

SPECIFICATION

1. TITLE OF THE INVENTION

DEVICE FOR DISPLAYING MAP INFORMATION

2. WHAT IS CLAIMED IS:

A device for displaying map information, said device being configured to store map information in a storage device, read said map information from said storage device, and displays it on a display device, wherein:

Said map information consists of multiple map pieces respectively associated with various magnification factors;

Said maps are respectively classified into multiple hierarchical levels according to the display priority; and

Said maps and said hierarchical levels are switched according to said magnification factor.

3. DETAILED DESCRIPTION OF THE INVENTION

FIELD OF INDUSTRIAL APPLICATION

The present invention pertains to a device applied to navigation systems in order to display map information. Particularly, it pertains to the data structure of map information stored in a storage device, e.g., a CD-ROM.

SUMMARY OF THE INVENTION

According to the present invention, the map-information display device is configured to store map information in a storage device, read the map information from the storage device, and display it on a display device. The map information consists of multiple map pieces, which are respectively associated with various magnification factors. Each map is classified into multiple hierarchical levels according to the display priority. The maps and hierarchical levels are switched according to the magnification factor, making it possible to reduce the amount of data to be prepared, achieve high-speed access, and continuously alter the magnification factor.

PRIOR ART

As for navigation systems, autonomous navigation systems configured to display a map and the vehicle's position on the screen of a CRT display are beginning to be used in practical applications. Incorporating location information pertaining to the vehicle's external environment is also being considered for future applications. Map information is stored in a storage device, e.g., a CD-ROM. Conventionally known map databases are typically configured to prepare maps in different stages according to how much detail the map should include. For example, one such system that has been proposed is configured to prepare maps in the following five levels: A national map, a regional map, a district map, a basic map, and a detailed map. These map levels can be selected through the operation of switches, etc.

PROBLEMS TO BE RESOLVED BY THE INVENTION

One problem with the above-mentioned map data structure is the limitation in terms of the maps' magnification factor (scale ratio). It will be preferable if the magnification factor of a map can be set arbitrarily at any given scale according to the user's preference. However, in order to achieve such an arbitrary magnification-factor setting with the conventional data structure, it is necessary to provide a large number of stages for different levels of a map, which not only results in a massive amount of data but also an increased number of accesses, thus hindering the ability to operate at high speed.

Accordingly, the purpose of the present invention is to provide a device for displaying map information, such a device being capable of altering the magnification factor continuously or in small steps without entailing the aforementioned problems, such as the increased amount of data to be prepared or the slow access speed.

MEANS FOR RESOLVING THE PROBLEM

According to the present invention, the map-information display device stores map information in a storage device, reads the map information from the storage device, and displays it on a display device.

The map information consists of multiple map pieces, which are respectively associated with various magnification factors. Each map is classified into multiple hierarchical levels according to the display priority. The map and hierarchical levels are switched according to the magnification factor.

OPERATIONAL ADVANTAGES

Map information stored in a storage device, e.g., a CD-ROM, consists of several, for example, three pieces of the map as classified by the magnification factor. These maps are referred to as the zeroth-order mesh, the first-order mesh, and the second-order mesh, from the lowest magnification factor to the highest, i.e., from the widest field of view on the CRT display

to the narrowest. The data for each mesh is divided into multiple, for example, ten hierarchical levels (e.g., 0 to 9) according to the display priority.

Suppose the magnification factor of the display is altered through the operation of switches, such as zoom keys. In this case, the zeroth-order mesh data are used in the low magnification factor range; the first-order mesh data are used in the medium magnification factor range; and the second-order mesh data are used in the high magnification factor range. The data for each mesh are divided into hierarchical levels. Accordingly, whether to show or hide items in the map is controlled according to the hierarchical level when the magnification factor is altered within the range that involves the use of data in the respective meshes. The magnification factor for the display can be changed continuously through data processing. As the magnification factor for the display increases, entailing the increased level of detail, the pieces of information with lower priority are sequentially added to and thus displayed together with the higher-priority pieces of information. As such, the data for each mesh are classified into hierarchical levels, thus making it possible to alter the magnification factor continuously or in small steps, doing so with a small amount of data and through a high-speed operation.

WORKING EXAMPLES

The following is an explanation of an embodiment of the present invention with reference to drawings:

Figure 1 shows an example of a navigation system to which the present invention can be applied. In Figure 1, reference code 1 represents a data bus. Microcomputer 2 is coupled to data bus 1. Additionally, microcomputer 2 is supplied with output signals from vehicle sensors 3. Vehicle sensors 3 used herein include a geomagnetic sensor (to detect the absolute orientation), a vehicle speed sensor (to detect the distance traveled), a steering sensor (to detect the direction of travel), and a transmission sensor (to detect the forward or backward movement of the vehicle).

Data bus 1 is also provided with a CD-ROM driver (referenced with the code number 4) so that the map data stored in CD-ROM 5 is transferred to microcomputer 2 through CD-ROM driver 4 and data bus 1. Furthermore, data bus 1 is provided with operation switches 9 that can be operated by the vehicle operator.

Data from microcomputer 2 is fed to depiction processor 6, which forms image data. The image data thus formed are then fed to color CRT display 8. The image data is also fed to a D/A converter (not shown) so that the image signal is fed to color CRT display 8 in the form of analog RGB outputs. Color CRT display 8 is mounted on the car dashboard.

Operation switches 9 are arranged as shown in Figure 2. Reference code 11 represents cursor keys. Cursor keys 11 are used to move the cursor on the map view, scroll up and down the screen, and select desired options with the cursor. Reference code 12A represents a zoom-in key, and reference code 12B represents a zoom-out key. One can display an enlarged map

view by pressing zoom-in key 12A or can shrink the map on the screen by pressing zoom-out key 12B. Reference code 13 represents a function key. Function key 13, when pressed, displays various functions (such as the options of items to be displayed, the destination setting and search features, etc.) in a menu format on a section of the screen (e.g., the right-hand side) so that the user can select desired options from the menu with cursor keys 11. Reference code 14 represents a set key. The function chosen with cursor keys 11 is executed when set key 14 is pressed.

Figure 3 shows a flowchart that illustrates the operation of the navigation system described above. First, an assessment is performed to determine if the cursor has moved (step 21). If the cursor has not moved, then an assessment is performed to determine if the vehicle has moved (step 22). If the vehicle has not moved, an assessment is performed to determine if zoom key 12A or 12B has been pressed (step 23).

If the cursor or the vehicle has moved, an assessment is performed to determine if any contiguous map data are required (step 24). If contiguous data are unnecessary, a depiction operation will be performed to display the map on color CRT display 8 (step 26). When contiguous data are required, such map data is read from CD-ROM 5 (step 25), followed by the execution of the depiction operation (step 26). After the depiction operation, the control shifts to step 23 to assess if zoom key 12A or 12B has been pressed.

If zoom key 12A or 12B has been pressed, an assessment is performed to determine, based on the zoom factor, whether the map level needs to be changed (step 27). When no change of the map level is required, a depiction operation (step 29) is executed so as to display the map on color CRT display 8. If a change of the map level is required, the map data is read from CD-ROM 5, after which the control shifts to the depiction operation (step 29). If zoom key 12A or 12B has not been pressed or after the depiction operation (step 29), the control returns to step 21 and repeats the same actions as those described above.

Vector, character, and font data are recorded on CD-ROM 5. Figure 4 shows the format of said data sets recorded on CD-ROM 5.

Vector data are recorded on CD-ROM 5 in units of "records" (shown in Figure 4) for each link of line segments drawn. Line segments are drawn as a linked set of multiple lines, as shown in Figure 4B. That is, coordinate data indicating the positions of the start and end points of the respective multiple lines, i.e., (X(1), Y(1)), (X(2), Y(2)), and so on, are included in vector data. Additionally, a single record in vector data consists of the class, link number, subclass, route number, hierarchical level, the number of interpolation points, and coordinate data. The class represents the type of road, such as a national, toll, local road, etc. The subclass represents a more detailed category than said class and includes the rank of a national road, etc. The route number represents the subclass of each class, such as the number given to the road. The link number represents the number of the link. The hierarchical level represents the numeric data

(0 to 9) corresponding to the display priority. The number of interpolation points represents the number of start and end points in the link (e.g., six in the example shown in Figure 4 B).

Figure 4C shows the format of character data. The character data consists of the class, subclass, serial number, hierarchical level, normalized coordinates (X, Y), number of *Kanji* words, and *Kanji*-character string. The class represents, for example, data used to distinguish the names of intersections, places, facilities, and railway stations. The subclass represents data for the subcategory of each class. The sequence number represents the number used within each class. The normalized coordinates represent coordinate data that indicate the position at which characters should be displayed. The hierarchical level represents data that indicates the display priority in the same manner as described above. The number of *Kanji* words represents the number of *Kanji* characters. And the *Kanji*-character string is a standardized character code.

The font data is recorded on CD-ROM 5 in the format shown in Figure 4D. The class refers to data used to distinguish font types. For example, highway numbers, national and main road numbers, parking lots, etc., are distinguished by class. The font number is a number that specifies the font pattern. The serial number is a number consecutively added, for example, in the order of creation. The normalization coordinates are data used to indicate the position at which the font should be displayed.

CD-ROM 5 contains three sets of map data with different magnification factors, as shown in Figure 5. These three data sets are referred to as the "zeroth-order mesh," the "first-order mesh," and the "second-order mesh," respectively, according to the length of one side of the map displayed (from the longest to the shortest).

In the zeroth-order mesh, map 30 of the area with length "a" on one side constitutes a single file. Data are read out from CD-ROM 5 on a file-by-file basis. In the first-order mesh, map 31 (indicated by the shaded area in the figure) of the area with length "b" on one side (i.e., a segment of the side "a" of map 30) constitutes a single file. For example, the size of map 31 is defined by dividing the vertical and horizontal lengths of map 30, respectively (to a size of one-sixteenth). In the second-order mesh, map 32 (indicated by the shaded area in the figure) of the area with length "c" on one side (i.e., a segment of side "b" of map 31) constitutes a single file. For example, the size of map 32 is defined by dividing the vertical and horizontal lengths of map 31, respectively (to a size of one-sixteenth). One of said maps 30, 31, and 32 are read from CD-ROM 5, processed in depiction processor 6, and then displayed on the screen of color CRT display 8. Each map file may be divided into four parts to achieve the scrolling feature.

The above-mentioned zoom-in (enlarge) and zoom-out (shrink) are achieved by multiplying the map vector data by a coefficient that corresponds to the magnification or reduction factor. This process is performed in depiction processor 6. Once map 30 (i.e., the zeroth-order mesh) is enlarged through a zoomed-in action and thus reaches the size of map 31 (i.e., the first-order mesh), the level of the map is changed from the zeroth-order mesh to the first-order mesh. In other words, map 31, i.e., the first-order mesh, is read from CD-ROM 5;

once map 31 (i.e., the first-order mesh) is enlarged through a zoomed-in action and thus reaches the size of map 32 (i.e., the second-order mesh), the level of the map is changed from the first-order mesh to the second-order mesh; and when zoomed in further, a map of the size with side “d” on one side is displayed. The zoom-out operation is performed in reverse of the zoom-in operation described above.

The map switches between these three levels as the hierarchical level is altered stage-by-stage according to the magnification factor. In this example, ten hierarchical levels are set from 0 to 9, as shown in Figure 6. Data indicating the hierarchical level is appended to each data record stored in CD-ROM 5 (see Figure 4).

As mentioned above, the mesh order is switched between the zeroth, first, and second orders; that is, the level of the map is altered through the zoom-in or zoom-out operation. Changes are made to hierarchical levels within each mesh. For example, the hierarchical level in the first-order mesh changes sequentially from 0 to 9 in conjunction with the zoom-in operation, through which map 31 is enlarged from the size with side “b” to that with a smaller side length. The hierarchical levels of the other zeroth-order and second-order meshes will also be changed in a similar manner. In Figure 6, the areas inside the graph represent the hierarchical levels to be displayed, whereas the areas outside the graph represent the hierarchical levels that are not displayed. The sequence of hierarchical levels 0 to 9 corresponds to the display priorities, according to which 0 is the highest display priority, meaning that the display priority is lower with higher numbers.

The following is an explanation of the change in hierarchical levels in a mesh with reference to Figure 7. The horizontal axis of Figure 7 shows the magnification factors as logarithms. Figure 7 assumes that the magnification factor can be changed in the range of 1 to 50. The higher the magnification factor is, the more the map is enlarged. Reference codes 33A, 33B, and 33C represent the show and hide thresholds, respectively. Threshold 33A represents the threshold value used when the display density is lowest. Threshold 33B, indicated by a dashed line, represents the threshold value used when the display density is medium. Threshold 33C represents the threshold value used when the display density is highest. The display density can be set arbitrarily through the operation of cursor keys 11 and function key 13 included in operation switches 9.

The hierarchical levels above these thresholds are deemed to be within the range to be displayed, while the levels below these thresholds are in the range to be hidden. As the magnification factor increases, the hierarchical levels displayed become higher. For example, when the display density is low in the lowest magnification-factor range, data with a hierarchical level of 0 are displayed. Data with hierarchical levels of 0 and 1 are displayed when the display density is medium. Data with hierarchical levels 0, 1, and 2 are displayed when the display density is high.

As such, the hierarchical levels displayed vary with the magnification factor. Accordingly, the amount of information and thus the level of detail displayed in the map view on color CRT display 8 increase as the user holds zoom-in key 12A to enlarge the map on the display. For example, through a zoomed-in operation, smaller roads and details of highway interchanges are displayed together with main roads. More detailed information other than the information about roads is also displayed as the hierarchical level becomes higher.

The hierarchical levels shown in Figure 7 are determined, for example, by using the integer of the value obtained from the formula below:

$$\text{Hierarchical level} = \text{Display density} - \left(\log_{10} \left(\frac{l}{S} \right) \right) \times 5.8859$$

Display density: 0 (when low), 1 (when medium), or 2 (when high)

S: The length of one side of the map that is displayed on the screen

l: The length of one side retained as the map data

5.8859: An example constant used to form a slope

Incidentally, the present invention can be applied to a map-information display device for other systems besides navigation systems. Additionally, the storage device used herein is not limited to a CD-ROM but may be a floppy disk, etc.

EFFECTS OF THE INVENTION

Unlike the prior art that requires the preparation of maps in multiple levels corresponding to the magnification factors, the present invention does not need to duplicate map data for different magnification factors in the storage device and, therefore, can prevent the accumulation of a massive amount of data. The present invention makes it easy to change the magnification factor continuously or in small steps. Therefore, it is effective in preventing the operation speed from slowing down due to an increase in the number of accesses.

4. BRIEF EXPLANATION OF THE DRAWINGS

Figure 1 shows a block diagram of an example navigation system to which the present invention can be applied.

Figure 2 shows a front view that illustrates an example arrangement of the control switches.

Figure 3 shows a flowchart used to describe the operation of the navigation system.

Figure 4 shows a schematic diagram used to describe the structure of data recorded on the CD-ROM.

Figure 5 is a schematic diagram used to describe the map data recorded on the CD-ROM.

Figures 6 and 7 show schematic diagrams used to explain the hierarchical levels of map data.

EXPLANATION OF REFERENCE CODING

- 5: CD-ROM
- 9: Operation switches,
- 11: Cursor keys,
- 12A: Zoom-in key
- 12B: Zoom-out key

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Figure 1

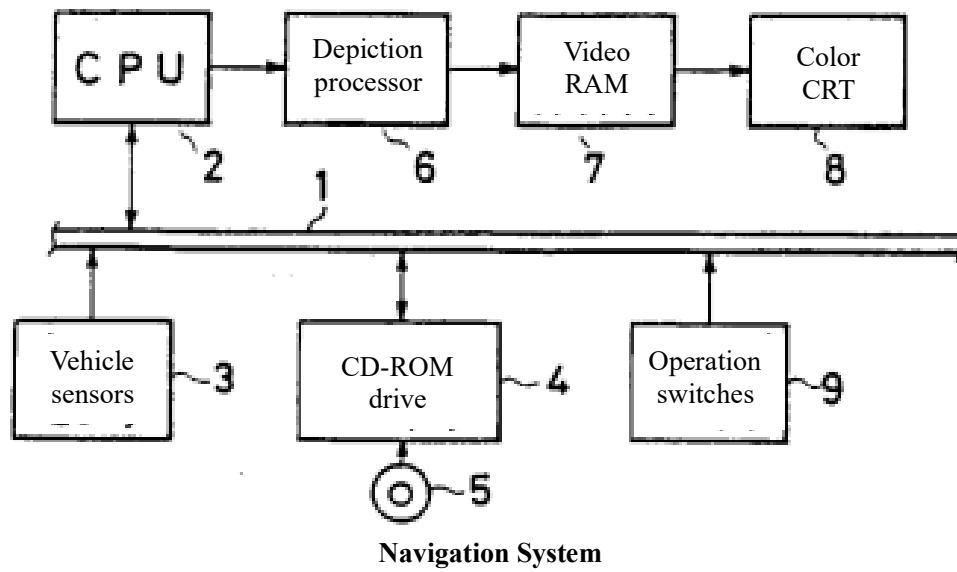
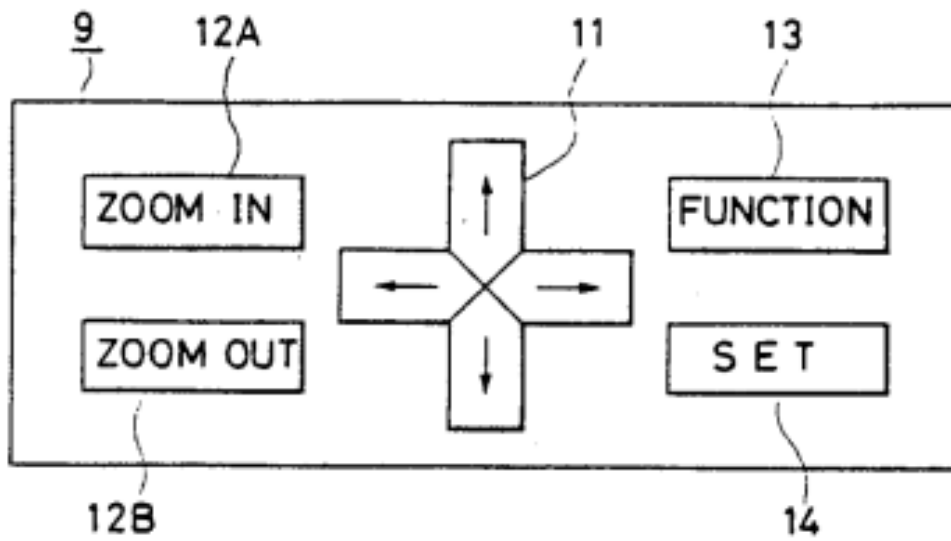
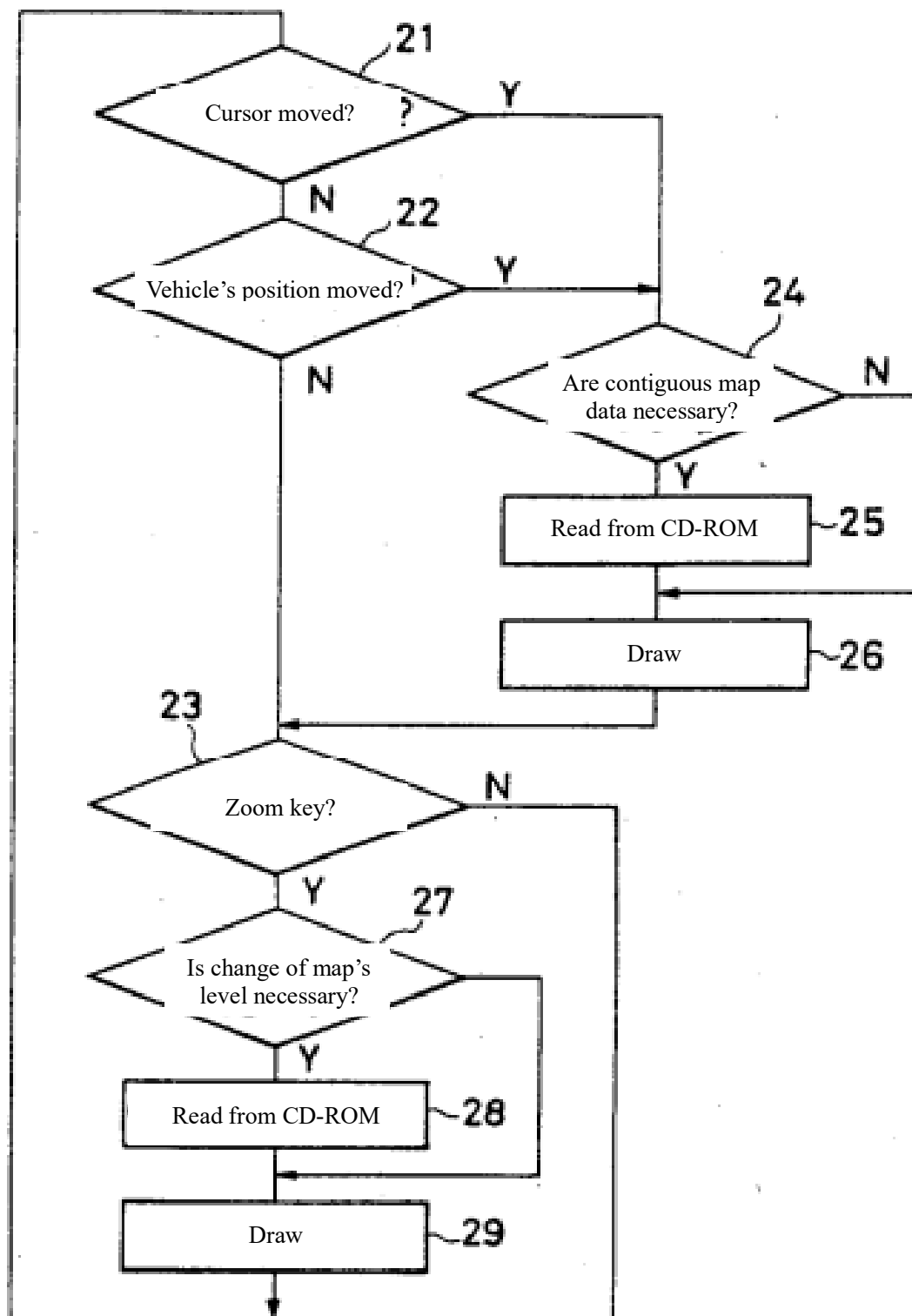


Figure 2



Layout of Operation Switches

Figure 3



Flowchart

Figure 4

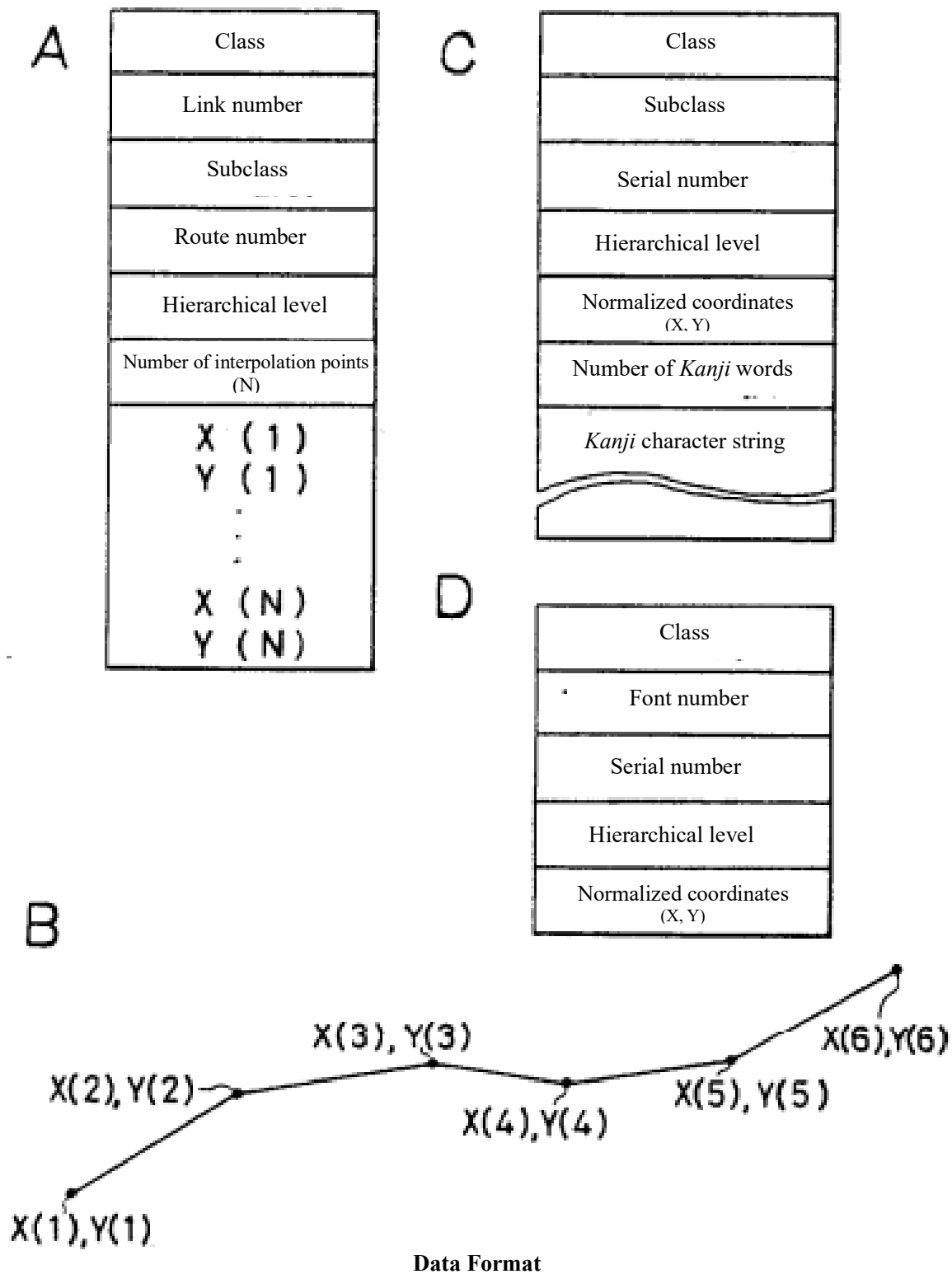


Figure 5

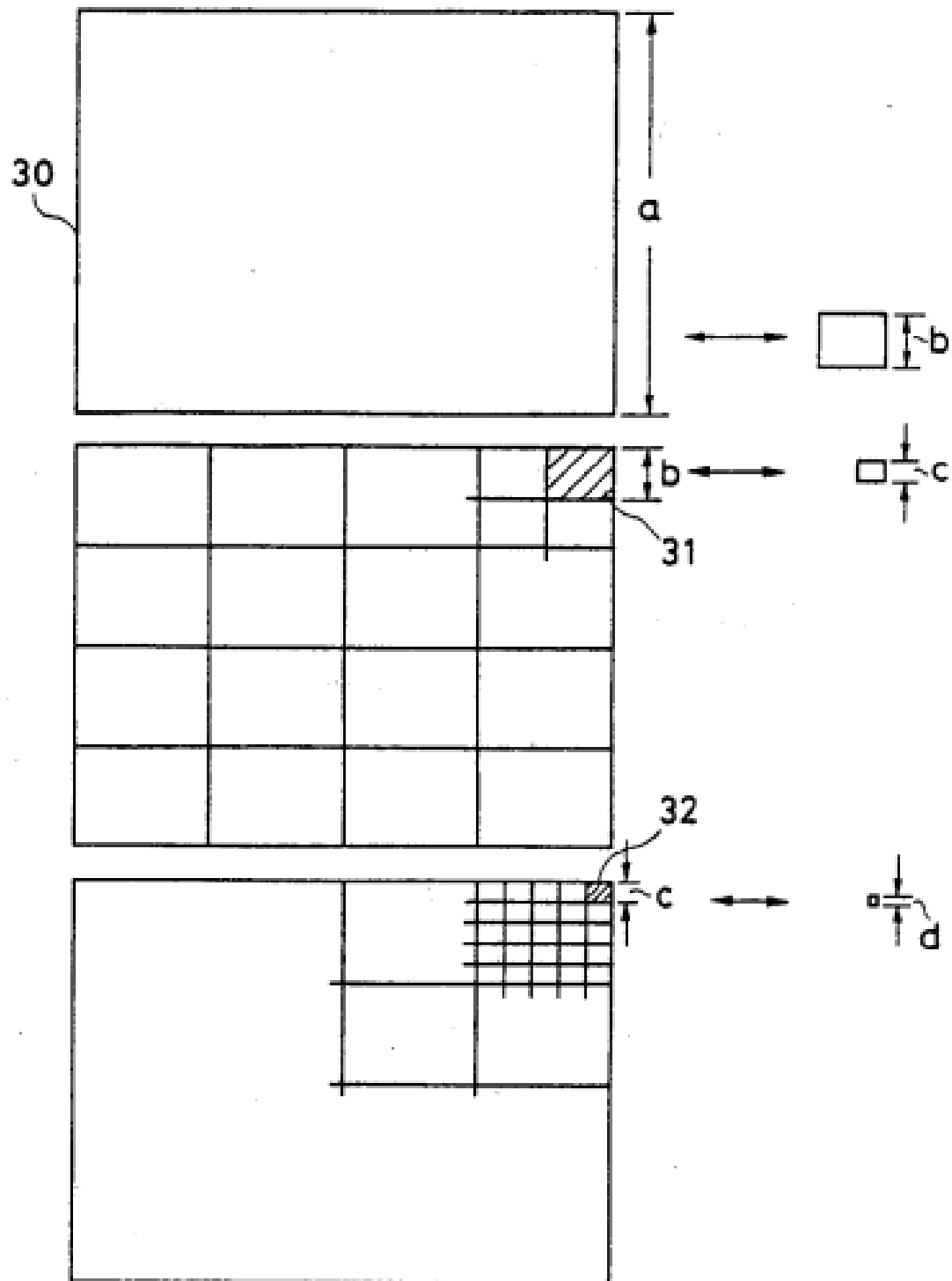


Figure 6

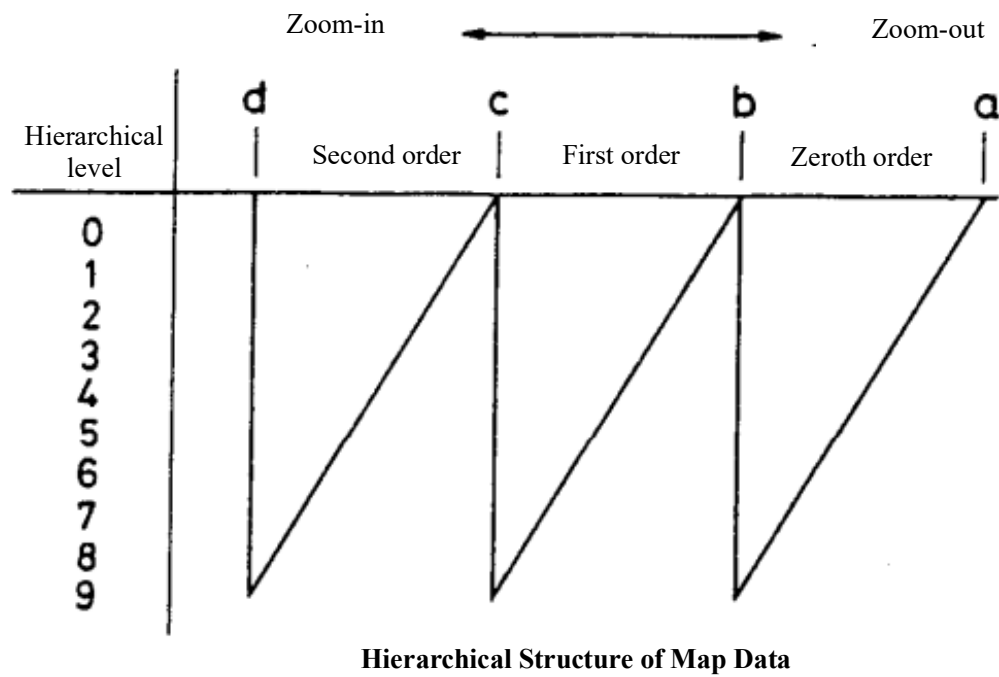
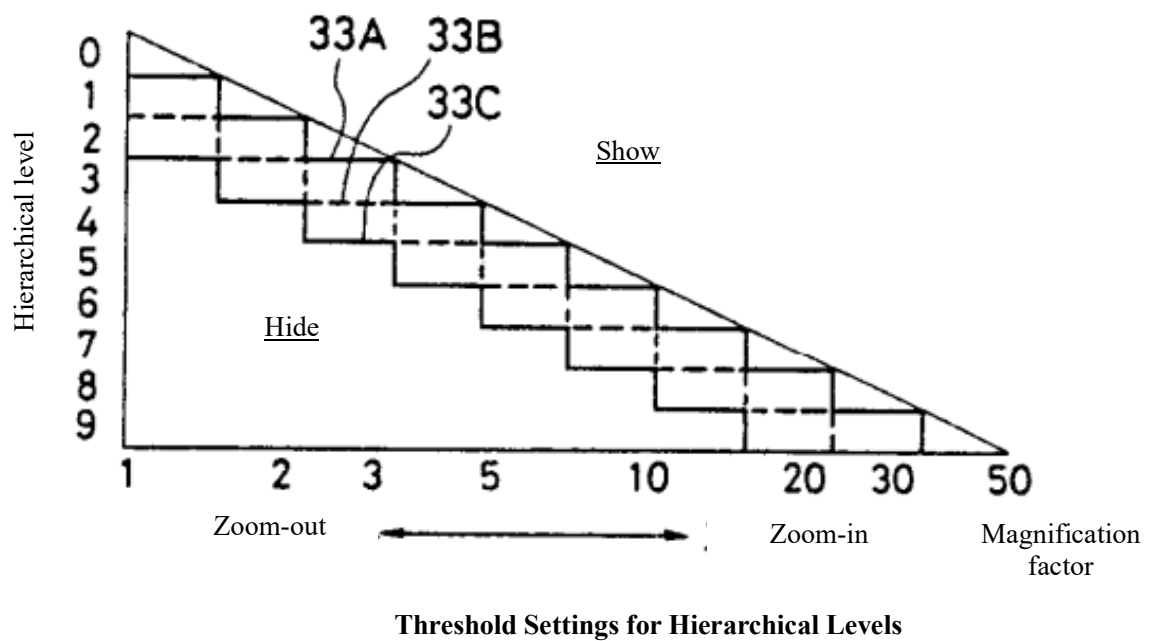


Figure 7



I, Yukie Hirose, hereby declare as follows:

1. I, Yukie Hirose, hereby certify that I am a professional translator fluent in both Japanese and English and I am competent to translate from Japanese into English.
2. I am a translator at Nelles Translations, which is located at 3 Grant Square, #336, Hinsdale, IL 60521.
3. I possess advanced knowledge of the Japanese and English languages.
4. The attached translation is, to the best of my knowledge and belief, a true and accurate translation from the Japanese patent JPH02-4285-A to English.
5. I declare under penalty of perjury that all statements made herein of my own knowledge are true and all statements made on information and belief are believed to be true, and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment or both, under Section 1001 of Title 18 of the United States Code.

Dated: 10/3/23

A handwritten signature in black ink, appearing to read 'Yukie Hirose', is written over a solid black horizontal line.

Ms. Yukie Hirose