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H4F
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(54) Image contour tracing

(57) A system for contour tracing to prepare contour coordinates by identifying contour lines of a figure from an image defined in a plurality of scan lines, comprising a memory (1, Figure 1) in which are stored image transition points relating to contour lines of the figure in each scan line. Image transition points of two lines are transferred to buffer line stores (4, 5) from where they are compared (6) so as to identify predetermined basic contour patterns, Figure 2. The thus extracted basic patterns are then linked (7) to define a contour, Figure 3, and are converted into contour coordinates.

The system is capable of obtaining at high speeds the contour coordinates of a figure or document.

FIG. 2

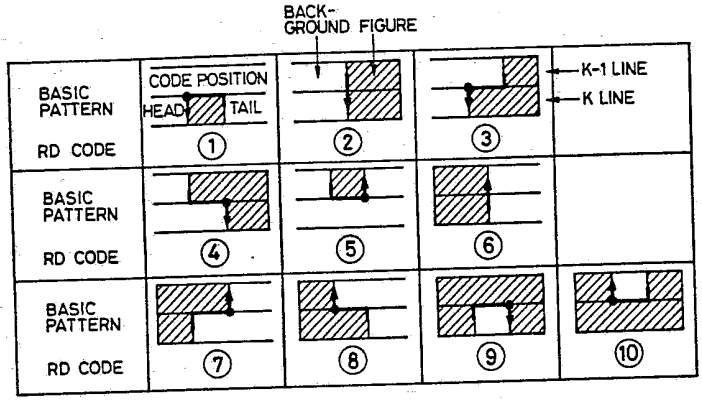
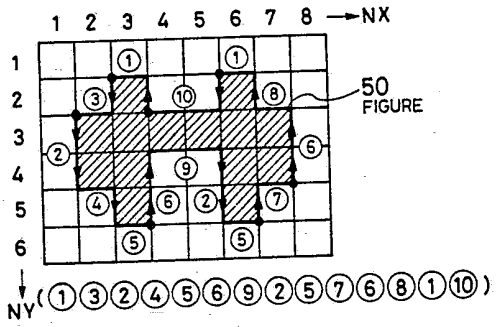


FIG. 3



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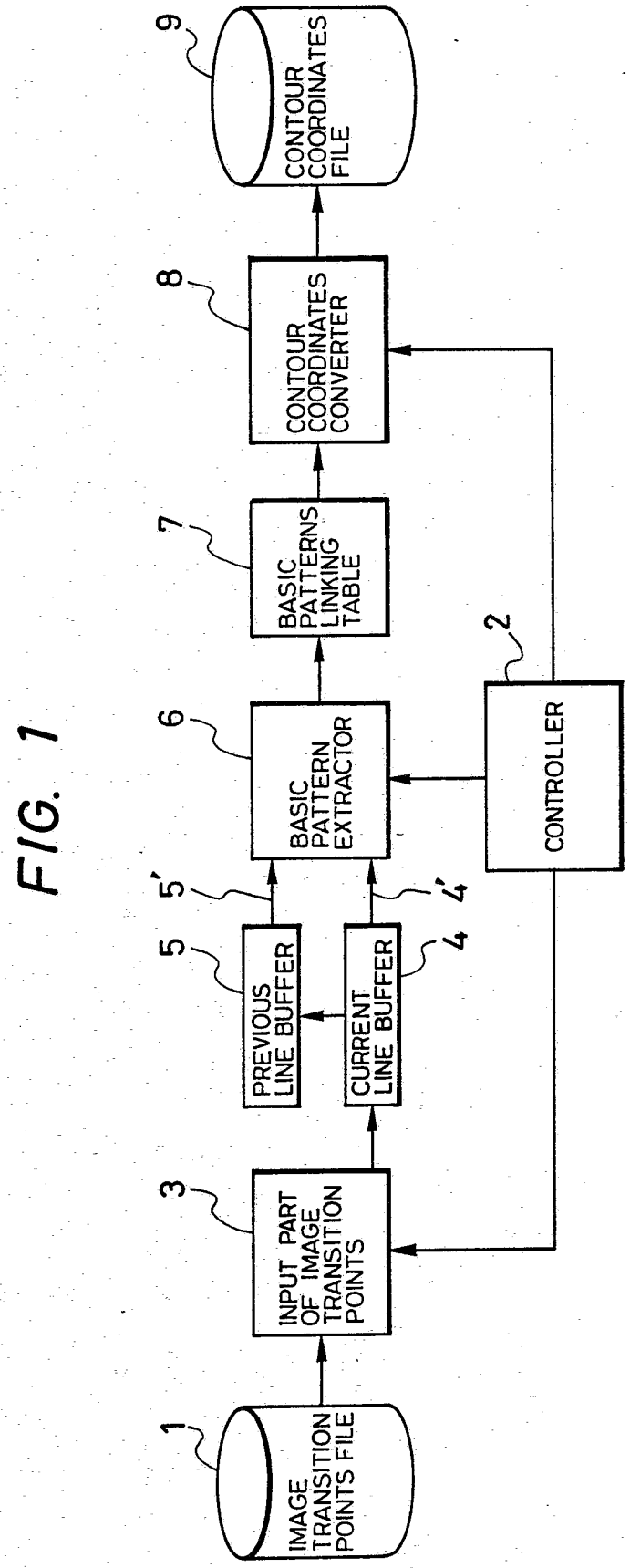


FIG. 1

FIG. 2

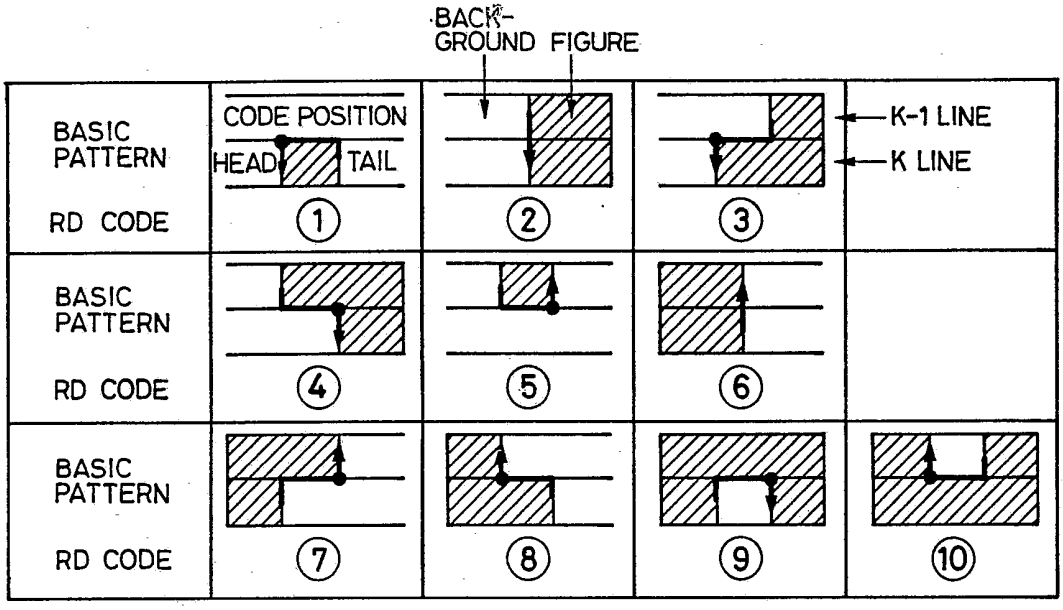


FIG. 3

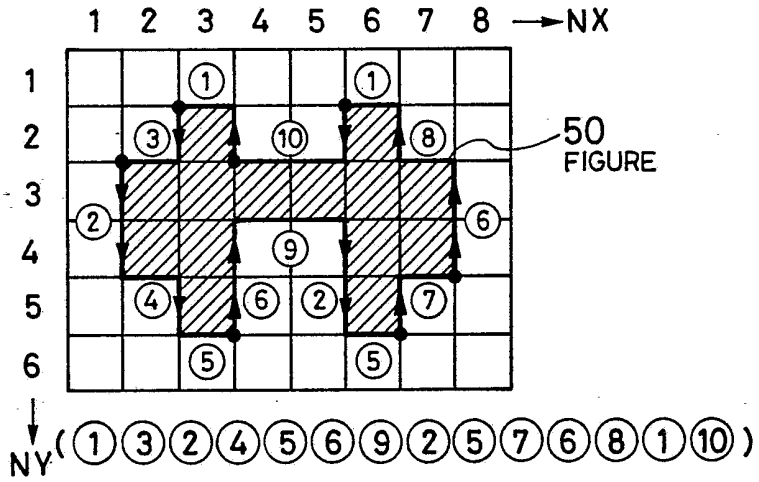
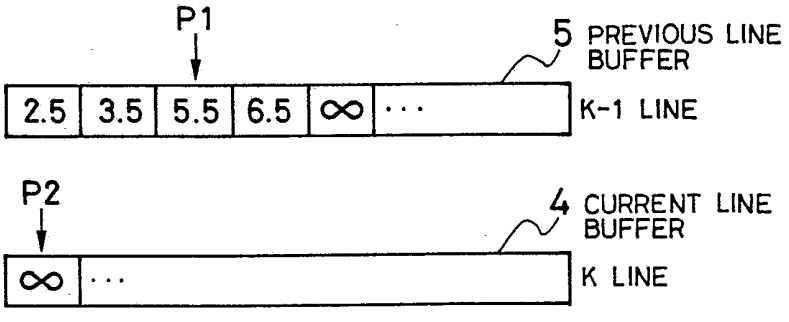


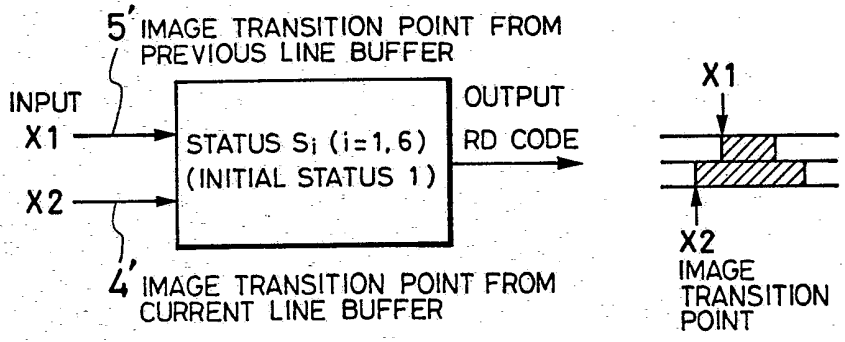
FIG. 4



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FIG. 5

(a) OUTLINE OF THE AUTOMATON



(b) DETAILS OF THE AUTOMATON

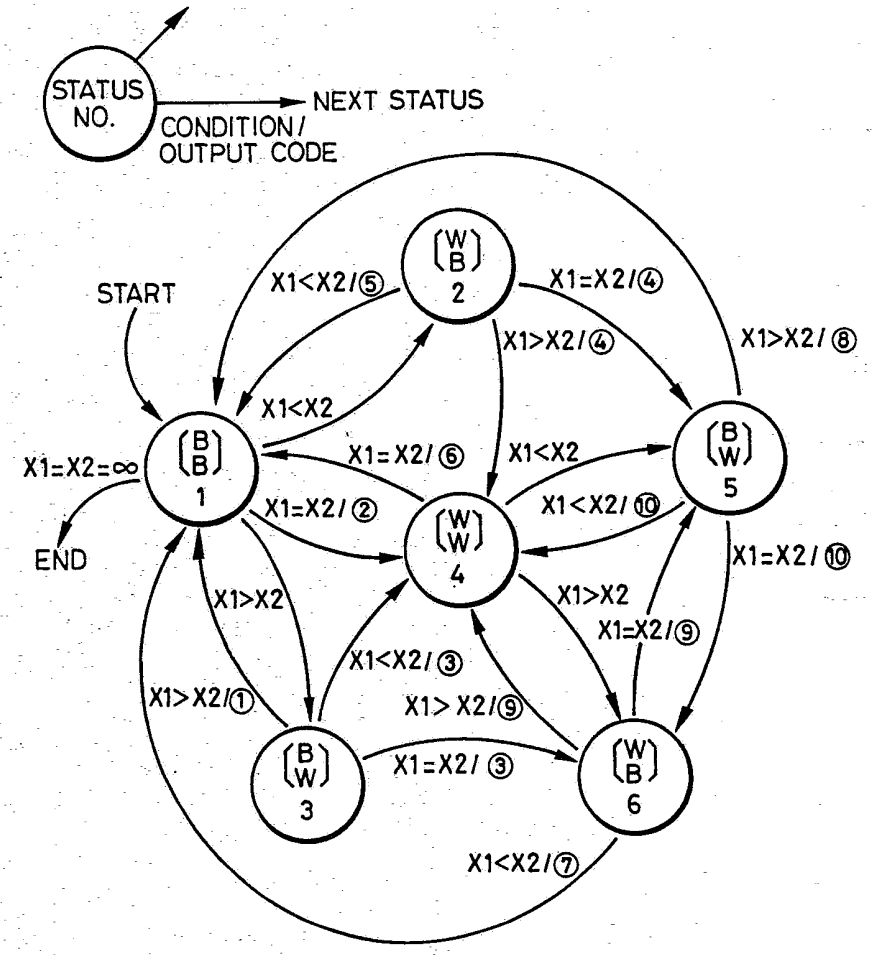


FIG. 6

CURRENT STATUS	CONDITION X1 : X2	X RENEWAL	RD CODE EXTRACTION & ENTRY	NEXT CONTROL	
				NEXT STATUS	LINE BUFFER WHICH IS READ THE NEXT IMAGE TRANSITION POINT
1	<	—	—	2	PREVIOUS LINE
	=	—	②	4	BOTH LINES
	>	X ← X2	—	3	CURRENT LINE
2	<	X ← X1	⑤	1	PREVIOUS LINE
	=	X ← X1	④	5	BOTH LINES
	>	X ← X2	④	4	CURRENT LINE
3	<	—	③	4	PREVIOUS LINE
	=	—	③	6	BOTH LINES
	>	—	①	1	CURRENT LINE
4	<	X ← X1	—	5	PREVIOUS LINE
	=	—	⑥	1	BOTH LINES
	>	—	—	6	CURRENT LINE
5	<	—	⑩	4	PREVIOUS LINE
	=	—	⑩	6	BOTH LINES
	>	—	⑧	1	CURRENT LINE
6	<	X ← X1	⑦	1	PREVIOUS LINE
	=	X ← X1	⑨	5	BOTH LINES
	>	X ← X2	⑨	4	CURRENT LINE

INITIAL STATUS : 1
TERMINAL STATUS : 1

X :X COORDINATE WHEN ON RD CODE ENTERED
X1:X COORDINATE OF THE IMAGE TRANSITION POINT WHICH IS READ FROM PREVIOUS LINE BUFFER
X2:X COORDINATE OF THE IMAGE TRANSITION POINT WHICH IS READ FROM CURRENT LINE BUFFER

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FIG. 7

RD-LIST

	X	Y	CODE	LINK	W-LINK	
1	2.5	1.5	①	3	2	7
2	5.5	1.5	①	4	3	
3	1.5	2.5	③	6	5	
4	3.5	2.5	⑩	1	0	
5	6.5	2.5	⑧	2	6	
6	—	—	②	9	7	
7	5.5	3.5	⑨	11	8	
8	—	—	⑥	5	9	
9	2.5	4.5	④	13	10	
10	—	—	⑥	7	11	
11	—	—	②	14	12	(B=0)
12	7.5	4.5	⑦	8	0	←C
13	3.5	5.5	⑤	10	0	
A→14	6.5	5.5	⑤	12	0	

RD-LIST(1,i)--- RD-LIST(5,i)

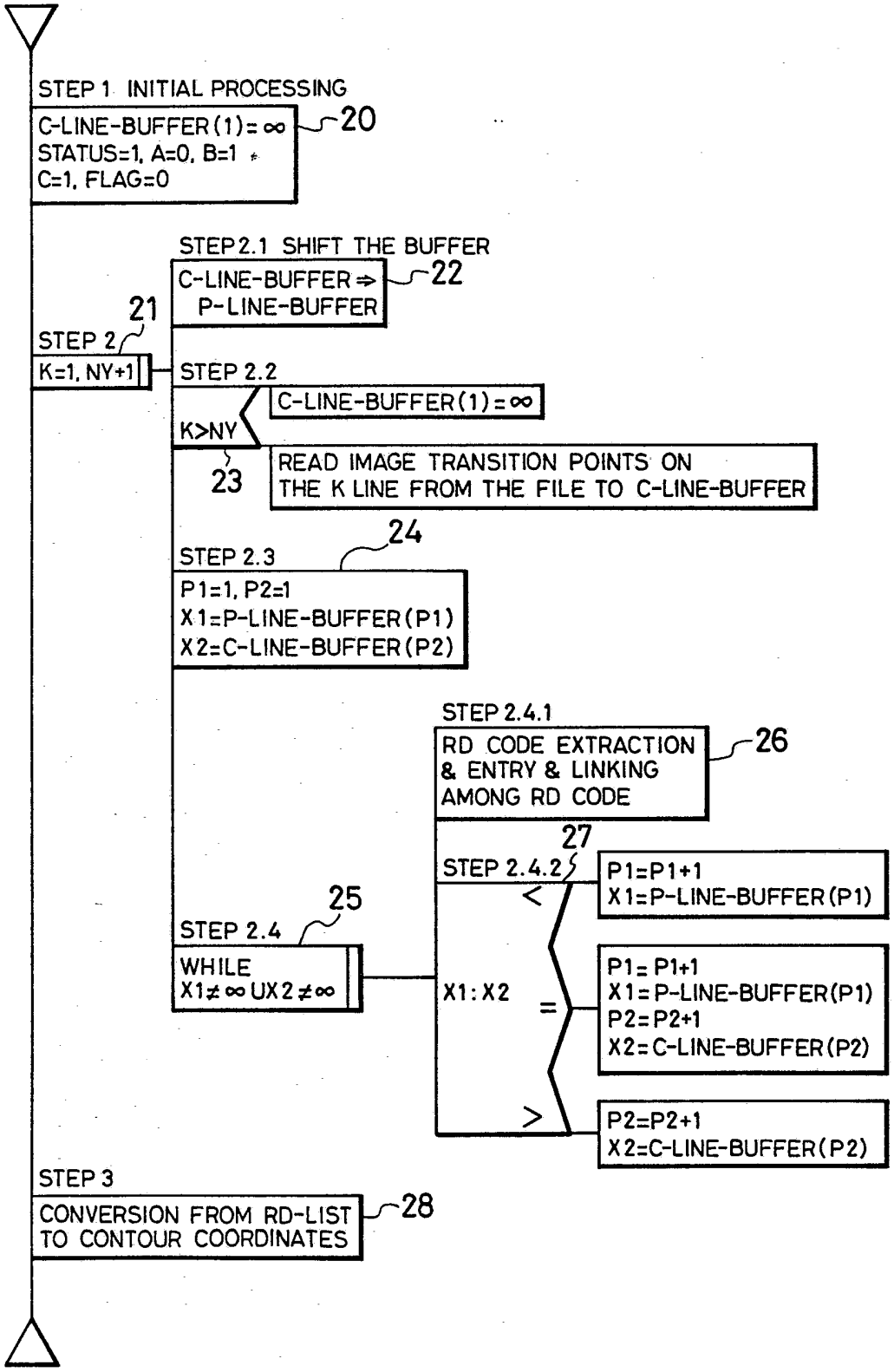
A : THE POINTER WHICH INDICATES THE RD CODE ENTRY ADDRESS

B : THE POINTER WHICH INDICATES THE TOP ADDRESS OF WAITING LIST FOR RD CODE LINKING

C : THE POINTER WHICH INDICATES THE LAST ADDRESS OF WAITING LIST FOR RD CODE LINKING

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FIG. 8



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"METHOD OF AND SYSTEM FOR CONTOUR TRACING"

The present invention relates to a method of and system for contour tracing to prepare contour coordinates of a figure from a sampled image that consist of a set of a plurality of lines, and particularly to a method of and system for contour tracing that is capable of obtaining at high speeds the contour coordinates of a figure from the compression-encoded image of a figure or document.

A conventional method of extracting the contour coordinates of a figure in an image or of a material body consists of, first, finding the coordinates of image transition points when the scanning is effected from two directions that meet at right angles with each other relative to the image, and then examining the continuity of these coordinate values, in order to obtain the contour coordinates as disclosed in Japanese Patent Laid-Open No. 111786/1982.

According to the above specification, the image transition points must be extracted in both the horizontal and vertical directions, which results in a great amount of processing in order to cover the whole surface of image. After the coordinates of the image transition points are extracted, the tracing has to be effected using a mask on a coordinate table requiring an extended processing time.

An object of the present invention is to provide a method of and system for contour tracing at high speeds without involving the above-mentioned problems. For this

purpose, the present invention deals with a contour tracing system which prepares the contour coordinates by tracing the contour lines of a figure from a sampled image that consists of a set of a plurality of lines, wherein:

an image transition point is detected for each line;

part of a figure, determined by a relationship of the position of an image transition point of a first line and the position of an image transition point of a second line that precedes said first line, is extracted based upon a basic pattern that constitutes a part of a plurality of predetermined figure contour lines; and

the thus extracted basic patterns are integrated and are converted into contour coordinates.

The present invention will now be described by way of examples with reference to the accompanying drawings, wherein:-

Fig. 1 is a block diagram illustrating the whole structure according to an embodiment of the present invention;

Fig. 2 is a diagram showing various kinds of basic patterns;

Fig. 3 is a diagram showing an example of describing a contour of a figure using basic patterns of Fig. 2;

Fig. 4 is a diagram illustrating the data

structure of line buffers;

Fig. 5 shows an automation of a basic pattern extracting portion of Fig. 1;

Fig. 6 is a table of image transition point analysis illustrating the automation of Fig. 5 depending upon the statuses;

Fig. 7 illustrates the data structure of the basis pattern link table of Fig. 1; and

Fig. 8 is a flow chart (PAD) of the whole processing.

First an outline of the operation of the present invention will be described by way of the embodiments.

To extract a basic pattern which constitutes a portion of a contour line, reference is made to an

image transition point of a current line that is stored and an image transition point (X coordinate) of a previous line. A particular basic pattern is extracted from a relationship of positions at this moment, and is coupled by a pointer to the basic pattern extracted in the processing of the previous line. As the basic pattern is extracted for one line, the image transition point of the current line is transferred to a previous line memory unit, and an image transition point of a new line is input to a current line memory unit. The above-mentioned processing is effected for all of the lines, and then the basic patterns coupled by the pointers are integrated to obtain contour coordinates.

The above-mentioned system makes it possible to trace the contour using image transition points of one direction only. Furthermore, pointers are imparted to the basic patterns so that they can be converted into contour coordinates at high speeds.

In the processing for transferring the contents of the current line memory unit to the previous line memory unit, addresses of each of the line memory means are alternatingly switched so that the data need not really be transferred.

The invention will now be described in conjunction

with the drawings. Fig. 1 is a block diagram illustrating the basic system of the method of tracing a contour according to the present invention. The system comprises an image transition point file 1; a controller 2; the input part of image transition points 3; a current line buffer 4; a previous line buffer 5; a basic pattern extractor 6; a basic pattern linking table 7; and a contour coordinate file 8. The image transition point file 1 stores coordinates of image transition points of each of the lines that will be input to the current line buffer 4 through the input part of image transition points 3 for each of the lines. At this moment, the image transition points that have previously been stored in the current line buffer 4 are transferred to the previous line buffer 5. Next, the basic pattern extractor 6 reads the contents of the line buffers 4 and 5 one by one, and extracts the basic pattern that constitutes a portion of the contour line based upon the magnitude of the coordinates. The extracted basic pattern is stored in the basic pattern linking table 7. Here, the basic pattern is linked by a pointer to the basic pattern extracted in the previous line. After the basic patterns are

all extracted for the contents of the line buffers 4 and 5, an image transition point of the next line is read out from the image transition point file 1. After the above-mentioned process is effected for all of the lines, the contour coordinate converter 8 integrates the basic patterns of the basic pattern linking table 7 while tracing the pointers and prepare contour coordinates and sends them to the contour coordinate file 9, whereby the tracing of the contour is finished. The controller 2 controls all of the above-mentioned processings.

Fig. 2 shows ten kinds of basic patterns extracted by the basic pattern extractor 6. The contour lines can all be expressed by the combinations of these basic patterns. Reference numberals 1 to 10 within circles are attached to these basic patterns to call them RD codes (run-type direction codes). An end point of the arrow at the tip of the RD code is called the head and an end point on the other side is called the tail. In Fig. 2, circles stand for positions of representative points of RD codes that are determined to specify the positions. When the contour lines are to be described by basic patterns called RD codes, the pointer is so operated that the head of the RD code is necessarily linked to the tail of another RD code.

Fig. 3 illustrates an example where the contour of a figure in an image having an image size of 8 x 6 is described using RD codes. The contour of a figure 50 is expressed as (① ③ ② ... ⑩) using 14 RD codes. The RD codes can be easily converted into general contour coordinates. If the positions of representative points only of RD codes are used as contour coordinates, then the intermediate coordinates are not included. However, the intermediate coordinates can be interpolated by using the positions of representative points of the preceding succeeding codes. In (① ③ ...), for example, if the position of representative point of ① is (2.5, 1.5) and if the position of a representative point of ③ is (1.5, 2.5), then the intermediate coordinate is (2.5, 2.5) and the coordinates are given as ((2.5, 1.5) (2.5, 2.5) (1.5, 2.5) ...). Here, the positions of representative points have a fraction 0.5 because of the reason that the coordinate at the center of the pixel is used as a reference. The fraction may be cut away to simplify the notation, as a matter of course.

Fig. 4 illustrates the data structure of line buffers according to an embodiment. X coordinates of image transition points are stored in the current

line buffer 4 and in the previous line buffer 5, and an end code ∞ is contained at the end of data. A pointer P1 is used for reading the previous line buffer 5 and a pointer P2 is used for reading the current line buffer 4.

Fig. 5 illustrates an automaton for extracting RD codes in the basic pattern extractor 6, wherein $\begin{bmatrix} B \\ B \end{bmatrix}$ $\begin{bmatrix} W \\ B \end{bmatrix}$ $\begin{bmatrix} B \\ W \end{bmatrix}$ $\begin{bmatrix} W \\ W \end{bmatrix}$ represent a combination of runs between the upper and lower lines under a given status. The upper stage illustrate the kinds of runs in the previous line and the lower stage illustrates the kinds of runs in the current line, symbol B denotes a black run (continuation of 1s, i.e., continuation of black pixels on the image) and symbol W denotes a white run (continuation of 0s, i.e., continuation of white pixels). In Fig. 5, symbol X1 denotes a position of image transition point read from the previous line buffer 5 and symbol X2 denotes a position of image transition point read from the current line buffer 4. There are a total of six statuses, and the start of scanning and the end of scanning necessarily pass through the status 1 with each line as a unit. Under each status, there are three kinds of status transitions depending upon the result of comparison of X1 with X2, whereby RD codes ① to ⑩ are extracted.

The image transition points X1, X2 are read from the line buffers 5 and 4 in the order of increasing values of image transition points by comparing them. If the image transition points have the same value, they are read from both line buffers. According to this automaton, the RD code (1) is extracted under the following conditions; i.e., X1 > X2 holds under the status 1, and after X2 is renewed X1 > X2 holds under the status 3. If interpreted from the standpoint of figure, this means that it is confirmed that the upper side of the run (black run in this case) to which attention has now been given is the background. As explained with reference to Fig. 4, the code ∞ is contained in the end of the line buffer and is regarded to be a left edge B from the standpoint of processing. Therefore, after the data are all read out, the status 1 is resumed, i.e., $\begin{bmatrix} B \\ B \end{bmatrix}$ is resumed.

Fig. 6 shows the processings to be executed relying upon the automaton of Fig. 5 that are grouped depending upon the statuses. X coordinate of the position of representative point of RD code is renewed, and RD code is extracted, entered and is renewed to the number of the next status, and the next image transition point is read depending upon the condition of which one of X1 or X2 is greater than the other.

When the RD code is being entered, the linking is effected to the RD code that is waiting for being linked. The RD codes can be classified into those of two kinds:

(1) Those that do not wait for being linked:

⑤ ⑩ --- head and tail are both rising

(2) Those that wait for being linked:

①②③④⑥⑦⑧⑨ --- head or tail is descending

As for the RD codes of the group (2), they are controlled by the pointer as the waiting list for linking at the time of being extracted, and the RD code that is now extracted is successively linked to the RD code in the waiting list for linking.

Fig. 7 illustrates a basic pattern linking table according to an embodiment. The basic pattern linking table 7 consists of five items, i.e., a representative point position X, Y of the RD code, a code number CODE thereof, a link pointer for linking the RD codes, and a W-link pointer which temporarily lists those RD codes that are waiting for being linked. Further, there are three pointers A, B and C for operating the basic pattern linking table 7. The pointer A is the one that indicates an address for a new RD code entry, the pointer B is the one that indicates the top address of waiting list for RD

code linking, and the pointer C is the one that indicates the last address of waiting list for RD code linking. Here, Fig. 7 illustrates the case where the object 50 shown in Fig. 3 is processed.

Fig. 8 is a flow chart (PAD) illustrating the procedure for processing the contour tracing using the controller 2 of Fig. 1. In the flow chart of Fig. 8, variables are defined as below:

C-Line-Buffer: current line buffer 4

P-Line-Buffer: previous line buffer 5

Status: status numbers (1 to 6)

A, B, C: pointers

Flag: control flag (0 or 1) of the pointer B

K: line number of the image that is now being scanned.

NY: a maximum line number of the image

RD-List: basic pattern linking table 7

[Flow of Processing for Contour Tracing]

Step 1: Initialization

C-Line-Buffer(1) = ∞ ; set the current line buffer 4 to be "empty".

Status = 1; set the initial status of automation to be 1.

A = 0, B = 1, C = 1, Flag = 0; initialize variables.

Step 2: Execute the processing after (NY + 1)-th time

Step 2.1: Shift the line buffer.

Here, the buffer shift is a system in which the data is not really transferred but the address of line buffer is switched depending upon whether an odd number or an even number of K.

The content of C-Line-Buffer is transferred to P-Line-Buffer (in practice, addresses of C-Line-Buffer and P-Line-Buffer are switched).

Step 2.2: Image transition points of one line are read out. If K > NY, C-Line-Buffer(1) = ∞. If not, read image transition points of one line from the image transition point file 1 and set them to the C-Line-Buffer.

Step 2.3: Initialization for contour tracing between the two lines.

Initialization:

$P_1 = 1$, $P_2 = 1$: Initialize the read pointers of line buffers 5 and 4.

X1 = P-Line-Buffer(P1); Set the top data of the previous line buffer 5 to the variable X1.

X2 = C-Line-Buffer(P2); Set the top data of the current line buffer 4 to the variable X2.

Step 2.4: Contour tracing between the two lines.

Execute the following processings until X1 and X2 both acquire the code ∞.

Step 2.4.1: Extraction, entry and linking of RD codes.

Step 2.4.2: Data renewal of X1 and X2.

Note: Steps 2.4.1 and 2.4.2 are based upon the Table of Fig. 6.

Step 3: Convert the RD codes found in the Step 2 into coordinates.

According to the above-mentioned embodiment, the image memory for contour tracing needs be a line buffer for two lines presenting advantage in economy. Furthermore, the image transition point positions in one direction only are utilized for the contour tracing, enabling the tracing operation to be carried out at a speed faster than the system which utilizes image transition point positions of two directions. Further, ten basic patterns that constitute the contour line can be adapted to the figures of any kind making it possible to faithfully describe the contour of the figure. Image files of documents and drawings have usually been converted into run length codes which match well with the contour tracing system of the present invention. Moreover, the embodiment does not employ any special arithmetic unit but employs

an ordinary general-purpose computer to guarantee high-speed operation.

According to the present invention as described in the foregoing, the contour tracing can be executed using image transition points of one direction only. Furthermore, since the pointers are attached to the basic patterns extracted by comparing the positions of image transition points between the two lines, no additional search is required for converting the basic patterns into the contour coordinates. Therefore, the contour coordinates are obtained at high speeds.

Claims:

1. A method of contour tracing to prepare contour coordinates by tracing contour lines of a figure from a sampled image that consists of a set of a plurality of lines, said method including the steps of:-

(a) detecting an image transition point for each line;

(b) extracting a part of the figure determined by a relationship of the position of an image transition point of a first line and the position of an image transition point of a second line that precedes said first line, based upon a basic pattern that constitutes a part of a plurality of predetermined figure contour lines; and

(c) integrating the thus extracted basic patterns to convert them into contour coordinates.

2. A method of contour tracing to prepare contour coordinates by tracing contour lines of a figure from a sampled image that consists of a set of a plurality of lines, said method including the steps of:-

(a) detecting an image transition point for each line;

(b) encoding part of the figure using basic patterns that are classified into ten groups based upon a relationship between the position of an image transition

point of a first line and the position of an image transition point of a second line that precedes said first line; and

(c) integrating the thus extracted basic patterns to convert them into contour coordinates.

3. A method of contour tracing according to claim 1 or 2, wherein the basic pattern consists of ten folded lines each being made up of one or three vectors, and the first and third vectors are vertical vectors.

4. A method of contour tracing according to claim 3, wherein the first and third vectors have a fixed length of 0.5 or 1, and said second vector is a horizontal vector having a variable length.

5. A system for contour tracing to prepare contour coordinates by tracing contour lines of a figure from a sampled image that consists of a set of a plurality of lines, said system including:

(a) means for detecting an image transition point for each line;

(b) means for extracting part of the figure in compliance with a relationship between the position of an image transition point of a first line and the position of an image transition point of a second line that precedes said first line, based upon a basic pattern that constitutes a part of a plurality of

predetermined figure contour lines; and

(c) integrator means for integrating the thus extracted basic patterns in order to convert them into contour coordinates.

6. A method of contour tracing to prepare contour coordinates by tracing contour lines of a figure from a sampled image that consists of a set of a plurality of lines, substantially as herein described with reference to the accompanying drawings.

7. A system for contour tracing to prepare contour coordinates by tracing contour lines of a figure from a sampled image that consists of a set of a plurality of lines, constructed substantially as herein described with reference to and as illustrated in the accompanying drawings.

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