Rice Blast Area Monitoring Based on HJ-CCD Imagery

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Abstract. It is difficult to determine the health of rice for simple vegetation index (NDVI) thresholding method which is widely used through remote sensing technology in crop disaster monitoring. The study selected binary logistic regression which were respectively established vegetation index getting from measured spectral and the relationship model between health status. The results show that the triangular vegetation index TVI model is with better reliability. When remote sensing monitoring rice blast was taken into account, geographical range was widely involved and rice-growing conditions were existing obvious differences in the local area, using a 3 × 3 pixel neighborhood consistency assumption to eliminate differences in the local environment. Applying China's own property "environmental disaster satellite" CCD sensor data into the model and the stress range of extracting rice blast was basically consistent with Plant Protection Institute of Heilongjiang Academy of Agricultural Reclamation Sciences as well as the ground measured results, among which TVI model results accuracy reached 76.47%, which can meet remote sensing monitoring requirements. of the blast area.

Keywords: HJ-CCD,regression analysis,rice,rice blast, vegetation index.

1 Introduction

Rice is one of the world's major food crops, and Chinese rice sown area accounts for 1 / 4 of the whole food crops, the second production accounts for more than half. However, rice blast is the main factor affecting rice production as well as one of the major diseases[1], and in the general disease epidemics year cut 10% to 20%, 40% in severe damage to 50%, or even failure. Therefore, it is important for food security to rapidly and timely mastery the occurrence of rice blast conditions. Traditional rice blast monitoring is mainly based on the field survey and sampling which requires considerable human and material resources, and has no real-time monitoring capabilities. However, the remote sensing technology with rapid, real-time, large area, without undermining and other characteristics is showing the traditional blast monitoring methods can not compare with it.

Domestic and foreign scholars have done a lot of method studys about remote sense monitoring rice blast, which are mainly to analyze the characteristics waveband of spectral reflectance or the relationship between vegetation index getting from characteristics band combination and health status. Qin et al[2] used multi-spectral remote sensing technology to perform remote sensing monitoring of rice heath blight;

Qi Long et al from Jilin University studied on visual-based and multi-spectral classification technology of the rice blast resistance detection. In addition, many scholars have explored the relationship between the chlorophyll-related band (or band combination) and the blast. Although remote sensing for rice blast has done many studies, but few about the real business applications. Constraints is that, firstly, data acquisition costs is too much; Secondly, for a wide range of crop growing areas, the growth of their crops is affecting by the very complex environmental factors[3-4], resulting in difficult promotion and business-oriented approach.

"Environmental Mitigation satellite" is small satellite constellation system with Chinese independent intellectual property rights. The wide-band satellite equipped with a CCD sensor whose spatial resolution is 30 m, which is ideal data source of the remote operational monitoring blast. Using wide-band CCD sensor can detect the abnormal information of the blast, however, to determine the exact level of blast resistance, and the type and stage of stress and other issues, but also with the analysis of hyperspectral data[5] to determine the red edge position drift. The purpose of this study is to use the measured spectral data to model and analyze the relationship between the coerced and the health of rice, and based on analyzing the differences about vegetation index, to preliminarily explore the large-scale monitoring of ground blast occurred area method based on HJ-CCD data complex area environment.

2 Study area and data

2.1 Study area

This choice of study area is located in Heilongjiang Reclamation Qianjin farm which is at latitude 47°34’, longitude 132°17’ in the southeasten Sanjiang Plain; and the farm whose cultivated area is 830 thousand mu is based on growing rice, and a large state-owned mechanized farms. In recent years, large-scale cultivation rice variety Kongyu 131 accompanies weak resistance, high frenquency blast occurred within the region, and then which causes serious rice production. Especially in 2010, it is found that rice blast large-scale outbreak in the agricultural census. In addition, Plant Protection Institute of Heilongjiang Land Reclamation Sciences randomly surveyed 300 district fields in blast hardest-hit areas in 2010, and found that 125 fields have infected with rice blast, rhiziomania fields rate achieving on average 41.7% as a result of a direct threat to rice production safety.

2.2 data acquisition and processing

2.2.1 Field spectroscopy

In 2010,Information Institute of Heilongjiang Academy of Land Reclamation Sciences conducted a field spectroscopy in study regional, and a total of 58 sites were measured data, and observation stations were covering the entire farm, and focused on coercion by the rice blast area. All stations, 26 sites rice was threatened by the blast stress, and 32 sites rice was not endangered. For the site with rice blast coercion, taking four group crop canopy spectral data; taking respectively two groups of the rice with the blast and the adjacent normal rice data.

Ground field spectroscopy instruments used ASD FieldSpec and Spectroradiometer for ProFR2500, and the spectral range is 350 ~ 2500 nm, and sampling interval in the 350 ~ 1000 nm is 1.4 nm, 1000 ~ 2500 nm for 2 nm. When observing, the probe was vertically downward from the ground level 1.3 m, view angle for 25 °. In the working process, the mean value choice was repeated 30 times within the field of view limits, and before each spectral measurement, a standard whiteboard was used to correct[6] .

Studies adopted the method to wide-band CCD image achieving the rice blast area monitoring, and based on the band width of satellite images, all the measured spectral reflectance of rice canopy was calculated mean value: 520 ~ 600 nm (green band), 630 ~ 690 nm (red band), 760 ~ 900 nm (near infrared), so as to match the ground truth spectral data and remote sensing image data.

2.2.2 Remote Sensing Image Data

Study mainly selected two almost no cloud layer images which was acquried by A star CCD2 sensor (referred to as HJ-1A-CCD2) of small satellite constellation system for the environment disaster reduction, and used GPS ground control points to perform the geometric correction, and controlled positioning precision within half a pixel.

3 Models and Methods

3.1 the mechanism of remote sensing monitoring for blast area

This paper discusses vegetation index monitoring methods to blast stress area. In a wide range of rice growing areas, different regions will make the rice growth conditions difference because of the affection of the growth conditions (varieties, planting time, fertilization status, etc.), and from the spectral point of view, if not discuss it separately, it is difficult to distinguish rice blast paddy from normal rice. On the other hand, QianJin farm grows a broad range of rice, most farmland for large-scale bulk distribution. Based on this, we propose a algorithm assumption based on 3 × 3 neighborhood consistency: assuming, within 3 × 3 pixel area, rice varieties, planting time, and the same growing environment in the vicinity range will largely reduce vegetation index difference resulting in the growing conditions through comparison among adjacent inter-pixel.

3.2 Logistic regression model building

The study introduced three vegetation indices: Normalized Difference Vegetation Index, NDVI, Renormalised Difference Vegetation Index, RDVI and Triangular Vegetation Inde, TVI to establish a logistic regression model for the measured spectrum (Table 1). NDVI is the most widely used vegetation index in monitoring green vegetation respect. However, in the process of field observation, it is found that rice leaves were relatively sparse in more serious areas of rice blast, so it could not be ignored in the contribution of the spectrum to soil, therefore, the study introduced Lu and Bu Ruiang's RDVI, because it respectively took the dense and sparse vegetation sensitive advantages of NDVI and DVI (difference vegetation index). TVI, by Broge and Leblanc[7] proposed, could well detect the crops spectral reflectance rate minor or moderate increase caused by the disease stress in the red band, and decreases in the green band, as well as sharp fall in the infrared and so on feature information.

Table 1. Applied vegetation indexes

Abbreviations	Name	Formula	References
NDVI	Normalized Difference Vegetation Index	NDVI=(NIR-R)/(NIR+R)	Rouse Et(1973)
RDVI	Renormalised Difference Vegetation Index	RDVI= (NDVI·DVI)1/2, (DVI= NIR-R)	Roujean Et(1995)
TVI	Triangular Vegetation Index	TVI=0.5×(120(NIR－G)－200(R－G))	N.H.BrogeEt (2000)

Notes:NIR—Near infrared band;R——Red light band;G—Green light band.

In the study, the health of rice was devided into the normal growth and rice stess coercion. Adopting the method to evaluation for stress rice and nomoral rice vegetation index in order to calculate the stress level of rice blast, and get a relative amount, but also to some extent reduce the environmental factors effect because of different sites. Spectral data for each measured site respectively included two sets of normal rice spectrum and two group of stress rice spectrum, and then to calculate ratio between vegetation index getting from canopy spectra of stress rice and the normal cross rice vegetation index. Obviously, as for as normal rice was concerned, this ratio was equal to 1, and the ratio of stress rice was between 0 and 1.

Rice health condition from normal state to change by the stress was non-linear process, and coerced probability was not sensitive in the vicinity of p = 0 and p = 1, but rice blast stress probability meeted logical curve. In order to get the distribution area of rice blast stress, choosing to use binary logistic regression method to take the ratio to stress rice and neighborhood normal rice vegetation index through the above-mentioned calculating method as independent variables, and to establish binary logistic regression model of rice blast monitoring. The basic logistic regression expression as follows[8]

$$Y=\mathrm{logit}(p)=\ln\{p/(1-p)\}. \tag{1}$$

$$Y=a+bX+\varepsilon. \tag{2}$$

In it: X - covariable, dimensionless, is the ratio of normal growth and under stress rice vegetation index; a, b - coefficient, dimensionless, as sample logistic regression coefficient through these vegetation index ratio; p- the probability of rice blast under stress, dimensionless; ε is infinitely small quantities, dimensionless. Probability p will be represented by Y, the result is

$$P=ey/(1+ey)=ea+bx+g/(1+ ea+bx+g). \quad (\mathbf{3})$$

when the ratio of vegetation index is 1, p is 0, otherwise p will be between 0 and 1, which means no stress. When probability p was more than 0.5, the logic is true, and rice is under stress. logit (p) is the odds ratio of the dependent variable Y or natural logarithm of the log likelihood ratio, and is called log odds ratio, log likelihood ratio or logit. After model established, introducing goodness of fit and forecasting accuracy to determine the adequacy of the model[9]. Goodness of fit was used to evaluate the consistency between model predictions and the corresponding observations. Used covariates was taken as the ratio vegetation index, which belongsed to a continuous variable. Because the number of covariant type was relatively larger, which resulted in a number of covariant type with small sample observations, so the goodness of fit test method proposed by Hosmer and Lemeshow (1989) was selected. The basic idea of this method was to group data based on the predicted probability values, if the significance level P value was less than 0.05, then the model goodness of fit was higher. Predictive accuracy used pseudo determination coefficient of Cox and Snell (1989), Nagelkerke, the greater the coefficient was, the higher degree of curve fitting was, ie the model was more credible.

3.3 the model Application of satellite remote sensing images

When model was established, ground truth spectral data used the ratio of vegetation index, so before the logistic regression model was applied to remote sensing data analysis, you needed to choose pixel vegetation index to operate ratio calculation. As the the range of rice blast stress only accounted for a small region part, so, after calculation unit transformed to the neighboring 3 × 3 pixels, it is believed that there was at least one pixel within the nine pixels existing in a healthy condition. The selection way to rice healthy growth pixel is to compare vegetation index of 9 pixel, and then to select one of the largest pixel as rice health growing areas, on this basis, to perform ratio calculating for all the vegetation index in each calculation unit and healthy growth pixel vegetation index so as to access the ratio vegetation index of each pixel in the calculation unit. Obviously, the pixel ratio vegetation index of the health rice was 1, while the other pixel values were between 0 and 1. After using 3 × 3 window to obtain ratio vegetation index for the whole scene images, using the established logistic regression model to calculate the probability of each pixel rice blast stress, and as a criterion, when the probability p was more than 0.5, rice was under stress, otherwise the rice of normal growth, then to count the rice number of blast stress pixels in order to get rice affected area.

4 Results and validation

4.1 extraction of rice vegetation range

In this study, 2010 satellite imagery was selected, and supervised classification method to extract the scope of rice cultivation in the study area was adopted. In the supervised classification process, the transformation dispersion values between the rice samples and samples of other features reached 2000, indicating the separation degree between rice and other surface classes was very good[10], on the above base, we can look forward to getting better classification results using this sample.

Figure1 shows the classification results, where the green area stands for the rice-growing range. Mergering non-crop types in the map with only considering classification accuracy of rice and non-rice, and to select 51 ground reference validation

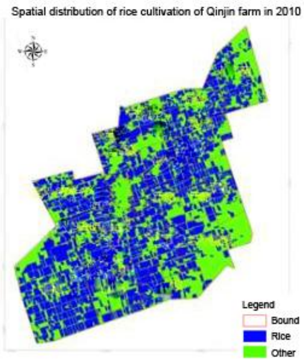

Fig. 1. Classification results of HJ-1A- CCD2 image, 2010

samples to perform accuracy verification. Table 2 shows the classification accuracy evaluation form[11], and the overall classification accuracy reaches 94.12%, and kappa coefficient is 0.8 or more. Rice cultivating area statistics in classification results is 74.6 acres, which shows a difference of 3.18% from recorded 72.3 hectares plan cultivation area of Qianjin farm in 2010, indicating that classification accuracy can meet the requirements.

Table 2. Precision evaluation of the supervised classification

Category	Refer Data	Number Of Random Sample	Correct Number of Samples	Producer accuracy	User Accuracy	Kappa Coefficient
Other	36	35	34	94.44%	97.14%	0.903
Rice	15	16	14	93.33%	87.50%	0.823
The Overall Accuracy			94.12%			

4.2 Ratio vegetation index based on logistic regression model

The use of coercion by the blast and the normal growth of neighborhood rice NDVI, RDVI and TVI ratio vegetation index establish the binary logistic regression model. 78 groups samples obtained in the 26 measured sites, applicability of the model results shown in Table 3. It can be seen ,although pseudo determination coefficient of NVDI modle is high. Cox & Snell R2 and Nagelkerke R2 reached 0.665 and 0.887, but the Hosmer-Lemeshow goodness of fit P is higher, the model was abandoned. RDVI and TVI established logistic regression model,although the pseudo coefficient determination is not high,but statistically very significant,P is 0, the equation of goodness of fit is high.Therefore, RDVI and TVI model is used.

Table3. Goodness of fit and reliability of the logistical models

Vegetation Index	Cox & SnellR2	Nagelkerke R2	Hosmer-Lemeshow P Value
NDVI	0.665	0.887	0.473
RDVI	0.554	0.739	0
TVI	0.480	0.640	0

4.3 Blast Range CCD image extraction and validation results

The use of TVI and RDVI extract information about the exception of blast from the satellite images to obtain the probability map of occurrence blast, probability greater than 0.5, considered by the blast hazards,The resulting stress range distribution of rice by the blast is shown in Figure 2.Figure 2a is the result of extraction by the RDVI model, Figure 2b is the result of extraction by the TVI model.By the statistical analysis,blast area of the rice-growing area extracted by the RDVI model and TVI model were 15.6% and 18.7%.

In 2010,Heilongjiang Academy of Agricultural Reclamation Plant Protection had a blast of field survey on the QianJin Farm,the results showed that incidence of rice blast is relatively high. The information about the exception of blast extracted from the satellite images was consistent basically with the census results of Plant Protection Station.

To further analyze the accuracy of the logistic regression model,the rice –growing state measured with rice range stressed of blast by matching the spatial location, is results from the model in line with the actual observation?The results shown in Table 4.Measured at 58 sites,There are 26 sites at which the rice is stressed by the blast, 32 sites at which the rice is healthy.When the blast information is extracted through the RDVI model, obtained14 sites stressed and 22healthy sites, the overall accuracy of Extraction is 62.07%. When the blast information is extracted through the TVI model, obtained 20 sites stressed and 24 healthy sites, the overall accuracy of Extraction is 75.86%.Both RDVI and TVI model can obtain good results,In contrast,TVI model better meet the monitoring requirements of rice blast.

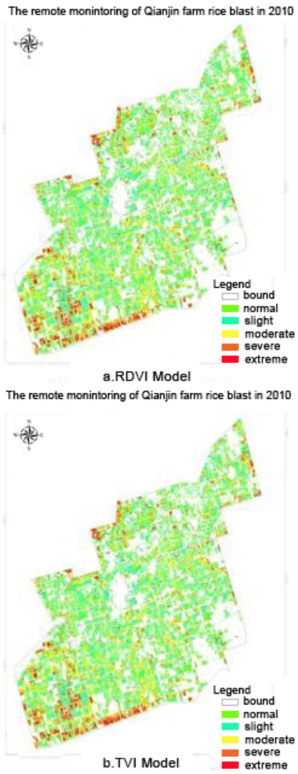

Fig. 2. Distribution map of ShengLi farm stressed rice

Table 4 Precision of the extracted rice blast area by logistical model

	sites stressed	healthy sites	Accuracy %
RDVI	14	7	61.76
TVI	20	6	76.47
number of sites	26	8	——

5 Conclusion

For the measured spectra of field, due to the combined effects of various environmental factors, the rice of different regions showed different spectral characteristics. In the present study, for each site affected by rice blast stress gets the 4 set of spectral data, 2 groups spectral data affected by the stress rice and the 2 set normal spectral data. During data analysis, the vegetation indices stressed and adjacent normal rice seek ratio, putting forward a kind binary logistic regression method to the vegetation index ratio as indpendent variables, model to monitor the health status of rice. The results show that the goodness of fit of binary logistic regression model was created by TVI ratio is better. When rice blast information monitoring of remote sensing images with this model, we proposed a hypothetical algorithm based on the consistency of the 3 × 3 neighborhood. For the elimination of local environmental differences which can be ignored，Better to avoid the impact of a variety of environmental differences which exist between the different regions in the whole scene images.

This study，preliminary using China's HJ-1A- CCD2 data to the remote sensing monitoring of the rice blast。HJ-CCD data with extensive coverage, short revisit cycle, the higher resolution et，offers the possibility of periodic monitoring of crop growth status. This study Proposed ideas, can help to use the data to operational monitoring of health status in rice.

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