeling the target areas, moving to other positions, breeding offspring, or vanishing in the image [3]. Furthermore, considering the distributed targets, we have introduced communicating, ribbon breeding and inheriting behaviors.

3. MAIN STEPS OF THE ALGORITHM

Main steps of the proposed algorithm are listed as follows: First, we distribute an initial set of agents in the image randomly. For each of the active agents the local spectral histograms in the neighborhood are computed, and the results are compared with the sea surface image. After communicating to the other agents around, with the neighborhood information and the "knowledge" inherited from its father, each agent will decide to move, inherit, breed, label, or die. This will stop until there are no active agents. Finally, a mathematical morphology method is used to remove small false objects which could not be a distributed target.

4. EXPERIMENTAL RESULTS

Some SAR images are used to test the algorithm. Limited by the pages we only give one detection result in figure 1. The results show that the method is effective even if the targets are diffusing and of low contrast. Unlike the conventional raster scan method, the agents need not compute the LSH of all pixels, and the computation time is reduced.

5. REFERENCES

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