

CHARACTER RECOGNITION APPARATUS, CHARACTER RECOGNITION METHOD AND RECORDING MEDIUM

Technical Field

5 [0001]

The present invention relates to a character recognition apparatus, a character recognition method and a recording medium, especially, to a character recognition apparatus, a character recognition method
10 and a recording medium, in which character recognition is carried out to a gray-scale image.

Background Art

[0002]

15 A technique of carrying out character recognition to a picked-up image imaged by an image pickup device is applied to various applications in addition to number plate recognition. In the character recognition to the picked-up image,
20 generally, processing which generates a binarized image from the picked-up image is carried out, and moreover, character recognition processing is carried out to the binarized image. For example, such a technique is disclosed in Japanese Patent No.
25 3,411,795 (Patent Literature 1).

[0003]

One problem of the technique which generates the binarized image from the picked-up image and carries out the character recognition processing to
30 the binarized image is in that a good binarized image cannot be obtained when the picked-up image is of poor quality. For example, when the contrast is insufficient in the picked-up image, the binarized image in which neighbor character are concatenated is
35 generated in the binarization processing, which decreases the precision of the character recognition.

Japanese Patent No. 3,798,582 (Patent Literature 2)
discloses a technique of separating characters
contacting in a binarized image. However, this
technique does not fundamentally solve the problem
5 that a good binarized image cannot be obtained.
[0004]

In order to cope with such a problem, the
inventors considers to carry out character recognition
processing without carrying out binarization
10 processing, i.e. to carry out the character
recognition processing to a gray-scale image (a light
and shade image). According to their study result,
one problem when the character recognition processing
is carried out without carrying out the binarization
15 processing, is to set candidates of an area where each
character exists (to be referred to as "character
candidate areas") appropriately. When the character
candidate area is improperly set in order to carry out
the character recognition processing to the gray-scale
20 image, a wrong character recognition result is
obtained, i.e. erroneous character recognition occurs.
In the binarized image, after noise is removed, it is
enough to set a part where black pixels continuously
exist as a character candidate area (when the
25 background is white). However, such processing cannot
be carried out to the gray-scale image. The erroneous
character recognition can be restrained by setting
many character candidate areas appropriately. On the
other hand, it causes the increase of a data
30 processing quantity in the character recognition
processing, i.e. a long processing time to set
excessively many character candidate areas.
[0005]

From such a background, a technique of
35 setting a character candidate area appropriately is
demanded in case where character recognition

processing is carried out to a gray-scale image.

Citation List

[0006]

- 5 [Patent Literature 1] Japanese Patent No. 3,411,795
[Patent literature 2] Japanese Patent No. 3,798,582

Summary of the Invention

[0007]

10 Therefore, an object of the present invention
is to provide a technique of setting a character
candidate area appropriately when carrying out
character recognition processing to a gray-scale
image.

15 [0008]

In an aspect of the present invention, a
character recognition apparatus includes character
height direction range detecting means, character
width direction range detecting means, character
20 center candidate range determining means, character
candidate area setting means, character recognition
means and character recognition result determining
means. The character height direction range detecting
means detects a character height direction range as a
25 range in a character height direction perpendicular to
a character width direction in a character string from
an object image which is a gray-scale image and in
which the character string is picked up that contains
a plurality of characters arranged in a character
30 width direction. The character width direction range
detecting means detects a character width direction
range as a range in the character width direction in
which characters of the character string are arranged,
from the object image. The character center candidate
35 range determining means determines a character center
candidate range for each character of the character

string as an area which contains a center of the
character height direction range in the character
height direction and contains a center of the
character width direction range in the character width
5 direction in the object image. The character
candidate area setting means sets a plurality of
rectangular character candidate areas in which an
intersection of diagonal lines coincides with each
point of the character center candidate range. The
10 character recognition means carries out character
recognition processing to each of a part of the
plurality of character candidate areas of the object
image, and acquiring a character recognition result
for each of the plurality of character candidate areas
15 to each of characters of the character string. The
character recognition result determining means
determines a character recognition result for each
character of the character string from the character
recognition results of the plurality of character
20 candidate areas.

[0009]

In an embodiment, the character height
direction range detecting means generates a first
projection histogram which is a distribution of a
25 summation of brightness values of pixels arranged in
the character width direction and calculated in each
position to the object image in the character height
direction, carries out smoothing processing to the
first projection histogram to calculate first smoothed
30 data, and detects an upper end and a lower end in the
character height direction range as positions in which
a sign of a difference between the first projection
histogram and the smoothed data is inverted.

[0010]

35 In an embodiment, the character width
direction range detecting means generates a second

projection histogram which is a distribution of a summation of brightness values of pixels that are arranged in the character height direction and that is calculated for each position in the character width
5 direction of the object image, and carries out the smoothing processing to the second projection histogram to calculate second smoothed data, detects a start point candidate and an end point candidate from the positions where a sign of a difference between the
10 second projection histogram and the second smoothed data is inverted, selects a start point in the character width direction range of each character of the character string from among the start point candidates, and selects an end point in the character
15 width direction range of each character of the character string from among the end point candidates.
[0011]

As a desirable application, the present invention is applied to a case where the object image
20 is a plate area image in which a number plate is picked up, or an image obtained by carrying out image processing to the plate area image. In an embodiment, the object image may be an image obtained by carrying out preprocessing to a plate area image in which a
25 number plate is picked up. The preprocessing carries out a brightness correction processing that restrains brightness of a part having high brightness values of the plate area image, and carries out a linear conversion such that an average of brightness values
30 of the pixels and a standard deviation become predetermined values, respectively; differential filter processing to an image obtained by the brightness correction processing to generate an edge image; filling processing to fill an inside of a
35 character contour which is contained in the edge image; and removing processing to an image obtained by

the filling processing to remove a low frequency component.

[0012]

In another aspect of the present invention, a
5 character recognition method includes: detecting a
character height direction range as a range in a
character height direction perpendicular to a
character width direction in a character string from
an object image which is a gray-scale image and in
10 which the character string is picked up that contains
characters arranged in the character width direction;
detecting a character width direction range as a range
in a character width direction in which characters of
the character string are arranged, from the object
15 image; determining a character center candidate range
to each character of the character string as an area
which contains a center of the character height
direction range and contains a center of the character
width direction range in the character width direction
20 for the object image; setting a plurality of
rectangular character candidate areas, in each of
which an intersection of diagonal lines coincides with
each of points of the character center candidate
range; carrying out character recognition processing
25 to each of a part of the plurality of character
candidate areas of the object image, and acquiring a
character recognition result for each of the plurality
of character candidate areas to each of characters of
the character string; and determining a character
30 recognition result for each character of the character
string from the character recognition results of each
of the plurality of character candidate areas.

[0013]

In further another aspect of the present
35 invention, a program which is stored in a non-
transitory recording medium makes an processor execute

a group of steps of: detecting a character height direction range as a range in a character height direction perpendicular to a character width direction in a character string from an object image which is a gray-scale image and in which the character string is picked up that contains characters arranged in the character width direction; detecting a character width direction range as a range in a character width direction in which characters of the character string are arranged, from the object image; determining a character center candidate range to each character of the character string as an area which contains a center of the character height direction range and contains a center of the character width direction range in the character width direction for the object image; setting a plurality of rectangular character candidate areas, in each of which an intersection of diagonal lines coincides with each of points of the character center candidate range; carrying out character recognition processing to each of a part of the plurality of character candidate areas of the object image, and acquiring a character recognition result for each of the plurality of character candidate areas to each of characters of the character string; and determining a character recognition result for each character of the character string from the character recognition results of each of the plurality of character candidate areas.

[0014]

According to the present invention, when character recognition processing is carried out to a gray-scale image, a character candidate area can be appropriately set.

Brief Description of the Drawings

[0015]

[FIG. 1]

FIG. 1 is a block diagram showing a configuration of a character recognition apparatus according to an embodiment of the present invention.

5 [FIG. 2]

FIG. 2 is a flow chart showing the outline of a character recognition method according to the embodiment of the present invention.

[FIG. 3]

10 FIG. 3 is a flow chart showing preprocessing in the character recognition method of the present embodiment.

[FIG. 4A]

15 FIG. 4A is a flow chart showing detection processing of a character height direction range in the character recognition method of the present embodiment.

[FIG. 4B]

20 FIG. 4B is a conceptual diagram showing detection processing of the character height direction range in the character recognition method of the present embodiment.

[FIG. 5A]

25 FIG. 5A is a conceptual diagram showing an example of the configuration of a number plate.

[FIG. 5B]

FIG. 5B is a flow chart showing the detection processing of a character height direction range which is carried out to the number plate of FIG. 5A.

30 [FIG. 6]

FIG. 6 is a flow chart showing character width direction range detection processing in the character recognition method of the present embodiment.

35 [FIG. 7]

FIG. 7 is a conceptual diagram showing

character width direction range detection processing in the character recognition method of the present embodiment.

[FIG. 8]

5 FIG. 8 is a flow chart showing character center candidate range setting processing in the character recognition method of the present embodiment.

[FIG. 9]

10 FIG. 9 is a conceptual diagram showing character center candidate range setting processing in the character recognition method of the present embodiment.

[FIG. 10]

15 FIG. 10 is a flow chart showing processing of determining the character area and the character recognition result in the character recognition method of the present embodiment.

[FIG. 11]

20 FIG. 11 is a conceptual diagram showing a relation of a specific point in the character center candidate range and a character candidate area set for the specific point.

[FIG. 12]

25 FIG. 12 is a conceptual diagram showing the character candidate area set in the processing of determining the character area and the character recognition result in the present embodiment.

30 **Description of Embodiments**

[0016]

 FIG. 1 is a block diagram showing a configuration of a character recognition apparatus 1 according to an embodiment of the present invention.
35 In the present embodiment, the character recognition apparatus 1 is used for number plate recognition.

That is, the character recognition apparatus 1 carries out character recognition processing to plate area image data 21 supplied externally and generates plate recognition data 22. In this case, the plate area
5 image data 21 is image data of a plate area image, i.e. an image which shows a number plate (vehicle registration number plate or vehicle number plate). For example, the plate area image data 21 is acquired through image processing in which a part of the
10 vehicle picked-up image corresponding to the number plate is cut out, or extracted from the vehicle picked-up image. Note that the plate area image data 21 is image data of the gray-scale image. Also, the plate recognition data 22 is data showing the
15 character recognition result acquired by the character recognition processing (i.e. a recognized character).
[0017]

The character recognition apparatus 1 is provided with an image processing IC (integrated
20 circuit) 2, an external interface (I/F) 3, an external storage unit 4, a memory 5 and a ROM (read only memory) 6. The external interface 3 supplies the plate area image data 21 received externally, to the image processing IC 2. The external storage unit 4
25 saves data which is generated by the character recognition processing in the character recognition apparatus 1. The data stored in the external storage unit 4 contains the plate recognition data 22. The memory 5 is used as a working area for the calculation
30 processing by the image processing IC 2. The ROM 6 saves a program which is executed by the image processing IC 2. The program stored in the ROM 6 contains character recognition software 6a which is a program for the character recognition processing.
35 [0018]

When a rewritable nonvolatile memory (e.g.

flash memory) is used as the ROM 6, a recording medium storing the character recognition software 6a may be used for the installation of the character recognition software 6a into the ROM 6. Also, the character
5 recognition software 6a may be stored in the external storage unit 4. In this case, the recording medium storing the character recognition software 6a may be used for the installation of the character recognition software 6a to the external storage unit 4.

10 [0019]

The image processing IC 2 is provided with a processing module 11, an image input interface 12, a data I/O interface 13, a memory controller 14 and a ROM controller 15. The processing module 11, the
15 image input interface 12, the data I/O interface 13, the memory controller 14 and the ROM controller 15 are connected by an internal bus 16. The processing module 11 executes the character recognition software 6a to carry out the character recognition processing
20 to the plate area image data 21, while using the memory 5 as the working area. The image input interface 12 is an interface used to supply the plate area image data 21 to the image processing IC 2. The data I/O interface 13 is an interface to access the
25 external storage unit 4. The memory controller 14 is an interface to access the memory 5. Also, the ROM controller 15 is an interface to access the ROM 6.

[0020]

Each of steps of the character recognition
30 method described below is executed by using a hardware resource shown in FIG. 1. Below, the character recognition method of the present embodiment will be described in detail.

[0021]

35 FIG. 2 is a flow chart showing the character recognition method of the present embodiment. The

above-mentioned character recognition software 6a is a program code group to execute the character recognition method.

[0022]

5 The character recognition method of the present embodiment roughly contains preprocessing (Step S01), processing of detecting a range in a direction of a character height (Step S02), processing of detecting a range in a direction of a character
10 width (Step S03), processing of setting a range of character center candidate (Step S04), and processing of determining a character area and a character recognition result (step S05). Hereinafter, each step will be described in detail.

15 [0023]

1. Preprocessing

First, the preprocessing (step S01) is carried out to the plate area image data 21. The preprocessing is image processing to exclude a
20 disturbance component around a character as far as it is possible and to emphasize a line forming the character (character line). Note that the preprocessing to be described below is desirable for the precious character recognition but is not
25 indispensable theoretically.

[0024]

In the preprocessing (step S01), first, brightness correction processing is carried out (Step S11). In the brightness correction processing, first,
30 processing of restraining the brightness values of a part of pixels having high brightness values due to halation and so on is carried out. Moreover, a linear conversion is carried out so that an average and a standard deviation of brightness values of pixels
35 become predetermined values, respectively.

[0025]

Moreover, processing by a differential filter such as a Sobel filter is carried out to the image data which has been acquired through the brightness correction processing at step S01 to generate an edge image (Step S12). A character contour line appears in the edge image.

[0026]

Filling processing is carried out to the acquired edge image to fill the inside of an area surrounded by the character contour line in the edge image, thereby to generate a filled image (Step S13). Such filling processing can be realized by carrying out, for example, processing using a maximum value filter and a minimum value filter to the edge image. In this case, as the filter size in the character width direction (i.e. the horizontal direction), for example, the thickness of the character line is selected, and as the filter size in the character height direction (i.e. the vertical direction), one pixel is selected. Here, note that the characters are arranged in the horizontal direction in the plate area image and the edge image.

[0027]

Moreover, processing of removing a low frequency component in the character width direction is carried out to the filling image acquired through the processing at step S13 (Step S14). When images of parts such as a bumper and a trunk of the vehicle other than the characters of the number plate are contained, the above processing is carried out to remove the images of the parts. More specifically, after carrying out the processing using the minimum value filter and carrying out the processing using the maximum value filter, a difference between the filling image acquired at step S13 and the processing result is calculated. The image data corresponding to the

difference is image data acquired at step S14.

[0028]

Above, the preprocessing completes. The image data obtained through the preprocessing is stored in the external storage unit 4. Note that the image obtained through the preprocessing is a gray-scale image (is not a binarized image).

[0029]

2. Detection processing of range in character height direction

Next, the detection processing of a range in the character height direction is carried out to the image data obtained in the preprocessing (of step S01) (Step S02). The detection processing of the character height direction range is processing of detecting an upper end and a lower end in the character height direction range (the character height direction range) where a character string exists in the image of the processing object (that is, the image obtained by the preprocessing). FIG. 4A is a flow chart showing steps carried out in the detection processing of the character height direction range, and FIG. 4B is a diagram conceptually showing the detection processing of the character height direction range.

[0030]

First, a y-axial projection histogram is generated (Step S21). Here, the y-axial projection histogram is a distribution of summations of the brightness values of pixels arranged in the character width direction in each position of the image in the character height direction. As shown in FIG. 4B, assuming that the brightness of the pixel at the coordinates (x, y) is expressed by $B(x, y)$ in the xy -coordinate system in which the y axis is the vertical direction of the image and the x axis is the horizontal direction of the image, the y-axial

projection histogram is obtained as $S_{\Sigma 1}(y)$ which is defined by the following equation (1):

$$S_{\Sigma 1}(y) = \Sigma B(i, y) \quad (1)$$

Here, Σ is a summation of the brightness values in all the pixels, in each of which the y-axial coordinate is y. In FIG. 4B, a graph 31 shows the y-axial projection histogram $S_{\Sigma 1}(y)$.

[0031]

Moreover, processing (smoothing processing) by a smoothing filter is carried out to the y-axial projection histogram $S_{\Sigma 1}(y)$ to calculate smoothing data (Step S22). The filter size of the smoothing filter is selected to be a size equivalent to the height of one character. In the present embodiment, the processing which calculates a moving average is used as the smoothing processing. That is, as the smoothing data, the moving average $S^{\wedge}_{\Sigma 1}(y)$ of the y-axial projection histogram $S_{\Sigma 1}(y)$ is calculated. In FIG. 4B, a graph 32 shows the moving average $S^{\wedge}_{\Sigma 1}(y)$.

[0032]

Moreover, the upper end and the lower end of the character height direction range are detected by using the y-axial projection histogram $S_{\Sigma 1}(y)$ and the moving average $S^{\wedge}_{\Sigma 1}(y)$ (Step S24). In the detection of the upper end and the lower end of the character height direction range at step S24, first, a peak point 33 is detected which is a position in the character height direction when the smoothing data takes a maximum value. In the present embodiment, the y coordinate when the moving average $S^{\wedge}_{\Sigma 1}(y)$ takes the maximum value is detected as a peak point 33.

Moreover, positions when the value of the smoothing data is greater than a value of the y-axial projection histogram $S_{\Sigma 1}(y)$ are searched from the peak point 33 as a start point, and the positions when the value of the smoothing data is greater than the value of the y-

axial projection histogram $S_{21}(y)$ are detected as the positions of the upper end and of lower end of the character height direction range. In FIG. 4B, a reference numeral 34 denotes the upper end of the character height direction range detected at step S24 and a reference numeral 35 denotes the lower end of the character height direction range.

[0033]

In the present embodiment using the moving average $S^{\wedge}_{21}(y)$ as the smoothing data, the positions when the moving average $S^{\wedge}_{21}(y)$ is greater than the value of the y-axial projection histogram $S_{21}(y)$ are detected as positions of the upper end 34 and the lower end 35 in the area where the character exists. In this case, the positions when the moving average $S^{\wedge}_{21}(y)$ becomes greater than the value of the y-axial projection histogram $S_{21}(y)$ for the first time, may be detected as the upper end 34 and the lower end 46. Also, when the moving average $S^{\wedge}_{21}(y)$ is greater than the value of the y-axial projection histogram $S_{21}(y)$ over a series of pixels of a predetermined number in the character height direction, the y coordinate of either of the series of pixels (typically, pixel at the center) may be detected as the positions of the upper end 34 and the lower end 46.

[0034]

Moreover, the plate area image is determined to be related to which of a 1-stage plate and a 2-stage plate (Step S24). When the plate area image is an image of the 2-stage plate, the processing which detects the upper end 34 and the lower end 35 is carried out to one of two character strings which are contained in the number plate, in the processing of the above-mentioned steps S21 to S23. Therefore, when the plate area image is an image of the 2-stage plate, the same processing as the processing of the above-

mentioned steps S21 to S23 is carried out to the other character string in which the processing which detects the upper end 34 and the lower end 35 has not been carried out. The upper end and the lower end of the character height direction range of the other character string are detected (Step S25).
[0035]

Here, when it is previously known that the number plate of the picked-up plate area image is related to which of the 1-stage plate and the 2-stage plate, it is not necessary to determine whether the image of the 1-stage plate or the 2-stage plate (step S24). When the number plate picked-up in the plate area image is the 1-stage plate, the detection processing of the character height direction range completes in the processing of the above-mentioned steps S21 to S23. Also, when the number plate picked-up in the plate area image is the 2-stage plate, the same processing as the processing of the above-mentioned steps S21 to S23 is carried out to the other character string to which the processing which detects the upper end 34 and the lower end 35 has not been carried out at step S25.
[0036]

For example, as shown in FIG. 5A, the number plate in Japan includes an upper-stage character string 51 in which characters of an area name 53 in a relatively small size and characters of classification number 54 are arranged in a horizontal direction, and a lower-stage character string 52 of specification number 55 in a relatively large size and Hiragana 56. Therefore, in the character recognition processing of a Japanese number plate, it is not necessary to carry out the determination processing of step S24 of whether the plate area image is for the 1-stage plate or for the 2-stage plate.

[0037]

When the character recognition processing is carried out to the plate area image of the Japanese number plate, the upper end 34 and the lower end 35 of the character height direction range are detected from the character string 52 in the processing of steps S21 to S23. In this case, as shown in FIG. 5B, after the processing of steps S21 to S23 is carried out, the same processing as the processing of the above-mentioned steps S21 to S23 is carried out to the character string 51 in the upper-stage, and the upper end and the lower end of the character height direction range in the character string 51 of the upper stage may be detected (Step S26).

15 [0038]

Upper and lower ends data indicating the positions of the upper end and the lower end detected in the above-mentioned detection processing of the character height direction range is stored in the external storage unit 4.

[0039]

3. Character width direction range detection

Moreover, the character width direction range detection processing is carried out to the image data obtained by the preprocessing (step S01) (Step S03). The character width direction range detection processing is processing which detects a candidate (a start point candidate) of a start point and a candidate (an end point candidate) of an end point, in a horizontal direction range (hereinafter, to be referred to as "a character width direction range") in which it is considered that each character exists. Note that the start point candidate which is detected through the character width direction range detection processing is "a candidate" and is not finally determined as the start point in the horizontal

direction of the area where each character exists. In the same way, the end point candidate is thoroughly "a candidate" and it is not finally determined as the end point in the horizontal direction of the area where
5 each character exists.

[0040]

FIG. 6 is a flow chart showing processing which is carried out in the character width direction range detection processing, and FIG. 7 is a diagram
10 conceptually showing the character width direction range detection processing. First, the x-axial projection histogram is generated (Step S31). Here, the x-axial projection histogram is a distribution of summations of brightness values of pixels which are
15 arranged in the vertical direction and calculated in each of positions of the horizontal position of the image. Referring to FIG. 7, when the brightness of the pixel which is in the coordinates (x, y) is assumed as B(x, y), the x-axial projection histogram
20 is obtained as $S_{x2}(x)$ which is defined by the following equation (2):

$$S_{x2}(x) = \sum B(x, j) \quad (2)$$

Here, $\sum$ is a summation of all the pixels that the x-axial coordinate is x. In FIG. 7, a graph 41 shows
25 the x-axial projection histogram $S_{x2}(x)$.

[0041]

Moreover, the processing (smoothing processing) using a smoothing filter is carried out to the x-axial projection histogram $S_{x2}(x)$ to calculate
30 smoothing data (Step S32). The filter size of the smoothing filter is selected to have the size which is equivalent to the width of one character. In the present embodiment, processing which calculates a moving average is used as the smoothing processing.
35 That is, as the smoothing data, the moving average $S_{x2}^{\wedge}(x)$ of the x-axial projection histogram $S_{x2}(x)$ is

calculated. In FIG. 7, a graph 42 shows the moving average $S_{x2}(x)$.

[0042]

Moreover, a start point candidate and an end point candidate in the character width direction range of each character are detected by using the x-axial projection histogram $S_{x2}(x)$ and the moving average $S_{x2}(x)$ (Step S24). In the present embodiment, the start point candidate and the end point candidate are searched from the one end of the image and detected, more specifically, is searched from the left end and detected. That is, the start point candidate is detected as a candidate of the start point of the character width direction range for each character and the end point candidate is detected as a candidate of the end point of the character width direction range. In the detection of the start point candidate and the end point candidate, a difference between the moving average and the x-axial projection histogram is calculated for each x-coordinate.

The start point candidate and the end point candidate are detected as positions where the sign of the difference between the moving average and the x-axial projection histogram is inverted. For example, when the difference $S_{x2}(x) - S_{x2}(x)$ in which the x-axial projection histogram is subtracted from the moving average is calculated for each x-coordinate, the start point candidate is calculated as the x-coordinate when the sign of the difference $S_{x2}(x) - S_{x2}(x)$ is inverted from plus to minus, and the end point candidate is calculated as the x-coordinate when the sign of the difference $S_{x2}(x) - S_{x2}(x)$ is inverted from minus to plus. In FIG. 7, the detected start point candidate is shown by the symbol "○ (circle)" and the detected end point candidate is shown by the symbol "□ (box)".

[0043]

Through the above processing, the processing which detects the start point candidate and the end point candidate is carried out for one of the character strings arranged in the horizontal direction. When the plate area image is an image of the 2-stage plate, the processing of the above-mentioned steps S31 to S33 is carried out to the other character string in which the start point candidate and the end point candidate have been not detected (Step S34). The positions of the detected start point candidate and end point candidate are stored in the external storage unit 4 as start and end candidate data.

[0044]

4. Character center position candidate range setting processing

In the character center position candidate range setting processing (step S04), the character center candidate range for each character is determined based on the upper end and the lower end of the character height direction range detected by the above-mentioned detection processing of the character height direction range, and the data of the start point candidate and the end point candidate detected by the character width direction range detection processing. The character center candidate range is a range of a candidate of a position where the center of each character exists. In the processing (step S05) which determines the character area and a character recognition result to be carried out later, any position in the character center candidate range is determined as a position where the center of each character exists.

[0045]

The position of the character center candidate range in the character height direction

(i.e. the y-axial direction) is determined as a range that contains the central position of the character height direction range detected by the detection processing of the character height direction range
5 (Step S41). The position of the character center candidate range in the character height direction is common to all the characters of the character string arranged in the horizontal direction. As an example, it is determined to be a range from $(y_{MIN} + y_{MAX})/2 - m$
10 to $(y_{MIN} + y_{MAX})/2 + m$ by using a predetermined value m , the y-coordinates y_{MAX} in the upper end, and the y-coordinate y_{MIN} in the lower end, which are detected in the detection processing of the character height direction range. In this case, the position candidate
15 of the center in the vertical direction for each character has the degrees of freedom of $(2m)$ pixels. The reason that the degrees of freedom to an extent is given to the position candidate where the center of each character exists is in that it is assumed that
20 the number plate is obliquely picked up in the plate area image.

[0046]

Moreover, a position of the character center candidate range in the horizontal direction (i.e. the
25 x-axial direction) is determined to each of the characters (Step S42). In the determination processing of a position in the horizontal direction in the character center candidate range to each of the characters, first, a pair of the start point and the
30 end point in the character width direction range corresponding to each character is selected from the start point candidates and the end point candidates detected in the above-mentioned character width direction range detection processing. Here, the start
35 point in the character width direction range is selected from the start point candidates detected in

the character width direction range detection processing and the end point in the character width direction range is selected from the end point candidates. In the present embodiment that the start point candidate and the end point candidate are detected through the search from the left side, it is enough that the i^{th} start point candidate and the i^{th} end point candidate from the left side are determined as the start point and the end point for the i^{th} character from the left side. However, there is an adequate range for the width of the character, and when the start point and the end point which are out of the adequate range, are determined, a neighbor start point candidate or a neighbor end point candidate is used to determine the pair of the start point and the end point, instead of the points out of the adequate range. The pair of the start point and the end point in the character width direction range for each character is determined by such a procedure.

20 [0047]

The position of the character center candidate range in the horizontal direction (i.e. the the x-axial direction) is determined as a range that contains a center of the character width direction range determined for each character. In the present embodiment, the position is determined to be in a range from $(x_{\text{MIN}} + x_{\text{MAX}})/2 - k$ to $(x_{\text{MIN}} + x_{\text{MAX}})/2 + k$ by using the x-coordinate x_{MIN} of the start point and the x-coordinate x_{MAX} of the end point for each character, and a predetermined value k . In this case, the candidate of the position of the center of each character in the horizontal direction has the degrees of freedom of the $(2k)$ pixels. This is because it is assumed that there is a variance in the width of the character in the plate area image.

35 [0048]

Through the above processing, the processing which determines the character center candidate range for each character has been carried out to one of the character strings in the horizontal direction. When
5 the plate area image is an image of the 2-stage plate, the processing of the above-mentioned step S41 to S42 is carried out to the other character string to which the processing which determines the character center candidate range has not been carried out (Step S43).
10 Data showing the determined character center candidate range (the character center candidate range data) is stored in the external storage unit 4.

[0049]

5. Processing of determining character area and
15 character recognition result

Next, the processing of determining an area of each character and a character recognition result is carried out (Step S05).

[0050]

20 FIG. 10 is a flow chart showing steps of the processing of determining the character area and character recognition result to be carried out, and FIG. 11 and FIG. 12 are diagrams conceptually showing the character width direction range detection
25 processing.

[0051]

In detail, as shown in FIG. 10, the character center candidate range corresponding to the character to be first processed (the character in leftmost
30 location in the present embodiment) is first selected (Step S50).

[0052]

Moreover, a plurality of character candidate areas in which the height and/or the width are
35 different to each other, are set for each point (each pixel) in the selected character center candidate

range (Step S51). For example, when the character center candidate range is formed from 3×3 (= 9) pixels, nine character candidate areas respectively corresponding to the 9 pixels are set. In the present embodiment, the character candidate area is rectangular (that is, a rectangle (which contains a square)). FIG. 11 is a diagram showing a relation of a specific point 61 in the character center candidate range and a character candidate area 62 set for the specific point. The character candidate area 62 set for the specific point 61 in the character center candidate range is determined so that the intersection of diagonal lines 63 of the character candidate area 62 is coincident with the specific point 61. As shown in FIG. 12, a reference size (of reference height and reference width) has been defined for the character candidate area, and the height and the width of each character candidate area are determined as the height and the width which are identical to those of the reference size, or the height and the width obtained by increasing or decreasing those of the reference size. The maximum increments and decrements of the height and the width are previously set as parameters. [0053]

Next, the character recognition processing is carried out to the image in each character candidate area (Step S52). In the present embodiment, the character recognition processing is carried out by a pattern matching using a template (a template matching method), and in the character recognition processing, a character recognition result and an evaluation value are determined. For example, as the evaluation value, a degree of similarity calculated in the template matching method may be used.

[0054]

Moreover, the character candidate area with

the highest evaluation value and the character recognition result of the image in the character candidate area are extracted (Step S53). For example, when the character center candidate range is formed from the 9 pixels, the character candidate area having the highest evaluation value is extracted from the 9 character candidate areas and the character recognition result of the image in the extracted character candidate area is extracted.

10 [0055]

When the evaluation value is greater than a reference value (Step S54: Yes), the character candidate area having the highest evaluation value and the character recognition result corresponding to the area are determined as the character area where a character of the processing object exists and the character recognition result (Step S55). When being not such a case (step S54: No), the area which does not contain any character is assumed to have been given as the character candidate area, and as a result, the character recognition result is abandoned.

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[0056]

The processing of step S51 to S55 is repeatedly carried out until it is executed to all the character center candidate ranges (Step S56). When the character center candidate range exists in which the processing of step S51 to S55 has not been carried out, the character center candidate range corresponding to the next character is selected (step S57), and once again, the processing of step S51 to S55 is carried out. When the processing of step S51 to S55 is carried out to all the character center candidate ranges, the character area and the character recognition result for each of the characters is determined (Step S58). Data showing the determined character area and character recognition result are

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30
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stored in the external storage unit 4 as plate
recognition data 22.

[0057]

As described above, in the character
5 recognition processing of the present embodiment, the
character center candidate range is determined for
each character based on the y-axial projection
histogram and the x-axial projection histogram. The
character candidate area is determined for each point
10 in the character center candidate range. In the
present embodiment, the character candidate area is
set in the condition that the degrees of freedom to an
extent are given to the center of each character, so
that erroneous recognition can be restrained. On the
15 other hand, because the character center candidate
range is limited to an extent by the detection result
of the character height direction range by the
detection processing of the character height direction
range and the detection result of the character width
20 direction range by the character width direction range
detection processing, the number of character
candidate areas to be set can be restrained to an
extent. Therefore, it is possible to restrain a data
processing quantity of the character recognition
25 processing and to reduce the processing time.

[0058]

As described above, the embodiments of the
present invention have been specifically described but
the present invention is not limited to the above-
30 mentioned embodiments. It would be obvious to a
person skilled in the art that various modifications
can be applied to the present invention. For example,
in the above, the embodiments that the present
invention is applied to the number plate recognition
35 (the recognition of characters written in the number
plate) have been described. However, the present

invention can be applied to general character recognition to the picked-up image which is a gray-scale image.

CLAIMS

1. A character recognition apparatus comprising:
character height direction range detecting
means for detecting a character height direction range
5 as a range in a character height direction
perpendicular to a character width direction in a
character string from an object image which is a gray-
scale image and in which the character string is
picked up that contains a plurality of characters
10 arranged in a character width direction;
character width direction range detecting
means for detecting a character width direction range
as a range in the character width direction in which
characters of the character string are arranged, from
15 the object image;
character center candidate range determining
means for determining a character center candidate
range for each character of the character string as an
area which contains a center of the character height
20 direction range in the character height direction and
contains a center of the character width direction
range in the character width direction in the object
image;
character candidate area setting means for
25 setting a plurality of rectangular character candidate
areas in which an intersection of diagonal lines
coincides with each point of the character center
candidate range;
character recognition means for carrying out
30 character recognition processing to each of a part of
the plurality of character candidate areas of the
object image, and acquiring a character recognition
result for each of the plurality of character
candidate areas to each of characters of the character
35 string; and
character recognition result determining

means for determining a character recognition result for each character of the character string from the character recognition results of the plurality of character candidate areas.

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2. The character recognition apparatus according to claim 1, wherein the character height direction range detecting means generates a first projection histogram which is a distribution of a summation of
10 brightness values of pixels arranged in the character width direction and calculated in each position to the object image in the character height direction, carries out smoothing processing to the first projection histogram to calculate first smoothed data,
15 and detects an upper end and a lower end in the character height direction range as positions in which a sign of a difference between the first projection histogram and the smoothed data is inverted.

20 3. The character recognition apparatus according to claim 1 or 2, wherein the character width direction range detecting means generates a second projection histogram which is a distribution of a summation of brightness values of pixels that are arranged in the
25 character height direction and that is calculated for each position in the character width direction of the object image, and carries out the smoothing processing to the second projection histogram to calculate second smoothed data, detects a start point candidate and an
30 end point candidate from the positions where a sign of a difference between the second projection histogram and the second smoothed data is inverted, selects a start point in the character width direction range of each character of the character string from among the
35 start point candidates, and selects an end point in the character width direction range of each character

of the character string from among the end point candidates.

4. The character recognition apparatus according to any one of claims 1 to 3, wherein the object image is a plate area image in which a number plate is picked up, or an image obtained by carrying out image processing to the plate area image.

10 5. The character recognition apparatus according to any one of claims 1 to 3, wherein the object image is an image obtained by carrying out preprocessing to a plate area image in which a number plate is picked up, and

15 wherein the preprocessing carries out a brightness correction processing that restrains brightness of a part having high brightness values of the plate area image, and carries out a linear conversion such that an average of brightness values
20 of the pixels and a standard deviation become predetermined values, respectively; differential filter processing to an image obtained by the brightness correction processing to generate an edge image; filling processing to fill an inside of a
25 character contour which is contained in the edge image; and removing processing to an image obtained by the filling processing to remove a low frequency component.

30 6. A character recognition method comprising:
 detecting a character height direction range as a range in a character height direction perpendicular to a character width direction in a character string from an object image which is a gray-
35 scale image and in which the character string is picked up that contains characters arranged in the

character width direction;

detecting a character width direction range
as a range in a character width direction in which
characters of the character string are arranged, from
5 the object image;

determining a character center candidate
range to each character of the character string as an
area which contains a center of the character height
direction range and contains a center of the character
10 width direction range in the character width direction
for the object image;

setting a plurality of rectangular character
candidate areas, in each of which an intersection of
diagonal lines coincides with each of points of the
15 character center candidate range;

carrying out character recognition processing
to each of a part of the plurality of character
candidate areas of the object image, and acquiring a
character recognition result for each of the plurality
20 of character candidate areas to each of characters of
the character string; and

determining a character recognition result
for each character of the character string from the
character recognition results of each of the plurality
25 of character candidate areas.

7. A non-transitory computer-readable recording
medium which stores a program, when being executed,
for making a processor execute a group of steps of:
30 detecting a character height direction
range as a range in a character height direction
perpendicular to a character width direction in a
character string from an object image which is a gray-
scale image and in which the character string is
35 picked up that contains characters arranged in the
character width direction;

detecting a character width direction range as a range in a character width direction in which characters of the character string are arranged, from the object image;

5 determining a character center candidate range to each character of the character string as an area which contains a center of the character height direction range and contains a center of the character width direction range in the character width direction
10 for the object image;

 setting a plurality of rectangular character candidate areas, in each of which an intersection of diagonal lines coincides with each of points of the character center candidate range;

15 carrying out character recognition processing to each of a part of the plurality of character candidate areas of the object image, and acquiring a character recognition result for each of the plurality of character candidate areas to each of characters of
20 the character string; and

 determining a character recognition result for each character of the character string from the character recognition results of each of the plurality of character candidate areas.

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