

Fast Extracting of Change Area from Remote Sensing Image by Fuzzy Theory and Case Base Reasoning

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Abstract—This study presents the technology to combine the remote sensing image of SPOT and FORMOSAT-2 satellite image by Fuzzy theory and case base reasoning. This method adopt three experience identify factors of NDVI, shape, and color to establish the membership function. The Fuzzy theory was applied to estimate the process of thinking as the human brain; while the Case Base Reasoning method was used to increase the capability of self-loop learning and support its consistency with the real nature. The results show that the successful rate of identification was between 90 percent. The Case Base Reasoning results show that the two data similarity was between 46 percent. The Fuzzy and Case Base Reasoning difference factor was (satellite sensors, inclination, date, shadowing, etc.). The rate can be increase if there is enough experienced data. It reveal that fuzzy theory with case base reasoning indeed can rapid screen the change area from remote sensing image in before and after the disaster event.

Keywords: *fuzzy theory, case base reasoning, image extraction, image variation*

I. INTRODUCTION

The objective of monitoring the change of catchment area is to avoid the damage from the nature disaster or excessive development. Previous method uses the software to identify the build the land category, and followed by the human experience to check it one by one. However, it has to spend a lot of time to identify the image from the remote sensing images. If it is possible to automatically study and train the capability of selection system, then the time of distinguish can be effectively reduced.

Using image segmentation software to produce the image segmentation vector and extract the variation region is a common practice for remote sensing technique in the past. The process is: select image to segment, output the segmentation vector file, use the software to extract the vector layer, and screen for variation area. The work was done by the accumulation of human experience. The memory capability of

human can accumulate the previous experience, and it can compile the things touched to the rules of information.

Human brain can trigger the corresponding rules to the next move. If there were no corresponding rules, it can also trigger the fuzzy space for self-learning and reasoning. This capability can be simulated by the case base reasoning with fuzzy theory. Therefore, we use the fuzzy theory and case base reasoning to construct a quantitative fuzzy space structure to learn the human brain logic and estimate the variation region in the remote sensing image.

II. METHODOLOGY

Jose et al.[3]using Case Base Reasoning design remote sensing search system. Every image have severl classify index in database. The user can use these index combination search any image conform their demand. All user need not understand any programming language or Structured Query Language (SQL) in search process. Hsu and Hong[2]research typhoon remote sensing image classified according Wavelet Transform and Fuzzy Neural Network. They used Case Base Reasoning and Fuzzy damage estimated agricultural products and inhabitants damage. The experiment shows that their method can fast estimate typhoon damage area.

A. Set the membership function and numerical value of prediction indexes

Three indexes were adopted in this study as the experience rules for quick discrimination, which were: NDVI value difference, shape ratio, and color difference ratio (TABLE 1).

1) NDVI.

The meaning of NDVI value difference is to compare the ratio of red light absorption and near-infrared light reflection by green plant in the remote sensing image. The numerical value of NDVI difference is the difference of the early image and late image. Its value was ranged between -2~2.

- Define the NDVI value of previous image is a, and the value of post-image is b. The range of a single NDVI value is between -1 to 1.
- Let $f(a) = \{1, -1\}$ $f(b) = \{-1, 1\}$, then $f(b) - f(a) = -2$ and 2 , so the maximum threshold value is between -2~2.

- The different value of NDVI is in the range between -2 to 2. According to the induction of manual experience, if the difference values of NDVI lower than 0.3, it could be regarded as no change.
- Let $f(a) = \{0.2, 0.5\}$ $f(b) = \{0.5, 0.2\}$, we set the range as.
- If the value is between -0.3 to 0.3, then there is no change. If the value is between 0.2 to -0.3, then there is change exists.

The function of NDVI is to rapidly analyze the plant growth rate in the variation region. Otsu have proposed a rule for plant in the remote sensing image in 1979.[4]The color value of image was divided into two area as vegetation and non-vegetation.

2) Shape ratio

The definition of shape ratio is the ratio of post stage area to the previous stage area. It has to be assigned with the value accordant to the error factors of location, shape, and twist, etc. If the values lower than 1, then it is the reduction change. If the value is 1 to 1.5, then there is no change. If the value is greater than 1.5, then it is the diffusion change.

The shape ratio is not applicable to the land use type as: from never to have, from having to no, and the simplest change of type. The shape ratio is applicable to the condition when the land use types have no change, and only the area shape changes. The shape ratio is also applicable to the area which has been labeled as the variable region.

3) Color difference value

The color difference value is the total post RGB value minus the previous value of previous RGB in the same area. The total RGB value in the remote sensing image should not over $255+255+255=765$. So the category range for the index is:

- Set the total RGB for the previous image is a, and for the post image is b. Then $b-a = 765$ or -765 .
- Therefore, the range of the maximum threshold value is between -765 to 765.

According to the induction of manual experience, the value of RGB difference lower than 30 is an acceptable value. Therefore, the membership function value of the fuzzy interval is defined as the following. If the value is lower than 30, then it is similar. If the value is between 30 to 765 or 765 to -30, then it is not similar.

B. Construct fuzzy and case base reasoning

The MATLAB fuzzy toolbox was used to construct a structure of rapid extraction. Three groups of indicators were identified. The functional forms and membership function value were shown as Figure1. to Figure 4..

Since, every index has three attribute of fuzzy interval. So, every index has four critical range. Kaufmann, Gupta[1] induced several kinds type of membership function. Most suitable for all index are trapezoidal fuzzy number. As in (1) :

$$f(x, a, b, c, d) = \begin{cases} 0 & x \leq a \\ \frac{x-a}{b-a} & a \leq x \leq b \\ 1 & b \leq x \leq c \\ \frac{d-x}{d-c} & c \leq x \leq d \\ 0 & x \geq d \end{cases} \quad (1)$$

$a \leq b, c \leq d$

The trapezoidal function was chosen in this study because the interval of threshold value for the three indexes in this study is relatively fixed. Twenty seven rules of < IF...THEN > were formulating as the following:

1. If (NDVI is nochange) and (shape is nochange) and (color is Similar) then (expectedvalue is nochange)
2. If (NDVI is nochange) and (shape is nochange) and (color is Dissimilar) then (expectedvalue is yeschange)
3. If (NDVI is nochange) and (shape is nochange) and (color is Dissimilar) then (expectedvalue is yeschange)
4. If (NDVI is nochange) and (shape is Reduction) and (color is Similar) then (expectedvalue is yeschange)
5. If (NDVI is nochange) and (shape is Reduction) and (color is Dissimilar) then (expectedvalue is yeschange)
6. If (NDVI is nochange) and (shape is Reduction) and (color is Dissimilar) then (expectedvalue is yeschange)
7. If (NDVI is nochange) and (shape is Diffusion) and (color is Similar) then (expectedvalue is yeschange)
8. If (NDVI is nochange) and (shape is Diffusion) and (color is Dissimilar) then (expectedvalue is yeschange)
9. If (NDVI is nochange) and (shape is Diffusion) and (color is Dissimilar) then (expectedvalue is yeschange)
10. If (NDVI is negative) and (shape is nochange) and (color is Similar) then (expectedvalue is yeschange)
11. If (NDVI is negative) and (shape is nochange) and (color is Dissimilar) then (expectedvalue is yeschange)
12. If (NDVI is negative) and (shape is nochange) and (color is Dissimilar) then (expectedvalue is yeschange)
13. If (NDVI is negative) and (shape is Reduction) and (color is Similar) then (expectedvalue is yeschange)
14. If (NDVI is negative) and (shape is Reduction) and (color is Dissimilar) then (expectedvalue is yeschange)
15. If (NDVI is negative) and (shape is Reduction) and (color is Dissimilar) then (expectedvalue is yeschange)
16. If (NDVI is negative) and (shape is Diffusion) and (color is Similar) then (expectedvalue is yeschange)
17. If (NDVI is negative) and (shape is Diffusion) and (color is Dissimilar) then (expectedvalue is yeschange)
18. If (NDVI is negative) and (shape is Diffusion) and (color is Dissimilar) then (expectedvalue is yeschange)
19. If (NDVI is positive) and (shape is nochange) and (color is Similar) then (expectedvalue is yeschange)
20. If (NDVI is positive) and (shape is nochange) and (color is Dissimilar) then (expectedvalue is yeschange)
21. If (NDVI is positive) and (shape is nochange) and (color is Dissimilar) then (expectedvalue is yeschange)
22. If (NDVI is positive) and (shape is Reduction) and (color is Similar) then (expectedvalue is yeschange)
23. If (NDVI is positive) and (shape is Reduction) and

- (color is Dissimilar) then (expectedvalue is yeschange)
24. If (NDVI is positive) and (shape is Reduction) and (color is Dissimilar) then (expectedvalue is yeschange)
25. If (NDVI is positive) and (shape is Diffusion) and (color is Similar) then (expectedvalue is yeschange)
26. If (NDVI is positive) and (shape is Diffusion) and (color is Dissimilar) then (expectedvalue is yeschange)
27. If (NDVI is positive) and (shape is Diffusion) and (color is Dissimilar) then (expectedvalue is yeschange) .

TABLE 1. MEMBERSHIP FUNCTION AND NUMERICAL VALUE OF THE THREE EVALUATION INDEXES

evaluation index of Variation regional	Type of membership function	Attribute of fuzzy interval	Membership function value
Differences in NDVI values	Trapezoidal	NDVI differences values is positive	0.3 ~ 2
		NDVI no change	-0.3 ~ 0.3
		NDVI differences values is negative	-2 ~ -0.3
Shape ratio	Trapezoidal	No change	1 to 1.5 times
		Diffusion change	1.5 times to 10 times
		Reduction change	0 ~ 1 time
Color difference value	Trapezoidal	Similar	-30 ~ 30
		Dissimilar, positive value	30 ~ 765
		Dissimilar, negative value	-765 ~ -30

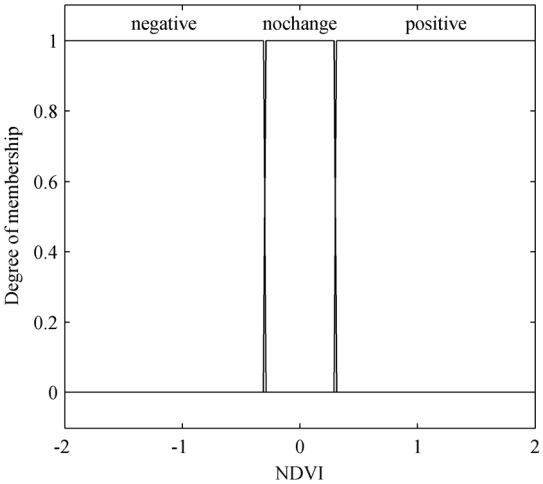


Figure 2. Differences in NDVI values

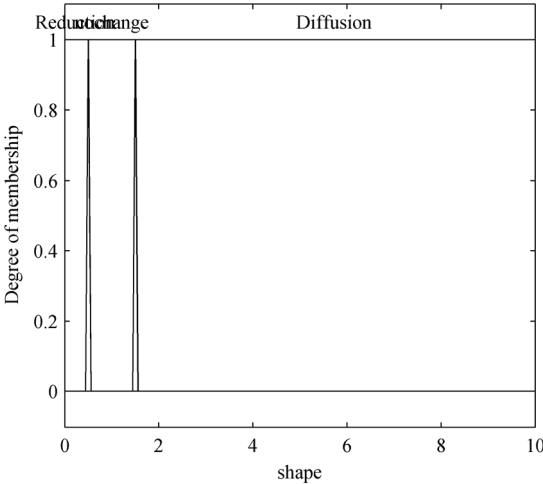


Figure 3. Shape ratio

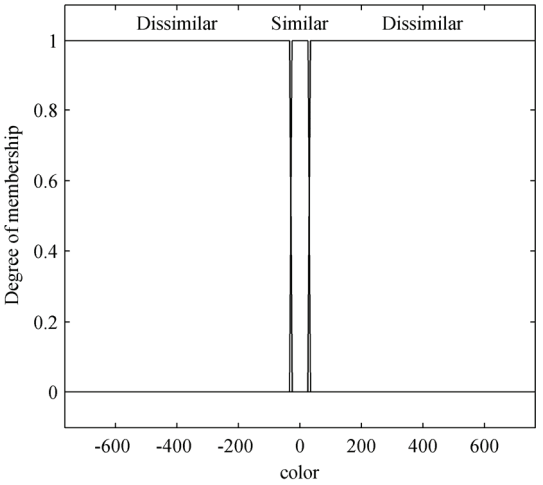
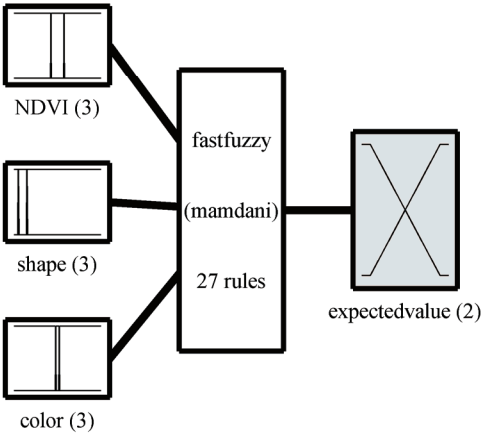


Figure 4. Color difference value



System fastfuzzy: 3 inputs, 1 outputs, 27 rules

Figure 1. Module chart (there are 3 indexes, 1 simulator, 27 rules)

III. RESULTS AND DISCUSSION

The study area was Shihmen Reservoir in Taoyuan County, Taiwan (Figure 6). The area of orchard planting showed rapid growth in the catchment area, according to the third stage governance planning of Shihmen Dam by Water Resource Agency, Ministry of Economic Affairs, Taiwan. These area were distributed in the slope place above 800 meters. It is more suitable for the planting of temperate fruit trees such as honey peach. And the low attitude area is more suitable for the planting of citrus trees. It shows that the land use was influenced by the demand of tourism and economic effect. There is a substantial degree of change comparing to the types of agriculture crop planting in earlier stage.

The forth stage investigation data from the project of SWCB-97-157 in 2008 were taken as the experience cases. Using four FORMOSAT-2 and SPOT panchromatic (pan) and multispectral (MS) images. The results were further verified by the three indexes. The expected value of variations was calculated by the module and obtains the value of 0.67, as shown in Figure 5. It means that if there is a possibility of change, its value will be greater than 0.67. Otherwise, the value of change will be lower than 0.67. The results of experience cases were shown in TABLE 2.

From the above TABLE 2 results, there are three cases with the expected value of variance lower than 0.67 among the thirty two cases. So the success rate of distinguish is $33/33=0.90$. The recognition rate is about 90%.

From the above TABLE 3 ~TABLE 6 results, using fourth contrast third case data and count total mean similarity. The total mean similarity is about 46 %(Figure 7).

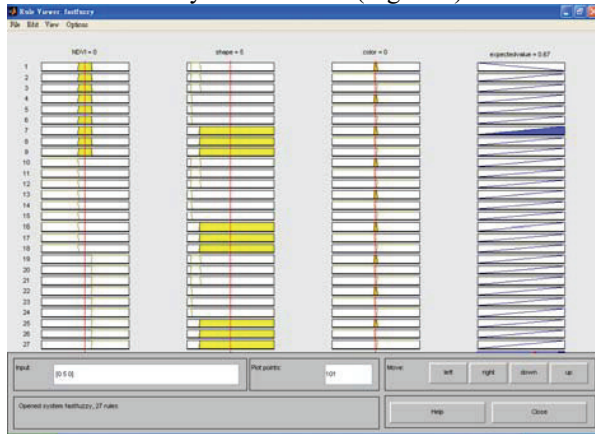


Figure 5 Interface of operation module

Shihmen Reservoir, Taoyuan, Taiwan

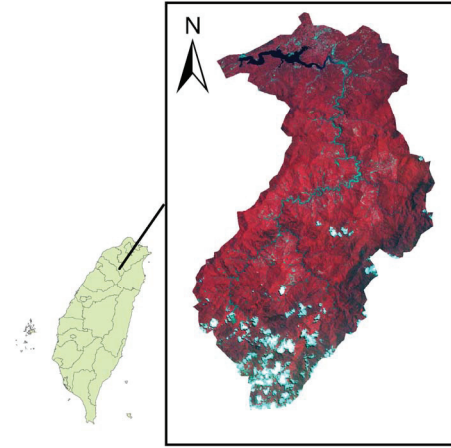


Figure 6 Shihmen reservoir

TABLE 2. THE FOURTH EXPERIENCE CASE IN 2008

No	Differences in NDVI values	Shape ratio	Color difference value	expected value of Variations
D1	-0.25	1.00	-128.00	0.67
D2	-0.63	1.00	-3.00	0.67
D3	-0.62	1.00	-13.00	0.67
D4	-0.47	1.00	-22.00	0.67
D5	-0.22	1.00	-93.00	0.67
D6	-0.34	1.00	-53.00	0.67
D7	-0.50	1.00	-1.00	0.67
D8	-0.38	2.56	-26.00	0.67
D9	-0.14	1.00	-90.00	0.67
D10	-0.42	1.00	-35.00	0.67
D11	-0.10	1.00	-47.00	0.67
D12	-0.40	1.00	29.00	0.67
D13	-0.35	1.00	66.00	0.67
D14	-0.51	1.00	10.00	0.67
D15	-0.54	1.00	-16.00	0.67
D16	-0.42	1.00	-14.00	0.67
D17	-0.58	1.00	-38.00	0.67
D18	-0.44	1.00	-23.00	0.67
D19	-0.30	1.00	-12.00	0.498
D20	-0.44	1.00	20.00	0.67
D21	-0.41	1.00	-100.00	0.67
D22	-0.35	1.00	15.00	0.67
D23	-0.27	1.00	-92.00	0.67
D24	-0.22	1.00	-62.00	0.67
D25	-0.42	1.00	41.00	0.67
D26	-0.56	1.00	-75.00	0.67
D27	-0.56	1.00	-40.00	0.67
D28	-0.43	1.00	-20.00	0.67
D29	-0.45	1.00	-47.00	0.67

D30	-0.28	1.00	-19.00	0.324
D31	-0.30	1.00	26.00	0.498
D32	-0.57	1.00	-3.00	0.67
D33	-0.05	1.00	-104.00	0.67

TABLE 3. FOURTH CONTRAST THIRD EVERY CASE SIMILARITY(D1~D9)

	D1	D2	D3	D4	D5	D6	D7	D8	D9
C1	0.67	0.33	0.33	0.67	0.67	0.67	0.67	0.67	0.67
C2	0.67	0.33	0.33	0.67	0.67	0.67	0.67	0.67	0.67
C3	0.67	0.33	0.33	0.33	0.67	1.00	0.33	0.67	1.00
C4	0.33	0.33	0.33	0.33	0.67	0.67	0.33	0.33	0.67
C5	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
C6	0.33	0.33	0.33	0.33	0.67	0.33	0.33	0.33	0.67
C7	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
C8	0.67	0.33	0.33	0.33	0.67	0.67	0.33	0.67	0.67
C9	0.33	0.33	0.33	0.33	0.33	0.67	0.33	0.33	0.33
C10	0.33	0.33	0.33	0.33	0.33	0.00	0.33	0.33	0.33
C11	0.33	0.67	0.67	0.67	0.67	0.33	0.67	0.67	0.67
C12	0.33	0.33	0.33	0.33	0.67	0.33	0.33	0.33	0.67
C13	0.67	0.33	0.33	0.33	0.67	0.33	0.33	0.33	0.67
C14	0.33	0.33	0.33	0.33	0.67	0.33	0.33	0.33	0.67
C15	0.33	0.33	0.33	0.33	0.33	0.33	0.67	0.33	0.33
C16	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33
C17	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.67
C18	0.33	0.33	0.67	0.33	0.33	0.33	0.67	0.33	0.33
C19	0.00	0.00	0.00	0.00	0.33	0.00	0.00	0.00	0.33
C20	0.33	0.33	0.33	0.33	0.33	0.67	0.33	0.67	0.33
C21	0.33	0.33	0.33	0.33	0.67	0.67	0.33	0.33	1.00
C22	0.67	0.33	0.33	0.67	0.67	0.67	0.33	0.67	0.67
Similarity	0.44	0.36	0.38	0.41	0.55	0.48	0.42	0.45	0.59

TABLE 4. FOURTH CONTRAST THIRD EVERY CASE SIMILARITY(D10~D18)

	D10	D11	D12	D13	D14	D15	D16	D17	D18
C1	0.67	0.67	0.67	1.00	0.67	0.67	0.67	0.67	0.67
C2	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
C3	1.00	1.00	0.67	0.67	0.33	0.33	0.67	0.67	0.67
C4	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33
C5	0.67	0.33	0.67	0.67	0.67	0.67	0.67	0.67	0.67
C6	0.33	0.67	0.33	0.67	0.33	0.33	0.33	0.33	0.33
C7	0.33	0.67	0.67	0.67	0.67	0.67	0.67	0.33	0.67
C8	0.33	0.67	0.33	0.67	0.33	0.33	0.33	0.33	0.33
C9	0.33	0.67	0.00	0.33	0.00	0.33	0.33	0.33	0.33
C10	0.33	0.33	0.00	0.00	0.33	0.33	0.33	0.00	0.33
C11	0.67	1.00	0.33	0.33	0.33	0.67	0.67	0.67	0.67
C12	0.33	0.67	0.33	0.33	0.33	0.33	0.33	0.33	0.33
C13	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33

C14	0.33	0.67	0.33	0.33	0.33	0.33	0.33	0.33	0.33
C15	0.33	0.33	0.67	0.33	0.67	0.33	0.33	0.33	0.33
C16	0.33	0.33	0.33	0.67	0.33	0.33	0.33	0.33	0.33
C17	0.33	0.67	0.67	0.67	0.33	0.33	0.33	0.33	0.33
C18	0.33	0.67	0.67	0.33	0.67	0.67	0.67	0.33	0.33
C19	0.00	0.33	0.00	0.33	0.00	0.00	0.00	0.00	0.00
C20	0.67	0.67	0.33	0.33	0.33	0.33	0.33	0.67	0.67
C21	0.33	1.00	0.33	0.33	0.33	0.33	0.33	0.33	0.33
C22	0.67	0.67	0.67	0.67	0.33	0.33	0.67	0.33	0.67
similarity	0.44	0.61	0.42	0.48	0.39	0.41	0.44	0.39	0.44

TABLE 5. FOURTH CONTRAST THIRD EVERY CASE SIMILARITY(D19~D27)

	D19	D20	D21	D22	D23	D24	D25	D26	D27
C1	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
C2	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
C3	0.67	0.67	0.67	0.67	1.00	1.00	0.67	0.67	0.67
C4	0.33	0.33	0.67	0.33	0.67	0.67	0.33	0.67	0.33
C5	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.67
C6	0.33	0.33	0.33	0.33	0.67	0.67	0.67	0.33	0.33
C7	1.00	0.67	0.33	1.00	0.67	0.67	0.67	0.33	0.33
C8	0.67	0.33	0.33	0.67	0.67	0.67	0.33	0.33	0.33
C9	0.67	0.00	0.00	0.33	0.33	0.33	0.00	0.00	0.33
C10	0.33	0.33	0.00	0.33	0.00	0.33	0.00	0.00	0.00
C11	0.67	0.33	0.33	0.33	0.33	0.67	0.33	0.33	0.67
C12	0.33	0.33	0.67	0.33	0.67	0.33	0.33	0.67	0.33
C13	0.33	0.33	0.67	0.33	0.67	0.33	0.33	0.33	0.33
C14	0.33	0.33	0.67	0.33	0.67	1.00	0.33	0.67	0.33
C15	0.33	0.67	0.33	0.67	0.33	0.33	0.67	0.33	0.33
C16	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33	0.33
C17	0.33	0.67	0.33	0.67	0.33	0.33	0.67	0.33	0.33
C18	0.67	0.67	0.33	0.67	0.33	0.33	0.67	0.33	0.33
C19	0.00	0.00	0.00	0.00	0.00	0.33	0.33	0.00	0.00
C20	0.33	0.33	0.33	0.33	0.33	0.67	0.33	0.67	0.67
C21	0.33	0.33	0.67	0.33	0.67	0.67	0.33	0.67	0.33
C22	0.67	0.67	0.67	0.67	0.67	0.67	0.67	0.33	0.33
Similarity	0.48	0.44	0.44	0.48	0.52	0.56	0.45	0.42	0.39

TABLE 6. FOURTH CONTRAST THIRD EVERY CASE SIMILARITY(D28~D32)

	D28	D29	D30	D31	D32	D33
C1	0.67	0.67	0.67	0.67	0.67	0.67
C2	0.67	0.67	0.67	0.67	0.67	0.67
C3	0.67	1.00	0.67	0.67	0.33	0.67
C4	0.33	0.33	0.33	0.33	0.33	0.67
C5	0.67	0.67	0.67	0.67	0.67	0.33
C6	0.33	0.33	0.67	0.33	0.33	0.67

C7	0.67	0.33	1.00	1.00	0.67	0.67
C8	0.33	0.33	0.67	0.67	0.33	0.67
C9	0.33	0.33	0.67	0.33	0.33	0.33
C10	0.33	0.00	0.33	0.00	0.33	0.33
C11	0.67	0.67	0.67	0.33	0.67	0.67
C12	0.33	0.33	0.33	0.33	0.33	1.00
C13	0.33	0.33	0.33	0.33	0.33	0.67
C14	0.33	0.33	0.33	0.33	0.33	1.00
C15	0.33	0.33	0.67	0.67	0.33	0.33
C16	0.33	0.33	0.33	0.33	0.33	0.67
C17	0.33	0.33	0.33	0.67	0.33	0.67
C18	0.33	0.33	0.33	0.67	0.67	0.67
C19	0.00	0.00	0.00	0.00	0.00	0.33
C20	0.33	0.67	0.33	0.33	0.33	0.67
C21	0.33	0.67	0.33	0.33	0.33	0.67
C22	0.67	0.67	0.67	0.67	0.33	0.67
Similarity	0.42	0.44	0.50	0.47	0.41	0.62

Figure 7 Fourth contrast third case total mean similarity

IV. CONCLUSION

It is necessary to appropriately monitor the environment according to the characteristic of land use in the watershed. If it was done by human observation to understand the hillside use condition, then it will take more time and more cost consuming. Remote sensing technology helps to provide the real time data, and can quickly glimpse the land picture status of watershed. This technology enforce the capability of variation region monitoring, and could save the time and cost. How to use this technology in the conservation of hillside deserves our attention.

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