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REMOTE SENSING IMAGE ANALYSIS USING NEURAL NETWORKS

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Abstract: The classification technique using neural networks has been recently developed. We apply a neural network of error back-propagation (BP) to classify remote sensing data including microwave and optical sensors for the estimation of rice-planted area. The method has capability of a nonlinear classification and the discrimination function can be determined by learning.

The satellite data were observed before and after planting rice. RADARSAT-1/SAR, ENVISAT-1/ASAR and SPOT-2/HRV data are used in Higashi-Hiroshima, Japan. Three images for RADARSAT and ENVISAT from April to June are used and one SPOT image is used for classification.

In case of the BP, the output layer has four clusters such as water region, urban area, rice-planted area and forest and the input data are the SAR data observed in three different seasons. Experimental results show that the present method is much better compared with classification of SAR image using the maximum likelihood (ML) method.

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1. Introduction

Rice is one of the most important agricultural product in wide areas of Japan. To monitor the rice is important for us to supply steady food. Rice monitoring and mapping methods are based on ground collected statistics. Much man-power is still required to estimate rice-planted area 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 hardly have been able to get necessary data at a suitable timing because it is often cloudy and rainy during the rice planting season in Japan.

On the other hand, space-borne synthetic aperture radar (SAR) penetrates through the cloud and observes the land surface in all weather conditions.

The back-scattering intensity of C-band SAR images, such as RADARSAT or ENVISAT-1/ASAR, changes greatly from non-cultivated bare soil condition before rice planting to inundated condition just after rice planting Suga et al, see [1], [2]. In previous works [3], the authors attempted to estimate rice-planted area using RADARSAT fine-mode data in an early stage.

ML classification has been used as land cover classification for remote sensing data. However, the classification results may obtain poor accuracy because it assumes that the distribution of each category data is normal distribution. Generally speaking, optical sensor image data can be often obeyed normal distribution. However, SAR intensity and amplitude data obeys a negative exponential distribution and Rayleigh distribution, respectively, see [4]. Thus, classification methods by neural networks are more effective for the SAR image classification because the classification function is determined by learning. BP classification is a method based on layered neural networks, which allows us to define a group of categories on the space of input data by supervised learning algorithm. In this study, the authors attempt to classify the rice-planted area from three temporal RADARSAT, ENVISAT and one SPOT data using BP classification and to compare with accuracy by ML classification.

2. Data Set and Study Area

RADARSAT satellite launched in November 1995 acquires C-band HH polarization SAR data in a several beam modes and incidence angles. In this study, the Fine beam F1 data were used to investigate the suitability for rice planted

Date	April 8, 1999 May 26, 1999 June 19, 1999
Mode	Fine 1 Far (F1F)
Wavelength	5.6cm (C-band)
Polarization	HH
Resolution	8 m

Table 1: RADARSAT-1 data characteristics

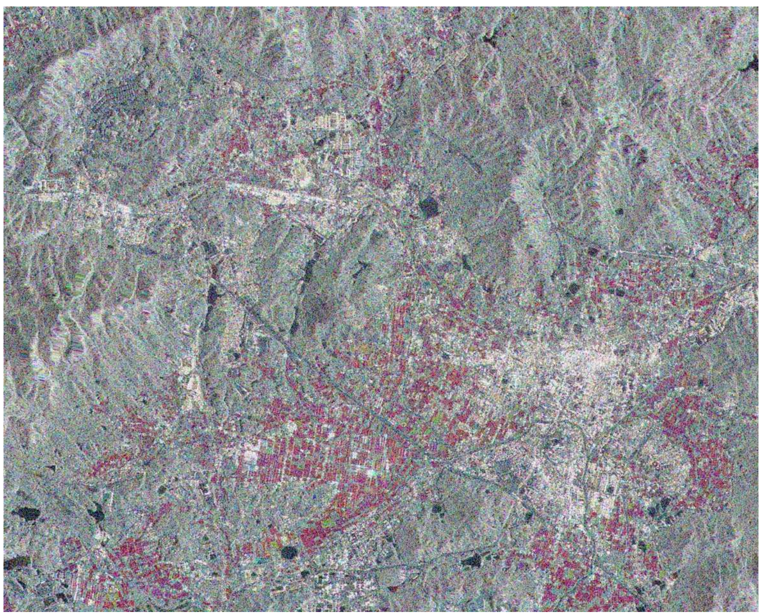


Figure 1: RADARSAT F1F mode image (R: April, G: May, B: June, in 1999) (c) CSA & RADARSAT International 1999

area extraction. Three multi-temporal RADARSAT data indicate in Table 2 taken on April 8, May 26 and June 19, in 1999. Figure 1 shows the RADARSAT image which was overlaid three temporal data. ENVISAT satellite launched in March 2002, and it observes with the same C-band as RADARSAT. In addition, Alternating Polarization (AP) mode has capability of changing the polarization. The AP mode HH/HV polarization data were used. Table 2 and Figure 2 show the ENVISAT data characteristics and HH polarization image which was overlaid three temporal data, respectively.

Date	April 28, 2006 May 20, 2006 June 24, 2006
Mode	Alternating Polarization (AP)
Wavelength	5.6cm (C-band)
Polarization	HH/HV
Resolution	30 m

Table 2: ENVISAT-1 data characteristics

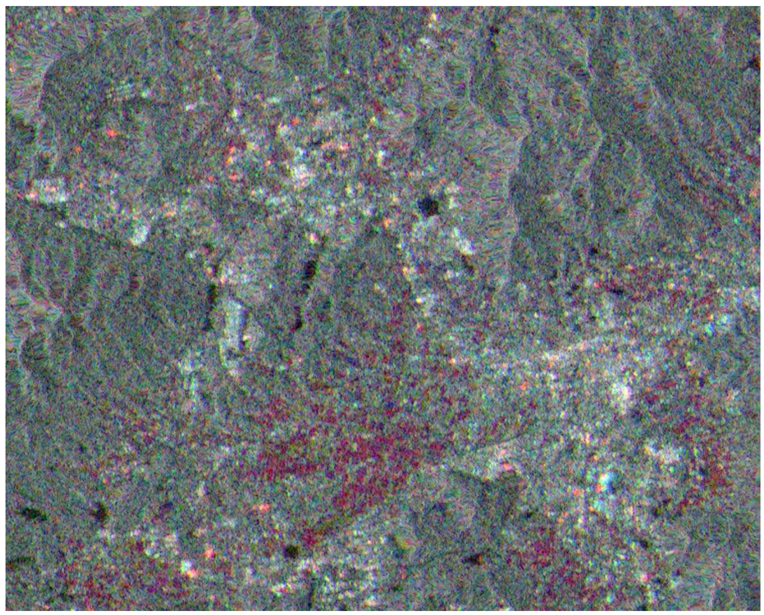


Figure 2: ENVISAT-1/ASAR HH polarization image (R: April, G: May, B: June, in 2006) (c) ESA 2006

SPOT/HRV data which has multi spectral sensor taken on June 21, 1999 were used. Figure 3 shows the SPOT image in the study area.

The land surface condition in the rice-planted area in April is a non-cultivated bare soil before rice planting with rather rough soil surface. The surface condition in May is almost smooth water surface just after rice planting and that of June is a mixed condition of growing rice and water surface. RADARSAT and ENVISAT data were processed from raw data to power images with 6.25m

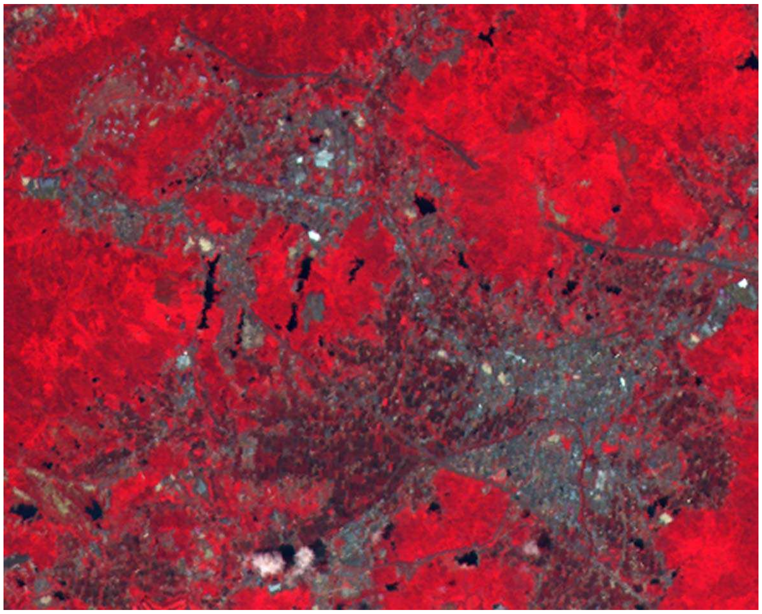


Figure 3: SPOT-2/HRV image (R: Band 3, G: Band 2, B: Band 1) (c) CNESS 1999

and 12.5m spatial resolution, respectively. Then the images were filtered using a median filter with a 7 7 moving window. All images were overlaid onto the topographic map with 1:25,000 scale.

The study site has a size of about 9.4 7.5 km in Higashi-Hiroshima, Japan, centered at latitude N 34.42, longitude E 132.70. This site was selected because it seems to be representative location of rice planting in Japan. The rice-planted area is distributed in plains and mountainous area. In the Figures 1, 2 and 3, middle-bottom center of images is plain area and upper of images is mountainous area.

3. Classification

Rice-planted area was extracted using two supervised classification methods from three temporal RADARSAT, ENVISAT and one SPOT image. One was ML classification and the other was BP classification. "water region", "urban area", "rice-planted area" and "forest" were selected as target categories.

Three layers of BP are used in this experiment. The number of neurons of input layers are equal to input image layers, i.e., RADARSAT is three, ENVISAT is six and SPOT is three. The hidden layer is chosen 7 neurons empirically. The number of neurons of output layers is equal to the number of the categories which is four neurons. The learning rate and momentum were set at 0.09 and 0.19, respectively. Training was carried out by the BP procedure until the mean square error becomes 0.01 or 10,000 iterations.

The training data and the test data for supervised classification were selected by the topographic map and a high resolution satellite data by EROS-A1 which has 1.8m resolution. The training data were extracted as the area of 5 5 pixels by each of ten points, namely 250 pixels in each category. However, RADARSAT acquired a lot of samples compared with SPOT empirically because SAR image pixels fluctuate by a speckle noise. For the purpose of extraction of rice-planted area, the training data of rice-planted area added 800 pixels to the data.

4. Experimental Results and Discussion

The quantitative verification of classification is performed by calculating the overall accuracy (OA), average accuracy (AA) and Kappa coefficients (K).

The classification accuracies for four categories using SPOT image by ML and BP classification methods are presented in Tables 3 and 4, respectively. The results of two methods were almost same accuracy. However, the rice classification accuracy of BP (90.12%) was better than that of ML (76.39%).

The classification results of RADARSAT data are shown in Tables 5 and 6. The OA and K of BP classification were better than the ML classification. The rice classification accuracy of BP is 60.70%. However, K of both method is poor .

The classification results of ENVISAT data are shown in Tables 7 and 8. The AA and K of BP classification were better than the ML classification. In addition, the rice classification accuracy of BP classification (77.67%) was better than ML classification (75.68%). The classification accuracy of ENVISAT is much better than that of RADARSAT.

Figure 4, (a), (b) and (c) show the classification image of RADARSAT, ENVISAT and SPOT, respectively. The urban and the forest area were different compared with RADARSAT and SPOT data because SAR back-scattering intensity occurs the bright and the dark areas due to the shadowing effect of

Class	Water	Urban	Rice	Forest
Water	96.38	0.00	0.86	2.76
Urban	0.00	98.49	0.63	0.89
Rice	0.37	19.56	76.39	3.68
Forest	0.01	0.38	0.31	99.30
OA = 96.76%, AA = 92.64%, K = 0.93				

Table 3: The confusion matrix for the classification using the ML classification (SPOT) (%)

Class	Water	Urban	Rice	Forest
Water	95.14	0.00	4.66	0.21
Urban	0.02	90.09	4.84	5.05
Rice	0.17	3.65	90.12	6.06
Forest	0.00	0.01	0.67	99.31
OA = 96.74%, AA = 93.67%, K = 0.93				

Table 4: The confusion matrix for the classification using the BP classification (SPOT) (%)

Class	Water	Urban	Rice	Forest
Water	87.66	1.30	2.62	8.42
Urban	0.92	61.44	1.69	35.95
Rice	0.78	6.59	58.85	33.78
Forest	0.94	34.54	5.14	59.37
OA = 50.90%, AA = 66.83%, K = 0.28				

Table 5: The confusion matrix for the classification using the ML classification (RADARSAT) (%)

the topography.

On the other hand, the effect of ENVISAT AP mode is less than that of RADARSAT because AP mode has multi polarization data. We found experimentally that the use of a neural network of BP method overcomes the performance of the ML classifier using RADARSAT and ENVISAT data for rice-planted area extraction.

Class	Water	Urban	Rice	Forest
Water	78.50	0.72	2.25	18.54
Urban	0.17	55.92	2.30	41.61
Rice	0.12	5.52	60.70	33.66
Forest	0.13	25.11	4.95	69.81
OA= 66.44%, AA = 66.23%, K = 0.34				

Table 6: The confusion matrix for the classification using the BP classification (RADARSAT) (%)

Class	Water	Urban	Rice	Forest
Water	88.30	0.00	4.84	6.87
Urban	0.12	58.13	2.10	39.65
Rice	1.43	0.25	75.68	22.65
Forest	0.60	6.68	1.59	91.13
OA = 88.43%, AA = 78.31%, K = 0.63				

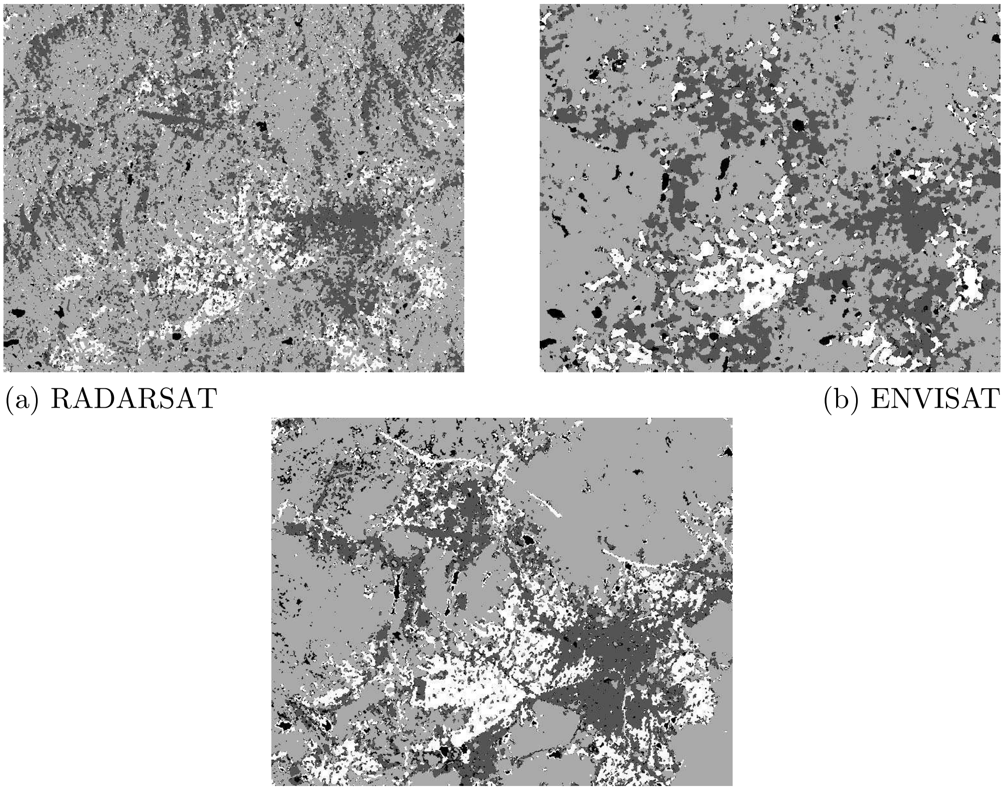
Table 7: The confusion matrix for the classification using the ML classification (ENVISAT) (%)

Class	Water	Urban	Rice	Forest
Water	88.00	0.11	4.37	7.51
Urban	0.01	57.74	2.27	39.98
Rice	1.12	3.55	77.67	17.66
Forest	0.16	3.89	0.53	95.42
OA = 87.07%, AA = 79.71%, K = 0.69				

Table 8: The confusion matrix for the classification using the BP classification (ENVISAT) (%)

5. Conclusions

Rice-planted area extraction was attempted using multi-temporal RADARSAT/SAR and ENVISAT-1/ASAR and one SPOT/HRV data taken in an early stage of rice growing season by ML and BP classifiers. The BP classification is better than the classification by the ML for rice-planted area extraction. In addition, the BP classification using SAR data is more effective than that



(a) RADARSAT (b) ENVISAT

(c) SPOT

Figure 4: Images of classification results by BP (white: rice, light gray: forest, dark gray: urban, black: water)

of optical sensor data. However, the classification accuracy of RADARSAT is poor compared with ENVISAT data. In future work, we will apply our proposed method to other SAR data due to the extraction rice-planted area.

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