CHARACTER RECOGNITION APPARATUS, CHARACTER RECOGNITION METHOD AND RECORDING MEDIUM

Technical Field

[0001]

The present invention is related to a character recognition apparatus, a character recognition method and a recording medium. Especially, the present invention is related to a character recognition apparatus, a character recognition method and a recording medium, in which character recognition processing is carried out to a gray-scale image.

Background Art

[0002]

The technique of carrying out character recognition processing to a picked-up image picked up by an image pickup device is applied to various applications such as number plate recognition. Moreover, in the character recognition to the picked-up image, the processing of generating a binarized image from the picked-up image is generally carried out, and the character recognition processing is carried out to the binarized image. For example, such a technique is disclosed in Patent Literature 1 (JP 2006-338578A).

[0003]

One problem of the technique of generating the binarized image from the picked-up image and carrying out the character recognition processing to the binarized image is in that a good binarized image is not obtained when the image is of poor quality. For example, in a number plate recognition apparatus in recent years, the picking-up is carried out in a low light level and a low resolution, with realizing

the low cost of the image pickup device. When the light level lowers, a shadow generates and the signal-to-noise ratio decreases so that a brightness distribution becomes not uniform. In addition, a character feature quantity of the picked-up image has decreased upon decrease of a resolution. In such a situation, the binarized image in which the character shape collapsed is generated in the present binarization processing (e.g. a binarized image in which a character line has disappeared is generated) and the precision of the character recognition processing has decreased. If an image pickup device is used which can pick up an image of a high quality, the above problem can be avoided. However, the image pickup device of the high quality is generally expensive and is disadvantageous in viewpoint of cost reduction.

[0004]

In order to cope with the problem that a good binarized image cannot be obtained when the image is of poor quality, the inventors of the present invention have studied a technique of carrying out the character recognition processing without binarizing, that is, a technique of carrying out the character recognition processing to a gray-scale image (light and shade image). The character recognition processing to the gray-scale image is disclosed in, for example, Patent Literature 2 (JP 2008-251029A) and Non-Patent Literature 1 (IEICE Transactions on Fundamentals of Electronics, Communications and Computer Sciences D-II, Vol. J82-D-II, No. 11 "Accuracy Improvement by Gradient Feature and Variance Absorbing Covariance Matrix in Handwritten Chinese Character Recognition" by Kazuhiro SAWA et al.). Patent Literature 2 discloses a technique of improving a precision of character recognition by acquiring a

high resolution image by a superresolution processing method in the character recognition processing. Also, Non-Patent Literature 1 discloses a technique of identifying a character class by a statistical pattern recognition using a feature quantity such as a brightness gradient obtained from the gray-scale image.

[0005]

In the character recognition processing to the gray-scale image, it is desirable to realize the improvement of precision of the character recognition and the reduction of a calculation quantity at the same time. However, according to the consideration of the inventors, the above-mentioned conventional technique has still room for the improvement.

Citation List

[0006]

[Patent Literature 1] JP 2006-338578A

[Patent Literature 2] JP 2008-251029A

[0007]

[Non-Patent Literature 1] "Accuracy Improvement by Gradient Feature and Variance Absorbing Covariance Matrix in Handwritten Chinese Character Recognition" by Kazuhiro SAWA et al., IEICE Transactions on Fundamentals of Electronics, Communications and Computer Sciences D-II, Vol. J82-D-II, No. 11

Summary of the Invention

[0008]

Therefore, an object of the present invention is to provide a technique of realizing the improvement of precision of character recognition and the reduction of a calculation quantity at the same time, in the character recognition processing to a gray-scale image.

[0009]

In an aspect of the present invention, a character recognition apparatus is provided which carries out character recognition processing to a gray-scale image obtained by picking up a character string of characters arranged in a specific direction. The character recognition apparatus includes first character recognition means for carrying out the character recognition processing for each of first characters as N_C (N_C is an integer equal to or more than 2) characters from a first end of the character string; and second character recognition means for carrying out the character recognition processing for a second character different from the first characters. The first character recognition means sets a plurality of first character areas having various character area sizes for each of positions on the gray-scale image in the character recognition processing for each of the first characters, carries out the character recognition processing to each of the plurality of first character areas to calculate a character recognition result and an evaluation value, determines the character recognition result of the first character based on the calculated evaluation values, and determines a first optimal character area size as an optimal character area size from among the various character area sizes. The second character recognition means sets a plurality of second character areas having the first optimal character area size for each of positions on the gray-scale image, carries out the character recognition processing to each of the plurality of second character areas to calculate a character recognition result and an evaluation value, and determines the character recognition result of the second character based on the character recognition result and the evaluation value which are calculated

for each of the plurality of second character areas.

[0010]

At this time, it is desirable that the first character recognition means determines a character position of each of the first characters based on the evaluation values, and determines an optimal character spacing size showing an optimal character spacing from the determined character positions, and that the second character recognition means sets positions of the plurality of second character areas based on the optimal character spacing size.

[0011]

In an embodiment, the first character recognition means ranks the character recognition result obtained for each of the positions of the plurality of first character areas, based on the evaluation values. It is desirable that the first character recognition means extracts the character recognition results corresponding to top m_C (m_C is a predetermined integer greater than N_C) evaluation values from among the character recognition results obtained for the positions of the plurality of first character areas and having a first rank for each position, calculates a first average as an average of the evaluation values of the m_C character recognition results, and the first character recognition means determines the character area size corresponding to the highest first average as an optimal character area size.

[0012]

In this case, it is desirable that the first character recognition means generates an evaluation value - brightness value conversion plot image as an image in which pixels having brightness values corresponding to the evaluation values of the m_C character recognition results are positioned on the

position of the character area corresponding to each of the m_C character recognition results in each of the character area sizes, and carries out binarization processing to the evaluation value - brightness value conversion plot image to generate a binarized image. The first character recognition means carries out labeling processing to the binarized image to give a label to each of sets of concatenated pixels of an identical color, calculates a second average as an average of the evaluation values of the character recognition results corresponding to the pixels which belongs to each of the labels, calculates a distance between a gravity position of each of the labels and a gravity position of another label sequentially from the label having a higher second average, and repeatedly carries out processing which removes each label when the distance to the gravity position of the other label is shorter than a predetermined threshold value, until N_C labels are left. Also, the first character recognition means selects the pixel having the highest evaluation value of the character recognition profit result corresponding to each label, of the pixels belonging to each of the N_C remaining labels, determines the position of the pixel having the highest evaluation value as the character position of the first character, and determines the optimal character spacing size which is an optimal character spacing from the determined character position. The second character recognition means sets the position of the plurality of second character areas based on the optimal character spacing size.

[0013]

In an embodiment, the character recognition apparatus may further include third character recognition means for carrying out the character recognition processing for third characters of the N_C

characters of the character string from a second end opposite to the first end; fourth character recognition means for carrying out the character recognition processing for fourth characters which are characters of the character string other than the N_C characters from the second end; and final character recognition result determining means. The third character recognition means sets a plurality of third character areas of various character area sizes for each of positions on the gray-scale image in the character recognition processing of the third characters, carries out the character recognition processing to each of the plurality of third character areas to calculate a character recognition result and an evaluation value, and determines the character recognition results of the third characters and a second optimal character area size as sizes of optimal character areas based on the calculated evaluation values. The fourth character recognition means sets a plurality of fourth character areas having the second optimal character area size for each of positions on the gray-scale image, carries out the character recognition processing to each of the plurality of fourth character areas to calculate a character recognition result and an evaluation value, and determines the character recognition results of the fourth characters based on the character recognition results and the evaluation values calculated for the plurality of fourth character areas. When the character recognition result of a specific character of the character string which is obtained by the first character recognition means and the second character recognition means coincides with the character recognition result of the specific character which is obtained by the third character recognition means and the fourth character recognition means, the final

character recognition result determining means determines the coinciding character recognition result as a final character recognition result of the specific character. When does not coincide, the final character recognition result determining means determines one having a higher evaluation value, of the character recognition result of the specific character which is obtained by the first character recognition means and the second character recognition means and the character recognition result of the specific character which is obtained by the third character recognition means and the fourth character recognition means, as a final character recognition result of the specific character.

[0014]

In an embodiment, the first character recognition means includes memory means for storing similar character data indicating similar characters, and determines an optimal character area size, without using character recognition results and evaluation values for the similar characters, among the character recognition results obtained by carrying out the character recognition processing to each of the plurality of first character areas.

[0015]

In another aspect of the present invention, a character recognition apparatus which carries out character recognition processing to a gray-scale image obtained by picking up a character string of characters arranged in a specific direction, includes: first character recognition means for carrying out the character recognition processing for each of first characters as N_C (N_C is an integer equal to or more than 2) characters from an end of the character string; and second character recognition means for carrying out the character recognition processing for

a second character different from the first characters. The first character recognition means sets a plurality of first character areas having various character area sizes for each of positions on the gray-scale image in the character recognition processing for each of the first characters, carries out the character recognition processing to each of the plurality of first character areas to calculate a character recognition result and an evaluation value, determines the character recognition result of the first character and a character position of the first character based on the calculated evaluation values, and determines an optimal character spacing size from the determined character positions. The second character recognition means sets a plurality of second character areas for each of positions on the gray-scale image according to the optimal character spacing size, carries out the character recognition processing to each of the plurality of second character areas to calculate a character recognition result and an evaluation value, and determines the character recognition result of the second character based on the character recognition result and the evaluation value which are calculated for each of the plurality of second character areas.

[0016]

In further another aspect of the present invention, a character recognition method of carrying out character recognition processing to a gray-scale image obtained by picking up a character string of characters arranged in a specific direction, includes: carrying out the character recognition processing for each of first characters as N_C (N_C is an integer equal to or more than 2) characters from an end of the character string; and carrying out the character recognition processing for a second character

different from the first characters. The carrying out the character recognition processing for each of first characters includes: setting a plurality of first character areas having various character area sizes for each of positions on the gray-scale image in the character recognition processing for each of the first characters; carrying out the character recognition processing to each of the plurality of first character areas to calculate a character recognition result and an evaluation value; determining the character recognition result of the first character based on the calculated evaluation values; and determines a first optimal character area size from among the various character area sizes. The carrying out the character recognition processing for a second character includes: setting a plurality of second character areas having the first optimal character area size for each of positions on the gray-scale image; carrying out the character recognition processing to each of the plurality of second character areas to calculate a character recognition result and an evaluation value; and determining the character recognition result of the second character based on the character recognition result and the evaluation value which are calculated for each of the plurality of second character areas.

[0017]

In further another aspect of the present invention, a character recognition method of carrying out character recognition processing to a gray-scale image obtained by picking up a character string of characters arranged in a specific direction, includes: carrying out the character recognition processing for each of first characters as N_C (N_C is an integer equal to or more than 2) characters from an end of the character string; and carrying out the character

recognition processing for a second character different from the first characters. The carrying out the character recognition processing for each of first characters includes: setting a plurality of first character areas having various character area sizes for each of positions on the gray-scale image in the character recognition processing for each of the first characters; carrying out the character recognition processing to each of the plurality of first character areas to calculate a character recognition result and an evaluation value; determining the character recognition result of the first character and a character position of the first character based on the calculated evaluation values; and determining an optimal character spacing size from the determined character positions. The carrying out the character recognition processing for a second character includes: setting a plurality of second character areas for each of positions on the gray-scale image according to the optimal character spacing size; carrying out the character recognition processing to each of the plurality of second character areas to calculate a character recognition result and an evaluation value; and determining the character recognition result of the second character based on the character recognition result and the evaluation value which are calculated for each of the plurality of second character areas.

[0018]

In further another aspect of the present invention, a non-transitory computer readable recording medium is provided which stores a program for making a processing unit to carry out character recognition processing to a gray-scale image obtained by picking up a character string of characters arranged in a specific direction. The program makes

the processing unit carry out the following steps: carrying out the character recognition processing for each of first characters as N_C (N_C is an integer equal to or more than 2) characters from an end of the character string; and carrying out the character recognition processing for a second character different from the first characters. The carrying out the character recognition processing for each of first characters includes: setting a plurality of first character areas having various character area sizes for each of positions on the gray-scale image in the character recognition processing for each of the first characters; carrying out the character recognition processing to each of the plurality of first character areas to calculate a character recognition result and an evaluation value; determining the character recognition result of the first character based on the calculated evaluation values; and determines a first optimal character area size from among the various character area sizes. The carrying out the character recognition processing for a second character includes: setting a plurality of second character areas having the first optimal character area size for each of positions on the gray-scale image; carrying out the character recognition processing to each of the plurality of second character areas to calculate a character recognition result and an evaluation value; and determining the character recognition result of the second character based on the character recognition result and the evaluation value which are calculated for each of the plurality of second character areas.

[0019]

In further another aspect of the present invention, a non-transitory computer readable recording medium is provided which stores a program

for making a processing unit to carry out character recognition processing to a gray-scale image obtained by picking up a character string of characters arranged in a specific direction. The program makes the processing unit carry out the following steps: carrying out the character recognition processing for each of first characters as N_c (N_c is an integer equal to or more than 2) characters from an end of the character string; and carrying out the character recognition processing for a second character different from the first characters. The carrying out the character recognition processing for each of first characters includes: setting a plurality of first character areas having various character area sizes for each of positions on the gray-scale image in the character recognition processing for each of the first characters; carrying out the character recognition processing to each of the plurality of first character areas to calculate a character recognition result and an evaluation value; determining the character recognition result of the first character and a character position of the first character based on the calculated evaluation values; and determining an optimal character spacing size from the determined character positions. The carrying out the character recognition processing for a second character includes: setting a plurality of second character areas for each of positions on the gray-scale image according to the optimal character spacing size; carrying out the character recognition processing to each of the plurality of second character areas to calculate a character recognition result and an evaluation value; and determining the character recognition result of the second character based on the character recognition result and the evaluation value which are calculated for each of the plurality

of second character areas.

[0020]

According to the present invention, when carrying out the character recognition processing to a gray-scale image, the improvement of precision of character recognition and the reduction of a calculation quantity can be realized at the same time.

Brief Description of the Drawings

[0021]

[FIG. 1]

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

[FIG. 2]

FIG. 2 is a conceptual diagram showing an example of a plate area image to which character recognition processing is carried out in the embodiment.

[FIG. 3]

FIG. 3 is a flow chart showing the outline of a character recognition method of the embodiment.

[FIG. 4]

FIG. 4 is a diagram showing the definition of a character area which is set to a plate area image and a position of the character area in the embodiment.

[FIG. 5]

FIG. 5 is a flow chart showing processing to N_C characters from one of ends in the character recognition method of the present embodiment.

[FIG. 6]

FIG. 6 is a diagram conceptually showing the contents of the character recognition processing to an area position (i, j).

[FIG. 7]

FIG. 7 is a diagram conceptually showing the contents of data processing which is carried out to the area size #k at step S15 in the embodiment.

[FIG. 8]

FIG. 8 is a diagram conceptually showing an evaluation value - brightness value conversion plot image which is generated in the present embodiment.

[FIG. 9]

FIG. 9 is a list of averages μ_k of evaluation values obtained for the area size #k and used in character area size determining processing of the present embodiment.

[FIG. 10]

FIG. 10 is a diagram showing the processing of determining the character position and the character spacing size in the present embodiment.

[FIG. 11]

FIG. 11 is a conceptual diagram showing an example of the character recognition processing carried out to $(N_C+1)^{th}$ character from one of the ends.

Description of Embodiments

[0022]

FIG. 1 is a block diagram showing the configuration of a character recognition apparatus according to an embodiment of the present invention. In the present embodiment, the character recognition apparatus 1 is used for recognition of characters on a number plate. That is, the character recognition apparatus 1 carries out character recognition processing to plate area image data 21 supplied externally, to generate plate recognition data 22. In this situation, the plate area image data 21 is image data of a plate area image, i.e. an image including a number plate (a vehicle registration number plate or a vehicle number plate). For example, the image is

obtained through image processing of extracting a part corresponding to the number plate from a picked-up image when a vehicle is picked up. Note that the plate area image data 21 is image data of a gray-scale image. Also, the plate recognition data 22 is data showing a character recognition result (i.e. recognized characters) obtained through the character recognition processing.

[0023]

The character recognition apparatus 1 includes an image processing IC (integrated 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 from an external unit, to the image processing IC 2. The external storage unit 4 stores data generated through the character recognition processing by the character recognition apparatus 1. The data which is stored in the external storage unit 4, contains the plate recognition data 22. The memory 5 is used as a working area for calculation processing by the image processing IC 2. The ROM 6 stores a program which is executed by the image processing IC 2. The program which is stored in the ROM 6, contains character recognition software 6a which is a program to be executed for the character recognition processing.

[0024]

When a rewritable nonvolatile memory (e.g. a flash memory) is used as ROM 6, a recording medium in which the character recognition software 6a has been recorded may be used for installation of the character recognition software 6a into the ROM 6. Also, the character recognition software 6a may be stored in the external storage unit 4. In this case, the recording medium in which the character recognition software 6a

has been stored, may be used for the installation of the character recognition software 6a into the external storage unit 4.

[0025]

The image processing IC 2 includes a processing module 11, an image input interface (I/F) 12, a data I/O interface 13, a memory controller 14 and a ROM controller 15. The processing module 11, the 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 while using the memory 5 as a working area, to carry out the character recognition processing to the plate area image data 21. The image input interface 12 is an interface used to input the plate area image data 21 to the image processing IC 2. The data I/O interface 13 is an interface used to access the external storage unit 4. The memory controller 14 is an interface used to access the memory 5. Also, the ROM controller 15 is an interface used to access ROM 6.

[0026]

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

[0027]

FIG. 2 shows an example of an image of the plate area image data 21, i.e. a plate area image to which the character recognition processing is carried out, in the character recognition method of the present embodiment. The plate area image is a gray-scale image in the present embodiment and is obtained by extracting a part corresponding to the number plate

from a vehicle picked-up image obtained when picking up a vehicle. The following description is made by using an xy coordinate system defined in the plate area image. Here, an x-axial is prescribed in a character width direction (a lateral direction) of the plate area image, and a y-axial is prescribed in a character height direction (a vertical direction) in the plate area image. The character recognition method of the present embodiment presupposes that the size of each character is approximately same in the plate area image. For example, such a presupposition is proper when carrying out the number plate recognition.

[0028]

FIG. 3 is a flow chart showing an outline of the character recognition method of the present embodiment. The above-mentioned character recognition software 6a is a program code group used to execute the character recognition method.

[0029]

In the character recognition method of the present embodiment, first, the character recognition processing is carried out to N_C characters from one end of the plate area image (Step S01). Here, N_C is the specified number of characters. The plate area image of FIG. 2 shows an example in which the character recognition processing is carried out to three characters from the left end at step S01.

[0030]

In the character recognition processing at step S01, character areas with various sizes are set on positions of the plate area image and the character recognition processing is carried out to each of the set character areas. Here, the character area is an area in which each character is assumed to exist. FIG. 4 is a diagram showing an example of the

character area. In the present embodiment, the character area 31 is rectangular (that is, a rectangle (which contains a square)). The position of each character area 31 is defined as a center of the character area 31, i.e. a point of intersection 33 of diagonal lines 32. Moreover, based on evaluation values calculated in the character recognition processing, the optimal character recognition result (i.e. recognized character) and the position and size of the optimal character area are determined.

[0031]

Next, the character recognition processing to the remaining characters is carried out by using data obtained in the character recognition processing to the N_C characters at step S01 (Step S02). At step S02, data of the size of the character area and the character spacing obtained in the character recognition processing at step S01 is used. The character recognition method of the present embodiment decreases a search range in the character recognition processing at step S02 by such a technique, and the improvement of precision of the character recognition and the reduction of a calculation quantity are realized at the same time. Hereinafter, the processing in each step will be described in detail.

[0032]

FIG. 5 is a flow chart showing the details of the character recognition processing to the N_C characters at step S01. In the processing at step S01, roughly, after an initial setting (step S11) is carried out, character areas with various sizes are set on various positions, and the character recognition processing is carried out to each of the set character areas (Steps S12 to S15). Moreover, based on the evaluation values calculated in the character recognition processing, the optimal

character area size, the optimal character position, the optimal character spacing size and the optimal character recognition result are determined (Steps S16 to S18). Below, the character recognition processing to the N_c characters at step S01 will be described in detail.

[0033]

At step S11, a character area initial size, a character area size increment (x-direction increment and y-direction increment) and a maximum value of character area size (x-direction maximum value and y-direction maximum value) and a shift quantity of the character area are defined. The character area initial size is a size of the character area which is set initially and contains a size of the character area in the x-direction (that is, a width of the character area) and a size thereof in the y-direction (that is, a height of the character area). The character area size increment is an increment when the size of the character area is changed in case of search of the optimal character area, and contains the x-direction increment and the y-direction increment. The character area size maximum value is a maximum value of the size when the size of the character area is changed in case of search of the optimal character area, and contains the x-direction maximum value and the y-direction maximum value. The shift quantity of the character area is a specified value of a variation of the position of the character area when the position of the character area is changed in case of search of the optimal character area and contains the x-direction shift quantity and the y-direction shift quantity. These initial setting values are determined according to the position of the plate area image of the vehicle picked-up image.

[0034]

The processing of steps S12 to S15 is repeatedly carried out for the same number of times as the number of possible area sizes. First, the size of the character area is set (Step S12). In the processing for the first time, the character area size is set to a character area initial size defined as the initial setting. On the other hand, in the processing for the second time and the subsequent, the character area size is set to a size changed from the character area initial size based on the x-direction increment and the y-direction increment. The character area size set at step S12 is referred to as an area size #k, and k is an index showing the area size.

[0035]

Moreover, the position of the character area is set (Step S13). The position set at step S13 is referred to as an area position (i, j). Here, i is an index showing a position in the x-direction and j is an index showing a position in the y-direction. As described above, in the present embodiment, the character area is rectangular and the position of the character area is defined as the character area center. In the processing of step S13 for the first time, the position of the character area is set to a predetermined processing start position. In the plate area image, because the position where the N_c characters exists, especially, the position of the leftmost character can be assumed in a range with some extent, it is enough that the processing start position is determined appropriately in the assumed range. In the processing for the second time and the subsequent, the position of the character area is set while changing the position of the character area according to the shift quantity of the character area which is contained in the initial setting values.

[0036]

Moreover, the character recognition processing is carried out to the character area in the position determined at step S13 (Step S14). When the position of the character area is determined as the position (i, j) at step S13, a character recognition result (i.e. a recognized character) for the character area in the position (i, j), and an evaluation value are obtained in the character recognition processing at step S14. Moreover, the character recognition result for the character area in the position (i, j) is ranked based on the evaluation value. For example, as a specific algorithm of the character recognition processing at step S14, the algorithm disclosed in the above-mentioned Non-Patent Literature 1 may be used.

[0037]

FIG. 6 is a diagram showing a specific instance of the character recognition processing at step S14. Taking a case of the character recognition processing to the plate area image in FIG. 2 as an example, the character "S" having the evaluation value of 0.911 is obtained as a first rank character recognition result for the leftmost character, and the character "2" having the evaluation value of 0.566 is obtained as a second rank character recognition result. Here, the evaluation value is in a range of 0 to 1.0, and takes a value nearer 1.0 when the coincidence degree with a character template is higher in the character recognition processing.

[0038]

The processing of steps S13 and S14 is repeatedly carried out while changing the position of the character area. The processing of steps S13 and S14 is repeatedly carried out until the character recognition processing to the character area in all the positions in the permissible position range is completed. In the plate area image, because the

position where the N_c characters from the leftmost position exit can be assumed with some extent, the permissible position range of the character area can be determined appropriately according to the assumed position.

[0039]

Regarding the area size #k set at step S12, when the character recognition processing to the character area in all of the positions in the permissible position range is completed, the data processing described below is carried out to the character areas corresponding to the higher evaluation values (Step S15).

[0040]

At step S15, first, the character recognition result and the evaluation value in the first rank are selected for each area position (i, j), as shown in FIG. 7. Moreover, the character recognition results and the evaluation values corresponding to top m_c evaluation values are extracted from among the character recognition results in the first rank for each of the area positions. Moreover, an average μ_k of the evaluation values for the extracted top m_c character recognition results is calculated. Here, k is an index showing an area size, and μ_k shows the average of the evaluation values for the top m_c character recognition results calculated in correspondence to the area size #k.

[0041]

Moreover, the evaluation value - brightness value conversion plot image shown in FIG. 8 is generated from the evaluation values of the top m_c (m_c is a predetermined value) character recognition results calculated in correspondence to the area size #k. In this situation, the evaluation value - brightness value conversion plot image is an image

generated by supposing that a pixel of the character recognition result corresponding to the area position (i, j) has a brightness value corresponding to the evaluation value of the character recognition result, for each of the character recognition results corresponding to the top m_c evaluation values from among the character recognition results in the first rank for each of the area positions. As the result, the non-zero brightness value is given to the m_c pixels. The brightness value of "0" is set to the other pixels. Note that the predetermined value m_c is determined appropriately to be greater than N_c and a value of several times (e.g. 5 times) of N_c is previously set as the predetermined value m_c.

[0042]

FIG. 8 shows an example of the evaluation value - brightness value conversion plot image. The evaluation value - brightness value conversion plot image corresponding to the area size #k is shown by reference numeral 24-k in FIG. 8. Here, n_s is the number of possible area sizes. As described later, the evaluation value - brightness value conversion plot image is used for the determination of the character position and the determination of a character spacing size.

[0043]

The processing of the above-mentioned steps S12 to S15 is repeatedly carried out while updating the character area size. At this time, at step S12, the character area size is set while changing the character area size used in the immediately previous processing based on the x-direction increment and the y-direction increment. Also, because step S15 is carried out for each area size, as shown in FIG. 9, the average μ_k of the evaluation values is obtained for each area size #k.

[0044]

After the processing of steps S12 to S15 is carried out to all the possible character area sizes, character area size determining processing is carried out (Step S16). At step S16, the area size corresponding to the highest of the averages μ_k calculated at step S15 is finally adopted as the character area size. The character area size adopted at step S16 is used for the character recognition processing to the $(N_C+1)^{th}$ character, as mentioned later.

[0045]

Next, the character position and character spacing size of each character are determined (Step S17). In this situation, in the present embodiment, the character position of each character is defined as the center of the character area corresponding to the character. Moreover, the character spacing size is defined as an interval between the character positions of the neighbor characters.

[0046]

FIG. 10 is a conceptual diagram showing a procedure of determining the character position and the character spacing size at step S17. First, the evaluation value - brightness value conversion plot image corresponding to the character area size adopted at step S16 is selected (Step S21). When the character area size adopted at step S16 is the area size #k, the evaluation value - brightness value conversion plot image 24-k is selected.

[0047]

Moreover, binarization processing is carried out to binarize the selected evaluation value - brightness value conversion plot image based on a predetermined brightness threshold value. Moreover, labeling processing is carried out to the image

(binarized image) obtained in the binarization processing (Step S22). The labeling processing is processing of assigning an identical label to the concatenated pixels of an identical color (white or black) in the binarized image. In the present embodiment, the binarization processing is carried out so that a pixel having the brightness value equal to or higher than the brightness threshold value is determined to be white and the other pixel is determined to be black, in the evaluation value - brightness value conversion plot image. Moreover, an identical label is given to a set of concatenated "white" pixels. In FIG. 10, an example is shown in which four labels #1 to #4 are given at step S22.

[0048]

When the number of labels determined at step S22 is more than the number of characters (i.e. the specified character number N_C) to be subjected to the character recognition processing at step S01, labels improper as the character positions are removed (Step S23). At step S23, first, the average μ_L of the evaluation values is calculated for each label #L. The brightness value of each pixel belonging to each label corresponds to the evaluation value for the character recognition result of the character area in the position of the pixel, and the average of the evaluation values corresponding to the pixels belonging to the label #L is calculated as μ_L. Moreover, the gravity position of each label #L is calculated. Because each label #L includes one pixel or a plurality of pixels, the gravity position of each label #L is calculated from the positions of the pixels belonging to the label #L.

[0049]

Moreover, processing of calculating a distance between the gravity position of each label

and the gravity position of another label, and excluding the label when the distance from the gravity position of the other label to the label is equal to or smaller than a threshold D_{TH} is repeatedly carried out in order from the label having the higher average μ_L until the labels of the same number as the specified number of characters N_C are left. Through this processing, each label is related to each of the N_C characters from the leftmost end.

[0050]

Moreover, the label corresponding to the character recognition result having the highest evaluation value of the labels is selected, and the position of the center of the pixels of the label corresponding to the character recognition result having the highest evaluation value is determined as the character position for the character (Step S24). Here, in the present embodiment, note that the character position of each character is defined as the position of the center of the character area.

[0051]

Moreover, a distance to the character position of the neighbor character in the x-direction is calculated and a character spacing size (i.e. a character interval) is determined based on the calculated distance. When a plurality of distances to the character positions of the neighbor characters in the x-direction exist, the character spacing size is determined by carrying out processing of the plurality of distances. For example, an average of the plurality of distances may be the character spacing size. The character spacing size determined at step S24 is used for the character recognition processing of the $(N_C+1)^{th}$ character and the subsequent, to be mentioned later.

[0052]

Moreover, the character recognition result of the character area which is positioned on the character position of each character determined at step S17 and has the character area size determined at step S16 is selected as the character recognition result of each character (Step S18).

[0053]

Through the above procedure, the character recognition result for the N_C characters from the leftmost end is obtained, and the optimal character area size (that is, the character area size determined at step S16) and the optimal character spacing size (that is, the character spacing size determined at step S17) are obtained.

[0054]

Step S02:

Next, the character recognition processing is carried out to the remaining characters ($(N_C+1)^{th}$ character and the subsequent from the leftmost end in the present embodiment). The optimal character area size and the optimal character spacing size which have been obtained in the above-mentioned processing are used in the character recognition processing of the remaining characters, and thus, the reduction of the search range of the character recognition processing is attempted.

[0055]

FIG. 11 is a diagram showing the character recognition processing of the $(N_C+1)^{th}$ character. In the processing of the $(N_C+1)^{th}$ character, the reference position of the character position of the $(N_C+1)^{th}$ character is determined as the position which is shifted into the x-direction by the optimal character spacing size DX obtained in the above-mentioned processing from the character position of the N_C^{th} character (determined at the above-mentioned step

S17). Moreover, the character area is set while sequentially changing the position in the reference position and its peripheral range, and the character recognition processing is carried out to the set character area. At this time, as a reference size (width and height) of the set character area, the optimal character area size obtained in the above-mentioned processing is used. In FIG. 11, of the optimal character area size, a size in the x-direction (i.e. width) is shown by the symbol "W" and a size in the y-direction (i.e. height) is shown by the symbol "H". Regarding the character area set in this character recognition processing, the width and the height are set while sequentially changing the width and the height in the width and height of reference size and their peripheral ranges. Moreover, the character recognition result having the highest evaluation value calculated in the character recognition processing (i.e. recognized character) and the position of character area are determined as the character recognition result and the character position of the $(N_C+1)^{th}$ character.

[0056]

Moreover, the processing is carried out to the $(N_C+2)^{th}$ character and the subsequent from the leftmost end, in the same way. The reference position of the character position of the $(N_C+2)^{th}$ character is determined as the position shifted in the x-direction by the character spacing size DX from the character position (determined at the above-mentioned processing) of the $(N_C+1)^{th}$ character. Moreover, the character area is set while sequentially changing the position of the character area in the reference position and it peripheral range, and sequentially changing the width and height of the character area in the width and height of the reference size, and their

peripheral ranges, and the character recognition processing is carried out to each set character area. Moreover, the character recognition result having the highest evaluation value calculated in the character recognition processing (i.e. recognized character) and the position of the character area are determined as the character recognition result and the character position of the $(N_C+2)^{th}$ character. Hereinafter, the similar processing is repeatedly carried out until the character recognition processing completes to all the characters.

[0057]

When it is assumed that there are plate area images for a plurality of kinds of number plates, the kind of the number plate is specified based on the character spacing size obtained in the above-mentioned processing, and processing according to the kind of the number plate which has been specified in the character recognition processing of the $(N_C+1)^{th}$ character and the subsequent may be carried out. For example, measure processing to the specific similar character may be carried out.

[0058]

In the character recognition method according to the present embodiment which has been described above, the character recognition processing is carried out without carrying out the binarization processing to the plate area image. Therefore, a problem accompanied by the binarization processing can be avoided. For example, the character recognition is possible even if the plate area image has a part where the brightness is not uniform. In addition, in the character recognition method of the present embodiment, because the character recognition processing of the remaining characters is carried out by using the character area size and the character

spacing size which are obtained in the character recognition processing of the N_C characters from the end, a search range in the character recognition processing of the remaining characters can be reduced.

[0059]

Note that in the above-mentioned embodiment, the character recognition processing of the remaining characters is carried out by using the character area size and the character spacing size which have been obtained in the character recognition processing of the N_C characters from the end. However, the character recognition processing of the remaining characters may be carried out by using only one of the character area size and the character spacing size. In this case, the effect that the search range can be reduced is obtained.

[0060]

Also, in the above-mentioned embodiment, the character recognition processing is carried out in order from the leftmost character. However, the order may be opposite. For example, the character recognition processing may be carried out in order from the rightmost character. Also, when the characters are arranged in line in the upper and lower direction, the character recognition processing may be carried out in order from the uppermost character and oppositely, the character recognition processing may be carried out in order from the lowermost character.

[0061]

Moreover, the above-mentioned character recognition processing is carried out two times in opposite directions to each other and the character recognition results obtained in the character recognition processing may be compared. In this case, when the character recognition results of some character are different, the character recognition

result with the higher evaluation value may be selected as the final character recognition result.

[0062]

In one modification example, like the above-mentioned embodiment, the character recognition result and the evaluation value of each character are obtained by carrying out the character recognition processing in order from the leftmost character. Moreover, the character recognition result and the evaluation value of each character are obtained by carrying out the character recognition processing in order from the rightmost character. More specifically, processing similar to step S01 is first carried out to the rightmost N_C characters, and after obtaining the character recognition result and the evaluation value of each of the N_C characters, processing similar to step S02 is carried out to the remaining characters to obtain the character recognition result and the evaluation value of each of the remaining characters. In this case, regarding the remaining characters, the character recognition result and the evaluation value of each of the remaining characters are obtained from the rightmost character of the remaining characters. After that, the character recognition result obtained by carrying out the character recognition processing in order from the leftmost character, and the character recognition result obtained by carrying out the character recognition processing in order from the rightmost character are compared. When the character recognition results are identical to each other with respect to some character, the identical character recognition result is selected as the final character recognition result of the character. On the other hand, when the character recognition results are different with respect to some character, the

character recognition result with the higher evaluation value is selected as the final character recognition result of the character.

[0063]

According to such a technique, when a shadow and so on are generated on a part of the plate, because it is possible to determine a character area size and a character spacing size based on the result of the area where there is not the shadow (the area of the higher evaluation value as the result), the recognition precision can be improved.

[0064]

As another modification example of the present embodiment, when a character (character similar to it) which is easy for a recognition error to occur is known, and the similar character is obtained as the character recognition result, the character area size may be determined without using the character recognition result and the evaluation value. For example, as an example of the similar character, B and 8, D and 0, 7 and Z and so on are exemplified.

[0065]

For example, at step S15, the character recognition result and the evaluation value corresponding to a first rank for each area position (i, j) are selected, and then the character recognition results and the evaluation values corresponding to the top m_c evaluation values are extracted from among the above-selected character recognition results and evaluation values. In this case, m_c sets of the character recognition results and the evaluation values may be extracted except for the character recognition results of the similar characters. In this case, the average μ_k is calculated as an average of the evaluation values of the top m_c

character recognition results except for the character recognition results of the similar characters. At this time, it is enough to store a list of the similar characters in a suitable storage unit (e.g. an external storage unit 4).

[0066]

In the above, the embodiments of the present invention are specifically described, but the present invention is not limited to the above-mentioned embodiments. It is obvious to a person skilled in the art that it is possible to implement the present invention in the form of various modifications. For example, the embodiments when the present invention is applied to the number plate recognition (the recognition of characters written on the number plate) are described in the above. However, it is possible to apply the present invention to general character recognition to a picked-up image as a gray-scale image.

CLAIMS

1. A character recognition apparatus which carries out character recognition processing to a gray-scale image obtained by picking up a character string of characters arranged in a specific direction, comprising:

first character recognition means for carrying out the character recognition processing for each of first characters as N_C (N_C is an integer equal to or more than 2) characters from a first end of the character string; and

second character recognition means for carrying out the character recognition processing for each of second characters different from the first characters,

wherein the first character recognition means sets a plurality of first character areas having various character area sizes for each of positions on the gray-scale image in the character recognition processing for each of the first characters, carries out the character recognition processing to each of the plurality of first character areas to calculate a character recognition result and an evaluation value, determines the character recognition result of the first character based on the calculated evaluation values, and determines a first optimal character area size as an optimal character area size from among the various character area sizes, and

wherein the second character recognition means sets a plurality of second character areas having the first optimal character area size for each of positions on the gray-scale image, carries out the character recognition processing to each of the plurality of second character areas to calculate a character recognition result and an evaluation value, and determines the character recognition result of the

second character based on the character recognition result and the evaluation value which are calculated for each of the plurality of second character areas.

2. The character recognition apparatus according to claim 1, wherein the first character recognition means determines a character position of each of the first characters based on the evaluation values, and determines an optimal character spacing size showing an optimal character spacing from the determined character positions, and

wherein the second character recognition means sets positions of the plurality of second character areas based on the optimal character spacing size.

3. The character recognition apparatus according to claim 1, wherein the first character recognition means ranks the character recognition result obtained for each of the positions of the plurality of first character areas, based on the evaluation values,

wherein the first character recognition means extracts the character recognition results corresponding to top m_c (m_c is a predetermined integer greater than N_c) evaluation values from among the character recognition results obtained for the positions of the plurality of first character areas and having a first rank for each position, and calculates a first average as an average of the evaluation values of the m_c character recognition results, and

wherein the first character recognition means determines the character area size corresponding to the highest first average as an optimal character area size.

4. The character recognition apparatus according to claim 3, wherein the first character recognition means generates an evaluation value - brightness value conversion plot image as an image in which pixels having brightness values corresponding to the evaluation values of the m_c character recognition results are positioned on the position of the character area corresponding to each of the m_c character recognition results in each of the character area sizes, and carries out binarization processing to the evaluation value - brightness value conversion plot image to generate a binarized image,

wherein the first character recognition means carries out labeling processing to the binarized image to give a label to each of sets of concatenated pixels of an identical color, and calculates a second average as an average of the evaluation values of the character recognition results corresponding to the pixels which belongs to each of the labels,

wherein the first character recognition means calculates a distance between a gravity position of each of the labels and a gravity position of another label sequentially from the label having a higher second average, and repeatedly carries out processing which removes each label when the distance to the gravity position of the other label is shorter than a predetermined threshold value, until N_c labels are left,

wherein the first character recognition means selects the pixel having the highest evaluation value of the character recognition profit result corresponding to each label, of the pixels belonging to each of the N_c remaining labels, determines the position of the pixel having the highest evaluation value as the character position of the first character, and determines the optimal character

spacing size which is an optimal character spacing from the determined character position, and

wherein the second character recognition means sets the position of the plurality of second character areas based on the optimal character spacing size.

5. The character recognition apparatus according to any one of claims 1 to 4, further comprising:

third character recognition means for carrying out the character recognition processing for third characters of the N_C characters of the character string from a second end opposite to the first end;

fourth character recognition means for carrying out the character recognition processing for fourth characters which are characters of the character string other than the N_C characters from the second end; and

final character recognition result determining means,

wherein the third character recognition means sets a plurality of third character areas of various character area sizes for each of positions on the gray-scale image in the character recognition processing of the third characters, carries out the character recognition processing to each of the plurality of third character areas to calculate a character recognition result and an evaluation value, and determines the character recognition results of the third characters and a second optimal character area size as sizes of optimal character areas based on the calculated evaluation values,

wherein the fourth character recognition means sets a plurality of fourth character areas having the second optimal character area size for each of positions on the gray-scale image, carries out the

character recognition processing to each of the plurality of fourth character areas to calculate a character recognition result and an evaluation value, and determines the character recognition results of the fourth characters based on the character recognition results and the evaluation values calculated for the plurality of fourth character areas, and

wherein the final character recognition result determining means determines, when the character recognition result of a specific character of the character string which is obtained by the first character recognition means and the second character recognition means coincides with the character recognition result of the specific character which is obtained by the third character recognition means and the fourth character recognition means, the coinciding character recognition result as a final character recognition result of the specific character, and determines, when does not coincide, one having a higher evaluation value, of the character recognition result of the specific character which is obtained by the first character recognition means and the second character recognition means and the character recognition result of the specific character which is obtained by the third character recognition means and the fourth character recognition means, as a final character recognition result of the specific character.

6. The character recognition apparatus according to any one of claims 1 to 4, wherein the first character recognition means comprises memory means for storing similar character data indicating similar characters, and

wherein the first character recognition means

determines an optimal character area size, without using character recognition results and evaluation values for the similar characters, among the character recognition results obtained by carrying out the character recognition processing to each of the plurality of first character areas.

7. A character recognition apparatus which carries out character recognition processing to a gray-scale image obtained by picking up a character string of characters arranged in a specific direction, comprising:

first character recognition means for carrying out the character recognition processing for each of first characters as N_C (N_C is an integer equal to or more than 2) characters from an end of the character string; and

second character recognition means for carrying out the character recognition processing for a second character different from the first characters,

wherein the first character recognition means sets a plurality of first character areas having various character area sizes for each of positions on the gray-scale image in the character recognition processing for each of the first characters, carries out the character recognition processing to each of the plurality of first character areas to calculate a character recognition result and an evaluation value, determines the character recognition result of the first character and a character position of the first character based on the calculated evaluation values, and determines an optimal character spacing size from the determined character positions, and

wherein the second character recognition means sets a plurality of second character areas for

each of positions on the gray-scale image according to the optimal character spacing size, carries out the character recognition processing to each of the plurality of second character areas to calculate a character recognition result and an evaluation value, and determines the character recognition result of the second character based on the character recognition result and the evaluation value which are calculated for each of the plurality of second character areas.

8. A character recognition method of carrying out character recognition processing to a gray-scale image obtained by picking up a character string of characters arranged in a specific direction, comprising:

carrying out the character recognition processing for each of first characters as N_C (N_C is an integer equal to or more than 2) characters from an end of the character string; and

carrying out the character recognition processing for a second character different from the first characters,

wherein said carrying out the character recognition processing for each of first characters comprises:

setting a plurality of first character areas having various character area sizes for each of positions on the gray-scale image in the character recognition processing for each of the first characters;

carrying out the character recognition processing to each of the plurality of first character areas to calculate a character recognition result and an evaluation value;

determining the character recognition result of the first character based on the calculated

evaluation values; and

determines a first optimal character area size from among the various character area sizes, and

wherein said carrying out the character recognition processing for a second character comprises:

setting a plurality of second character areas having the first optimal character area size for each of positions on the gray-scale image;

carrying out the character recognition processing to each of the plurality of second character areas to calculate a character recognition result and an evaluation value; and

determining the character recognition result of the second character based on the character recognition result and the evaluation value which are calculated for each of the plurality of second character areas.

9. A character recognition method of carrying out character recognition processing to a gray-scale image obtained by picking up a character string of characters arranged in a specific direction, comprising:

carrying out the character recognition processing for each of first characters as N_C (N_C is an integer equal to or more than 2) characters from an end of the character string; and

carrying out the character recognition processing for a second character different from the first characters,

wherein said carrying out the character recognition processing for each of first characters comprises:

setting a plurality of first character areas having various character area sizes for each of

positions on the gray-scale image in the character recognition processing for each of the first characters;

carrying out the character recognition processing to each of the plurality of first character areas to calculate a character recognition result and an evaluation value;

determining the character recognition result of the first character and a character position of the first character based on the calculated evaluation values; and

determining an optimal character spacing size from the determined character positions, and

wherein said carrying out the character recognition processing for a second character comprises:

setting a plurality of second character areas for each of positions on the gray-scale image according to the optimal character spacing size;

carrying out the character recognition processing to each of the plurality of second character areas to calculate a character recognition result and an evaluation value; and

determining the character recognition result of the second character based on the character recognition result and the evaluation value which are calculated for each of the plurality of second character areas.

10. A non-transitory computer readable recording medium which stores a program for making a processing unit to carry out character recognition processing to a gray-scale image obtained by picking up a character string of characters arranged in a specific direction,

wherein when being executed, said program makes the processing unit carry out the following

steps:

carrying out the character recognition processing for each of first characters as N_C (N_C is an integer equal to or more than 2) characters from an end of the character string; and

carrying out the character recognition processing for a second character different from the first characters,

wherein said carrying out the character recognition processing for each of first characters comprises:

setting a plurality of first character areas having various character area sizes for each of positions on the gray-scale image in the character recognition processing for each of the first characters;

carrying out the character recognition processing to each of the plurality of first character areas to calculate a character recognition result and an evaluation value;

determining the character recognition result of the first character based on the calculated evaluation values; and

determines a first optimal character area size from among the various character area sizes, and

wherein said carrying out the character recognition processing for a second character comprises:

setting a plurality of second character areas having the first optimal character area size for each of positions on the gray-scale image;

carrying out the character recognition processing to each of the plurality of second character areas to calculate a character recognition result and an evaluation value; and

determining the character recognition result

of the second character based on the character recognition result and the evaluation value which are calculated for each of the plurality of second character areas.

11. A non-transitory computer readable recording medium which stores a program for making a processing unit to carry out character recognition processing to a gray-scale image obtained by picking up a character string of characters arranged in a specific direction,

wherein when being executed, said program makes the processing unit carry out the following steps:

carrying out the character recognition processing for each of first characters as N_C (N_C is an integer equal to or more than 2) characters from an end of the character string; and

carrying out the character recognition processing for a second character different from the first characters,

wherein said carrying out the character recognition processing for each of first characters comprises:

setting a plurality of first character areas having various character area sizes for each of positions on the gray-scale image in the character recognition processing for each of the first characters;

carrying out the character recognition processing to each of the plurality of first character areas to calculate a character recognition result and an evaluation value;

determining the character recognition result of the first character and a character position of the first character based on the calculated evaluation values; and

determining an optimal character spacing size from the determined character positions, and

wherein said carrying out the character recognition processing for a second character comprises:

setting a plurality of second character areas for each of positions on the gray-scale image according to the optimal character spacing size;

carrying out the character recognition processing to each of the plurality of second character areas to calculate a character recognition result and an evaluation value; and

determining the character recognition result of the second character based on the character recognition result and the evaluation value which are calculated for each of the plurality of second character areas.