Study on Forest Vegetation Classification with Remote Sensing

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Abstract

This paper describes the study methods of identifying forest vegetation types, based on this study, forest vegetation classification method based on vegetation index is proposed. According to reflectance data of vegetation canopy and soil line equation NIR=1.506R+0.0076 in Jingyuetan, Changchun, China, many vegetation index are calculated and analyzed. The relationships between vegetation index and vegetation types are that PVI identifies broadleaf forest and conifer forest the most easily, the next is TSAVI and MSAVI, but their calculation is complex. RVI values of different conifer trees vary obviously, so RVI can classify conifer trees. In a word, combination of PVI and RVI is evaluated to classify different vegetation types.

Key words: Forest Vegetation, Classification with Remote Sensing, Vegetation Index

Introduction

Spectral feature of objects is one of the foundations of remote sensing techniques, especially that of forest vegetation is the research topic all over the world, because whether forests exist or not has an effect on living environment of human beings. By making a research on spectral features of forest vegetation community, we can extract forest thematic information from remote sensing information of different sources and forms (photographs or satellite images). We can further establish a theoretic basis for dividing forest types, plotting forest maps, surveying and utilizing and protecting forest resources, forecasting forest fire disaster and insect pests. Generally, Landsat and other remote sensing systems can readily distinguish between deciduous and coniferous forests, and can recognize shrublands and various other ecosystems. But identifying most tree types at the species level is much more difficult, unless high-resolution images are available and the trees have distinctive crowns and leaf shapes that produce fairly explicit spectral signatures. Research on forest vegetation classification with vegetation index is still very little. Vegetation index (VI) is defined as simple bands sensitive to chlorophyll absorption and cell wall reflectance mathematics (usually ratios of individual bands or of band sums or difference) to accentuate recognition of variation within types and densities of growing forests, fields and crops. Many researches have suggested the use of various classification methods for the temporal changes of vegetation greenness represented as normalized difference vegetation index (NDVI) (Loyd, 1990; Hale and Huff, 1993; Defris and Townshend, 1994). Wang (1990) and Jeong

Chang Seong(2001) developed the fuzzy image classification for continental scale multitemporal NDVI series images. This paper tries using vegetation index to classify forest vegetation, because the contrast of absorbing red waveband with reflecting near-infrared waveband strongly of different vegetation types is recognized as the theoretic basis of vegetation analysis with remote sensing. Vegetation index (VI) is highly related to leaf area index (LAI), absorbed photosynthetic active radiation (APAR) and vegetation cover. LAI is defined as the ratio of one-half the total area of leaves in vegetation to the total surface area containing that vegetation. VI reflects photosynthesis intensity of plants and manifests different forest vegetation types.

Geographical Characteristic of Research Area

Remote sensing test area in Jingyuetan, Changchun City, China was selected for research. This area belongs to Temperate Zone semi-moist continental monsoon climate. Annual precipitation is 571mm.Forest vegetation belongs to forest-grassland transitional belt from Changbaishan broadleaf forest to Songnen plain and it belongs to Changbaishan, Mongolia and North China floras.

Spectral curve analysis of forest vegetation

(1) Spectral reflectance curve characteristic of conifers is similar to that of broadleaf, that is, spectral reflectance is low in visible waveband (0.63-0.69 μ m) while it increases remarkably in near-infrared (0.76-0.90 μ m) waveband, but reflectance of Mongolian robur in each band is greater than that of conifers.

(2) Reflectance variation of different conifers in visible band is not great, but reflectance of larch is higher than that of other conifers in near infrared. Therefore near-infrared waveband is the more sensitive band to plants and is recognized as the best band to distinguish different plants.

Methodology

Categories of vegetation index

Vegetation index is decided based on vegetation canopy reflectance of red band (TM3) and near-infrared waveband (TM4) and the soil-line equation $NIR=a_1R+a_0$. Many vegetation indices are proposed and can be divided into three categories: (1) Intrinsic indices, which do not involve any external factors other than the measured spectral reflectance, such as ratio vegetation index (RVI) and NDVI. Intrinsic indices are related to the amount of vegetation and the biophysical properties of vegetation canopy, but NDVI is extremely sensitive to soil optical properties, and is difficult to interpret with low vegetation cover when the soil is not unknown. RVI can eliminate the difference coming from soil background. (2) Soil-line related indices, which include soil-line parameters, such as the perpendicular vegetation index (PVI), the weighted difference vegetation index (WDVI) and the transformed soil-adjusted vegetation index (TSAVI).Although PVI is better than NDVI at low vegetation densities, it is still affected by the soil. Soil-adjusted Vegetation Index (SAVI) is defined as:

$$SAVI=(1+L)(TM4-TM3)/(TM4+TM3+L) \quad (1)$$

with L=0.5,which has the minimum soil effects. Huete'research (1988) indicated that L becomes smaller in value as vegetation becomes more dense, and for more precise studies, three adjustment factors are preferable: L=1 for analyzing very low vegetation densities; L=0.5 for intermediate vegetation densities; L=0.25 for higher densities.

(3) Atmospherically corrected indices, such as ARVI and GEMI. In order to reduce the dependence of the NDVI on the atmospheric properties, Kaufman (1992) introduced the atmospheric information contained in the blue channel, defined as:

$$ARVI=(TM4-RB)/(TM4+RB) \quad (2)$$

RB is a combination of the reflectance in the blue (B) and in the red(R) channels: RB=R-r (B-R), and r depends on the aerosol type and this concept can be applied to other indices by changing R to RB.

Pinty and Verstraete (1992) proposed Global Environment Monitoring Index (GEMI), defined as:

$$GEMI=\eta(1-0.125\eta)-(R-0.125)/(1-R) \quad (3)$$

In which, $\eta=[2(TM4^2-TM3^2)+1.5TM4+0.5TM3]/(TM4+TM3+0.5)$ (4)

The problem of such an index is its complex formulation, which makes it difficult to use and interpret. Vegetation indices in this paper are shown in table 1.

Tab.1 Definition of Vegetation Index

Vegetation Index	Definition
RVI	TM 4/TM 3
NDVI	(TM 4−TM 3)/(TM 4+TM 3)
DVI	TM 4−TM 3
IPVI	TM 4/(TM 4+TM 3)
WDVI	$TM4-a_1TM3$
PVI	$(TM4-a_1TM3-a_0)/\sqrt{1+a_1^2}$
TVI	$\sqrt{(TM4-TM3)/(TM4+TM3)+0.5}$
TSAVI	$a_1(TM4-a_1TM3-a_0)/(TM3+a_1TM4-a_1a_0$
MSAVI	(1+L)(TM 4−TM 3)/(TM 4+TM 3+L) 其中 $L=1-2a_1NDVI\cdot WDVI$
G_2	$\sqrt{TM4/TM3}$
G_3	$\sqrt{(TM4-TM3)/(TM4+TM3)}$

Acquisition of remote sensing data

We captured spectral data of the main forest canopy from Jingyuetan remote sensing test area in Changchun, China from July to September in 1997.Instrument used is RS-II four-channel spectral radiometer whose four single channels respectively simulate normal band range of TM1, TM2, TM3, TM4. Test condition is at about 11:00am on a sunny day and the main axis of the lens is downward vertically and greenery of forest is filled with field of view. Spectral data is measured with comparison method. Spectral radiometer aimed at forest canopy and registered readings Vi in each channel, then spectral radiometer quickly aimed at standard board (Lambert characteristic is good and is labeled reflectance ρ_0). Output value V_0i in each channel is written down, because of the short time interval between the two measures (2-3 seconds), their illuminance is thought of as equal.

Formula of calculating canopy spectral reflectance is:

$$\rho = \rho_0 V_i / V_0 i \qquad (5)$$

i=1，2，3，4,respectively corresponding to four channels of spectral radiometer. Each vegetation type is measured 25 times; the average value is selected to be its spectral reflectance value, thus mainly eliminating the error caused by casual factors.

The relative altitude in the test area is not high and has no effect on test result. The sampling points selected in this test are on the same aspect and the influence of aspect is also eliminated.

Relationships between vegetation index and vegetation types

According to the measured value of vegetation canopy reflectance TM4、TM3 and soil-line equation NIR=1.506R+0.00786 in Jingyuetan, Changchun in China, each vegetation index calculated is shown in table 2.

Tab. 2 Vegetation Indices of different trees

Vegetation Index	Mongolia oak	Larch	Red pine	Pinus sylvestris L. var.mongolica Litv.	Oil pine
RVI	9.81	7.32	5.75	5.13	4.94
NDVI	0.81	0.76	0.70	0.67	0.66
DVI	0.37	0.23	0.19	0.17	0.13
IPVI	0.91	0.88	0.85	0.84	0.83
WDVI	0.35	0.22	0.17	0.15	0.11
PVI	1.81	0.12	0.09	0.08	0.06
TVI	1.15	1.12	1.10	1.08	1.08
TSAVI	0.80	0.33	0.65	0.34	0.60
MSAVI	0.71	0.45	0.037	0.31	0.21
G2	3.13	2.71	2.40	2.26	2.22
G3	0.9	0.87	0.84	0.82	0.81

We can see from table 2 that each kind of vegetation index value of Mongolia oak is higher than that of conifer.

Vegetation index values of red pine and oil pine are second to that of larch. The difference in vegetation index value between conifers is little, the least of which is close to zero (such as TVI), and the greatest is 1.57 (such as RVI). IPVI、 TVI and G_3 are the most difficult to distinguish broadleaf from conifer, the difference range among different trees is from zero to 0.03. PVI is the easiest to distinguish broadleaf from conifer, next are TSAVI and MSAVI, but their calculation is more complex. PVI of Mongolia oak is 1.81 and those of conifers are respectively 0.12, 0.09, 0.08 and 0.06. The difference of RVI between conifers is great. Their RVI values are 7.32, 5.75, 5.13 and 4.94.So RVI can be selected to distinguish each conifer.

Integration of PVI and RVI is evaluated to be an effective way to distinguish different forest vegetation types, as shown in table 3.

Tab.3 PVI and RVI of different Vegetation Types

vegetation index	broadleaf forest	coniferous forest
PVI	1.81	0.06-0.12
RVI	9.81	4.94-7.32

Discussion

Remote sensing vehicle is used to capture spectral data at certain altitude (20m) above forest canopy. Such spectral data can reflect spectral characteristics of forest vegetation colony, thus overcoming the limit of former capturing spectral data on the ground and making spectral data more practicable.

Using soil line equation NIR=1.506R+0.00786,we calculated and analyzed every vegetation index and the relationship between vegetation index and vegetation type is very clear. PVI is the easiest to distinguish broadleaf and conifer, the next is TSAVI and MSAVI, but their calculation is more complex. The difference between different RVI value is great, so RVI can be used to distinguish each conifer. Integration of PVI and RVI is the efficient way of distinguishing different vegetation types. The way of using vegetation index based on remote sensing techniques to classify vegetation types is simpler, quicker and more reliable, and it requires to be further applied and because there maybe other VI for classifying forest vegetation, various method is to be investigated in future research.

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References

[1]Loyd, D., 1990, A Phenological Classification of Tenestrial Vegetation Cover using Short-wave Vegetation

Index Imagery, *International Journal of remote Sensing*, 11(12): 2269-2270.

[2]Hale, A. T., and D. L. Huff, 1993, Monitoring Temporal Changes in Multivariate Classification. *Professional Geographer*, 45(2): 194-206.

[3]Defris,R. S. and J. R. G. Townshend, 1994, NDVI-Derived Land Cover Classification at a Global Scale, *International Journal of remote Sensing*, 15(17): 3567-3586.

[4]Wang, F., 1990, Fuzzy Supervised Classification of remote sensing Images, *IEEE Transactions on Geoscience and Remote Sensing*, 28(12): 194-201.

[5]Jeong Chang Seong and E. Lynn Usery, 2001, Fuzzy Image Classification for Continental-Scale Multitemporal NDVI Series Image using Invariant pixels and Image Stratification Method, *Photogrammetric Engineering and Remote Sensing*, 67(3): 287-294.