Extraction Rice-Planted Areas by RADARSAT Data Using Neural Networks

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Abstract: A classification technique using the neural networks has recently been developed. We apply a neural network of learning vector quantization (LVQ) to classify remote-sensing data, including microwave and optical sensors, for the estimation of a rice-planted area. The method has the capability of nonlinear discrimination, and the classification function is determined by learning. The satellite data were observed before and after planting rice in 1999. Three sets of RADARSAT and one set of SPOT/HRV data were used in Higashi–Hiroshima, Japan. Three RADARSAT images from April to June were used for this study. The LVQ classification was applied the RADARSAT and SPOT to evaluate the estimate of the area of planted-rice. The results show that the true production rate of the rice-planted area estimation of RADASAT by LVQ was approximately 60% compared with that of SPOT by LVQ. It is shown that the present method is much better than the SAR image classification by the maximum likelihood method.

Keywords: Remote sensing, Synthetic aperture radar, Learning vector quantization.

I. INTRODUCTION

Rice is the most important agricultural product in Japan, and is widely planted throughout the world. Much manpower is still required to estimate the area of planted-rice every year. Thus, the development of a system for monitoring the rice crop will be welcome. Satellite remote sensing images, such as LANDSAT TM or SPOT HRV, have been expected to be used to estimate the rice-planted area. However, these optical sensors have not always been able to get the necessary data at a suitable time because it is often cloudy and rainy during the rice-planting season in Japan. However, space-borne synthetic aperture radar (SAR) penetrates the cloud cover, and SAR observes the land surface in all weather conditions.

Suga et al [1] show that the back-scattering intensity of C-band SAR images, such as RADARSAT or ERS1/SAR, changes greatly from noncultivated bare soil conditions before rice planting to vegetative conditions just after rice planting. In addition, Ribbes et al [2], and Liew et al [3] show that RADARSAT images are rather sensitive to the change in rice biomass in a growing period. Thus, rice area estimation is expected to be realized at an early stage. In previous work [4], the authors attempted to estimate the rice-planted area using RADARSAT fine-mode data at an early stage. The estimation accuracy of the rice-planted area was approximately 40% compared with the estimated area by SPOT multispectral data.

In this study, the authors attempt to detect the rice-planted area from RADARSAT data using learning vector quantization (LVQ), and to compare the result with the accuracy by the maximum likelihood method (MLH).

II. TEST SITE AND DATA

The test area of about 9.4 × 7.5 km was in Higashi–Hiroshima, Japan, centered at latitude 34.42° N, longitude 132.70° E. This site is located in the eastern part of Hiroshima. Three multitemporal RADARSAT fine-mode (F1F) images, taken on April 8, May 26, and June 19 in 1999, were used as the test data. SPOT/HRV multispectral data taken on June 21, 1999, were used to generate a reference image for rice-planted area extraction. Figure 1 shows the RADARSAT image, which was overlaid by the three sets of temporal data, and Figure 2 shows the SPOT HRV image in part of the test site. These original images have three bands information, although the figures show a gray scale. The land surface condition in the rice-planted area on April 8 was noncultivated bare soil before rice planting, with a rather rough soil surface. The surface condition on May 26 is an almost smooth water surface just after rice planting, and that on June 19 is a mixed area of growing rice and water surface.

The raw RADARSAT data were processed using a Vexcel SAR Processor (VSARP), and single-look power images with 6.25 m ground resolution were generated. Then the images were filtered using a median filter with a 7 × 7 moving window. All RADARSAT and SPOT images were overlaid onto the topographic map at a 1 : 25 000 scale.

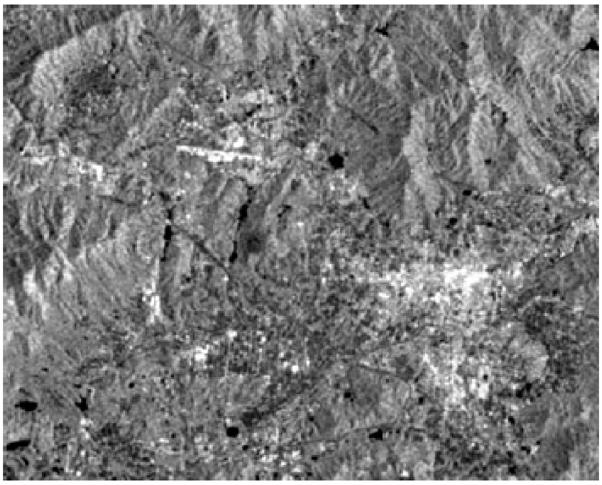

Fig. 1. Layered RADARSAT F1F mode image in the test site © CSA & RADARSAT International 1999

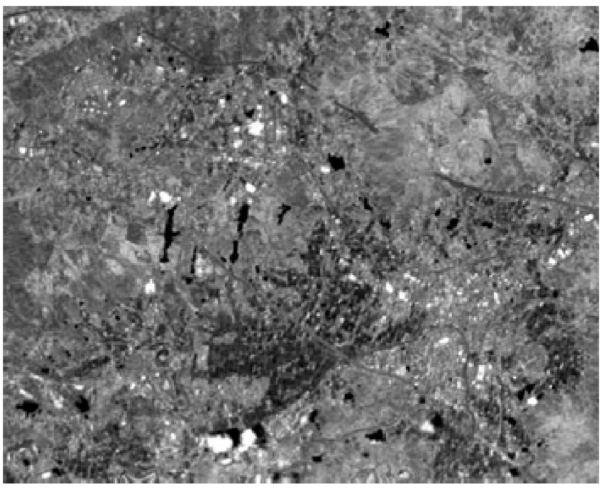

Fig. 2. SPOT-2/HRV image in the test site © CNESS 1999

III. CLASSIFICATION

The rice-planted area was extracted using two supervised classification methods from three temporal RADARSAT images and one SPOT image. One was the maximum likelihood method (MLH), and the other was a learning vector quantization (LVQ) classifier.

MLH has been used for land cover classification from satellite images. However, the classification results may be of low accuracy because the system assumes that the distribution of each category data is a normal distribution. Generally speaking, optical sensor image data can often show a normal distribution. However, SAR data shows an exponential distribution. Thus, classification methods by neural networks are effective for SAR image classification because the classification function is determined by learning. Kohonen's LVQ is a classification method based on competitive neural networks which allows us to define a group of categories in the space of the input data by a supervised learning algorithm.

A water region, an urban area, a rice-planted area, and two kinds of "forest" were selected as target categories. We considered three subclasses in the water regions and urban areas, and four subclasses in the rice-planted areas and forests. We then considered them as being in the same class. The training data for supervised classification were selected using the topographic map and true ground. Training data for the SPOT image were extracted as an area of 5 × 5 pixels at each of ten points, i.e., 250 pixels in each category. On the other hand, RADARSAT acquired a lot of samples compared with SPOT because SAR image pixels fluctuate in speckled noise. For the purpose of extracting the rice-planted area, the training data of a rice-planted area added 800 pixels to the data.

IV. EXPERIMENTAL RESULTS AND DISCUSSION

At first, the SPOT image as an optical sensor was classified by two methods and the results were compared. As can be seen in Tables 1 and 2, the results of the confusion matrix were examined by SPOT data. The results of the two methods were almost the same, but LVQ was a little better at high accuracy levels. The results of the classification rate are shown in Tables 3 and 4. Table 4 shows the result by LVQ classifier of multitemporal RADARSAT data. The results were

Table 1. The confusion matrix for the classification using the MLH (SPOT) (%)

	Water	Urban	Rice	Forest
Water	100.0	0.0	0.0	0.0
Urban	0.0	100.0	0.0	0.0
Rice	0.0	0.0	100.0	0.0
Forest	0.0	0.0	0.4	99.6

Table 2. The confusion matrix for the classification using the LVQ (SPOT) (%)

	Water	Urban	Rice	Forest
Water	100.0	0.0	0.0	0.0
Urban	0.0	100.0	0.0	0.0
Rice	0.0	0.0	100.0	0.0
Forest	0.0	0.0	0.0	100.0

better than those with the MLH. In particular, the rice classification accuracy of LVQ is much better than that of the MLH. Figures 3 and 4 show the classification images by RADARSAT and SPOT, respectively. The rice-planted area was obtained by the three temporal RADARSAT images. The classification results of the urban and forest areas were different in these two images because SAR back-scattering intensity occurs in the dark areas due to the shadowing effect of the topography. On the other hand, the water and rice areas were similar in these two images. We defined two indices, true production rate (TPR) and false production rate (FPR), for the rice-planted areas found by RADARSAT. The TPR is the coincidence rate of the rice-planted areas found by RADARSAT within those by SPOT, and the FPR is the rate of non-rice-planted areas found by SPOT within the rice-planted areas found by RADARSAT. As the rice-planted area images extracted by RADARSAT are still contaminated by speckling noises, the majority filter with a 7 × 7 window was applied to the rice images extracted by RADARSAT before the evaluation. The rice image extracted by SPOT was also filtered by the same majority operation as for RADARSAT to make the ground resolutions compatible with each other. We found experimentally that about 60% of rice areas found by SPOT were extracted by RADARSAT, and about 35% of the areas found by RADARSAT were outside the areas of rice found by SPOT using LVQ (Table 5). This result for the TPR was better than that of the MLH. Figure 5 shows the results of rice-planted area extraction in part of the test site. The white region shows the rice-planted area of each image. In Figure 5, the rice areas extracted in the a and b results by RADARSAT seem similar to those in the result by SPOT.

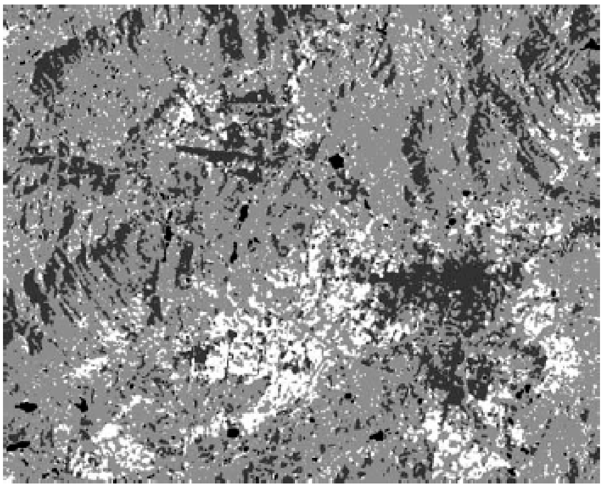

Fig. 3. Classification result of RADARSAT F1F image by LVQ (White: rice, Light gray: Forest, Dark gray: urban, Black: water)

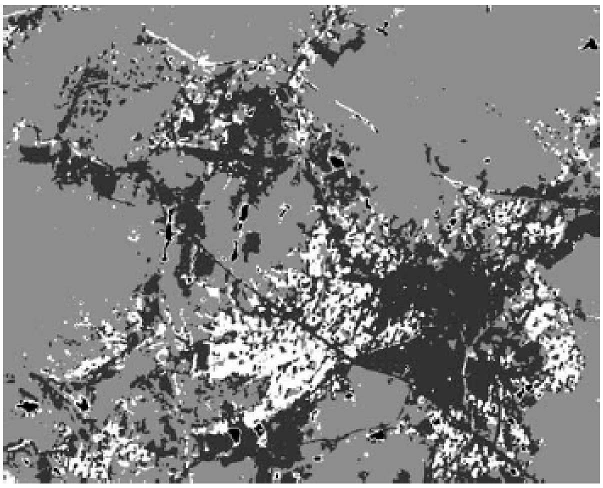

Fig. 4. Classification result of SPOT/HRV image by LVQ (White: rice, Light gray: Forest, Dark gray: urban, Black: water)

Table 3. The confusion matrix for the classification using the MLH (RADARSAT) (%)

	Water	Urban	Rice	Forest
Water	100.0	0.0	0.0	0.0
Urban	0.0	62.0	0.0	38.0
Rice	0.0	4.5	53.3	42.2
Forest	2.0	3.6	9.2	85.2

Table 4. The confusion matrix for the classification using the LVQ (RADARSAT) (%)

	Water	Urban	Rice	Forest
Water	100.0	0.0	0.0	0.0
Urban	0.0	71.2	0.0	28.8
Rice	0.0	0.0	87.2	12.8
Forest	2.8	6.6	2.4	88.2

Table 5. Result of rice-planted area evaluation by RADARSAT compared to SPOT by LVQ

Method	TPR (%)	FPR (%)
MLH	46.7	24.6
LVQ	59.1	35.6

V. CONCLUSION

Rice-planted area extraction was attempted using multitemporal RADARSAT data taken at an early stage of the rice-growing season by MLH and LVQ classifications. The LVQ classification is much better than the classification by the MLH for rice-planted area extraction by RADARSAT data. However, for a quantitative evaluation, the rice-planted area found by RADARSAT extracted about 60% of those found by SPOT. In future work, we will apply this proposed method to other SAR data to extract rice-planted areas.

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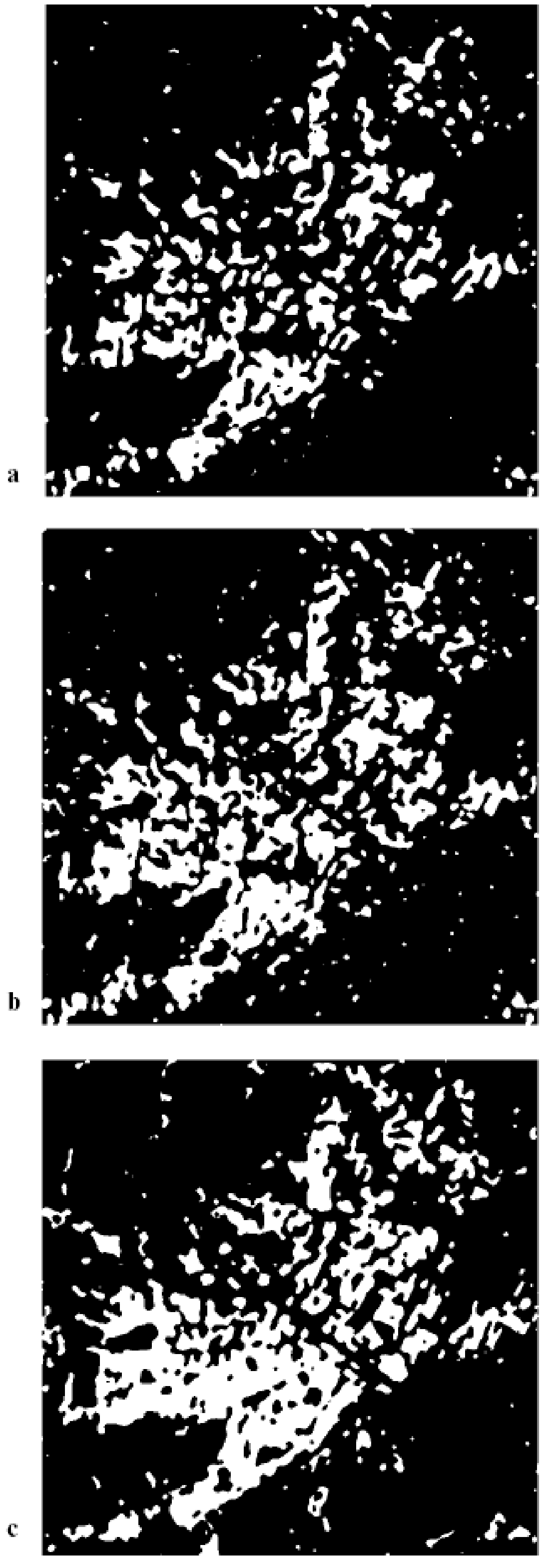

Fig. 5. Results of rice-planted area extraction in part of test site. a RADARSAT MLH, b RADARSAT LVQ, c SPOT LVQ (White: rice-planted area)