COMPUTER ASSISTED INFORMATION EXTRACTION FROM SATELLITE IMAGES FOR UPDATING NATIONAL LAND USE INFORMATION DATA BASE IN JAPAN

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ABSTRACT:

A personal computer based image interpretation system called CASYII(Computer Assisted System for Image Interpretation) has been developed. In this system, human image interpretation technique is highly supported by it's various graphic functions, and allows users to update land use information effectively by comparing old land use data and latest satellite images on the display. Since FY 1991, the National Land Agency of Japan has been using this system for updating the national land use information data base from latest satellite images. This paper describes the outline of this project, and explains how the human image interpretation technique is combined with digital image processing.

KEY WORDS: SPOT, HSI, Image Interpretation, Land Use Data, CASYII

1. INTRODUCTION

1.1 Digital National Land Information

Since 1974, under the cooperation with Geographical Survey Institute and other agencies, the National Land Agency of Japan has been collecting and updating various land information in digital form called the Digital National Land Information. This information include but not limited to topographic data, geological data, climate data, land use data, administrative division data. Most of the data are produced and updated by in situ investigations, air photo interpretation, topographical map interpretation etc. As the conventional survey method takes lots of time and cost, the National Land Agency had been investigating the possibility of using satellite remote sensing technology for updating the data.

Among the Digital National Land Information, the land use data was expected to be one of the most suitable data to be updated from satellite images. The mesh size of the original land use data was 10m, and 100m mesh data for public use were created from the 10m data with majority vote method. The original land use data were consisted of 15 items, which are shown on Table 1 as "old land use items". In order to reduce the time and cost for updating the land use data, under the contract of National Land Agency and Geographical Survey Institute, Remote Sensing Technology Center of Japan(RESTEC) has been involved in studying the possibility of using satellite data for it.

1.2 Limitation of Point-wise Classification

Landsat TM and SPOT data suggested us possibilities of extracting detailed land cover information from satellite data. However, at the same time, limitation of applying traditional point-wise classification methods, such as the maximum likelihood classification, to the high spatial resolution data have become clear. One of the main reason of this is that the conventional land use items can not always be represented by particular spectral characteristics of satellite data. Fig. 1 shows the spectral characteristics of the each land use item area which were updated by image interpretation of a SPOT/TM composite image.

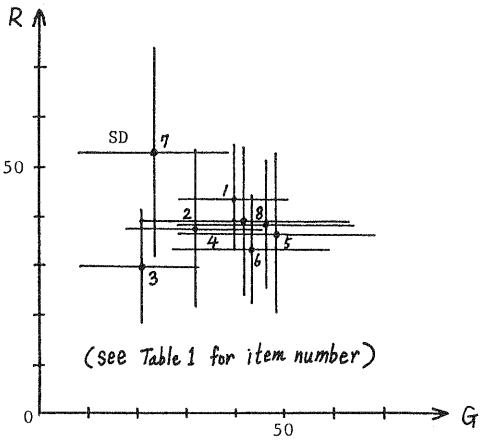


Fig. 1 Spectral characteristics of the each land use item area which were updated by image interpretation of a SPOT/TM composite image. (see Fig.3)

* Moved to the Geographical Survey Institute of Japan in April, 1992.

This result shows the difficulty of applying point-wise classification to satellite data for updating the land use data. Texture analysis is expected to be one of the solution. But, it is still on the way. These situation suggest us the necessity of introducing human image interpretation approach to the procedure of land use data renewal with satellite data.

2. SYSTEM DEVELOPMENT

2.1 Development Concept

In order to break the limitation of conventional classification methods, the authors decided to develop a land use data updating system based on image interpretation approach assisted with various digital image processing techniques. The basic concept of the system development are summarized as follows.

(1)Utilize human image interpretation technique.
(2)Utilize Decision tree method.
(3)Divide roles to 2 levels;
  * Pre/post processing with large computer systems.
  * Update processing with personal computers systems.
(4)Only update the changed areas of the old land use data. (Do not perform classification to all data.)
(5)Utilize various digital image processing technique.
(6)Simplify parameters of operations.
(7)Use additional information such as maps

2.2 Combination of Land Use Items

Considering the spectral and spatial characteristics of satellite data, the 15 land use items were combined to 10 items and "Golf course" was added as a new item. Table 1 shows the relation between the new and the old land use items. In advance to the updating procedure of the land use data, the item number of the old land use data were converted to the new item number according to this table.

2.3 Data Used

The following data were used for this study.

(1)Satellite Data
  *SPOT Panchromatic Data(PA)
  *TM Data
(2)Old Land Use Data
  resolution:10m(work file)
  unit size:1000Pixel X 1000Lines for one 1/25,000 topographic map
  (The size of one 1/25,000 map is 7.5 minutes for Longitude and 5.0 minutes for Latitude)
(3)Reference Map
  *Topographic Map(1/25,000, 1/50,000)

2.4 CASYII

In order to update land use data efficiently and economically, a personal computer based satellite image interpretation system CASYII(Computer Assisted System for Image Interpretation) was developed. This system allows users to update old land use data by using latest satellite data and image interpretation technique with support of various graphic functions of the system.

2.4.1 System Configuration

Fig. 2 shows the system configuration of CASYII. The outlook of the system is shown in Fig. 3.

Table 1. Items of the land use data

No.	New land use item	No.	Old land use item
1	Rice field	1	Rice field
2	Garden or field other than rice field	2 3 4	Field other than rice field Fruit garden Tree garden other than fruit garden
3	Forest	5	Forest
4	Wasted land	6	Wasted land
5	Construction area	7 8	Construction area A (high dense) Construction area B (low dense)
6	Arterial road or railroad	9	Arterial road or railroad
7	Golf Course		NON
8	The other area	10	The other area
9	River area, lake or marsh	11 12 13	Lake or marsh River area A : non artificial area River area B : artificial area
10	Sea shore	14	Sea shore
11	Sea water	15	Sea water

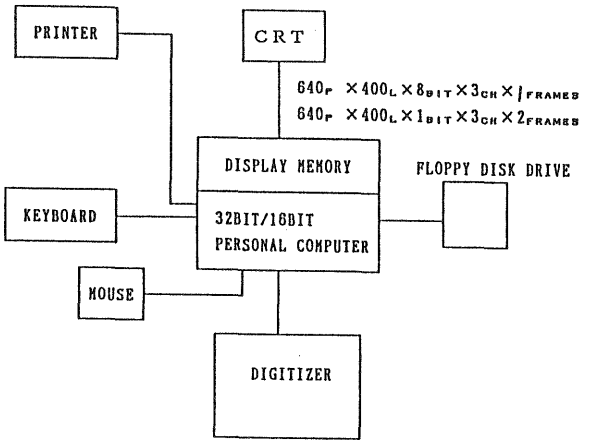


Fig. 2 CASYII System Configuration

Fig. 3 Operation of CASYII

2.4.2 Functions
CASYII has various functions as follows.

(1)Image Display
CASYII has a full color display memory and two 8 color image display memories which allow users to display false color images and pseudo color images.
(2)Flicker & Overlay
CASYII can alternatively display(flicker) two images stored in the two 8 color display memories. These images can be overlaid on the full color image as well.
(3)Area extraction
By using a mouse, users can extract certain areas from the display.
(4)Inter-display memory execution
Logical execution(AND,OR, XOR etc.) can be performed between the two 8 color display memories.

3. METHODOLOGY

3.1 Pre Processing

In order to overlay the satellite data with grid type land use data, it is necessary to perform geometric correction to the data. Further, due to the display size limitation(640x400) of the personal computers, both satellite and land use data must be divided into smaller unit size.

3.1.1 Geometric Correction
In this step, SPOT panchromatic data and TM data are geometrically corrected to overlay on old land use data.

3.1.2 SPOT/TM Data Composite Using HSI Transformation
In order to integrate SPOT PA data with TM data, HSI transformation is performed to the both data. Fig.4 shows the concept of SPOT data composite using HSI transformation.

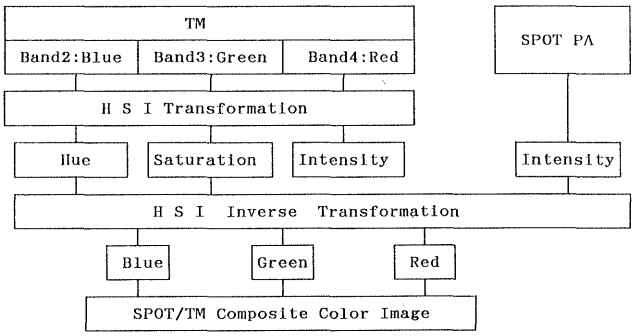


Fig. 4 Concept of SPOT/TM composite using HSI transformation

3.1.3 NVI Data Production
To support land use data updating procedure, the Normalized Vegetation Index(NVI) was computed from TM data using the following formula.

$$NVI = \frac{\text{Band 4 - Band 3}}{\text{Band 4 + Band 3}} \times 100 + 128$$

3.1.4 Sub-division of Data
Pre-processed SPOT/TM data, NVI data and old land use data are sub-divided into a processing unit size and stored in floppy disks to transfer data to personal computers. The data amount of one processing unit size are as follows.

SPOT/TM Data: 512 Pixel X 400 Lines X 3 Ch
NVI Data: 512 Pixel X 400 Lines X 1 Ch
Old Land Use Data : 512 Pixel X 400 Lines X 1 Ch

3.2 Land Use Data Updating Procedure

The pre-processed data will be provided to the personal computer based interactive processing sub-system and the old land use data are updated. Fig.5 shows the main flow of the concept of the updating procedure.

3.2.1 Water/Vegetation/Non-Vegetation Discrimination
(1)Firstly, SPOT/TM false color image is displayed on the CRT(see Fig.6(a)).
(2)The NVI level sliced image is overlaid on the false color image and the threshold level for discriminating water areas from land areas is selected.
(3)similarly, the threshold level for dividing land areas into vegetation areas and non-vegetation areas is selected.

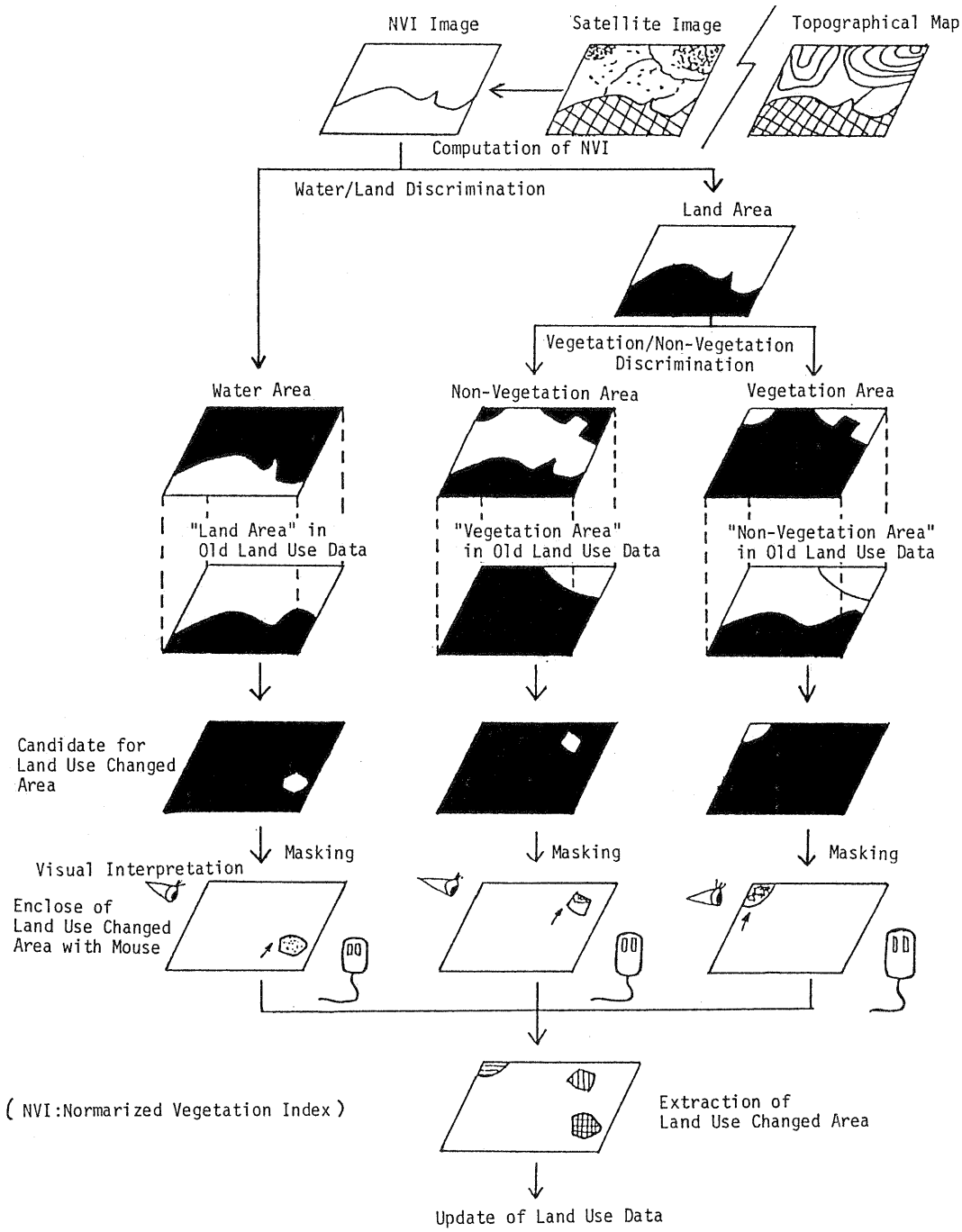


Fig.5 Concept of the land use data updating procedure

3.2.2 Vegetation to Non-Vegetation Renewal

(1)The NVI non-vegetation areas which items were vegetation in the old land use data are extracted. These areas will be the candidate for land use change. Fig6.(b) to (d) shows a example of this procedure.

(2)The candidate areas are colored in yellow and overlaid on the SPOT/TM false color image.

(3)The land use changed areas are selected by image interpretation and are enclosed with mouse.

(4)The new non-vegetation items are assigned to the enclosed areas.

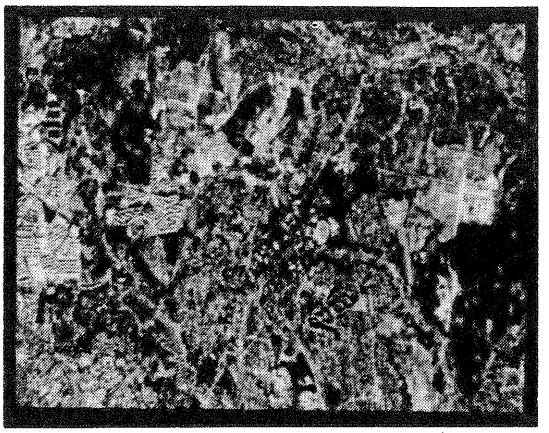
3.2.3 Vegetation to Water Renewal

(1)The NVI water areas which items were vegetation in the old land use data are extracted. These areas will be the candidate for land use change.

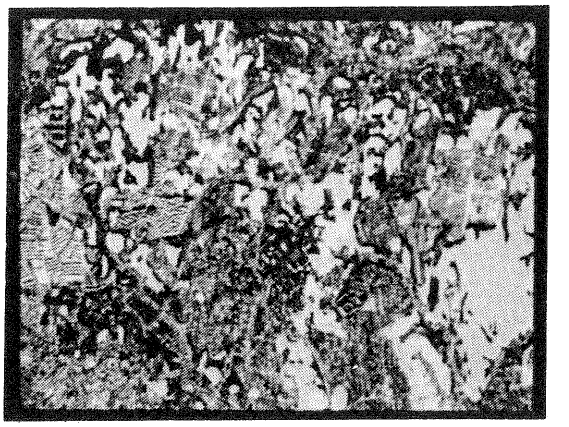
(2)The candidate areas are colored in yellow and overlaid on the SPOT/TM false color image.

(3)The land use changed areas are selected by image interpretation and are enclosed with mouse.

(4)The new water items are assigned to the enclosed areas.



(a) SPOT/TM composite image



(b) Forest area of the old land use data overlaid on SPOT/TM image.

(c) NVI vegetation area overlaid on SPOT/TM image.

(d) Candidate area for land use change derived from logical operation of (b) and (c).

Fig. 6 Images of the land use updating procedure (Forest ->Non-Vegetation)

3.2.4 Vegetation to Vegetation Renewal

(1)The NVI vegetation areas which items were vegetation in the old land use data are extracted. These areas will be the candidate for no change or land use item change within vegetation area.
(2)The candidate areas are colored in yellow and overlaid on the SPOT/TM false color image.
(3)The land use change areas are selected by image interpretation and are enclosed with mouse.
(4)The new vegetation items are assigned to the enclosed areas.

3.2.5 Non-Vegetation/Water Renewal

Similarly, old non-vegetation item areas and old water item areas are updated.

3.3 Post-processing

The land use data updated in the interactive processing sub-system are stored in floppy disks. In the post-processing system, the floppy based small size data are integrated to standard 1/25,000 map size(1000x1000) and various statistics of updated land use data are calculated.

4. EVALUATION

4.1 Test Site and Analyzed Data

4.1.1 Test site

Kanagawa Prefecture was selected as test site for evaluating the system, and total of 32 1/25,000 map area data were updated using the system. The test site is shown in Fig.7.

4.1.2 Satellite data

* SPOT PA data(331-279) of Nov. 11,1989
* TM data(107-35(2)) of Nov. 2, 1989

Fig.8 shows the TM image and SPOT/TM composite image of the test site.

4.2 Result

In order to evaluate the updated result, total of 30 areas were selected for evaluation, and field survey were performed. The result were evaluated in three levels as follows.

A:Correctly updated
B:Changed but the updated item was wrong
C:Unchanged area was updated

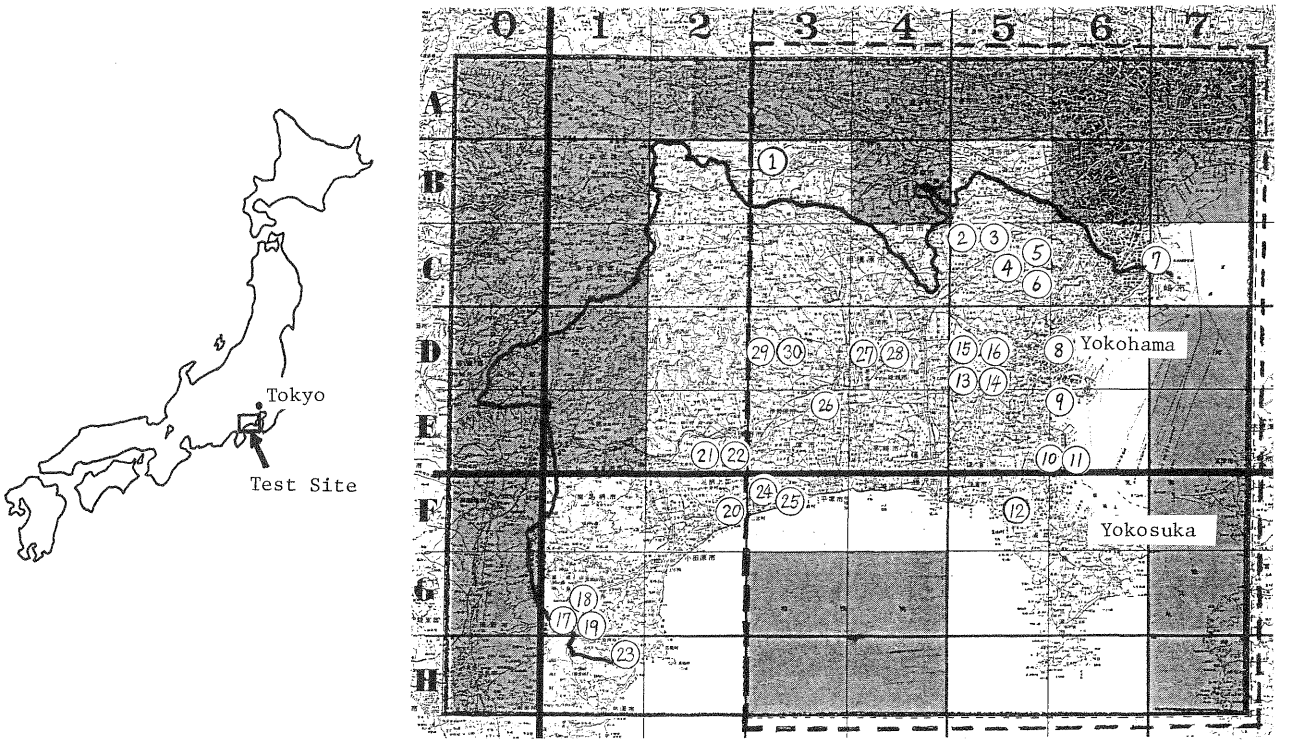
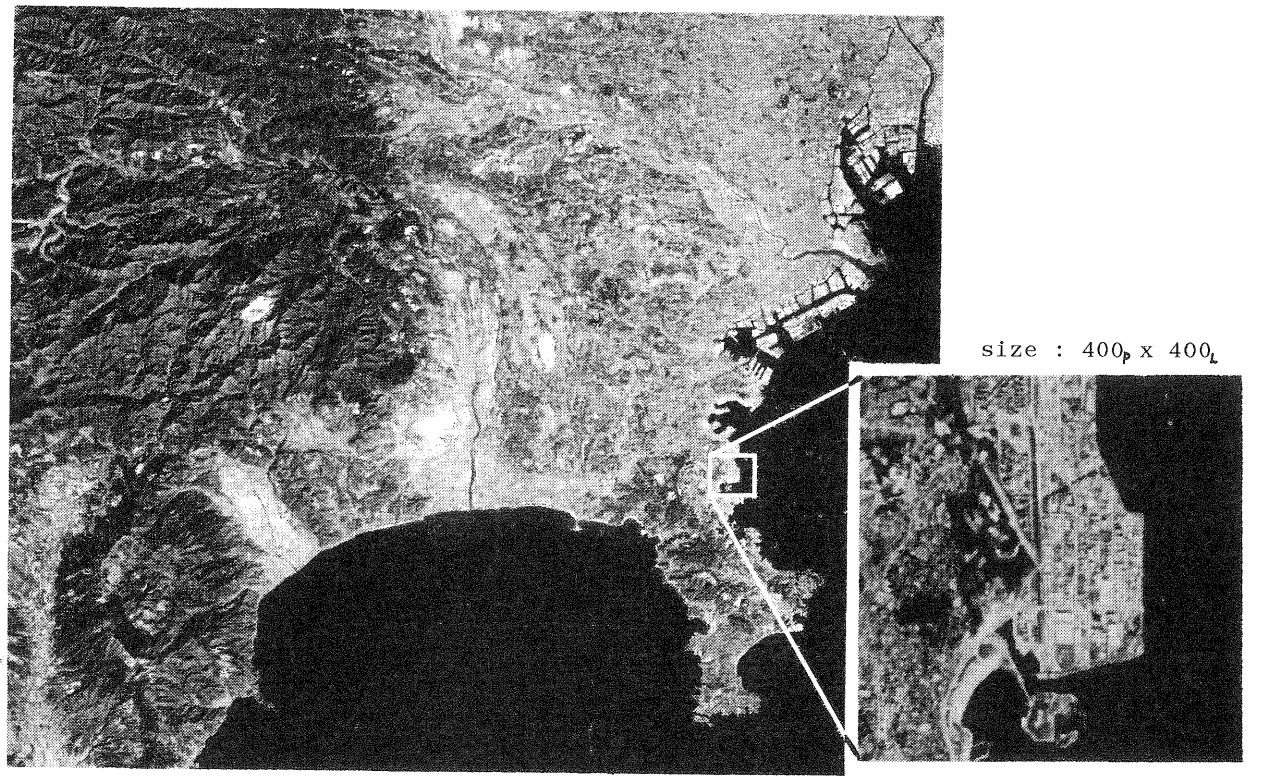


Fig. 7 Map of the test site (Kanagawa Prefecture)



(a)TM image

(b) SPOT/TM composite image
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Fig. 8 Satellite image of Kanagawa Prefecture

Fig. 9 shows an example of field evaluation sheet. Table 2 shows the evaluation result. Among 30 areas, 27 areas were "A", 3 areas were "B" and no "C". This result proved the usefulness of this system for updating the land use data from satellite data.

5. CONCLUSION

Through this study, a personal computer based satellite image interpretation system was developed. This system allows users to update conventional land use data by using latest high resolution technique with support of various functions of the system. The evaluation of the updated data by field survey proved the effectiveness of CASYII for updating land use data from satellite data.

The image interpretation approach seems to be retrogressive to the computer technology advancement. However, so far, the image interpretation approach is one of the most practical way to smoothly transfer the air photo based renewal system to the satellite data based renewal system. Moreover, the various digital image processing functions of CASYII allow users to update land use data more effectively and efficiently than only using photo interpretation technique.

Acknowledgement

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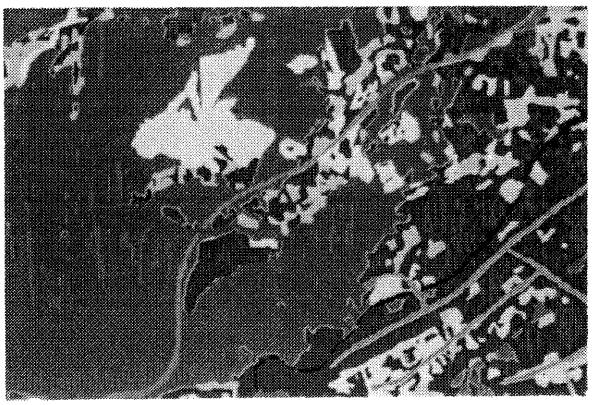
Table 2 Evaluation result

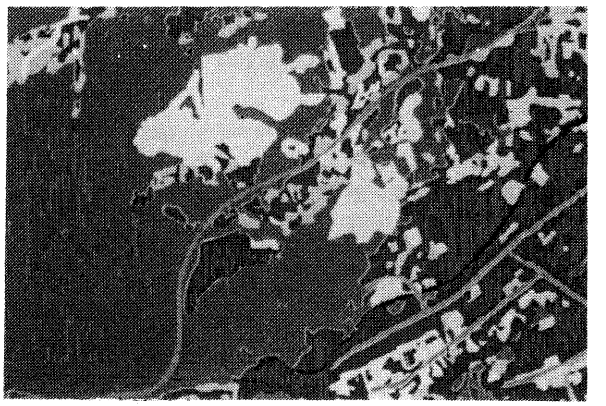
No.	Item of the old land use data	Updated item with satellite images	Evalustion result
1	3. Forest	8. The other area	A
2	3. Forest	8. The other area	A
3	8. The other area	6. Arterial road or railroad	A
4	3. Forest	8. The other area	A
5	5. Construction area	6. Arterial road or railroad	A
6	8. Other area	5. Construction area	A
7	11. Sea water	8. The other area	A
8	11. Sea water	6. Arterial road or railroad	A
9	8. The other area	5. Construction area	A
10	3. Sea water	8. The other area	A
11	8. The other area	5. Construction area	A
12	3. Forest	8. The other area	A
13	8. The other area	7. Golf course	A
14	3. Forest	5. Construction area	A
15	3. Forest	5. Construction area	A
16	3. Forest	8. The other area	A
17	8. The other area	7. Golf course	A
18	3. Forest	6. Arterial road or railroad	A
19	3. Forest	8. The other area	B
20	3. Forest	6. Arterial road or railroad	A
21	3. Forest	4. Wasted land	A
22	3. Forest	4. Wasted land	B
23	8. The other area	5. Construction area	A
24	3. Forest	8. The other area	A
25	8. The other area	5. Construction area	A
26	8. The other area	5. Construction area	A
27	3. Forest	5. Construction area	A
28	1. Rice field	8. The other area	B
29	3. Forest	8. The other area	A
30	8. The other area	5. Construction area	A

(a) SPOT/TM image

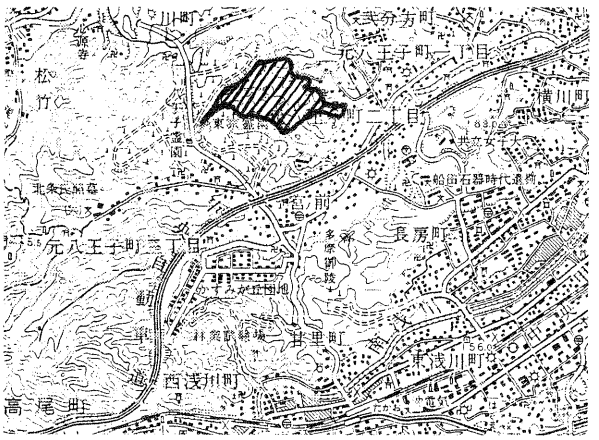


(b) Old land use data image

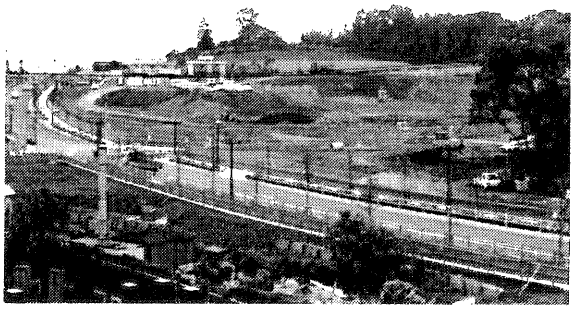
(c) Extracted land use changed area in the SPOT/TM image



(d) Updated land use data image



(e) Map



(f) field site

[Area No. 1] [Change Item : 3.Forest -> 8.The other area]
[Evaluation : A: Correctly updated]

Fig. 9 An example of updated area evaluation sheet