

## RASTER BASED 1/25,000 TOPOGRAPHIC MAP REVISION

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### ABSTRACT:

One to twenty-five thousand scale topographic maps are the largest scale base maps covering the whole territory of JAPAN. GEOGRAPHICAL SURVEY INSTITUTE revises them every 5 to 15 years. In order to shorten this cycle, and to reduce cost and time for the revision process, introduction of computer technology into the revision process of the maps has been studied since 1987 F.Y.

The new method is mainly based on raster technology. The previous maps, the target of the revision, have not yet been digitized. Therefore, it is very difficult to apply the vector based editing method to the revision process. However, it is not so difficult to obtain raster data of the previous map using drum scanner at the time of the revision. Therefore, we intended to develop the method to maintain the raster data of the 1/25,000 scale topographic maps as follows.

First of all, the previous version map is scanned and raster data of the map are obtained. On the other hand, vector data of changed parts are obtained using stereo plotter with coordinate encoders. Then, the raster data of the previous map are edited on a EWS referring the vector data of changed parts. Finally, the edited raster data are directly plotted into film using laser plotter for plate making.

**KEY WORDS:** Cartographic, Map Revision, Raster.

### 1. INTRODUCTION

One to twenty-five thousand scale topographic maps are the largest scale maps covering the whole territory of JAPAN. To revise these maps is one of the main tasks of GEOGRAPHICAL SURVEY INSTITUTE, national organization responsible for surveying and mapping of JAPAN. However, we have to maintain 4,411 sheets of maps in the limited budget and personnel, so a new revision method to reduce cost and time is truly needed.

In addition, the present revision method include the photact process - the special photographic process for copying the scribed plate of the original map - which is liable to make the quality of lines on the scribed plate worse, so the new method is required to maintain the quality of the original.

To solve these problem, we have been studying the introduction of computer technology into the map revision process since 1987 F.Y. One method is to digitize the map in the vector form, to overlay the changed parts which are obtained using the stereo plotter, and to revise the changed parts using CAD technology. However, this method takes much cost and time for initial vectorization of the maps. On the other hand, it is not so difficult to obtain raster data of the map using the scanner at the time of the revision. Therefore, we have chosen to develop the raster based map revision method. The development has not been completed, but so far this method has been shown to be very promising, so we regard this method as the main medium scale map revision method of next generation and are trying to introduce it in near future.

### 2. RASTER BASED 1/25,000 TOPOGRAPHIC MAP REVISION METHOD

#### 2.1 Flow of the Raster Based Revision Method

Figure 1 shows the flow of the raster based 1/25,000 topographic map revision method. First of all, the previous version map is scanned and raster data of the map are obtained. Second, vector data of changed parts are obtained using stereo plotter with coordinate encoders. Third, the raster data of the previous map are revised on a EWS referring the vector data of changed parts. Finally, by

plotting the revised raster data into films, the revised films for reproduction are produced.

The details of each process are described in the following.

#### 2.2 Scanning and Registration

The 1/25,000 topographic maps are printed in 3 colors, black, blue, and brown. In the process of conventional map production, corresponding to colors, line/surface features and annotation, 8 plates listed on table 1 are produced for each map. At this stage in the new method, each plate of the previous map is scanned, and the registration between plates is performed. Once raster data are obtained, this stage is not needed from the next revision.

2.2.1 Scanning Scanning pitch should be small from the point of map reproduction after digital processing, but should be large from the point of efficiency and the number of available scanners. From our experience, it is not enough to reproduce the map if the scanning pitch is 0.05mm, so the experiment of scanning, registration and reproduction by proof press was performed to get the suitable scanning pitch less than 0.05mm.

As a result of the experiment, except for annotation characters 0.025mm pitch was proved to be small enough to get the same quality as the map made by the conventional method. Therefore, all plates except annotation plate were supposed to be scanned in 0.025mm pitch. In this experiment, it took about 30 minutes to scan each plate by Optronics 4040 scanner. And a plate for scanning was produced from each plate in table 1 on a white base film in order to avoid the degradation of raster data image by the reflection at the back of film.

2.2.2 Registration As scanning is performed for each plate for scanning, the registration between plates should be done correctly. In the experiment we adopted the following method.

First of all, the registration plate on which 8 cross lines (hereafter we call them registration marks) are scribed at the 4 corners and 4 sides on the margin of the map is made. Second, each plate

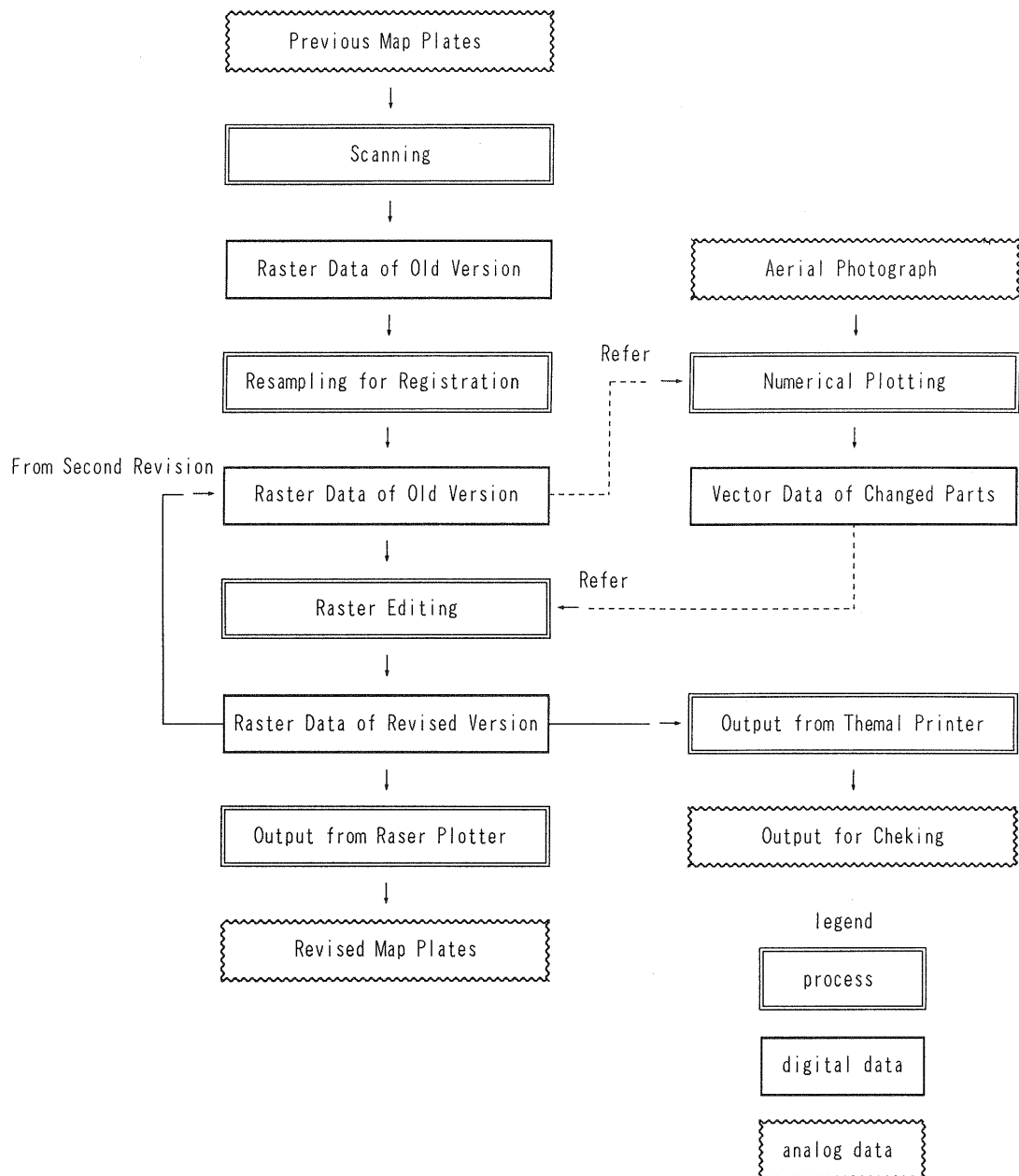


Figure 1 Flow of the Raster Based Revision Method

of the previous map is combined with the registration plate on the white film, and this combined plate is used for scanning. After scanning, the coordinates of registration marks of each plate and corner marks (marks which show the positions defined as the intersections of sheet lines) of the black plate are measured. After the measurement, transformation coefficients between the black plate and UTM coordinate system are calculated from the coordinates of corner marks, and those of between the black plate and other plates from the coordinates of registration marks of the black plate and those of other plates. Finally, after resampling black plate so that the upper sheet line coincides with the line direction of raster data, each plate except black is resampled to be adjusted to black plate using transformation coefficients calculated above. The time which takes for resampling were surprisingly improved by the method which directly resamples the compressed data by run length encoding.

### 2.3 Numerical Plotting

In this stage, vector data of changed parts are obtained by an analog plotter with coordinate encoders. Exterior orientation, data acquisition of changed parts, and the adjustment with raster data of the previous version map are performed on EWS. The development of this stage is ongoing.

### 2.4 Raster Editing

In this stage, raster data corresponding to each plate of the previous version map is edited on the screen while displaying vector data of changed parts as background. The basic edit operations are drawing and erasing, which are attained by the movement of mouse. It means an operator gets a scriber and a eraser on the screen of EWS.

#### 2.4.1 Functions of Raster Editing Program Table

| plate name                | color | conventional method |
|---------------------------|-------|---------------------|
| planimetric feature plate | black | scribing            |
| water plate               | blue  | scribing            |
| relief plate              | brown | scribing            |
| black mask plate          | black | stripping           |
| blue mask plate           | blue  | stripping           |
| brown mask plate          | brown | stripping           |
| annotation plate          | black | photo-lettering     |
| annotation mask plate     | black | brushing            |

Table 1 Constitution of the 1/25,000 topographic map

|  |  |
|--|--|
| <p>Display functions</p> <ul style="list-style-type: none"> <li>• Selection of scale of display</li> <li>• Selection of position of display(scroll)</li> <li>• Selection of plates to be displayed</li> <li>• Selection of display of adjacent sheet</li> <li>• Selection of display of vector data</li> </ul>   | <p>Selection of thickness of drawing</p> <ul style="list-style-type: none"> <li>• Line No.0 special(0.08mm)</li> <li>• Line No.1(0.10mm)</li> <li>• Line No.1 special(0.15mm)</li> <li>• Line No.2(0.20mm)</li> <li>• Line No.3(0.30mm)</li> <li>• Line No.4(0.40mm)</li> <li>• Line No.5</li> <li>• Road 0.4mm in width</li> <li>• Road 0.8mm in width</li> <li>• Road 1.0mm in width</li> <li>• Road with separation zone 1.0mm in width</li> <li>• Scriber with single needle</li> <li>• Scriber with double needles</li> <li>• Scriber with triple needles</li> </ul> <p>Selection of thickness of erasing</p> |
| <p>Basic drawing and erasing functions</p> <ul style="list-style-type: none"> <li>• Selection of a plate to be edited</li> <li>• Selection of edit mode <ul style="list-style-type: none"> <li>- Freehand drawing</li> <li>- Line drawing(sharp and round)</li> <li>- Interpolated line drawing</li> <li>- Rotary scriber drawing</li> <li>- Surface drawing</li> <li>- Point symbol drawing</li> <li>- Freehand erasing</li> <li>- Line locus erasing</li> <li>- Surface erasing</li> </ul> </li> </ul> | <p>Drawing Modifier</p> <p>Drawing in various line types</p> <p>Drawing in various surface types</p> <p>Undo, Redo</p> <p>Others</p> <p>Generation of grid and rule, etc.</p>  |

Table 2 Functions of Raster Editing Program

2 shows the functions of raster editing programs. As for display, the raster data of plural plates and the vector data can be simultaneously displayed. In addition, scrolling and the selection of scale (zoom in or out), plates to be displayed are available, and the display of adjacent sheet and vector data can be controlled.

As for the basic drawing and erasing functions, the selection of a plate to be edited, drawing or erasing mode, and the thickness of drawing or erasing are available.

In drawing or erasing mode, the movement of mouse defines several ways of drawing or erasing figures. Freehand drawing defines exactly same figure as the locus of mouse. Line drawing defines the lines

connecting points where a mouse is clicked. In line drawing, round mode makes the corner formed by 2 lines round like the round needle of scriber, and sharp mode makes the corner sharp like the chisel. Interpolated line drawing defines the smooth curve formed by the spline interpolation between points where a mouse is clicked. Rotary scriber drawing defines a figure formed by the locus of the edge of a stick when a mouse drags the other edge. This corresponds to the simulation of rotary scriber on the screen. Surface drawing paints the inside of the polygon formed by points where a mouse is clicked. Point symbol drawing sets the symbol selected in advance at the point where a mouse is clicked. Freehand erasing has the same function as freehand drawing except erasing instead of drawing. Line locus erasing erases the locus of the line

which has specified direction and length. Surface erasing has the same function as surface drawing except erasing instead of drawing.

The selection of thickness of drawing specifies the line thickness used for drawing. In addition, double or triple lines for representing roads can be drawn directly as shown in table 1. This corresponds to the simulation of the scribe with double or triple needles. By this function, roads whose weight is the largest in changed parts can be drawn rapidly and beautifully.

Drawing modifier is the operation for the locus of line which is drawn just before the operation and stored in memory. For example, following operations are among drawing modifiers. Figure 2 shows map symbols on 1:25,000 topographic maps.

- Replace the line drawn by the symbol, such as foot path, railroad and power line.
- Parallel to the line drawn as a road or others, generate the modified figure, such as the symbols of an elevated or cut-out section, revetment.
- Generate the pattern such as hatch and figure representing quarry inside the surface drawn.

Drawing modifier is explained in detail in the case of the generation of an elevated section of road. First of all, an operator has to specify whether the symbol is generated on one side of the road or both sides. Second, he/she has to select whether the symbol is accompanied with the whole locus of mouse or part of the locus. Moreover, if the symbol is generated as the succession of an elevated section already drawn, the connection, which is very important for a foot path or railroad, should be considered. The way of connection should be specified, such as no consideration for connection, or to make one side connect by adjusting the phase of pattern, or both sides by scaling the pattern up or down. This program analyzes these situations for all line types defined in the map regulations, and urges the operator to make the correct instruction.

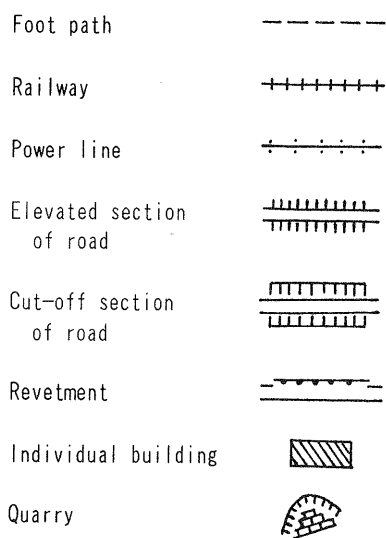


Figure 2 Examples of map symbols on 1/25,000 topographic maps

Undo is the operation to restore data to the status just before the drawing or erasing operation if it is not appropriate. Redo is the operation to revive the operation undone and restore data just before the undo operation. As the raster editing program stores edit operations after the start of this program (or after data saving operation), editing process can be easily undone or redone. However, if some operation is performed after undo, redo for this undo operation is not available. In scribe editing, if varnish is put on the place already scribed, it is very difficult to redraw. Therefore, raster editing is far better than scribe editing as for error corrections.

2.4.2 Format of Raster Data As raster data handling greatly influences the performance of editing program and user friendliness, it was carefully developed. Raster data consists of one file per one plate of each map sheet. Raster data of each map sheet consists of black plate(main planimetric features), blue plate(shoreline), brown plate(contour), black mask plate(residential area with trees), blue mask plate(water surface), brown mask plate(national highway), annotation plate, annotation mask plate(plate for opaquing parts overlapping with annotations), black, blue and brown plate for revision. Here, as for black, blue and brown plate, new and old version plates are prepared for editing convenience.

Raster data for each plate are binary image, and are compressed in run length encoding because each plate requires about 25MB memories if it is simply huddled as the image of one bit depth. In run length encoding, after data of each line are divided into sets of successive pixels of value 1(a set of successive pixels is called 'run') and that of value 0, image is described as a sequence of the lengths of runs.

If run length encoding is adopted for full image, and subimage to be displayed is located at the right side of the image, all pixels before the start pixel of subimage have to be read and decoded. This is not efficient from the point of both access time and calculation time. Therefore, after an image is divided into blocks of 256 pixels by 256 lines, run length encoding is adapted for each block(in this case, run length encoding describes only runs of value 1). As the width of the block is 256, the end position of run can be represented in a byte. For each line in the block, the number of runs of value 1 is recorded at the top of the record, and the start and end positions of runs of value 1 follow. And, each file has an index division in which the length and position in the file for each block are recorded, so the blocks needed can be randomly accessed. Moreover, the block which consists of only pixels of value 1 or only pixels of value 0 is noted as such in the index division, and is recorded no data. This is very effective for mask plates. Due to these devices, both the compression of amount of data and the rapid display can be attained.

Raster editing program saves all changes in a disk file after the program starts to run. Due to this, the function of undo and redo are attained. Moreover, in case the program execution is aborted by a blackout or bugs, this information is used for data restoration.

2.4.3 Output for Check When the operator or inspector checks the revised map, a hardcopy of the map is required. Thinking of introducing the raster editing method to plural work sites, the revised

map is output to two or three pieces using the non-expensive color thermal printer for small format.

### 2.5 Film Output and Reproduction

Topographic map data edited by the raster method is output on films using laser plotter. In this case, one method is to output mask plates and non-mask plates respectively, and to make plates for reproduction by photo process. The other method is to output plates for reproduction directly after combining mask and non-mask plate of same color on the computer. The latter is preferable from the point of work efficiency, but requires the raster plotter with 0.0125 mm output pitch for halftone plate. Reproduction process after this is same as conventional method.

### 3. MERIT OF RASTER BASED MAP REVISION

When the raster editing method is introduced in the routine work, following merits are expected.

First of all, the instruments required for edit change from a light table and scribes to CRT screen and a mouse. The efficiency of this method is not clear at present because it depends on programs. However, interactive editing on EWS gives less stress to the operator because different from scribing it permits the cancel of edit operation. In addition, the conventional method allows editing for only one plate simultaneously, because photo process intervenes every time after revising one plate. On the other hand, in the new method all plates except annotation mask can be edited simultaneously, so the process for the map revision becomes simple and its control becomes easy.

Second, the raster based map revision causes no degradation due to photact process. The raster method has a possibility to cause degradation when map plates are scanned, but from the experiment so far, there is practically no problem if we use such map plates as lines on map plates are thick enough after photact process. In addition, once map plates are scanned, no more scan is required. Therefore, the degradation is not accumulated by the repeat of revision. Namely, the degradation by photact process cannot be recovered, but does not get worse any more.

Finally, raster data of topographic maps are obtained as the by-product of the raster based revision. So far, GEOGRAPHICAL SURVEY INSTITUTE has been engaged in digitizing maps in vector format and has been servicing Digital National Land Information and so on. As digital map data in raster format are thought to get different demand from vector data, we intend to study how to serve raster data in future.

### 4. CONCLUSION

Raster based 1/25,000 topographic map revision method improves the efficiency of map revision while keeping the quality of map, prevents the degradation, and produces digital map data in raster format. GEOGRAPHICAL SURVEY INSTITUTE in Japan regards this method as most promising way of map revision, and is endeavoring to make this method practical.

Medium or small scale map is demanded that the positions of objects on the map are accurate and map representation is easy to see with full use of displacement, generalization, break to avoid

overlap and selection of what to represent. For these demand on map compilation, not a vector based method which is good at batch processing but a raster based method is suitable. In addition, different from digital large scale map, raster data cannot be used for analysis usually attained in vector based GIS, but can be easily displayed on the screen as a map easy to see. Moreover, as medium or small scale map has been already made in many cases, a raster based method has the advantage of digitizing map because the digitization is easily performed at the time of revision. Therefore, a raster based revision method has far advantage over a vector based method. Several concepts mentioned here are useful when a raster based method is applied for the medium scale map revision.

### 5. REMAINING PROBLEMS

The development of raster based 1/25,000 topographic map revision method has not been completed yet, and there are still some problems remaining.

First of all, to complete programs for numerical plotting and raster editing is most important and urgent. Figure 3 shows a screen of raster editing program being developed now. In addition, it is also urgent to prove this revision method to be effective by doing an experiment through all process using developed programs.

Second, the handling of a mouse is not superior to a pen. So to use a pen type digitizer instead of a mouse should be considered.

Third, it is necessary to decide how to handle the annotation plate in this method. The way we are now developing is as follows. The annotation plate is scanned in 0.0125mm pitch, and other plates are scanned in 0.025mm pitch. And the annotation plate is transformed into 0.025mm pitch to be handled in raster editing program. Moreover, in raster editing stage, for each annotation a sequence of letters, position, direction, font type, letter size and spacing between letters are input interactively. After that, raster data in 0.0125mm pitch is produced from these data by a batch processing and is merged with raster data in 0.0125mm pitch above mentioned.

Finally, as future plan we think of two ways of obtaining changed parts. One is to digitize changed parts from existing large scale maps, and the other is to scan aerial photographs by a small type scanner, to rectify them into orthophotos by using DEM, and to get changed parts after overlaying orthophotos on raster data of a previous version map. As the scale of existing maps used for 1/2,500 scale map revision are about ten times of the map to be revised, or the scale of aerial photographs are about same as that of the map to be revised in many cases, it seems that the limit of accuracy can be easily cleared for these ways. In anycase, study should be done from the aspects of both system development and accuracy.

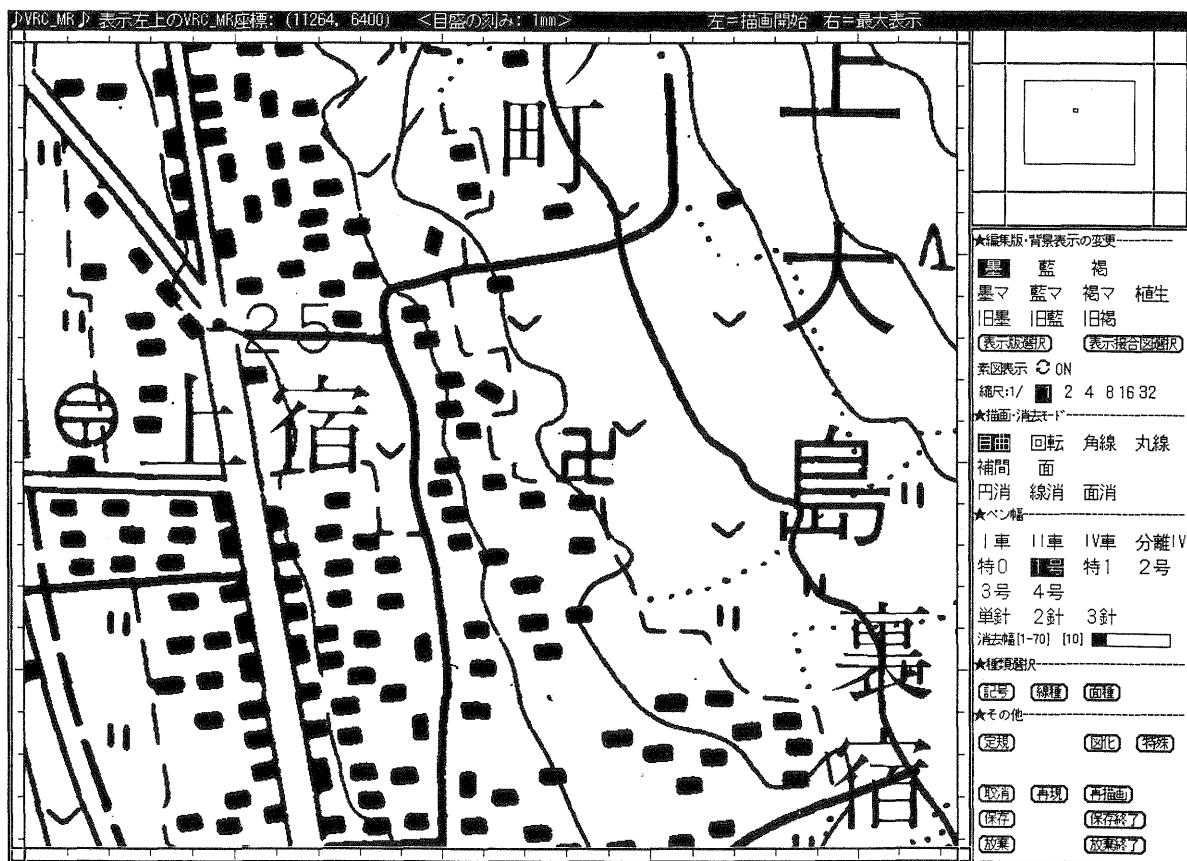


Figure 3 CRT Screen where Raster Editing is Performed