Extraction of farmland areas on different row directions with SAR image based on texture feature

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***Abstract*—Discrimination of farmland areas on different row directions from SAR image is very significant to the selection of the optimal row direction for the cultivation and the yield. In order to reduce the effects of the speckles and improve the accuracy, the paper put forward a method which extracts the farmland areas on different row directions with region growing algorithm based on gray-level co-occurrence matrix. Particularly, the method compounds three best GLCM texture feature images and transforms them using HIS algorithm and then uses the intensity image of HIS results for region growing algorithm in order to extract the farmland areas on different row directions. The extraction results with the method in this paper are proved to be quite satisfactory.**

***Key words*—SAR image, row direction, texture feature, region growing algorithm.**

I. Introduction

The extraction of farmland areas on different row directions with SAR image is very significant for guiding the farming practice and improving the yield [1, 2, 3]. Fields on different row directions can be distinguished in SAR image since their geometric structures and surface roughness affect the backscattering process to varying degrees. Nevertheless, the backscattering coefficients(gray values reflected in the SAR image) of fields on different row directions overlap a lot because the types of crops, the growth conditions, the soil moisture content and the local surface roughness generally vary to different extent and the speckles in SAR image are also inevitable. Therefore, they can't be discriminated and extracted very well only base on the backscattering coefficients [4]. However, the texture features of farmland areas on different row directions are quite distinct and can be used to improve the extraction accuracy. Many studies show that texture auxiliary image gray values can improve the extraction accuracies of the target objects in remote sensing images, yet most researchers only use the threshold method to process the texture images and the effects of window size and gray level are not well considered, so the extraction results are not that satisfactory [5, 6, 7]. In this paper, a method is put forward to extract the farmland areas on different row directions with region growing algorithm based on gray level co-occurrence matrix (GLCM), particularly, the method compounds three best texture feature images and transforms them using HIS algorithm, and then uses the intensity image of HIS transformation for region growing to extract the farmland areas on different certain row directions respectively.

II. STUDY AREA

The Envisat-ASAR PRI image of June 7 2010 accquired in this paper covers part of Baicheng in Jilin province and part of Wulanhaote in Inner Mongolia Autonomous Region, shown in Figure.1a. After radiometric calibration, geometric correction and image cropping, a study area in the region of 46.16 °N~46.20 °N, 123.08 °~123.13 °E is selected, shown in Figure.1b. The study area consists of a bare saline-alkali soil region (hereinafter referred to as background) and two farmland areas on different row directions (hereinafter referred to as area-I and area-II). The respective angles between the direction of the radar observation and area-I and area-II are 95.59 ° and 121.52 °. Area-I has the coarsest texture, followed by area-II and the texture of background is the smoothest.

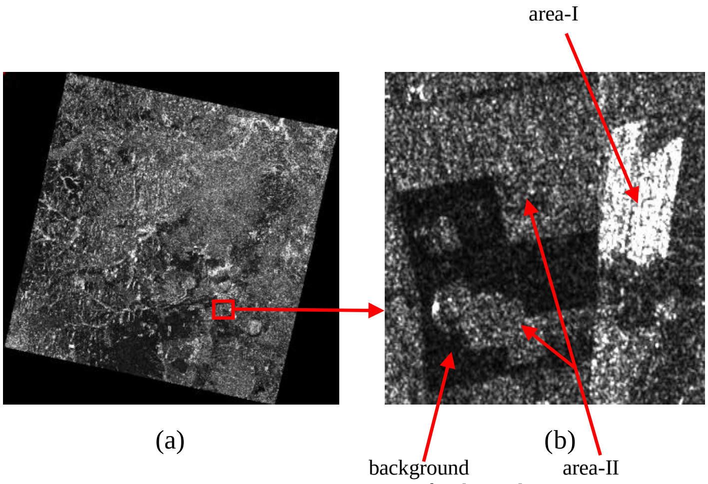


Figure.1. Envisat ASAR image for the study area

III. METHOD AND RESULTS

A. Gray Level Co-occurrence Matrix (GLCM)

Statistical method is superior to other methods describing the textures of area objects in remote sensing images since the objects usually distribute randomly and do not have regular patterns or periods. GLCM is a well-developed statistical method and is commonly used to extract the textures in remote sensing images. In this paper, we use 8 common texture feature measures derived form GLCM to extract farmland areas on different row directions and the background [8, 9, 10, 11, 12, 13].

$$COR = \left[\sum_{i=1}^{g} \sum_{j=1}^{g} (i \times j) p_{ij} - \mu_x \mu_y \right] / \sigma_x \sigma_y \tag{1}$$

$$ENT = -\sum_{i=1}^{g} \sum_{j=1}^{g} p_{ij} \log p_{ij} \tag{2}$$

$$CON = \sum_{n=0}^{g-1} n^2 \left[\sum_{i=1}^{g} \sum_{j=1}^{g} p_{ij} \right], |i - j| = n \tag{3}$$

$$ASM = \sum_{i=1}^{g} \sum_{j=1}^{g} p^2{}_{ij} \tag{4}$$

$$HOMO = \sum_{i=1}^{g} \sum_{j=1}^{g} \frac{1}{1+|i-j|} p_{ij} \tag{5}$$

$$MEAN = \frac{1}{g \times g} \sum_{i=1}^{g} \sum_{j=1}^{g} p_{ij} \tag{6}$$

$$VAR = \sum_{i=1}^{g} \sum_{j=1}^{g} (i-m)^2 p_{ij} \tag{7}$$

$$DIS = -\sum_{i=1}^{g} \sum_{j=1}^{g} (i-j) p_{ij} \tag{8}$$

Where g is for gray level, p_{ij} is for GLCM element, m is for the means of GLCM elements, $\mu_x, \mu_y, \sigma_x, \sigma_y$ are the means and standard deviations of p_x, p_y.

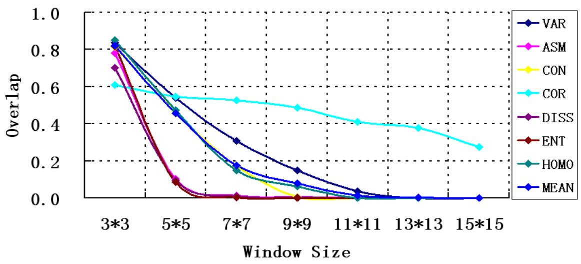
B. Region Growing Algorithm

The region growing algorithm is superior to the threshold method in texture extraction since it takes the spatial relationships among pixels into account and therefore the extraction accuracy is usually more satisfactory. Region growing algorithm usually sets a seed in the object region and determines the pixels which meet the predetermined criteria and then uses the selected pixels as new seeds to repeat the process until no more pixels are included. Therefore it is crucial to determine the original seed and the growing criteria for the extractions [14, 15, 16].

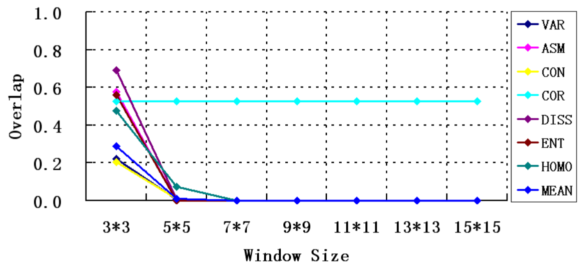
C. Extraction Processing and Results

The GLCM texture feature measures of different gray levels, different window sizes and different grain directions are computed first in the Matlab software environment. In this paper, the window sizes of 3*3, 5*5, 7*7, 9*9, 11*11, 13*13, 15*15, the gray levels of 16 and 32 and the directions of 0°,45°, 90°and 135°are selected as input parameters, in order to avoid the effect of directions, the mean texture feature measures of four directions are finally used. For the extraction of farmland area on one certain row direction, the overlaps of the texture feature measures between which and other object regions are then computed and compared, after that the three best texture feature images are selected, HIS transformation are performed in order to fully use all the optimal texture feature images, then the intensity image of HIS transformation is used for seeds collecting and region growing algorithm to extract the target region. Here, we choose the standard deviation between the seed gray value and the gray values in its neighborhood as the region growing criteria.

For area-I, the overlaps of GLCM texture feature measures between area-I and area-II and the overlaps of GLCM texture feature measures between area-I and background are computed respectively, as is shown in Figure.2a and Figure.2b. ASM, ENT and DIS images under window size w=7*7, gray level g=16 are then selected as the three optimal texture feature images for the extraction process and the result is shown in Figure 3.a.



(a)



(b)

Figure.2. Overlaps of the GLCM texture feasures. (a) between area-I and area-II, (b)between area-I and background.

The overlaps between area-II and other object regions and the overlaps between background and farmland areas on different row directions under different parameters are also computed. After that, we use ASM, HOMO and ENT images under window size w=5*5 and gray level g=32 for the extractions of both area-II and background and the results are shown in Figure.3d and Figure.3g.

In order to compare with the method in this paper, the extractions of farmland areas on different row directions and background using threshold method mentioned in reference [7] are performed with the results shown in Figure.3b, Figure.3e and Figure.3h.

The extractions under visual interpretation are also processed as accurate results shown in Figure.3c, Figure.3f and Figure.3i.

The summary results in Table 1 shows the success rates for area-I, area-II and background are 91.92%, 87.75% and 91.43% respectively and the overall accuracy is 88.75% with the method in this paper. However, the extraction results using the threshold method in reference [7] are less accurate, the success rate are only 83.41%, 86.93% and 65.84% for area-I, area-II and background respectively, and the overall accuracy is only 81.89%.

TABLE I. EXTRACTION RESULTS IN THIS PAPER

object areas	this paper	visual interpretation	correct extraction	missing extraction
area-I	6471	6040	5948（91.92%）	92（1.42%）
area-II	59828	58783	52499（87.75%）	6284（10.50%）
backgro und	14685	1533	13427（91.43%）	1926（13.11%）
sum	80984	80176	71874（88.75%）	8302（10.25%）

TABLE II. EXTRACTION RESULTS IN REFERENCE [7]

object areas	this paper	reference [7]	correct extraction	missing extraction
area-I	5040	6040	4204（83.41%）	836（16.59%）
area-II	56854	58783	49421（86.93%）	7433（13.07%）
backgrou nd	18310	15353	12055（65.84%）	6255（34.16%）
sum	80204	80176	65680（81.89%）	14524（18.10%）

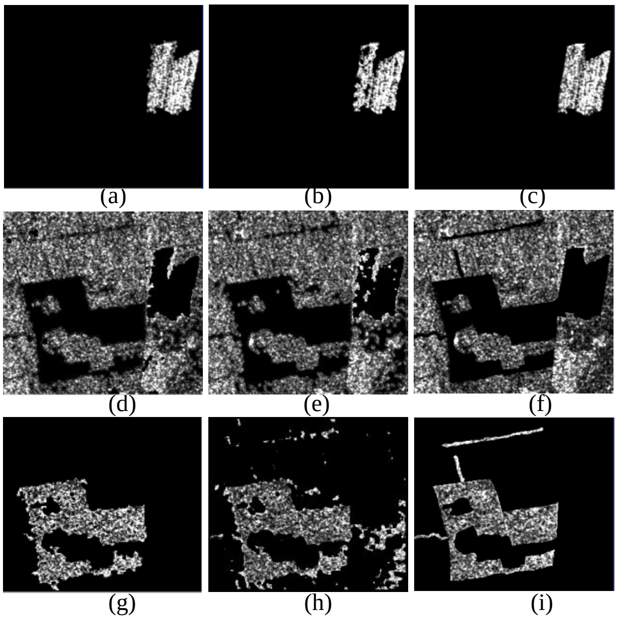


Figure.3. Extraction results with different methods. (a) area-I extraction result with method in this paper, (b) area-I extraction result in reference [7], (c) area-I extracton result with visual interpretation, (d) area-II extraction result with method in this paper, (e) area-II extraction result in reference [7], (f) area-II extraction result with visual interpretation, (g) background extraction result with method in this paper, (h) background extraction result in reference [7], (i) background extraction result with visual interpretation.

IV. DISCUSSION AND CONCLUSION

The GLCM texture feature measures are determined by the window size, the step length, the direction and the gray level. The step length of 1 pixel is employed in this paper for keeping more texture information. Moreover, the mean texture feature measures of 0°, 45°, 90° and 135° are computed under different combinations of parameters in order to avoid the influence of different orientations. Therefore, the texture feature measures are finally decided by the window size and the gray level.

In this paper, we choose window size 7*7 for the area-I extraction and window size 5*5 for both area-II and the background extractions, this is because the texture of area-I is coarser than those of area-II and the background. In general, the texture scale of one certain region usually distinct from other texture regions, therefore, the optimal window size is very important to compute the texture feature measures for the extraction since it can depict the texture of the object region fully and keep the boundary between various regions well. During the extraction process, gray level of 16 is selected for the area-I and gray level of 32 is determined for both area-II and the background. This is because the gray values of area-I range are a lot wider compared to both the background and the area-II in gray level of 16, namely the texture of area-I is more random, while the textures of area-II and the background are much more homogeneous. As a result, ASM, ENT and DIS images are selected as the three optimal texture feature images for HIS transformation and region growing to extract area-I since their overlays between area-I and other regions are nearly zero. For both area-II and the background extractions, window size 5*5 is selected because they are relatively homogeneous with a smaller texture scale. Moreover, gray level of 32 is selected because the texture of area-II becomes more random rather than that of the backgro in this condition while still differs a lot from the texture of area-I. Therefore, ASM, HOMO and ENT images are then chosen base on the overlays as the best three texture feature measures for the following process.

In addition, the seeds affect the extraction accuracy a lot during the region growing algorithm, this is because once the seeds are not representative enough or too close to the boundary, the extraction result of one certain object will be less accurate or cover other object regions. What's more, the selections of standard deviation and neighborhoods of the seeds during region growing process are also very sensitive to the extraction accuracy.

In this paper, parameters especially the window size and gray level are analyzed during computing the GLCM texture feature measures and the selections of optimal texture feature images for the HIS transformation and region growing algorithm. Besides, the influence of standard deviation as the criteria and the neighborhood selections of the seeds are also discussed. As a result, the extraction accuracies for farmland areas on different row directions are quite satisfactory compared to the conventional threshold method. In this paper, the textures of farmland areas on different row directions differ a lot since the angle of row directions between them is large, however, the texture differences will be not that obvious as the angle turns to be smaller. On the other hand, the backscattering process of SAR signal is quite sensitive to farmland areas on different row directions, therefore, it is very helpful to take the radiative transfer theory and the backscattering model into account for improving the extraction accuracy and this will be a further investigation we will focus on.

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