GRASS RESOURCES CLASSIFICATION AND EVALUATION

BASED ON MULTI-DATA AND MULTI-CRITERION IN THE SOUTH OF CHINA

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ABSTRACT

The computer classification of remote sensed data has made great progress and plays an important role in resources investigation. Unfortunately, the quantity and reliability of recognizable classes of ground objects are in many cases very limited, if only the spectral features of image are used. A better way is to simultaneously use many kinds of non-remote sensing data, such as DTM, geographic features, soil types, climate, relief, vertical and regional distribution of plants etc. , with remote sensing images. It can improve both the capability of recognition of ground object and the reliability of computer classification efficiently.

Because non-remote sensing data are useally expressed in the form of maps,we must registrate them with remote sensed images and compound them with false colour image accurately.In this paper two methods of registration and compound are discussed . The first one is to compound the precisely rectified TM images with various kinds of map data, which is called MATCHING.The obtained photo map production can be used as the basis for thematic map of classification results.The disadvantage of this method is that the radiant intensity will be degenerated after resampling. For this reason we use the second method called REVERSE-MATCHING which uses a reverse mathing function to registrate and compound the non-remote sensing data from map to original TM image for computer identification and classification.

Both methods are combinedly used to investigate the grass resources in area of Lichuan county of Hubei province. This investigation will provide a scientific basis for the local government to develop and utilize grass resources and to plan and manage stockfarm.

The investigation procedure , the important results and their accuracy and reliability are given in this paper.

1 FINE PROCESSING OF TM IMANGE DATA

At present, most products of the TM-CCT image data and image from are in the form of rough product at the ground receiving station. The residuals of these images are about 5-7 pixels and their planimetric accuracy is about 120-150m on ground. In order to improve their geometric accuracy and transform them into a certain map projection system as well as to match TM-image data with non-remote sensed data, the fine processing of the image data is necessery. The procedure of fine processing for our investigation is shown as follows.

1-1 RECTIFICATION BY GROUND CONTROL POINTS

The original TM image is rectified into UTM projection system by using the polynomial method during the fine processing. For this reason we have choosen 40 nature ground objects from large scale topographic map as control points.

Due to the number of control points more than the number of polynomial coefficients, a least squares adjustment should be done.

During the adjustment, gross errors have been detected in 7 control points. After rejecting these points the adjustment is performed by the remaining 33 points and the standard errors for control points are listed in Tabel 1. The 3rd-order polynomial is recommendable.

	1 order polynomial	2 order polynomail	3 order polynomial
x-direction	32.34206390	29.88285828	25.93333054
y-direction	26.39077377	26.10504331	24.68536568

Table 1. Standard error after adjustment

1-2 RESAMPLING

Three methods for the intensity resampling are tested[1]. Considering the spectral intensity of feature and gemetric accuracy of image. Bi-Linear interpolation method is used for resampling with the pixel size of 20mx20m.

$$\text{Bi-Linear interpolation} \quad I(p)=\sum_{i=1}^{2}\sum_{j=1}^{2} I(i,j)*W(i,j) \qquad (1)$$

2 MATCHING AND REVERSE MATCHING

2-1 MATCHING BETWEEN FINELY PROCESSED IMAGE AND NON-REMOTE DATA

Non-remote sensing data refers to these data which are acquired by non-remote sensing ways (such as topography, soil, landuse, climate, population and economy). Matching among multi-type of data is very important for classification and recognition of TM image in analysis and evaluation of resource and environment. Befor matching it with the fine processing image, the mon-remote sensed data have to be digitized, and they must have the same projection system of the fine processed image. Then the 1st-order polynomial can be used to match them. Diagram of matching see FIGURE1.

2-2 REVERSE MATCHING FROM MAPS TO ORIGINAL IMAGE

Because the resampling of TM image in fine processing lead to degrading of the spectral intensity, it is not beneficial to the computer classification and visual interpretation. In order to restore spectral information in original image, we make reverse matching from maps to the rough processing image. For this purpose reverse matching should be done with

$$NL=F'(L,P) \qquad NP=F'(L,P) \qquad (2)$$

in which L,P and NP,NL are coorinates of fine and rough processing.

The digital maps are also transformed into rough processsing image during reverse marching. Diagram of reverse matching see FIGURE2.

2-3 OUTPUT PRODUCTS AND THEIR ACCURACY

Two kinds of color TM image format maps are produced from computer system. they are MATCH image format map. And REVERSE MATCH image format map.

The residuals of match image format map after 3rd— order polynomial transformation are δx= 25.93m, δy= 24.67m (see table 1) The standard error on topographic maps are δx=δy= 25m. The total RMSRs are δx= 36.02m, δy=35.14m. after randomly selecting 14 check points the standard error are δx= 31.17m, δy= 17.11m.

Th accuracy of reverse match image format map is about 1.5 pixel, which can meet requirment of computer classification and evaluation.

3 APPLICATION OF MULTI-DATA IN CLASSIFICATION OF GRASS RESOURCES

3-1 GRASSLAND TAXONOMY IN THE SOUTH OF CHINA

The traditional taxonomy of the grassland in south part of china can be classed at 3 levels -- CLASS, GROUP, TYPE.

At the first level grassland is divided into 5 CLASSes:

(1) Grassland (2) Bush-grassland (3) Wood-grassland

(4) Meadow (5) Odd pieces of glassland

there are only (1),(2),(3) class in Lichuan county.

At the second level every class is divided into 3 GROUPs:

(1) High-mountain group, in which the terrain is higher than 1200m.

(2) Mid-mountain group, in which the terrain is between 800m and 1200m.

(3) Low-mountain group, in which the terrain is lower than 800m.

At the third level grassland-TYPEs are determined on the basis of grass format.

3-2 CLASSIFICATION

3-2-1 Classification based on spectral feature

The spectral bands TM3,TM4 and TM5 are used in classification of spectral feature. They are determined in feature selection. The algorithm of classification is maximum likelyhood method:

$$D_i(x)=P(x/i)P(i) \qquad (3)$$

$$P(x/i)= \frac{1}{|\Sigma_i|^{1/2}(2\pi)^{K/2}} EXP(-\frac{1}{2}(X-M_i)^T \Sigma_i^{-1} (X-M_i)) \qquad (4)$$

3-2-2 Classification based on textural feature

Some classes of grassland are still seriously confused after classification based of spectral feature, such as bushland and vegetable wood-grassland and grassland or bushland. But their texture feature are quite different. So we use texture measuring to distinguish the various confused classes. For this reason every 4x4 or 8x8 window of image with confused classes is one by one transformed into spatial frequency domain.

$$F(u,v) = FFT\ (f(x,y)) \quad (5)$$

Then we calculate their measures of texture:

$$TX_F = \delta_{si}/F_{si}(0,0) \quad (6)$$

or the measures of texture direct in spatial domain :

$$TX_s = \delta_{si}/M_{si} \quad (7)$$

Table 2 shows some measures of texture in 2 typical areas (Qiyu mountain and Fubao mountain).

Class	Measure of texture	
	TXs	TX_F
Wood-grassland	12	12
Forest	6	15
Grassland	8	10
Vegetable plot	10	11
Bush-grassland	8	18

Table 2. Texture measures of 5 classes

We using feature of spectrum and texture in image 3 classes of grassland at first level are extracted.

3-2-3 Classification based on non-remote sensed data

There is second level classification, each class is classified into 3 groups by DHM and soil classes, and natural extension of grassland should be considered at the same time. Finally, a grass resources distribution map of Lichuan county at scale 1:100000 has been output by computer. Table 3 shows the area of 9 groups in grass resources map.

	Grassland (ha)	Bush-grassland (ha)	Wood-grassland (ha)	Total (ha)
High-mountain Groups	34444	30432	51277	116153
Mid-mountain Groups	607	825	7954	9386
Low-mountain Groups	877	20	0	897
Total	35928	31277	59231	126436

TABLE 3. Area of 9 groups grassland in Lichuan county

A comparision between results of the computer classification and from field survey in this area is given in Tabel 4.

Classes of grassland	Area of computer classifica-tion (ha)	Area of field survey *1 (ha)	conformable percentage (%)	Statistical area *2 (ha)	confor-able percen-tage (%)
Grassland	35928	37090	96.87	38423	93.51
Bush—grassland	31277	28361	90.68	26172	83.6
Wood—grassland	59231	60840	97.36	63018	93.99
Total	126436	126291	99.89	127613	99.07

*1 From livestock burean of Lichuan,

*2 From livestock burean of Hubei.

TABLE 4. Area comparison for each kind of grassland between the computer classfication and field indentification.

3-2-4 Classification based on grass format

In the third level classification we use traditional methods such as 1) collecting sample-square of grass. 2) makeing specimen of forage grass.3) recognizing and extracting superior species of forage grass in grass format. Table 5. show grass types of 3 large stretches of grassland.

Name of grassland	Elevation (m)	Forage grass tape
Hanchi	1910-1951	Anaphalis contocta-Arthraxon hispidus-Eriophorum conosum-Pteridium aquilinum-Viburnum macrocephalum fortums-Artemisia apiacea hance
Mashan	1500-1700	Miscanthus sinensis arderss-Pteridium aquilinum-Anaphalis contocta-Paspalum thunbergii
	>1700	Anaphalis contocta-Pteridium aquilinam-Cacalia tangutica-Arthraxon hispidus-Imperate cylindrica
Qiyushan	1543-1784	Miscanthus sinensis arderss-Coteneaşe adpressusbois-Eriophorum canosum-Artemisia apiacea hanc-Anaphalis contocta-Salix dunnii ochneid-Arthraxon hispidus -Pteridium aquilinum

Table 5. Forage grass types in 3 large grassland

4 APPLICATION OF MATCHED MULTI-DATA IN EVALUATION OF GRASS RESOURSE

4-1 PROCEDURE OF GRASS RESOURCE EVALUATION

First we used various kinds of data to build a database of grass resources evaluation for this county. These data are from remote sensing images and non-remote sensing data such as hydrology, soil types, landuse types, elevation, slope, climate, agriculture economy etc and then we used computer to aid grass resources evaluation with various mathematical analysis models. The obtained results will provide a scientific basis for the local government to develop and utilize grass resources.

4-2 MATHMATICAL ANALYSIS MODELS

4-2-1 Region similarity analysis model

On the basis of geographical network system, lichuan county is divided into 57 grids (10x10 km). Various kinds of corresponding data in database are contained in every grid.

Generally, there are two steps for region similarity analysis:

step 1:

To fromulate fuzzy similarity matrix for 57 grids

$$A\{a(i,j)\quad \left[\begin{array}{l} i=1,2,\cdots\cdots,m \\ j=1,2,\cdots\cdots,n \end{array}\right\} \tag{8}$$

and

$$a(i,j)=\frac{\sum_{K=1}^{n} X_{(iK)}\,X_{(jK)}}{\sum_{K=1}^{n} X^2_{(iK)}\,X^2_{(jK)}} \tag{9}$$

x(i,k) is the Kth index in the ith grid

a(i,j) is similarity-degree of the ith and jth grid

step 2:

By using maximal brace tree and fuzzy cluster lichuan country is divided into 7 region there the nature condition and direction of development are similar. see Figure 3(a).

4-2-2 Region evaluation model for livestoke-farming suitability

The single condition parameter suitability is expressed as

$$e(ij)=\frac{d(ij)-a(j)}{b(j)-a(j)}*40+60\quad \left[\begin{array}{l} 1<i<L \text{ (L is Number of grids)} \\ 1<j<N \text{ (N is Number of parameters)} \end{array}\right. \tag{10}$$

and the general suitability is

$$E_{(i)}=\left(\prod_{j=1}^{n} e_{(ij)}{}^{c(j)}\right)^{\frac{1}{\sum_{j=1}^{n} c_{(j)}}} \tag{11}$$

where

a(j), b(j), c(j), is not permit value, satisfaction value, and weight respectively, d(ij) is the actual value of the jth parameter of the ith grid.

According to the modle analysis by computer we get the final result and point out that thirteen area of lichuan county are suitable for construction and developement of livestock-farm (see Figure 3(b)).

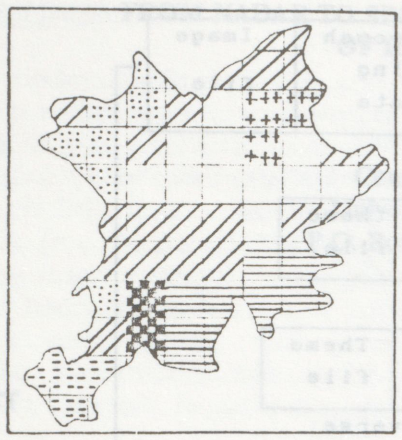

FIGURE 3(a)
Fuzzy cluster map of Region similarity in Lichuan county

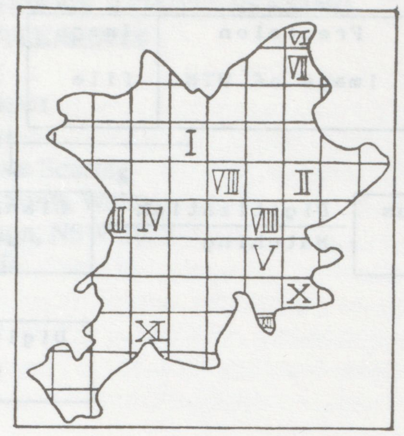

FIGURE 3(b)
Evaluated map of livestock-farming suitability in Lichuan county

5 FINAL REMARKS

1) Planimetic accuracy of procision tm data can meet requirment for producing image format maps of scale 1:100000.

2) Thᶜ classify relieability will be improved effectively if using mu i-data to recognize grassland.

3) The evaluation of grass resource by using multi-criterions will make more objective, more resunable conclusions.

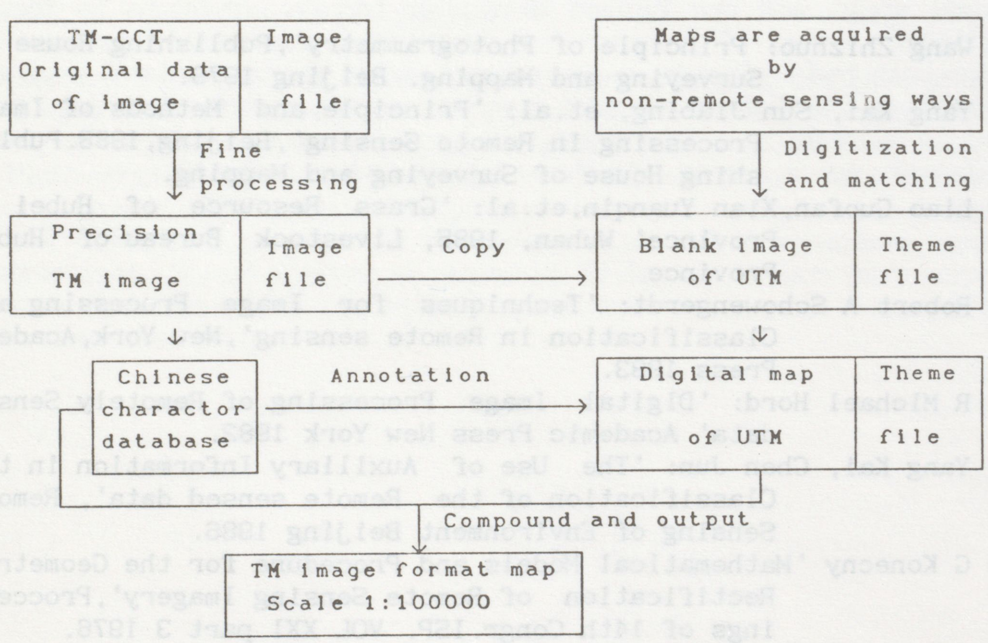

FIGURE 1. Diagram of matching

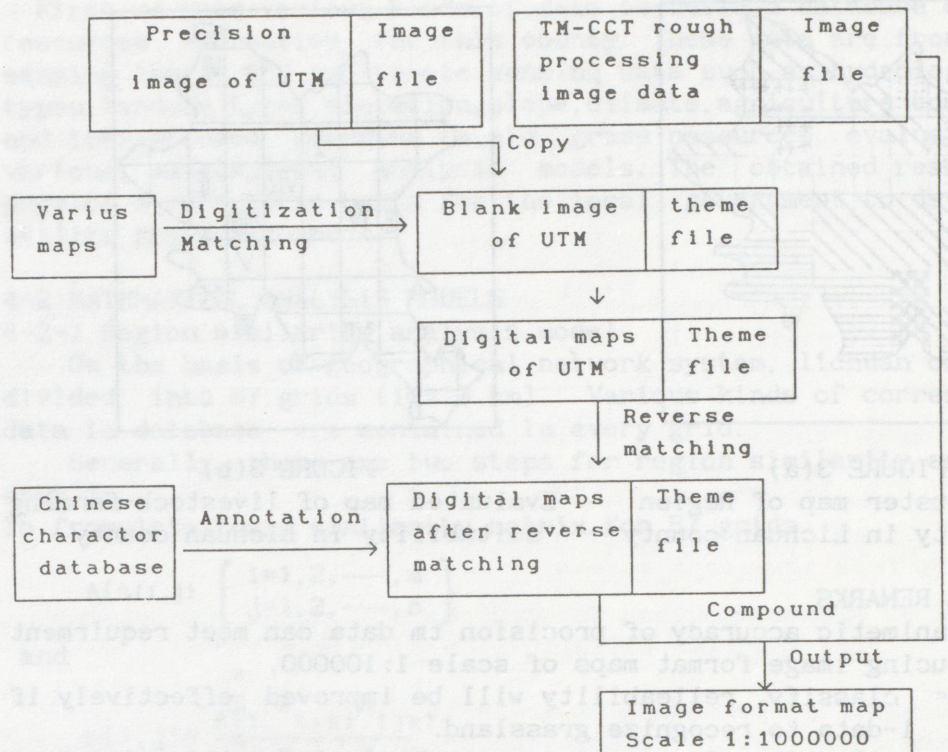

FIGURE 2. Diagram of reverse matching

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