

DESCRIPTION

LICENSE-PLATE NUMBER RECOGNITION SYSTEM

TECHNICAL FIELD

[0001]

The present invention relates to a license-plate number recognition system.

BACKGROUND ART

[0002]

One of the conventionally known systems performing license-plate number recognition for running vehicles captures an image of the front or rear of a vehicle based on a vehicle detection signal obtained from a vehicle detector, and performs image processing for recognition of a license-plate number of the vehicle. Such a license-plate number recognition system takes only one image for each vehicle and thus has a problem of not being able to correctly recognize the license-plate number of the target vehicle when the license-plate number does not properly appear in the captured image.

[0003]

The increasing speed of computers in recent years has enabled real-time processing of moving images. Some efforts are therefore being made to enhance the accuracy of recognition of license-plate numbers by successively taking multiple images capturing the license-plate number into a computer and executing the license-plate number recognition processing for the multiple images (for example, see Patent Documents 1 and 2).

Patent Document 1: Japanese Unexamined Patent Application Publication No. Hei 7-272189

Patent Document 2: Japanese Patent No. 3632287

Non-patent Document 1: Nakabayashi, Kitamura, and Kawaoka, "High-speed frame-less hand-written character reading scheme using ambiguous term search," Journal of the Institute of Electronics, Information and Communication Engineers D-II, Vol.

J74-D-n-II, No. 11, Dec. 1991, p.1528-1534

DISCLOSURE OF THE INVENTION

PROBLEMS TO BE SOLVED BY THE INVENTION

[0004]

However, in Patent Document 1 above, when multiple recognition results are obtained from images of the license-plate number of one vehicle by the license-plate number recognition processing, the identity of the license-plate number is judged using weighting evaluation of the number of matched characters in the recognition results of a number plate and the degree of coincidence of edge data of the images of the number plate. Since different types of data, that is, the degree of coincidence of characters and the degree of coincidence of edge data are evaluated, it is difficult to adjust the weights, and requires complicated processing in order to increase the recognition accuracy.

[0005]

In Patent Document 2, when multiple recognition results are obtained, a final recognition result is first determined by majority. When the final recognition result is not determined by majority, the result having the largest number of recognized characters is determined as the final result. Accordingly, when a disturbance component which is not a character, such as a part of a plate frame, is misjudged as a character, an incorrect result is outputted as the final recognition result, which in turn decreases the reliability of the system.

[0006]

In this perspective, an object of the present invention is to provide a license-plate number recognition system which is capable of performing license-plate number recognition processing for a running vehicle more easily with higher accuracy.

MEANS FOR SOLVING THE PROBLEMS

[0007]

A license-plate number recognition system according to a first aspect of the present invention for solving the aforementioned problems comprises: a camera which captures successive images of a number plate of a vehicle running on a road, at constant time intervals; and a license-plate number recognition processing unit which recognizes a license-plate number of the vehicle from a plurality of frame images captured by the camera. The license-plate number recognition processing means includes means that are used in a case where a plurality of license-plate number candidates are obtained from the frame images, the means including: means for determining a license-plate number by majority when recognition results of some of the license-plate number candidates are the same with each other; means for detecting numbers of characters of the license-plate number candidates when the plurality of license-plate number candidates are different from one another, and determining by character similarity a character recognized as a different result across the license-plate number candidates, when the detected numbers of characters of the license-plate number candidates are the same; and means for determining the license-plate number from positions of characters of the license-plate number candidates and from the recognition results of the characters, when the numbers of characters of the license-plate number candidates are not the same.

[0008]

A license-plate number recognition system according to a second aspect of the present invention for solving the aforementioned problems comprises: a camera which captures successive images of a number plate of a vehicle running on a road, at constant time intervals; and license-plate number recognition processing means for recognizing a license-plate number of the vehicle from a plurality of frame images captured by the camera. In a case where a plurality of license-plate number candidates are obtained from the frame images, the license-plate number recognition processing means: when

recognition results of some of the license-plate number candidates are the same with each other, determines a license-plate number by majority; when the plurality of license-plate number candidates are different from one another, detects numbers of characters of the license-plate number candidates; when the detected numbers of characters of the license-plate number candidates are the same, determines by character similarity a character recognized as a different result across the license-plate number candidates; and when the detected numbers of characters of the license-plate number candidates are not the same, determines, as a character constituting the license-plate number, a character whose recognition results and character positions are the same across the license-plate number candidates, while setting estimated character positions for a character whose recognition results and character positions are not the same across the license-plate number candidates as well as assigning a weight to each of the estimated character positions, then calculating a score for each of the recognition results corresponding to the estimated character positions based on the similarity of the recognition results and the weights, and thus determining, based on the scores, the character whose recognition results and character positions are not the same across the license-plate number candidates.

[0009]

A license-plate number recognition system according to a third aspect of the present invention for solving the aforementioned problems is characterized in that, in the first or second aspect, the camera captures rear and front number plates of the vehicle, and the captured frame images of the number plates are subjected to a recognition processing of the license-plate number.

[0010]

A license-plate number recognition system according to a fourth aspect of the present invention for solving the aforementioned problems is characterized in that, in the first

or second aspect, images of the same number plate are captured from different angles, and the captured frame images of the number plate are subjected to a recognition processing of the license-plate number.

[0011]

A license-plate number recognition system according to a fifth aspect of the present invention for solving the aforementioned problems is characterized in that, in the first or second aspect, after the recognition processing of the license-plate number, a determined recognition result obtained by the recognition processing of the license-plate number is checked against number plate information managed in a database, so as to correct the determined recognition result.

[0012]

A license-plate number recognition system according to a sixth aspect of the present invention for solving the aforementioned problems is characterized in that, in the first or second aspect, the license-plate number is determined using a license-plate number recognized from a frame image captured by another camera placed near the camera.

[0013]

A license-plate number recognition system according to a seventh aspect of the present invention for solving the aforementioned problems is characterized in that, in the first or second aspect, the character similarity is resolution of sections of the number plate captured in the frame images.

[0014]

A license-plate number recognition system according to an eighth aspect of the present invention for solving the aforementioned problems is characterized in that, in the first or second aspect, the character similarity is contrast of images of the number plate captured in the frame images.

[0015]

A license-plate number recognition system according to a ninth aspect of the present invention for solving the aforementioned problems is characterized in that, in the first

or second aspect, the license-plate number is determined in conjunction with a character arrangement rule of the number plate.

[0016]

A license-plate number recognition system according to a tenth aspect of the present invention for solving the aforementioned problems is characterized in that, in the first or second aspect, while the successive images of the number plate of the vehicle running on the road are captured at the constant time intervals by the camera, magnification of a lens of the camera is changed according to the position of the number plate in one of the frame images that is captured most recently.

[0017]

A license-plate number recognition system according to an eleventh aspect of the present invention for solving the aforementioned problems is characterized in that, in the first or second aspect, while the successive images of the number plate of the vehicle running on the road are captured at the constant time intervals by the camera, magnification of a lens of the camera is changed according to speed of the vehicle calculated based on a displacement of the number plate between two successive frame images most recently captured.

[0018]

A license-plate number recognition system according to a twelfth aspect of the present invention for solving the aforementioned problems is characterized in that, in the first or second aspect, the license-plate number recognition processing means sets a plurality of evaluation values for each of the frame images, and recognizes the license-plate number of the vehicle individually based on the plurality of evaluation values.

[0019]

A license-plate number recognition system according to a thirteenth aspect of the present invention for solving the aforementioned problems is characterized in that, in the twelfth aspect, the evaluation values are threshold values for

binarization performed for image processing on the frame images.

[0020]

A license-plate number recognition system according to a fourteenth aspect of the present invention for solving the aforementioned problems is characterized in that, in the twelfth aspect, the evaluation values are number plate cutout positions used in extracting the number plate images from the frame images.

[0021]

A license-plate number recognition system according to a fifteenth aspect of the present invention for solving the aforementioned problems is characterized in that, in the first or second aspect, after the recognition processing of the license-plate number, the determined recognition result is corrected by checking the determined recognition result obtained by the recognition processing of the license-plate number against number plate information previously acquired by using an edit distance used in evaluating similarity of two character strings as an evaluation value based on a minimum number of operations needed to transform one of the two character strings to the other.

[0022]

A license-plate number recognition system according to a sixteenth aspect of the present invention for solving the aforementioned problems is characterized in that, in the fifteenth aspect, the evaluation value has a factor varying depending on the operations.

[0023]

A license-plate number recognition system according to a seventeenth aspect of the present invention for solving the aforementioned problems is characterized in that, in the sixteenth aspect, the determined recognition result obtained by the recognition processing of the license-plate number is checked against the previously acquired number plate information, the checking being performed based on results of

similarity evaluation of characters to be compared using the edit distance up to a previously set specified rank.

[0024]

A license-plate number recognition system according to an eighteenth aspect of the present invention for solving the aforementioned problems is characterized in that, in the sixteenth aspect, the factor of the evaluation value is set based on statistical data of likelihood of misrecognizing characters to be compared.

[0025]

A license-plate number recognition system according to a nineteenth aspect of the present invention for solving the aforementioned problems is characterized in that, in any one of the fifth, thirteenth, and fourteenth aspects, when the determined recognition result is checked against the number plate information, in addition to checking the license-plate number, shape information of the number plate which is previously acquired is checked, so as to correct the determined recognition result.

[0026]

A license-plate number recognition system according to a twentieth aspect of the present invention for solving the aforementioned problems is characterized in that, in any one of the fifth, thirteenth, and fourteenth aspects, when the determined recognition result is checked against the number plate information, in addition to checking the license-plate number, color information of the number plate which is previously acquired is checked, so as to correct the determined recognition result.

[0027]

A license-plate number recognition system according to a twenty-first aspect of the present invention for solving the aforementioned problems is characterized in that, in any one of the fifth, thirteenth, and fourteenth aspects, when the determined recognition result is checked against the number plate information, in addition to checking the license-plate

number, body color information of the vehicle which is previously acquired is checked, so as to correct the determined recognition result.

EFFECTS OF THE INVENTION

[0028]

According to the license-plate number recognition system of the first invention, the recognition process of the license-plate number can be performed with high accuracy without the need for complicated adjustment or the like, thus providing highly reliable license-plate number recognition.

[0029]

According to the license-plate number recognition system of the second invention, the results of processing the plurality of images are integrated. Accordingly, even when a correct character is missing in the result of processing part of the images, the license-plate number can be recognized. Moreover, it is possible to obtain higher recognition accuracy than that obtained by processing only one image.

[0030]

According to the license-plate number recognition system of the third invention, in addition to the effect of the first or second invention, since the license-plate number recognition process is performed based on further information, the recognition accuracy of the license-plate number can be increased. Moreover, it is possible to avoid reduction in recognition accuracy of the license-plate number due to quality degradation, for example such as a dirty or damaged number plate and allow the license-plate number recognition process to be precisely executed.

[0031]

According to the license-plate number recognition system of the fourth invention, in addition to the effect of the first or second invention, it is possible to avoid reduction in license-plate number recognition accuracy due to difficulties of capturing images of the number plate depending on the position of the number plate and reliably execute the

license-plate number recognition process.

[0032]

According to the aforementioned license-plate number recognition system of the fifth invention, in addition to the effect of the first or second invention, since the license-plate number is recognized using image processing and vehicle information managed in the database, the accuracy in license-plate number recognition can be further increased.

[0033]

According to the license-plate number recognition system of the sixth invention, in addition to the effect of the first or second invention, since the license-plate number recognition process can be integrally performed using the results obtained from the frame images of the same number plate captured at different conditions, the accuracy in license-plate number recognition can be further increased.

[0034]

According to the license-plate number recognition system of the seventh invention, in addition to the effect of the first or second invention, since the processing results based on the image with higher certainty is given a higher priority, it is possible to prevent employment of unreliable results and maintain highly accurate recognition.

[0035]

According to the license-plate number recognition system of the eighth invention, in addition to the effect of the first or second invention, since the processing results based on the image with higher certainty is given a higher priority, it is possible to reduce the possibility of employing unreliable data and maintain highly accurate recognition.

[0036]

According to the aforementioned license-plate number recognition system of the ninth invention, in addition to the effect of the first or second invention, since the license-plate number recognition process is performed using the information in addition to that of the image processing, the recognition

accuracy can be further increased.

[0037]

According to the aforementioned license-plate number recognition system of the tenth or eleventh invention, in addition to the effect of the first or second invention, since the camera can always capture images of the number plate with a resolution equal to a certain level or more by changing the zoom power according to the distance to the vehicle, the recognition accuracy can be further increased.

[0038]

According to the license-plate number recognition system of the twelfth to fourteenth invention, the plurality of evaluation values are set for one image, and the results of the license-plate number recognition process based on the plurality of evaluation values are integrated. Accordingly, in addition to the effect of the first or second invention, evening the case where the accuracy in character recognition is low when the vehicle number recognition process is performed for each image based on an evaluation value, high recognition accuracy can be obtained.

[0039]

According to the license-plate number recognition system of the fifteenth invention, in addition to the effects of the first or second invention, by using the information stored in the vehicle information database which is different from the results of the image processing, it is possible to obtain an accurate license-plate number even when a part of the recognition results is unknown, for example. Furthermore, using the edit distance for checking means, the efficiency of the process concerning the checking can be increased.

[0040]

According to the license-plate number recognition system of one of the sixteenth to eighteenth inventions, even in the case where a plurality of matches are obtained in the fifteenth invention, the license-plate number can be determined, and the accuracy in recognition of the license-plate number can be

increased.

[0041]

According to the license-plate number recognition system of one of the nineteenth to twenty-first inventions, since the license-plate number is checked using information other than the license-plate numbers in addition to license-plate numbers, in addition to the effects of the fifth, thirteenth, or fourteenth inventions, the license-plate number can be specified more precisely and reliably.

BRIEF DESCRIPTION OF THE DRAWINGS

[0042]

Fig. 1 is an explanatory view showing an installation example of a license-plate number recognition system according to Embodiment 1.

Fig. 2 is a flowchart showing a procedure of a license-plate number recognition process performed by the license-plate number recognition system according to Embodiment 1.

Fig. 3 is an explanatory view schematically showing examples of images captured using the license-plate number recognition system according to Embodiment 1.

Fig. 4 is an explanatory view showing an installation example of a license-plate number measuring system according to Embodiment 2.

Fig. 5 is a flowchart showing a flow of a license-plate number recognition process in Embodiment 2.

Fig. 6 is an explanatory view schematically showing examples of frame images captured in Embodiment 2.

Fig. 7 is an explanatory view showing an installation example of a license-plate number measuring system according to Embodiment 3.

Fig. 8 is a flowchart showing a flow of a license-plate number recognition process in Embodiment 3.

Fig. 9 is a flowchart showing a flow of a license-plate number recognition process in Embodiment 4.

Fig. 10 is a conceptual view showing an example of license-plate number checking in Embodiment 4.

Fig. 11 is an explanatory view showing an installation example of a license-plate number recognition system according to Embodiment 5.

Fig. 12 is a flow chart showing a procedure of a license-plate number recognition process performed by the license-plate number recognition system according to Embodiment 5.

Fig. 13 is a flowchart showing a flow of a license-plate number recognition process in Embodiment 8.

Fig. 14 is a flowchart showing a flow of a license-plate number recognition process in Embodiment 9.

Fig. 15 is an explanatory view schematically showing examples of frame images captured in Embodiment 9.

Fig. 16 is a flowchart showing a flow of a license-plate number recognition process in Embodiment 10.

Fig. 17 is an explanatory view schematically showing examples of frame images captured in Embodiment 10.

Fig. 18 is a flowchart showing a flow of a license-plate number recognition process in Embodiment 11.

Fig. 19 is a flowchart showing a flow of the license-plate number recognition process in Embodiment 13.

Fig. 20 is a flowchart showing an example of a number plate recognition process in Embodiment 13.

Fig. 21 is a flowchart showing a flow of a license-plate number recognition process in Embodiment 14.

Fig. 22 is a conceptual view showing an example of license-plate number checking in Embodiment 15.

Fig. 23 is a conceptual view showing an example of license-plate number checking in Embodiment 16.

Fig. 24 is a conceptual view showing an example of license-plate number checking in Embodiment 18.

Fig. 25 is a flowchart showing a flow of a license-plate number recognition process in Embodiment 18.

Fig. 26 is a conceptual view showing an example of

license-plate number checking in Embodiment 19.

Fig. 27 is a flowchart showing a flow of a license-plate number recognition process in Embodiment 19.

Fig. 28 is a conceptual view showing an example of license-plate number checking in Embodiment 20.

Fig. 29 is a flowchart showing a flow of a license-plate number recognition process in Embodiment 20.

BEST MODES FOR CARRYING OUT THE INVENTION

[0043]

Hereinafter, concrete embodiments of the present invention will be described with reference to the drawings.
Embodiment 1

[0044]

A description is given of a first embodiment of the present invention based on Figs 1 to 3. Fig. 1 is a schematic view of a license-plate number recognition system according to this embodiment; Fig. 2 is a flowchart showing a procedure of license-plate number recognition process performed by the license-plate number recognition system according to this embodiment; and Fig. 3 is an explanatory view schematically showing examples of images captured using the license-plate number recognition system according to this embodiment.

[0045]

As shown in Fig. 1, the license-plate number recognition system according to this embodiment includes: a camera 10 fixed on a gate 40 provided across road 30; and a license-plate number recognition unit 20 which receives images captured by the camera 10. The camera 10 is installed so as to capture a rear number plate of a vehicle 50 running on the road 30 and performs continuous shooting making, for example, about 30 frames/sec at constant time intervals. The images captured by the camera 10 are successively inputted into the license-plate number recognition unit 20 and are subjected to a license-plate number recognition process.

[0046]

A description is given of the license-plate number recognition process executed in the license-plate number recognition unit 20 based on Fig. 2.

[0047]

As shown in Fig. 2, the license-plate number recognition unit 20 first continuously receives frame images captured by the camera 10 (step S101) and performs a number plate recognition process so as to recognize a number plate for each received frame image and extracts a license-plate number therefrom (step S102). The reception of the frame images (step S101) and the number plate recognition process (step S102) are repeatedly executed while the camera 10 captures images.

[0048]

The recognition results of the license-plate number obtained in the step S102 are outputted as license-plate number candidates, and it is judged whether there are multiple license-plate number candidates or not (step S201). In the case where there are no multiple license-plate number candidates, that is, all the inputted license-plate number candidates are the same or only one license-plate number candidate is inputted, it is judged that there is only one type of license-plate number candidates (no). In this case, the one license-plate number candidate is outputted as an integrated result.

[0049]

On the other hand, when it is judged that there are multiple license-plate number candidates (yes), the license-plate number recognition process is continued and another process is performed so as to group the multiple license-plate number candidates successively inputted (step S202). Specifically, multiple license-plate number candidates obtained from multiple sequential frame images of the number plate is grouped into a set (hereinafter, referred to as a license-plate number candidate group).

[0050]

Next, for each license-plate number candidate of the license-plate number candidate group, it is judged whether

there is a recognition result the same as each of the characters constituting each license-plate number candidate (a license-plate number component character) (step S203). For license-plate number component characters some recognition results of which are the same, when the recognition results match one character, the character is employed. When the recognition results match two or more characters, one of the characters which matches the maximum number of recognition results is employed. In other words, the process to determine the license-plate number component characters in the license-plate number candidate group by majority.

[0051]

Next, it is judged whether the license-plate number is determined by the step S203 (step S204). When the license-plate number is determined by the step S203 (yes), the result obtained by the step S203 is outputted as an integrated result.

[0052]

On the other hand, when any one of the license-plate number component characters is not determined (no), the process is continued, and it is judged whether all the license-plate number candidates in the license-plate number candidate group have the same number of license-plate number component characters (step S205). When all the license-plate number candidates have the same number of license-plate number component characters, characters of the license-plate number component characters whose recognition results are different from one another are subjected to character similarity evaluation, and the recognition result having the highest character similarity is employed to determine the license-plate number.

[0053]

Next, it is judged whether the license-plate number is determined (step S206). When all of the license-plate number component characters are determined by the step S205 (yes), this result is outputted as the integrated result.

[0054]

On the other hand, when any one of the license-plate number

component characters is not determined (no), the license-plate number recognition process is continued, and the following process is performed for each license-plate number component character (step S207).

[0055]

Specifically, when the number of characters does not match with those of the other license-plate number candidates in the step S205, the positions of the license-plate number component characters of each license-plate number candidate (hereinafter, referred to as character positions) on each image are detected. When positions and recognition results of the characters are the same across all the license-plate number candidates, the above recognition results are employed.

[0056]

On the other hand, characters whose character positions are the same but whose recognition results are different from one another are subjected to the character similarity evaluation, and the result having the highest character similarity is employed.

[0057]

Furthermore, characters having non-identical character positions across the license-plate number candidates are subjected to the character similarity evaluation. When the character similarity of a character does not reach a certain value, the size of the character is then detected, and the detected size of the character is compared to the size of another character that has been already determined. When the detected size of the character is a value larger or smaller than the size of the predetermined character, that is, when the ratio of the detected character does not reach a predetermined value, it is judged that the detected character is not the license-plate number component character, and a process to eliminate the same from the license-plate number candidates is performed. When the size of the character is within a predetermined evaluation value range, a process to output this character as an unknown character is performed. The unknown character herein means

that it is unknown whether the character of interest is one of the license-plate number component characters.

[0058]

The integrated result outputted in the step S201, S204, S206, or S207 is outputted as a determined recognition result (step S208).

[0059]

Next, the aforementioned process executed by the license-plate number recognition unit 20 will be concretely described by using frame images 61 to 64 shown in Fig 3 as examples. The frame images 61 to 64 schematically show sequential images of the rear number plate 51 of the vehicle 50 captured at constant intervals with the camera 10.

[0060]

Table 1 shows examples of the license-plate number candidates recognized from the frame images 61 to 64 by the aforementioned step S102 and the integrated results derived from the license-plate number candidates.

[0061] [Table 1]

	T	T+1	T+2	T+3	Integrated Result
Pattern 1 Some of results are the same. <u>-> Employ one of results by majority</u>	<u>ABC123</u>	<u>ABC123</u>	<u>ABC123</u>	ABC128	ABC123
Pattern 2 The recognition results have the same number of characters but different characters from one another. <u>-> Employ the result having highest character similarity</u>	<u>ABC123</u> <u>Evaluation</u> <u>value of 3:</u> <u>0.8</u>	<u>ABC128</u> <u>Evaluation</u> <u>value of 8:</u> <u>0.6</u>	<u>ABC126</u> <u>Evaluation</u> <u>n value of</u> <u>6:</u> 0.4	ABC12? Evaluation value of ?: 0.0	ABC123
	ABC13 (There is a gap between 1 and 3 in the image.)	ABC123	ABC1?34 (4 is a misread noise component)	ABC??? (123 are unrecognizable.)	ABC123

Pattern 3 The recognition results have different numbers of characters. -> <u>Evaluate character by character</u>	1. Character positions and recognition result match, between the images. -> Employ the recognition results. => <u>"A," "B," "C," "1," and "3" are determined.</u> 2. Character positions matches but recognition results do not match between the images. -> Employ the recognition result having the highest character similarity. => <u>"2" is determined.</u> 3. Character positions do not match between the images. -> Employ a recognition result which has a character similarity equal to or more than a certain value. ·For a recognition result whose character similarity is equal to or less than the certain value, when the character size thereof is deviated from that of the other characters, the recognition result is judged to be not a character. When the character size thereof is balanced with other characters, the recognition result is judged to be the unknown character. => <u>"4" is determined as noise and eliminated.</u>
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[0062]

In Table 1, T, T+1, T+2, and T+3 indicate time.

[0063]

Pattern 1 shown in Table 1 is an example in which some of the license-plate number candidates are the same with each other. The license-plate number candidates obtained from the frame images 61 to 63 captured at the time T, T+1, and T+2 all indicate "ABC123," matching with each other, whereas only the license-plate number candidate obtained from the frame image 64 captured at the time T+3 indicates "ABC128," different from the other license-plate number candidates. In such a case, by the steps of S203 and S204 shown in Fig. 2, the license-plate number "ABC123" which is the same license-plate number indicated by the multiple recognition results is outputted as the integrated result.

[0064]

Pattern 2 is an example in which all of the multiple license-plate number candidates are different from one another whereas the numbers of recognized characters thereof match with one another. In such a case, by the step S205 shown in Fig. 2, the license-plate number component characters at the right ends, which are different across all the license-plate number candidates of the license-plate number candidate group, are subjected to calculation of the character similarity. Here, in Pattern 2 shown in Table 1, the evaluation value of "3" is 0.8, which is the highest, and "3" is then determined as the license-plate number component character at the right end. Accordingly, the license-plate number candidate "ABC123" is outputted as the integrated result.

[0065]

Pattern 3 is an example in which the numbers of characters of the license-plate number candidates in the license-plate number candidate group are not the same with each other. For example, it may be a case where a noise component in the frame image 63 captured at the time T+2 is misread as a license-plate number component character "4." Here, it is assumed that the

character similarity of the noise component in the frame image 63 does not reach a predetermined value, and the ratio in size of the noise component to the license-plate number component characters is smaller than a predetermined ratio that is set in accordance with the size of license-plate number component.

[0066]

In such a case, by the step S207, characters whose character positions and recognition results are the same across the images are determined as the license-plate number component characters. The license-plate number component characters "A," "B," "C," "1," and "3" are thus determined.

[0067]

Next, characters whose character positions are the same but recognition results are different from one another, across the images, (here, the fifth character of each license-plate number candidate from the left) are subjected to the character similarity evaluation, and one of the characters having the highest character similarity is determined as a license-plate number component character. In Pattern 3, the evaluation value of "2" recognized from the frame image 62 captured at the time T+1 is assumed to be the highest, so that the fifth license-plate number component character from the left is determined to be "2."

[0068]

Next, a character whose character position is different across the images (here, the seventh character of each license-plate number candidate from the left), that is, the character "4" recognized from the frame image 63, is subjected to the character similarity evaluation. Here, as described above, the character similarity of the character "4" does not reach the predetermined value, and the ratio in character size of the character "4" is smaller than the predetermined ratio in comparison with other characters determined as the license-plate number component characters. Accordingly, the character "4" is determined not to be a character and is then eliminated from the license-plate number candidates.

Consequently, the license-plate number candidate "ABC123" is outputted as the integrated result.

[0069]

When the character similarity of the character "4" reaches the predetermined value, the character "4" is employed. In contrast, when the character similarity of the character "4" does not reach the predetermined value and the character size thereof is within a predetermined value range with respect to other characters determined as the license-plate number component character, the character of interest is outputted as the unknown character.

[0070]

According to the license-plate number recognition system of the aforementioned embodiment, it is possible to perform the license-plate number recognition process with high accuracy without complicated adjustments and the like, hence providing highly reliable license-plate number recognition.

EMBODIMENT 2

[0071]

Based on Figs. 4 to 6, a description is given of a second embodiment of the present invention. Fig. 4 is a schematic view of a license-plate number measuring system according to this embodiment. Fig. 5 is a flowchart showing a flow of a license-plate number recognition process in this embodiment. Fig. 6 is an explanatory view showing examples of frame images captured in this embodiment.

[0072]

As shown in Fig. 4, the license-plate number recognition system according to this embodiment includes cameras 11 and 12 which are respectively fixed to gates 41 and 42 provided on the road 30; and the license-plate number recognition unit 20 receiving images captured by the cameras 11 and 12.

[0073]

The cameras 11 and 12 are installed so as to capture images respectively of the rear and front number plates of the vehicle 50 running on the road 30 and performs continuous shooting

making, for example, about 30 frames/sec at constant time intervals. The images captured by the cameras 11 and 12 are synchronized with each other and successively inputted into the license-plate number recognition unit 20 in synchronization with each other. In other words, compared to the structure of Embodiment 1 above, this embodiment includes an additional camera to capture images of the front number plate of the vehicle 50, and the other structure of this embodiment is substantially the same as that of Embodiment 1.

[0074]

Based on Fig. 5, a description is given of the license-plate number recognition process executed in the license-plate number recognition unit 20 in this embodiment.

[0075]

As shown in Fig. 5, in the license-plate number recognition unit 20, first, the frame images captured by the cameras 11 and 12 are synchronized with each other and successively inputted (steps S111 and S121). Each of the frame images captured by the cameras 11 and 12 is subjected to the number plate recognition process to recognize the number plates 51 and 52 and extract the license-plate number (steps S112 and S122).

[0076]

The recognition results of the license-plate number obtained by the steps S102 and S104 are outputted as license-plate number candidates and are subjected to the recognition result integration process (step S200). Note that, the recognition result integration process (step S200) executes the same steps as the steps S201 to S208 shown in Fig. 2 and described in Embodiment 1, and the redundant description thereof is omitted.

[0077]

The process executed by the license-plate number recognition unit 20 in this embodiment will be described using an example in which the frame images 61 to 63 shown in Fig. 3 are captured by the camera 11 and the frame images 65 to 68 shown

in Fig. 6 are captured by the camera 12.

[0078]

The frame images 61 to 64 and the frame images 65 to 68 are captured at time T to T+3. The frame images 61 to 64 include sequential images of the rear number plate 51 of the vehicle 50 as shown in Fig 3, and the frame images 65 to 68 include sequential images of the front number plate 52 of the vehicle 50 as shown in Fig 6.

[0079]

Table 2 shows examples of the license-plate number candidates recognized from the frame images 61 to 68 shown in Figs. 3 and 6 by the number plate recognition process (the steps S112 and S122) in this embodiment.

[0080] [Table 2]

Time	T	T+1	T+2	T+3
Recognition Result Obtained from the Rear Number Plate	ABC123	ABC123	ABC123	ABC128
Recognition Results Obtained from the Front Number Plate	AB?1??	ABC126	ABC123	ABC123
Integrated Result	ABC123			

[0081]

In Table 2, T, T+1, T+2, and T+3 indicate time.

[0082]

The example shown in Table 2 is an example in which some of the license-plate number candidates are same with each other. Specifically, the license-plate number candidates obtained from the frame images 61, 62, and 63 of the rear number plate 51 of the vehicle 50 which are captured respectively at the time T, T+1, and T+2 and the license-plate number candidates obtained from the frame images 67 and 68 of the rear number plate 52 of the vehicle 50 which are captured respectively at the time T+2 and T+3 indicate the same "ABC123." Accordingly, in this example, the identical license-plate number candidate "ABC123" shown by the multiple recognition results is the integrated result and outputted as the determined recognition results.

[0083]

As described above, according to this embodiment, the license-plate number recognition process is performed based on a larger amount of information so that, in addition to the operational effects by Embodiment 1, the accuracy of the license-plate number recognition can be increased. Moreover, it is possible to prevent reduction in accuracy of the license-plate number recognition due to quality degradation of the number plate 51 or 52 caused by dirt or damage on the number plate, which in turn enhances the accuracy of the license-plate number recognition.

EMBODIMENT 3

[0084]

Based on Figs. 7 and 8, a description is given of a third embodiment of the present invention. Fig. 7 is an explanatory view showing an installation example of a license-plate number measuring system according in this embodiment. Fig. 8 is a flowchart showing a flow of a license-plate number recognition process in this embodiment.

[0085]

As shown in Fig. 7, the license-plate number recognition system according to this embodiment includes: a camera 13 fixed to the gate 40 provided on the road 30; a camera 14 placed on the side of the road 30 near the gate 40 and fixed at a position below the camera 13; and the license-plate number recognition unit 20 receiving images captured by the cameras 13 and 14.

[0086]

In other words, in addition to the camera 10 in Embodiment 1 described above, this embodiment includes an additional camera that captures images, from a different angle, of the same number plate as the camera 10 captures. The other structure of the license-plate number recognition system is substantially the same as that of Embodiment 1, and the redundant description thereof is omitted when appropriate.

[0087]

The cameras 13 and 14 are installed so as to capture images

of the rear number plate of the vehicle 50 running on the road 30, and perform continuous shooting making, for example, about 30 frames/sec at constant time intervals. The images captured by the cameras 13 and 14 are synchronized to each other, successively inputted into the license-plate number recognition unit 20, and then subjected to the license-plate number recognition process.

[0088]

A description is given of the license-plate number recognition process executed in the license-plate number recognition unit 20 based on Fig. 8.

[0089]

In the license-plate number recognition unit 20, first, the frame images captured by the cameras 13 and 14 are synchronized to each other and successively inputted (steps S131 and S141). All the frame images captured by the cameras 13 and 14 are subjected to the number plate recognition process to recognize the number plate, and extract the license-plate number (steps S132 and S142). The input of the frame images and the number plate recognition process are repeatedly executed while camera 10 captures images.

[0090]

The recognition results of the license-plate number obtained by the steps S132 and S142 are outputted as the license-plate number candidates, and are subjected to the recognition result integration process (step S200). It is to be noted that the recognition result integration process (step S200) executes the same steps as the steps S201 to S208 shown in Fig. 2 and described in Embodiment 1, and the specific description thereof is therefore omitted.

[0091]

According to this embodiment, the license-plate number recognition process is performed based on a larger amount of information so that, in addition to the operational effects by Embodiment 1, the accuracy of the license-plate number recognition can be increased. Moreover, it is possible to

prevent the decrease of the license-plate number recognition accuracy caused by a fact that a certain position of number plate makes it difficult to capture images of the number plate. Consequently, the license-plate number recognition process can be reliably executed.

[0092]

This embodiment shows the example using the two cameras 11 and 13. However, the embodiment may include three or more cameras which capture images of the same part from different positions. The images of number plate to be captured by the cameras are not limited to the rear number plate and may be the front number plate.

EMBODIMENT 4

[0093]

A description is given of a fourth embodiment of the present invention based on Figs. 9 and 10. Fig. 9 is a flowchart showing a flow of a license-plate number recognition process according to this embodiment, and Fig. 10 is a conceptual view of this embodiment. This embodiment is applied to the above structure shown in Fig. 1.

[0094]

As shown in Fig. 9, in addition to the process in Embodiment 1 above, the license-plate number recognition system according to this embodiment further includes a process to correct, when the determined recognition result includes an unknown character, the determined recognition result and derives a character outputted as the unknown character. In this embodiment, the process up to the step S200 (steps S201 to S208) is the same as that of Embodiment 1, and the redundant description thereof is omitted.

[0095]

In this embodiment, after the process of the step S200 is performed, it is judged whether the determined recognition result obtained in Embodiment 1 above contains an unknown character (step S301). When any unknown character is not contained, it is judged that the correction is unnecessary, and

the determined recognition result is outputted as a final result.

[0096]

On the other hand, when the inputted determined recognition result includes an unknown character, the process is continued. Then, information on the determined characters other than the unknown character is checked against a vehicle database managing number plate information so as to derive a character corresponding to the unknown character. The derived character is outputted as the final result (step S302).

[0097]

The integrated result outputted at the step S301 or S302 is outputted as a corrected determined recognition result (step S303).

[0098]

Based on Fig. 10, a description is given of the specific process to correct the recognition result. Fig. 10(a) shows an example where a unique license-plate number is derived by a license-plate number character arrangement rule; and Fig. 10(b) shows an example where there are multiple candidates of the license-plate number in the database.

Based on Fig. 10, a description is given of the specific process in the license-plate number recognition process unit 20. Fig. 10(a) shows an example where a unique license-plate number is derived by a license-plate number character arrangement rule; and Fig. 10(b) shows an example where there are multiple candidates of the license-plate number in the database.

[0099]

As shown in Fig. 10(a), in a license-plate number candidate 71 outputted by the recognition result integration process (the step S200), the left five characters "ABC12" are determined, and a character on the right end is unknown. Moreover, the vehicle information stored in a database 81 contains a license-plate number "ABC123" which is the only license-plate number whose left five characters match that of

the license-plate number candidate 71. In other words, the license-plate number component characters other than the unknown character match those of the license-plate number in the database 81, and the number of the unknown character is one. In such a case, the license-plate number is uniquely derived. Accordingly, "ABC123" is then outputted as a correction result (integrated result) 91.

[0100]

On the other hand, in the case where there are some characters corresponding the unknown character in the database 81, for example, even when it is judged at the step S200 that the character similarity of the unknown character is lower than the predetermined value, the license-plate number candidates 72-1, 72-2, and 72-3 are listed in advance in descending order of character similarity as shown in Fig. 10(b). As a character appropriate for the unknown character, a character with a highest character similarity among the characters corresponding to the unknown character is employed from the number plate information managed by the database 82. Accordingly, "ABC123" is outputted as a correction result (integrated result) 92.

[0101]

According to this embodiment, the license-plate number is recognized using image processing and the vehicle information managed in the database. Accordingly, in addition to the operational effects of Embodiment 1 above, the recognition accuracy of the license-plate number can be further increased.

EMBODIMENT 5

[0102]

Based on Figs. 11 and 12, a description is given of a fifth embodiment of the present invention. Fig. 11 is a schematic view of a license-plate number recognition system according to this embodiment; and Fig. 12 is a flowchart showing a procedure of a license-plate number recognition process performed by the license-plate number recognition system according to this

embodiment.

[0103]

As shown in Fig. 11, the license-plate number recognition system according to this embodiment includes: multiple cameras 15, 16, 17... respectively fixed on gates 45, 46, 47... provided across road 30; and a license-plate number recognition unit (not shown) which performs the license-plate number recognition process for frame images inputted from the respective cameras 15, 16, 17... The cameras 15, 16, 17... are installed so as to capture the rear number plate of the vehicle 50 running on the road 30, and performs continuous shooting making, for example, about 30 frames/sec at constant time intervals.

[0104]

In other words, in this embodiment, the license-plate number is recognized using information from more than one license-plate number recognition system shown in Embodiment 1, and each license-plate number recognition system is the same as that shown in Embodiment 1.

[0105]

A description is given of the license-plate number recognition process according to this embodiment based on Fig. 12.

[0106]

As shown in Fig. 12, the license-plate number recognition system according to this embodiment includes a road unit and a central unit. The road unit outputs the determined recognition results obtained by the steps S101, S102, and S200 based on the frame images captured by the multiple cameras 15, 16, 17... The steps S101, S102, and S200 are the same as the steps shown in Embodiments 1 to 4 above, and the redundant description thereof is omitted.

[0107]

Next, a description is given of a recognition process executed by the central unit based on Fig. 12.

[0108]

In the central unit, for example, it is judged whether

the determined recognition result obtained from a frame image captured by the camera 16 contains an unknown character (step S401). When the determined recognition result does not contain an unknown character (no), it is judged that correction is unnecessary, and the determined recognition result is outputted.

[0109]

On the other hand, when the determined recognition result contains an unknown character (yes), the recognition result correction process is continued to perform a process to extract the determined recognition results obtained from frame images captured by cameras provided near the camera 16 (for example, the cameras 15 and 17) (step S402).

[0110]

Furthermore, determined recognition results are extracted from the determined recognition results obtained by the step S403 (step S403), the extracted determined recognition results each having a capturing time near and being similar to that of the determined recognition result obtained by the step S403. Among the extracted determined recognition results, a license-plate number which does not contain an unknown character and matches multiple determined recognition results is selected (step S404). This selected license-plate number is outputted as a final determined recognition result (step S405).

[0111]

Table 3 shows examples of the recognition results obtained from images captured by the cameras 15, 16, and 17 in this embodiment. In this description, the cameras 15 to 17 are indicated by camera numbers N-1, N, and N+1.

[0112] [Table 3]

Camera Number	N-1	N	N+1
Time	07:05	07:15	07:30
Recognition Result	ABC123	AB?12?	ABC128
Integrated Result	ABC123		

[0113]

As shown in Table 3, when the recognition result obtained from an image captured by the camera 16 contains unknown characters, a recognition result which has a capturing time (or distance) near that of the obtained recognition result and which is similar to the same is extracted, thus determining the integrated result to be "ABC123."

[0114]

According to the aforementioned embodiment, the license-plate number recognition process can be comprehensively performed using the results obtained from frame images of a same number plate captured in different conditions, thus further increasing the recognition accuracy.

EMBODIMENT 6

[0115]

A description is given of a sixth embodiment of the present invention. In this embodiment, in the process at and after the step S205 shown in Fig. 2 in Embodiment 1, a resolution of a number plate section in a frame image, that is, the area of the number plate or size of the license-plate number on the frame image is used as the character similarity. The other structure of this embodiment is the same as that of Embodiment 1, and the redundant description thereof is omitted.

[0116]

Table 4 shows examples of the license-plate number candidates obtained from the frame images 61 to 64 shown in Fig. 3 and examples of detection results of the resolution of the number plate sections in the frame images 61 to 64 in this embodiment.

[0117] [Table 4]

Time	T	T+1	T+2	T+3
Recognition Result	ABC123	ABC126	ABC128	ABC12?
Resolution of Plate Section (Character Size on Image)	40x30	30x22	20x15	15x10
Integrated Result	ABC123			

[0118]

In Table 4, T, T+1, T+2, and T+3 indicate time.

[0119]

In the example shown in Table 4, all the license-plate number candidates are different from one another and have a same number of characters. Thus, the license-plate number recognition process proceeds to the step S205 shown in Fig. 2, where the character similarity evaluation is executed for a character having a recognition result are different from characters of the other candidates (the character at the right end in this embodiment).

[0120]

In this embodiment, the recognition results whose number plate sections have higher resolution in the frame images are considered to have higher character similarity, while the recognition results whose number plate sections have lower resolution in the frame images are considered to have lower character similarity, as described above. These recognition results are used for the license-plate number recognition process. Accordingly, in the example shown in Table 4, "ABC123" derived from the image 61 captured at the time T, which has the highest resolution, is outputted as the integrated result.

[0121]

According to the license-plate number recognition system of the aforementioned embodiment, the processing result obtained based on the image having greater accuracy is given a higher priority. It is therefore possible to prevent

employment of unreliable results and maintain highly accurate recognition.

EMBODIMENT 7

[0122]

A description is given of a seventh embodiment of the present invention. In this embodiment, when all the license-plate number candidates in a license-plate number candidate group are different from one another and the process at and after the step S205 shown in Fig. 2 is performed in Embodiment 1, a license-plate number candidate recognized from a frame image having a higher contrast between the characters and the background in the captured image of the number plate or a frame image including the number plate section with a higher edge strength, in other words, a frame image including a clearer image of the number plate is considered to have higher character similarity. The other structure of this embodiment is the same as that of Embodiment 1, and the redundant description thereof is omitted.

[0123]

Table 5 shows examples of the license-plate number candidates recognized by a number plate recognition process from the frame images 61 to 64 shown in Fig. 3 and examples of calculation results of the contrast of the number plate sections in the frame images 61 to 64. The contrast of the number plate section may be a difference in brightness between the characters and background in the number plate section or the like, for example.

[0124] [Table 5]

Time	T	T+1	T+2	T+3
Recognition Result	ABC123	ABC126	ABC128	ABC12?
Contrast of Plate Section (e.g., Brightness Difference between Characters and Background)	35	28	18	15
Integrated Result	ABC123			

[0125]

In table 5, T, T+1, T+2, and T+3 indicate time.

[0126]

The example shown in Table 5 is an example where all the license-plate number candidates are different from one another and have the same number of characters. Accordingly, the license-plate number recognition process proceeds to the step S205 shown in Fig. 2, where the character similarity evaluation is executed for the characters having recognition results that are different from characters of the other candidates (the characters at the right ends in this embodiment).

[0127]

In this embodiment, as described above, the recognition results which have high contrast of the number plate sections in the frame images are considered to have high character similarity, whereas the recognition results which have low contrast of the number plate sections are considered to have low character similarity. These recognition results are used for the license-plate number recognition process. Accordingly, in the example shown in Table 5, "ABC123" derived from the image

61 captured at the time T, which has the highest resolution, is outputted as the integrated result.

[0128]

According to the license-plate number recognition system of the aforementioned embodiment, the processing result obtained based on the image having a greater certainty is given a higher priority. It is therefore possible to reduce the possibility of employing unreliable data and maintain high recognition accuracy.

EMBODIMENT 8

[0129]

A description is given of Embodiment 8 based on Fig. 13. Fig. 13 is a flowchart showing a flow of a license-plate number recognition process in this embodiment.

[0130]

This embodiment is applied to the case where the license-plate number arrangement of the number plate has a character arrangement rule. For example, the arrangement pattern follows such rule as "left three characters are alphabetic, right three characters are numeric, and the second alphabetic character is "A" or "B."

[0131]

A description is given of the license-plate number recognition process executed in the license-plate number recognition unit 20 in this embodiment, based on Fig. 13.

[0132]

As shown in Fig. 13, in the license-plate number recognition system according to this embodiment, in parallel to the aforementioned steps S205 and S207 shown in Fig. 2, a process to determine each license-plate number component character by applying the character arrangement rule to the license-plate number candidates (steps S501 and S502). The other structure of this embodiment is the same as that of Embodiment 1, and the redundant description thereof is omitted.

[0133]

Table 6 shows examples of the license-plate number

candidates obtained from the frame images 61 to 64 shown in Fig. 3 in this embodiment.

[0134] [Table 6]

Time	T	T+1	T+2	T+3
Recognition Result	ABC123	ADC123	ADC1??	ABC12?
Integrated Result	ABC123			

[0135]

In Table 6, T, T+1, T+2, and T+3 indicate time.

[0136]

In the example shown in Table 6, all the license-plate number candidates are different from one another and have the same number of characters. Accordingly, the license-plate number recognition process shown in Fig. 13 proceeds to the step S205, where the character similarity evaluation is executed for characters whose recognition results are different from characters of the other candidates (the second, fifth, and sixth characters from the left in this embodiment).

[0137]

Here, Table 5 shows that the second characters from the left of the license-plate number candidates obtained from the frame images 61 and 64 are "B", and the second characters from the left of the license-plate number candidates obtained from the frame images 62 and 63 are "D." Accordingly, the second character cannot be determined by majority and is thus judged by the character similarity.

[0138]

At this time, if there is a rule defining that, for example, "the second alphabetic character is "A" or "B", " the alphabetic character of the second left license-plate number component character can be determined to be "B" in the step S501.

[0139]

Moreover, for example, even when the judgment using character similarity shows that the character similarities of

"B" and "D" are the same, the license-plate number component character can be determined to be "B" by referring to the character arrangement rule.

[0140]

With the license-plate number recognition system according to the aforementioned embodiment, the license-plate number recognition process is performed on the basis of information in addition to the information obtained from image processing, thus further increasing the recognition accuracy.

EMBODIMENT 9

[0141]

Based on Figs. 14 and 15, a description is given of a ninth embodiment of the present invention. Fig. 14 is a flowchart showing a flow of a license-plate number recognition process in this embodiment; and Fig. 15 is an explanatory view showing examples of frame images captured in this embodiment.

[0142]

In this embodiment, when multiple images are captured by the camera 10 in the above-described license-plate number recognition system according to Embodiment 1 shown in Figs. 1 and 3, a process allows frame image capturing while controlling the magnification of the lens of the camera 10 after the number plate is detected. The magnification of the lens of the camera 10 is determined based on positional information of the number plate in the frame image captured most recently.

[0143]

A description is given of the license-plate number recognition process executed by the license-plate number recognition unit 20 in this embodiment based on Fig. 14.

[0144]

As shown in Fig. 14, the license-plate number recognition system according to this embodiment performs: a frame image input process to receive sequential frame images captured by the camera 10, which is shown in Fig. 2 and described above (step S151); a number plate recognition process to recognize the number plate in each of the received frame images and extract

the license-plate number (step S152); and a process to calculate the magnification of the lens based on the positional information of the number plate on each frame image (step S153).

[0145]

The lens of the camera 10 is controlled so that the magnification of the lens is adjusted to the calculated value (step S154). The process returns to the step S151, and images of the number plate are captured by means of the camera 10 with the magnification of the lens being adjusted to the value calculated in the step S153. The thus obtained frame images are inputted into the license-plate number recognition unit 20. The other structure of the license-plate number recognition system of this embodiment is the same as that of Embodiment 1, and the redundant description thereof is omitted. Incidentally, the recognition result integration process (step S200) shown in Fig. 14 are the same as that executed in the steps S201 to S208 shown in Fig. 2 and described in Embodiment 1.

[0146]

In this embodiment, the process of the aforementioned steps S153 and S154 is performed to obtain frame images 161 to 164 shown in Fig. 15.

[0147]

Hereinafter, an example of the process executed by the license-plate number recognition unit 20 in the license-plate number recognition system according to this embodiment will be concretely described using the first to the fourth frame images 161 to 164 shown in Fig. 15 as examples. The frame images 161 to 164 schematically show sequential images of the rear number plate 51 of the vehicle 50 that are captured by the camera 10 at constant time intervals.

[0148]

In the license-plate number recognition unit 20, when the number plate 51 is detected from the first frame image 161 captured by the camera 10, the magnification of the lens to be applied for capturing the next frame image is calculated from a position p_1 and size s_1 of the number plate 51 in the first

frame image 161. The lens of the camera 10 is then adjusted to the magnification of the lens calculated at the step S153 so as to capture the next frame image. As a result, the second frame image 162 is obtained.

[0149]

Furthermore, based on the magnification of the lens calculated from a position p_2 and size s_2 of the number plate 51 on the second frame image 162, the third frame image 163 is obtained. Next, based on the magnification of the lens calculated from a position p_3 and size s_3 of the number plate 51 on the third frame image 163, the fourth frame image 164 is obtained.

[0150]

Table 7 shows examples of the license-plate number candidates obtained from the frame images 161 to 164 shown in Fig. 15 in this embodiment.

[0151] [Table 7]

Time	T	T+1	T+2	T+3
Recognition Result	ABC123	ABC123	ABC123	ABC123
Integrated Result	ABC123			

[0152]

In Table 7, T, T+1, T+2, and T+3 indicate time.

[0153]

In the example shown in Table 7, all the license-plate number candidates are the same. Accordingly, in the recognition result integration process (step S200), it is judged that there is only one type of the license-plate number candidates in the step S201 (no), and "ABC123" is outputted as the determined recognition result by the step S208. In this embodiment, the license-plate number on the frame images 161 to 164 can be obtained with high resolution. Accordingly, it can be expected that the recognition accuracy increases and it is more likely to obtain identical license-plate number

candidates.

[0154]

According to the license-plate number recognition system of the aforementioned embodiment, the images of the number plate 51 in the second to forth frame images 162 to 164 are magnified to substantially the same size when being captured. Accordingly, the license-plate number can be obtained with higher resolution than the frame images 62 to 64 shown in Fig. 3, for example. In this way, the license-plate number captured in the frame images 161 to 164 have preferable resolution, and accordingly, in addition to the operational effects of Embodiment 1, the recognition accuracy can be further increased.

[0155]

This embodiment has shown the example in which the magnification of the lens applied for capturing the subsequent frame image is calculated from the position and size of the number plate 51 in corresponding one of the frame images 161 to 163. However, the magnification of the lens applied for capturing the subsequent frame image may be calculated from only the position of the number plate 51 in corresponding one of the frame images 161 to 163.

EMBODIMENT 10

[0156]

Based on Figs. 16 and 17, a description is given of a tenth embodiment of the present invention. Fig. 16 is a flowchart showing a flow of a license-plate number recognition process in this embodiment; and Fig. 17 is an explanatory view showing examples of frame images captured in this embodiment.

[0157]

Compared to the license-plate number recognition system according to Embodiment 9 above, in this embodiment, the magnification of the lens of the camera 10 is determined based on vehicle speed calculated from positions of the number plate in the successive two frame images. The other structure of this embodiment is substantially the same as that of Embodiment 9.

[0158]

A description is given of the license-plate number recognition process executed in the license-plate number recognition system 20 in this embodiment, based on Fig. 16.

[0159]

As shown in Fig. 16, the license-plate number recognition system according to this embodiment performs:

a frame image input process to input successive frame images captured by the aforementioned camera 10 shown in Fig. 2 (step S161); a number plate recognition process to recognize the number plate from each of the inputted frame images and extract the license-plate number therefrom (step S162); and a process to measure the vehicle speed from the positions of the number plate in the successive two frame images and calculate the magnification of the lens based on the obtained vehicle speed information (step S163).

[0160]

The lens of the camera 10 is controlled so that the magnification of the lens is adjusted to the calculated value (step S164). The process returns to the step S161, where images of the number plate are captured by the camera 10 using the magnification of the lens calculated in the step S163. The thus obtained frame images are inputted into the license-plate number recognition unit 20. The other structure is the same as that of Embodiment 9, and the redundant description thereof is omitted.

[0161]

In this embodiment, the process of the aforementioned steps S163 and S163 is performed to obtain frame images 261 to 264 shown in Fig. 17.

[0162]

Hereinafter, an example of the process executed by the license-plate number recognition unit 20 in the license-plate number recognition system according to this embodiment will be concretely described using the first to fourth frame images 261 to 264 shown in Fig. 17 as examples. The frame images 261 to

264 schematically show successive images of the rear number plate 51 of the vehicle 50 captured by the camera 10 at constant time intervals.

[0163]

In the license-plate number recognition unit 20, when the number plate 51 is detected from the first frame image 261 captured by the camera 10, the vehicle speed of the vehicle 50 is measured from a difference d_1 between the positions of the number plate 51 in the first and second frame images 261 and 262, and the magnification of the lens to be applied for capturing the subsequent frame image is calculated. The lens of the camera 10 is then adjusted to the calculated magnification to capture the subsequent frame image. As a result, the third frame image 263 is obtained.

[0164]

Furthermore, the vehicle speed of the vehicle 50 is measured from a difference d_2 between the positions of the number plate 51 in the second and third frame images 262 and 263, and the magnification of the lens to be applied for capturing the subsequent frame image is calculated. Consequently, the fourth frame image 264 is obtained based on the calculated magnification of the lens.

[0165]

Table 8 shows examples of the license-plate number candidates obtained from the frame images 261 to 264 shown in Fig. 17 in this embodiment.

[0166] [Table 8]

Time	T	T+1	T+2	T+3
Recognition Result	ABC123	ABC123	ABC123	ABC123
Integrated Result	ABC123			

[0167]

In Table 8, T, T+1, T+2, and T+3 indicate time.

[0168]

In the example shown in Table 8, all the license-plate number candidates are same with each other. Accordingly, in the recognition result integration process (step S200), it is judged that there is only one type of license-plate number candidates in the step S201 (no), and "ABC123" is outputted as the determined recognition result by the step S208. In this embodiment, similar to Embodiment 9, the license-plate number on the frame images 261 to 264 can be obtained with high resolution. Accordingly, it can be expected that the recognition accuracy increases and it is more likely that the identical license-plate number candidates are obtained.

[0169]

According to the license-plate number recognition system of the aforementioned embodiment, the vehicle speed of the vehicle 50 is measured, and the magnification of the lens of the camera 10 is controlled based on the obtained vehicle speed information. This allows the images of the number plate 51 on the frame images 261 to 264 to be properly magnified while being captured. Accordingly, the license-plate number can be obtained with higher resolution than the resolutions of the frame images 62 to 64 shown in Fig. 3, for example. Accordingly, similar to Embodiment 9, in addition to the operational effects of Embodiment 1, the recognition accuracy can be further increased.

EMBODIMENT 11

[0170]

A description is given of an eleventh embodiment of the present invention based on Fig. 18. Fig. 18 is a flowchart showing a procedure of a license-plate number recognition process performed by a license-plate number recognition system according to this embodiment. This embodiment is an example of executing a process of steps S211 to S218 shown in Fig. 18 instead of the process of the steps S201 to S208 of Embodiment 1 above.

[0171]

Specifically, instead of the process of the step S207 of

Embodiment 1, the process of the step S217 shown in Fig. 18 is performed. The other structure of this embodiment is substantially the same as that described in Embodiment 1, and the redundant description is omitted. The process of the steps S211 to S216 and S218 are the same as the process of the aforementioned steps S201 to S206 and S208 shown in Fig. 2, respectively.

[0172]

As shown in Fig. 18, in this embodiment, it is judged at the step S216 whether the license-plate number is determined. When any one of the license-plate number component characters is not determined (no), the license-plate number recognition process is continued, and the following process is performed for each license-plate number component character (step S217).

[0173]

In other words, when the license-plate number candidates do not have the same number of characters, the character positions of the license-plate number component characters are detected for each license-plate number candidate. As for characters whose character positions and recognition results are the same across all the license-plate number candidates, the recognition result thereof is employed.

[0174]

On the other hand, when the character positions and recognition results are not the same across all the license-plate number candidates, that is, when the recognition results on the same character position are different across the candidates or when there is a character whose character position is different across the candidates, for example, the license-plate number is determined by using, for example, a string reading scheme disclosed in Non-patent Document 1 or the like.

[0175]

Specifically, multiple estimated positions are assumed for each character (hereinafter, referred to as estimated character positions). The estimated character positions are

assigned scores of the character similarity of the character obtained through the recognition result. At this time, the scores to be given are scores equals to a product of the character similarity and a score weighting factor. Here, the score weighting factor is previously set for each estimated character position. A process is performed in which, as a result of the assignment, each of the characters having the highest score in corresponding one of the estimated positions is employed for the estimated character position. In this embodiment, the weighting factor is set in advance according to the situations in the light of the installation environment of the camera 10, data obtained by the number plate recognition process (step S102), and the like.

[0176]

Hereinafter, the process executed by the license-plate number recognition unit 20 shown in Fig. 2 in this embodiment will be specifically described using the frame images 61 to 64 shown in Fig. 3.

[0177]

Table 9 shows examples of license-plate number candidates recognized from the frame images 61 to 64 by the above-described step S102.

[0178] [Table 9]

Time	T	T+1	T+2	T+3
Recognition Result	BC123	ABC123	ABD123	ABC12

[0179]

In the example shown in Table 9, the license-plate number candidates do not have the same number of characters in the license-plate number candidate group. Specifically, this is an example where "A" in the frame image 61 captured at the time T and "3" in the frame image 64 captured at the time T+3 are not recognized, and the recognition results are outputted as license-plate number candidates each having five characters. In addition, in this example, "C" in the frame image 63 captured

at the time T+2 is recognized as "D." As for character positions of the recognition results (hereinafter, referred to as recognition character positions) "1" to "5," or left five characters, the recognition results for each character position are not the same. In addition, as for the character of each recognition result at the recognition character position "6" or the sixth character of each recognition result from the left (hereinafter, the position of an m-th character from the left is expressed as the character position "m"), some recognition results contain no character at the sixth character position. Table 10 shows setting examples of the estimated character positions for each recognition character position. Note that, in the following description, for differentiation of the estimated character positions from the recognition character positions, the estimated character positions are indicated with "'."

[0180] [Table 10]

Setting Examples of Estimated Character Position for Each Recognition Character Position

Recognition Character Position	1	2	3	4	5	6
Estimated Character Position	1', 2'	1', 2', 3'	2', 3', 4'	3', 4', 5'	4', 5', 6'	5', 6', 7'

[0181]

As shown in Table 10, when the recognition results shown in Table 9 are obtained, missing characters, misrecognition due to the influence of noise, and the like (hereinafter, referred to as missing characters and the like) is considered. Thus, for each of the recognition character position of the license-plate number component characters of all the recognition results, multiple estimated character positions which are considered to be highly likely to be an actual character position (hereinafter, referred to as correct

character positions) are defined (for example, for a recognition character position "i," the estimated character positions are "(i-1)'," "i'," "(i+1)'," etc.).

[0182]

When the number of license-plate number component characters is already known, the estimated character positions may be set by reflecting the number of license-plate number component characters thereon. For example, when the known number of license-plate number component characters is 6, the estimated character positions defined for the recognition character position "6" are set to only "5'" and "6'." Moreover, the number of the estimated character positions set for each recognition character position is not limited two or three and may be properly set as needed.

[0183]

Next, the weighting factors are previously set for all the defined estimated character positions. Table 11 shows setting examples of the weighting factors for the estimated character positions.

[0184]

[Table 11]

Example of Weighting Factor for Estimated Character Position

Recognition Character position Estimated Character Position	1	2	3	4	5	6
1'	1.0	0.8				
2'	0.8	1.0	0.7			
3'		0.7	1.0	0.7		
4'			0.7	1.0	0.7	
5'				0.7	1.0	0.7
6'					0.7	1.0
7'						0.8

[0185]

In the example shown in Fig. 11, it is assumed that the recognition character positions are most likely to be the correct character positions, and the weighting factor of each estimated character position defined as the same position as the corresponding recognition character position (for example, the estimated character position "1'" for the recognition character position "1") is set to 1.0.

[0186]

Moreover, it is assumed that, for each recognition character position, character positions different from the recognition character positions are slightly less likely to be the correct positions, and weighting factors of estimated character positions defined as positions different from the recognition character position (for example, the estimated character positions "1'" and "3'" for the recognition character position "2") are set to values more than 0 and less than 1 (here, 0.7 or 0.8).

[0187]

The weighting factors shown in Table 11 are just examples and can be set according to various conditions instead, for example, by reflecting actual values of the character positions varying due to missing characters or the like.

[0188]

Table 12 shows an example of assigning scores calculated by reflecting the weighting factors shown in Table 11 on the character similarities of the license-plate number component characters of the recognition results obtained from the frame images 61 to 64 captured at the respective times (T to T+3).

[0189] [Table 12]

Examples of Assigned Score for Recognition Result

Time: T

Recognition Character Position	1	2	3	4	5
Recognition Result	B	C	1	2	3
Similarity	0.8	0.8	0.8	0.8	0.8
Estimated Character Position					
1'	0.80	0.64			
2'	0.64	0.80	0.56		
3'		0.56	0.80	0.64	
4'			0.56	0.80	0.56
5'				0.64	0.80
6'					0.56
7'					

Time: T+1

Recognition Character Position	1	2	3	4	5	6
Recognition Result	A	B	C	1	2	3
Similarity	0.5	0.7	0.7	0.7	0.7	0.7
Estimated Character Position						
1'	0.50	0.56				
2'	0.40	0.70	0.49			
3'		0.49	0.70	0.64		
4'			0.49	0.70	0.49	
5'				0.56	0.70	0.49
6'					0.49	0.70
7'						0.56

Time: T+2

Recognition Character Position	1	2	3	4	5
Recognition Result	A	B	C	1	2
Similarity	0.6	0.7	0.7	0.7	0.6
Estimated Character Position					
1'	0.60	0.56			
2'	0.48	0.70	0.49		
3'		0.49	0.70	0.56	
4'			0.49	0.70	0.42
5'				0.56	0.60
6'					0.42
7'					

Time: T+3

Recognition Character Position	1	2	3	4	5	6
Recognition Result	A	B	D	1	2	3
Similarity	0.5	0.7	0.4	0.6	0.7	0.7
Estimated Character Position						
1'	0.50	0.56				
2'	0.40	0.70	0.28			
3'		0.49	0.40	0.48		
4'			0.28	0.60	0.49	
5'				0.48	0.70	0.49
6'					0.49	0.70
7'						0.56

[0190]

The scores shown in Table 12 are calculated as products

of the character similarities by the weighting factors shown in Table 11. For example, the score "0.8" of the character "B" in the recognition character position "1" and in the estimated character position "1'" at the time T is calculated as a product of the character similarity "0.8" of the character "B" and the weighting factor "1.0." Each character similarity shown in Table 12 is just an example and has different values according to the various conditions.

[0191]

After the scores are calculated for the recognition results obtained at the individual times (T to T+3), the score results corresponding to the same recognition result and the same estimated character position are summed up. Table 13 shows the assignment results.

[0192] [Table 13]

Examples of Weighting Factor for Estimated Character Position
Time: T

Recognition results Estimated Character Position	A	B	C	1	2	3	D
1'	1.60	2.48					
2'	1.28	2.74	1.54				0.28
3'		2.11	2.36	2.40			0.40
4'			1.54	2.56	2.20		0.28
5'				1.60	2.64	1.78	
6'					1.40	1.96	
7'						1.12	
Assignment Result	ABC123						

[0193]

For example, in Table 13, the score "1.6" in the estimated

character position "1'" and the recognition result "A" is a sum of the scores "0.5," "0.6," and "0.5" in the estimated position "1'" and the recognition result "A" at the time T+1, T+2, and T+3 shown in Table 12.

[0194]

Based on the assigned score results, an estimated character position at which the recognition result of the license-plate number component character has the highest point is considered to be the correct character position. Specifically, in the example shown in Fig. 13, the license-plate number component character "B" is employed for the character position "2" at which with "B" has the highest score. In a similar manner, the license-plate number component character "2" is employed for the character position "5;" the license-plate number component character "1," the character position "4;" the license-plate number component character "C," the character position "3;" the license-plate number component character "3," the character position "6;" the license-plate number component character "A," the character position "1." Accordingly, "ABC123" is outputted as the determined recognition result. Incidentally, the license-plate number component character "D" is not employed because of its low points.

[0195] According to the license-plate number recognition system of the aforementioned embodiment, the results of processing of the multiple images are integrated. Accordingly, the license-plate number can be recognized even when processing of some images results in a missing correct character. Moreover, it is possible to obtain higher recognition accuracy than that obtained by processing only one image.

[0196]

In this embodiment, an example is illustrated in which the estimated character positions are set when the license-plate number candidates all have the same character position but different recognition results. However, when the character positions are the same across the license-plate

number candidates but the recognition results are different like this case, as described in Embodiment 1 above, an option such as employing the result with highest similarity is possible. It is obvious that various changes as this can be made without departing from the scope of the present invention.

EMBODIMENT 12

[0197]

A description is given of a twentieth embodiment of the present invention below. At the process performed at the step S217 in Embodiment 11 above when the recognition results do not have the same number of characters and the same character positions across the license-plate number candidates, there is a case where there is only a small difference between the character similarities of the adjacent levels, for example, between the highest and second highest character similarities, the character similarities being used for determining the recognition result. With such case taken into consideration, in this embodiment, the scores are calculated up to appropriately specified rank (in this embodiment, the second highest character similarity) and are assigned. The other processes are the same as that described in the embodiment, and the redundant description is omitted.

[0198]

Table 14 shows examples of the license-plate number candidates obtained from the frame images 61 to 64 shown in Fig. 3 by the step S102 shown in Fig. 18.

[0199]

[Table 14]

Time	T	T+1	T+2	T+3
Recognition Result	BC123	ABC123	HBD123	HBC12

[0200]

In the example shown in Table 14, the license-plate number candidates in the license-plate number candidate group do not have the same number of characters. Specifically, this example shows that "A" in the frame image 61 captured at the time T and

"3" in the frame image 64 captured at the time T3 are not recognized, and the recognition results thereof are outputted as the license-plate number candidates each having five characters. Moreover, the example shows that "A" and "C" in the frame image 63 captured at the time T+2 are recognized as "H" and "D", respectively. As for the characters of the recognition results at the character positions "1" to "5" (hereinafter, referred to as recognition character positions), some of the recognition results at corresponding character positions are different across the license-plate number candidates. In addition, as for the recognition character position "6," some recognition results do not contain a character corresponding to the character position.

[0201]

In this embodiment, the description is given under the following assumption: in the results of the character similarity evaluation of the character corresponding to the recognition character position "1" in the frame image 63 captured at the time T+2, the highest character similarity is 0.5 for "H," and the second highest character similarity is 0.45 for "A."

[0202]

In this embodiment, using the estimated character positions and the weighting factors of the character similarities shown in Tables 10 and 11 set in Embodiment 11 above, when the highest and second highest character similarities of the characters corresponding to an estimated character position are similar to each other, for example, when the difference in character similarity therebetween is smaller than a previously set value, the characters having the highest and second highest character similarities are considered as candidates for the license-plate number component characters. Table 15 shows an example in which, for each of the frame images 61 to 64 captured at the times T to T+3, the scores calculated by reflecting the weighting factors shown in Table 11 on the character similarities of the license-plate number component characters

are calculated for the obtained recognition results.

[0203] [Table 15]

Example of Assigned Score of Recognition Result

Time: T

Recognition Character Position	1	2	3	4	5
Recognition Result	B	C	1	2	3
Similarity	0.8	0.8	0.8	0.8	0.8
Estimated Character Position					
1'	0.80	0.64			
2'	0.64	0.80	0.56		
3'		0.56	0.80	0.64	
4'			0.56	0.80	0.56
5'				0.64	0.80
6'					0.56
7'					

Time: T+1

Recognition Character Position	1	2	3	4	5	6
Recognition Result	A	B	C	1	2	3
Similarity	0.5	0.7	0.7	0.7	0.7	0.7
Estimated Character Position						
1'	0.50	0.56				
2'	0.40	0.70	0.49			
3'		0.49	0.70	0.56		
4'			0.49	0.70	0.49	
5'				0.56	0.70	0.49
6'					0.49	0.70
7'						0.56

Time: T+2

Recognition Character Position	1		2	3	4	5	6
Recognition Result	H	A	B	D	1	2	3
Similarity	0.5 (1)	0.45 (2)	0.7 (1)	0.4 (1)	0.6 (1)	0.7 (1)	0.7 (1)
Estimated Character Position							
1'	0.50	0.45	0.56				
2'	0.40	0.36	0.70	0.28			
3'			0.49	0.40	0.48		
4'				0.28	0.60	0.49	
5'					0.48	0.70	0.49
6'						0.49	0.70
7'							0.56

Time: T+3

Recognition Character Position	1		2	3	4	5
Recognition Result	H	A	B	C	1	2
Similarity	0.6 (1)	0.55 (2)	0.7 (1)	0.7 (1)	0.7 (1)	0.6 (1)
Estimated Character Position						
1'	0.60	0.55	0.56			
2'	0.48	0.44	0.70	0.49		
3'			0.49	0.70	0.56	
4'				0.49	0.70	0.42
5'					0.56	0.60
6'						0.42
7'						

[0204]

Table 15 shows an example in which, in the recognition results at the times T+2 and T+3, the highest and second highest character similarities of the license-plate number component characters at the recognition character position "1" are similar to each other. Table 16 shows integrated results, one result showing a case where only the result having the highest character similarity is applied based on the recognition results shown in Table 14; and the other result showing a case where the results having the highest and second highest character similarities are applied.

[0205] [Table 16]

Result of Applying Only Highest Character Similarity

Recognition results Estimated Character Position	A	B	C	1	2	3	D	H
1'	0.50	2.48						1.00
2'	0.40	2.74	1.54				0.28	0.80
3'		2.11	2.36	2.40			0.40	
4'			1.54	2.56	2.20		0.28	
5'				1.60	2.64	1.78		
6'					1.40	1.96		
7'						1.12		
Assignment Result	HBC123							

Results of Applying Highest and Second Highest Character Similarities

Recognition results Estimated Character Position	A	B	C	1	2	3	D	H
1'	1.50	2.48						1.00
2'	1.20	2.74	1.54				0.28	0.80
3'		2.11	2.36	2.40			0.40	
4'			1.54	2.56	2.20		0.28	
5'				1.60	2.64	1.78		
6'					1.40	1.96		
7'						1.12		
Assignment Result	ABC123							

[0206]

As shown in Table 16, when only the result having the highest character similarity is applied, the integrated result turns out to be "HBC123," hence leading to misrecognition. When the results having the highest and second highest character similarities are applied, the integrated result becomes "ABC123." It can be seen that the correct result is outputted as the determined recognition result.

[0207]

As described above, according to this embodiment, in addition to the operational effect by Embodiment 11, even when the character recognition accuracy from the individual images is low, it is possible to obtain high recognition accuracy by integrating the results of processing of multiple images.

[0208]

Table 16 shows only the scores of the characters having only a small difference between the highest and second highest character similarities. The second highest character similarities of the other characters are assumed to be close to substantially zero, and thus the scores thereof are omitted. For each character position, when the character similarities lower than the first character similarity are small, that is, when the difference between the highest and second highest character similarities is larger than a previously set value, for example, the recognition results having the second highest character similarity or lower may be eliminated by preprocessing. In this embodiment, the assignment of scores is performed in consideration of the results of the highest and second highest character similarities. However, the present invention is not limited to this and can be variously changed as needed.

EMBODIMENT 13

[0209]

Based on Figs. 19 and 20, a description is given of a thirteenth embodiment. Fig. 19 is a flowchart showing a flow of a license-plate number recognition process in this embodiment; and Fig. 20 is a flowchart showing a flow of a number plate recognition process. This embodiment is an example of, in Embodiment 11 above, setting multiple evaluation values for one frame image so as to extract the license-plate number, and performing the number plate recognition process based on the individual evaluation values. This embodiment is applied to the aforementioned structure shown in Fig. 18. The other structure of this embodiment is substantially the same as that of Embodiment 11 above shown in Fig. 18, and thus the redundant description is omitted.

[0210]

As shown in Fig. 19, in the license-plate number recognition unit 20 of this embodiment, first, a frame image captured by the camera 10 is inputted (step S171). Next,

multiple binarization threshold values a_1 to a_i for extracting the license-plate number are set for the inputted frame image, and the number plate recognition process to extract the license-plate number is performed based on the multiple binarization threshold values a_1 to a_i (step S172).

[0211]

The process of the steps S171 and S172 is performed on all the frame images of the number plate of the vehicle that are captured successively, and then the obtained recognition results are used to perform the recognition result integration process (step S200). Here, the recognition result integration process (step S200) is the same as the steps S211 to S218 shown in Fig. 18, and the detailed description thereof is omitted.

[0212]

In this embodiment, the number plate recognition process (step S172) is performed according to the flow shown in Fig. 20. Specifically, first, the frame image inputted by the step S171 is subjected to a process to extract and cut out an image of a number plate (step S172-1). Next, the image of the number plate cut out by the step S172-1 is subjected to a process to extract characters by binarization (step S172-2). Subsequently, the characters extracted by the step 172-2 are subjected to a recognition process using the character similarity (step S172-3), and the derived result is outputted as the recognition result (step S172-4). In this embodiment, the process performed at the above step S172-2 is performed based on the multiple binarization threshold values a_1 to a_i .

[0213]

According to this embodiment, the multiple binarization threshold values a_1 to a_i are set for one frame image, and all the frame images are subjected to the multiple number plate recognition processes (step S172) based on the multiple binarization threshold values a_1 to a_i . It is therefore possible to avoid that the frame images cannot be recognized due to the influence of shade or low contrast image, thus increasing the recognition accuracy.

EMBODIMENT 14

[0214]

Based on Fig. 21, a description is given of a fourteenth embodiment of the present invention. Fig. 21 is a flowchart showing a flow of a license-plate number recognition process in this embodiment. In this embodiment, instead of the multiple binarization threshold values a_1 to a_i as the evaluation values used for extracting the license-plate number in Embodiment 13 above, multiple number plate cutout positions b_1 to b_j are used. The other structure of this embodiment is substantially the same as that of Embodiment 13 above shown in Fig. 19.

[0215]

As shown in Fig. 21, in the license-plate number recognition unit 20 of this embodiment, first, a frame image captured by the camera 10 is inputted (step S181). Next, for the inputted frame image, the multiple number plate cutout positions b_1 to b_j are set as evaluation values used for extracting the license-plate number, and the number plate recognition process is performed based on each of the multiple number plate cutout positions b_1 to b_j thus set (step S182). Incidentally, the multiple number plate positions may be set by including, for example, a normal cutting position and a position vertically and horizontally shifted from the normal cutting position by predetermined distances.

[0216]

The process of the steps S181 and S182 is performed on all the frame images of the number plate of the vehicle that are captured successively, and then the thus obtained recognition results are used to perform the recognition result integration process (step S200). Here, the recognition result integration process (step S200) is the same as the steps S211 to S218 shown in Fig. 18, and the detailed description thereof is therefore omitted.

[0217]

In this embodiment, the number plate recognition process (step S182) is performed according to the same flow as the

aforementioned steps S172-1 to 172-4 shown in Fig. 20. When processing the plate cutout process corresponding to the step S172-1 explained in Embodiment 13 above shown in Fig. 20, the number plate recognition process (step S182) is performed based on each of the multiple number plate cutout positions b_1 to b_j .
[0218]

According to this embodiment, the multiple number plate cutout positions b_1 to b_j are set for a frame image, and all the frame images are subjected to the multiple number plate recognition process (step S182) based on the multiple number plate cutout positions b_1 to b_j . Accordingly, compared to the case where a single number plate cutout position is set for each frame image, it is possible to reduce the possibility of misrecognizing the shape of the number plate in the frame image due to the decrease in quality of the number plate (dirty or damaged number plate or the like) and reliably extract the license-plate number, thus further increasing the recognition accuracy.

EMBODIMENT 15

[0219]

Based on Fig. 22, a description is given of a fifteenth embodiment of the present invention. Fig. 22 is an explanatory view showing an example of checking the recognition result and a database in this embodiment. In this embodiment, the determined recognition result obtained by the above-described recognition result integration process (step S200) shown in Fig. 18 in Embodiment 11 above is checked against the number plate information (license-plate number information) stored in the vehicle information database so as to correct a recognition result. Here, the recognition result integration process (step S200) is the same as the process of the steps S211 to S218 shown in Fig. 18, and the detailed description thereof is therefore omitted.

[0220]

The process concerning the license-plate number recognition, which is substantially the same as shown in Fig.

9, checks the determined recognition result against the number plate information stored in the vehicle information database and corrects the license-plate number by so-called fuzzy search using the Levenshtein distance. Here, the Levenshtein distance, which serves as checking means for specifying the license-plate number in the process of the step S302, is an edit distance for evaluating the similarity between two character strings as an evaluation value. The evaluation value herein is the minimum number of operations needed to transform one character string to the other.

[0221]

The Levenshtein distance is the minimum number of character operations including insertion, deletion, and substitution, which allow one character string to be transformed to the other, and shows as the evaluation value indicating how different the two character strings are.

[0222]

In this embodiment, as a result of checking, a license-plate number having the shortest Levenshtein distance to the determined recognition result is outputted as a correct license-plate number.

[0223]

As shown in Fig. 22, the description is given taking an example in which: the determined recognition result 73 obtained by the recognition result integration process (step S200) in Embodiment 11 is "ABC12;" the license-plate number is not determined because of the missing last character; and numbers of the license-plate numbers stored in the vehicle information database 83 include license-plate numbers "ABC119," "ABC123," and "ABC135" which are similar to the determined recognition result.

[0224]

In the example shown in Fig. 22, the Levenshtein distance between the determined recognition result 73 ("ABC12" herein) and the license-plate number "ABC119" stored in the license-plate number database 83 is "2" because the

license-plate number component character "2" at the character position "5" of the determined recognition result "ABC12" needs to be substituted with "1" and the license-plate number component character "9" needs to be inserted to the character position "6."

[0225]

The Levenshtein distance between the determined recognition result 73 ("ABC12" herein) and the license-plate number "ABC123" stored in the license-plate number database 83 is "1" because the license-plate number component character "3" needs to be inserted to the character position "6."

[0226]

The Levenshtein distance between the determined recognition result 73 ("ABC12" herein) and the license-plate number "ABC135" stored in the license-plate number database 83 is "2" because the license-plate number component character "2" in the character position "5" of the determined recognition result "ABC12" needs to be substituted with "3" and the license-plate number component character "5" needs to be inserted to the character position "6."

[0227]

Accordingly, in the example shown in Fig. 22, the license-plate number "ABC123" which has the smallest Levenshtein distance to the determined recognition result 73 ("ABC12" herein) is obtained as a search result 93 and determined as the license-plate number of the vehicle.

[0228]

As described above, this embodiment uses information stored in the vehicle information database other than the results by image processing, thereby obtaining an accurate license-plate number even when, for example, a part of the recognition result is unknown. Furthermore, using the Levenshtein distance as checking means can increase the efficiency of the process concerning the checking.

[0229]

As the edit distance, in addition to the aforementioned

Levenshtein distance, the Damerau distance or the like may be used. Alternately, the hamming distance may be also used when the recognition results have the same number of characters as the character strings to be checked against, that is, the license-plate number stored in the vehicle information database. Thus, a suitable type of edit distance should be used as needed.

[0230]

It is to be noted that the Damerau distance is an evaluation means for evaluating the similarity of two character strings by using the number of processes performed to transform one character string into the other (substitution, insertion, deletion, or transposition of adjacent characters) (the smaller the number of processes is, the higher the similarity is), whereas the hamming distance is an evaluation means for evaluating the similarity of two character strings having the same number of characters, by using the number of substitutions performed to transform one character string into the other.

[0231]

The algorithms to calculate the edit distance include dynamic programming, an automaton-based algorithm, a bit parallel method, and the like, but the detailed descriptions thereof are omitted.

EMBODIMENT 16

[0232]

Based on Fig. 23, a description is given of a sixteenth embodiment of the present invention. Fig. 23 is an explanatory view showing an example of checkup of the recognition result against the database in Embodiment 15 above. This embodiment is an example in which, when the result is not determined in Embodiment 15 above, for example, checking is performed using the character similarities which is the information of the recognition results of each license-plate number component character used in the recognition result integration process, so that the license-plate number is corrected. The other structure of this embodiment is substantially the same as that of Embodiment 15, and the redundant description is therefore

omitted.

[0233]

For example, assume a case where a determined recognition result 74 obtained by the recognition result integration process (step S200) of Embodiment 11 is "HBC123" while vehicle information database 84 stores "ABC123" and "BBC123" as the number plate information, as shown in Fig. 23. In such case, the fuzzy search explained in Embodiment 15 results in the Levenshtein distance of "1" to the both license-plate numbers "ABC123" and "BBC123." The license-plate number therefore cannot be determined uniquely.

[0234]

Accordingly, in this embodiment, in such a case where the license-plate number is not determined by the process explained in Embodiment 15, further fuzzy search is performed by using the weighted Levenshtein distance as the edit distance in which the character operations to transform one character string to the other are assigned different factors. For two character strings to be compared, in the case of performing substitution (insertion or delete) of characters for example to transform one character string into the other, the weighted Levenshtein distance is used for evaluation by setting different weighting factors to individual operations based on defined indices so that the Levenshtein distance has a different value for each operation.

[0235]

A description is given below of an example in which the index mentioned above is the character similarity used in the recognition result integration process (step S200) of Embodiment 11. Table 17 shows examples of character candidates extracted to obtain the character in the character position "1" in the number plate recognition process (step S102), in descending order of the character similarity.

[0236]

[Table 17]

Rank	Character Candidate	Similarity
1	H	0.60
2	A	0.50
3	B	0.40

[0237]

In this embodiment, as shown in Fig. 23, a character to be substituted for the license-plate number component character "H" of the determined recognition result 74 ("HBC123") is considered to be "A" or "B," and "A" and "B" fall in a range of the first to k-th character similarities as the candidate for the license-plate number component character at the character position "1" as shown in Table 17 (k is the number of character candidates extracted for each character position in the number plate recognition process). The checkup of the license-plate number is then performed by using the Levenshtein distance between two characters that is defined as "1 - character similarity," the Levenshtein distance being defined by using the character similarity used in the recognition result integration process (step S200).

[0238]

Specifically, when transforming a determined recognition result 74 ("HBC123") into "ABC123" stored in the vehicle information database 84 as shown in Fig. 23, the weighted Levenshtein distance becomes "(1.0-0.5=) 0.5" according to Table 17 because "H" outputted as the determined recognition result is substituted with "A" as the character in the character position "1." On the other hand, when transforming the determined recognition result 74 ("HBC123") into "BBC123" stored in the vehicle information database 84, the weighted Levenshtein distance becomes "(1.0-0.4=) 0.6" according to Table 17 because "H" outputted as the determined recognition result is substituted with "B" as the character in the character position "1."

[0239]

As a result, "ABC123" which has a smaller weighted

Levenshtein distance to the determined recognition result "HBC123" is determined as a research result 94. The aforementioned calculation of the weighted Levenshtein distance is just an example, and the weighted Levenshtein distance should be defined so that a character having a higher character similarity has a smaller Levenshtein distance.

[0240]

According to this embodiment, even when the fuzzy search explained in Embodiment 15 provides more than one matching result, the license-plate number can be determined, and the recognition accuracy of the license-plate number can be further increased.

[0241]

This embodiment shows the example in which the edit distance is the weighted Levenshtein distance, but it is obvious that various changes can be made without departing from the scope of the present invention.

EMBODIMENT 17

[0242]

A description is given of a seventeenth embodiment of the present invention. This embodiment is an example of using statistical data with regard to the likelihood of misrecognition of characters to be compared instead of the character similarity used as the index to define the weighting factor of the Levenshtein distance, which is used in Embodiment 16 to check the determined recognition result against the license-plate numbers stored in the vehicle information database. The other structure of this embodiment is substantially the same as that of Embodiment 16, and the redundant description thereof is omitted.

[0243]

Table 18 shows examples of character candidates extracted by the number plate recognition process (step S102) in the example shown in Fig. 23 so as to obtain a character in the character position "1" of the license-plate number, the character candidates being indicated in descending order of the

character similarity.

[0244] [Table 18]

Rank	Character Candidate	Similarity
1	H	0.60
2	A	0.01
3	B	0.01

[0245]

As shown in Table 18, according to Embodiment 16 above, when the character similarity of the character candidate "H" in the character position "1" is higher than the character similarities of the character candidates "A" and "B," the weighted Levenshtein distances to the license-plate numbers "ABC123" and "BBC123" are both equal to $(1.0-0.1)=0.9$, and thus the license-plate number cannot be uniquely determined.

[0246]

Accordingly, in this embodiment, the Levenshtein distances are weighted based on the frequency of error used as the evaluation value obtained from combinations of characters often misrecognized, using the statistical results in the recognition result integration process (step S200) shown in Fig. 18. For example, the frequency error is set beforehand as a ratio of the number of characters that are often misrecognized to the total number of characters which is obtained by tallying statics of characters easily mistaken for a character. Table 19 shows an example of misrecognition statistical values.

[0247] [Table 19]

Misrecognition Statistical Value of A

Rank	Candidate Character	Error Rate
1	H	0.50
2	8	0.20
3	-	0.10
4	-	0.08
5	-	0.02

Misrecognition Statistical Value of B

Rank	Candidate Character	Error Rate
1	8	0.50
2	H	0.20
3	-	0.15
4	-	0.10
5	-	0.05

[0248]

According to Table 19, when transforming the determined recognition result 74 ("HBC123") shown in Fig. 23 into "ABC123" stored in the vehicle information database 83, "H" is substituted with "A," and thus the weighted Levenshtein distance is $(1.0 - 0.5 =) 0.5$. When transforming the determined recognition result 74 ("HBC123") into "BBC123" stored in the vehicle information database 84, "H" is substituted with "B," and thus the weighted Levenshtein distance is $(1.0 - 0.2 =) 0.8$. Accordingly, "ABC123" which has a smaller weighted Levenshtein distance is determined as a search result 94. Note that the above-described calculation of the weighted Levenshtein distance is just an example. The Levenshtein distance should be defined so that the Levenshtein distance between two characters which are more likely to be misrecognized is smaller.

[0249]

According to this embodiment, compared to Embodiment 16, in the case where the fuzzy search for the vehicle information database explained in Embodiment 15 provides more than one matching result, the reliability will not be reduced even when the second highest or lower character similarity is low as shown in Table 18, and it is possible to determine the matching result without information concerning the recognition result for each character.

EMBODIMENT 18

[0250]

Based on Figs. 24 and 25, a detail description is given of an eighteenth embodiment of the present invention. Fig. 24 is an explanatory view showing an example of checking the license-plate number according to this embodiment; and Fig. 25 is a flowchart showing a flow of a license-plate number recognition process in this embodiment. This embodiment shows an example in which the shape of the number plate (for example, size, aspect ratio, or the like of the number plate) is further checked to correct the license-plate number in a case of Embodiments 16 or 17 where the license-plate number is not determined as a result of checking the determined recognition result against the license-plate numbers stored in the vehicle information database. The other structure of this embodiment is substantially the same as that of Embodiment 16 or 17 above, and the redundant description thereof is omitted.

[0251]

As shown in Fig. 24, in this embodiment, license-plate numbers and number plate shape corresponding to the license-plate numbers are stored in advance in a vehicle information database 85 as the number plate information.

[0252]

In the license-plate number recognition unit 20, a process shown in Fig. 25 is performed. To be more specific, first, the license-plate number extraction process (step S100) is performed, that is, frame images captured by the camera 10 (step S101) are successively inputted. The number plate recognition process (step S102) to recognize the number plate from each inputted frame image and extract the license-plate number is performed. At this time, in the license-plate number recognition unit 20, the shape of the number plate is extracted and stored.

[0253]

Subsequently, the recognition result integration process (step S200) is performed, and then it is judged whether the

determined recognition result contains an unknown character (step S311). If the result of the judgment shows that no unknown character is contained (no), the result obtained by the recognition result integration process is outputted as the license-plate number. On the other hand, when any unknown character is contained (yes), the determined recognition result is checked against the number plate information stored in the vehicle information database 85 (step S312).

[0254]

When the license-plate number is determined as the result of checking (yes), this result is determined as the license-plate number of the vehicle. When the license-plate number is not determined (no) for the reason that there are multiple candidates for the license-plate number or the other reasons, the information of the shape of the number plate is checked (step S313), and the obtained result is determined as the license-plate number of the vehicle.

[0255]

For example, as shown in Fig. 24, a determined recognition result 75 obtained by the recognition result integration process explained in Embodiment 11 is "HBC123," which is checked against the number plate information stored in the vehicle information database 85. As a result, there are license-plate number candidates of "ABC123" and "BBC123," and thus the license-plate number is not determined. In such a case, the information of the shape of the number plate is checked (step S313). Table 20 shows examples of the aspect ratio of the number plate of the license-plate number candidates shown in Fig. 24.

[0256]

[Table 20]

	Aspect Ratio
ABC119	0.40
ABC123	0.50
BBC123	0.36

[0257]

In the example shown in Fig. 24, vertical and horizontal

length (vertical length, horizontal length) of the shape of the number plate derived in the license-plate number recognition unit 20 is (21, 40), and thus the aspect ratio (vertical length/horizontal length) thereof is 0.525. On the other hand, vertical and horizontal lengths of the shape of the number plates for the license-plate numbers "ABC123" and "BBC123" are (22, 44) and (20, 55), respectively, and thus the aspect ratios (vertical length/horizontal length) thereof are 0.50 and 0.36, respectively, as shown in Table 20. Accordingly, the license-plate number "ABC123" having an aspect ratio (0.5) closest to the aspect ratio 0.525 of the number plate derived in the license-plate number recognition unit 20 is obtained as a detection result 95 and is determined as the license-plate number of the vehicle.

[0258]

According to the aforementioned embodiment, using the information concerning the shape of the number plate in addition to the information obtained by the recognition result integration process makes it possible to specify the license-plate number more accurately and reliably.

[0259]

This embodiment has shown an example in which the number plate shape is checked because the checked result is not determined in Embodiment 16 or 17. However, checking the shape of the number plate even when the number of license-plate numbers obtained as a result of checking the license-plate number information stored in the vehicle information database is one, leads to a further increased accuracy of specifying license-plate number.

EMBODIMENT 19

[0260]

Using Figs. 26 and 27, a description is given of a nineteenth embodiment of the present invention. Fig. 26 is an explanatory view showing an example of checking the license-plate number in this embodiment; and Fig. 27 is a flowchart showing a flow of a license-plate number recognition

process according to this embodiment. In this embodiment, instead of checking the number plate shape shown in Embodiment 18, the license-plate number is corrected by checking color information of the number plate (for example, colors of characters and background of the number plate). The other structure of this embodiment is substantially the same as that of Embodiment 18, and the redundant description thereof is omitted.

[0261]

As shown in Fig. 26, in the vehicle information database of this embodiment, color information of each number plate (colors of characters and background color of the number plate in this embodiment) is stored in advance in addition to the license-plate number information.

[0262]

Then the process shown in Fig. 27 is performed in the license-plate number recognition unit 20. Specifically, first, the license-plate number extraction process (step S100) is performed. At this time, the license-plate number recognition unit 20 acquires information on colors of the number plate. Subsequently, the recognition result integration process (S200) is performed, and then it is judged whether the determined recognition result contains an unknown character (step S231).

[0263]

When the result of the judgment shows that any unknown character is not contained (no), the result obtained by the recognition result integration process is outputted as the license-plate number. On the other hand, when the determined recognition result contains an unknown character (yes), the result is checked against the number plate information stored in the vehicle information database 85 (step S322).

[0264]

When the license-plate number is determined as a result of checking (yes), the result thereof is determined as the license-plate number of the vehicle. When the license-plate

number is not determined (no), the colors of the number plate are further checked (step S323), and the obtained result is determined as the license-plate number of the vehicle.

[0265]

For example, the aforementioned determined recognition result 76 is "HBC123" as shown in Fig. 26. When checking against the vehicle information database 86 results in matches of license-plate numbers "ABC123" and "BBC123," and thus the license-plate number is not determined. This leads to the checking of the information of the number plate shape (step S323). Accordingly, "ABC123" that matches the vehicle whose number plate has same colors (characters, background) of (black, silver) is obtained as a search result 96 and determined as the license-plate number of the vehicle of interest.

[0266]

As described above, according to this embodiment, by using the information concerning the colors of the number plate in addition to the information obtained by the recognition result integration process, the license-plate number can be reliably specified.

[0267]

This embodiment has shown an example in which the number plate colors are checked because the checking result is not determined in Embodiments 16 or 17. However, checking the number plate colors even when checking the license-plate number information stored in the vehicle information database results in a single match, leads to a further increased accuracy of specifying a license-plate number.

EMBODIMENT 20

[0268]

Using Figs. 28 and 29, a description is given of a twentieth embodiment of the present invention. Fig. 28 is an explanatory view showing an example of checking the license-plate number in this embodiment; and Fig. 29 is a flowchart showing a flow of a license-plate number recognition process in this embodiment. In this embodiment, instead of

checking the number plate shape in Embodiment 18, information on the vehicle color is checked to correct the license-plate number. The other structure of this embodiment is substantially the same as that of Embodiment 18, and the redundant description thereof is omitted.

[0269]

In this embodiment, as shown in Fig. 28, color information of vehicle bodies in addition to the number plate information (license-plate number information) is stored in advance in the vehicle information database 87.

[0270]

Then the process shown in Fig. 29 is executed in the license-plate number recognition unit 20. Specifically, first, the license-plate number extraction process (step S100) is performed. At this time, in the license-plate number recognition unit 20, a process to recognize the color of the vehicle body is performed, and the recognized color information is stored. Subsequently, the recognition result integration process (S200) is performed, and then it is judged whether the determined recognition result contains an unknown character (step S331).

[0271]

When the result of the judgment shows that any unknown character is not contained (no), the result obtained by the recognition result integration process is outputted as the license-plate number. On the other hand, when any unknown character is contained (yes), the result is checked against the number plate information stored in the vehicle information database 87 (step S322).

[0272]

When the license-plate number is determined as a result of checking (yes), the result thereof is determined as the license-plate number of the vehicle. When the license-plate number is not determined (no), the color information of the vehicle body is checked (step S333), and the obtained result is determined as the license-plate number of the vehicle.

[0273]

For example, the aforementioned determined recognition result 77 is "HBC123" as shown in Fig. 28. When checking against the vehicle information database 87 results in matches of license-plate numbers "ABC123" and "BBC123," and thus the license-plate number is not determined. This leads to the checking of the color information of the vehicle body (step S333). Accordingly, "ABC123" of the vehicle whose body has same color (white) is obtained as a search result 97 and determined as the license-plate number of the vehicle of interest.

[0274]

As described above, according to this embodiment, by using the color information of the vehicle body in addition to the information obtained by the recognition result integration result (step S200), the license-plate number can be reliably specified.

[0275]

This embodiment has shown an example in which the vehicle body color information is checked because the checking result is not determined in Embodiments 15 above. However, checking the body color information even when checking the license-plate number information stored in the vehicle information database results in a single match, leads to a further increased accuracy of specifying a license-plate number.

[0276]

In Embodiments 1 to 20 above, it is assumed that the license-plate number extraction process (step S100), which is the process of the steps S101 to S102 shown in Fig. 2 (or a process equivalent thereto), is performed for each vehicle running on the road 30. The number plate recognition process is performed for every frame image of a number plate of a vehicle successively captured. After a license-plate number candidate is extracted from each frame image, the recognition result integration process (step S200), which is the process of the steps S201 to S208 shown in Fig. 2 (or a process equivalent thereof) is performed. In other words, each time of detecting a vehicle,

the camera 10 captures successive images of the number plate of the detected vehicle; the license-plate number candidates are extracted from the multiple frame images of the number plate of the single vehicle; and then the recognition result integration process (step S200) is performed.

[0277]

The present invention is not limited to Embodiments 1 to 20 above, and it is obvious that various changes including combination of each embodiment and the like can be made without departing from the scope of the present invention.

INDUSTRIAL APPLICABILITY

[0278]

The present invention is applicable to license-plate number recognition systems.

CLAIMS

[1] A license-plate number recognition system comprising:
a camera which captures successive images of a number plate of a vehicle running on a road, at constant time intervals;
and

a license-plate number recognition processing unit which recognizes a license-plate number of the vehicle from a plurality of frame images captured by the camera, wherein

the license-plate number recognition processing means includes means that are used in a case where a plurality of license-plate number candidates are obtained from the frame images, the means including

means for determining a license-plate number by majority when recognition results of some of the license-plate number candidates are the same with each other,

means for detecting numbers of characters of the license-plate number candidates when the plurality of license-plate number candidates are different from one another, and determining by character similarity a character recognized as a different result across the license-plate number candidates, when the detected numbers of characters of the license-plate number candidates are the same, and

means for determining the license-plate number from positions of characters of the license-plate number candidates and from the recognition results of the characters, when the numbers of characters of the license-plate number candidates are not the same.

[2] A license-plate number recognition system comprising:
a camera which captures successive images of a number plate of a vehicle running on a road, at constant time intervals;
and

license-plate number recognition processing means for recognizing a license-plate number of the vehicle from a plurality of frame images captured by the camera, wherein

in a case where a plurality of license-plate number candidates are obtained from the frame images, the license-plate number recognition processing means:

when recognition results of some of the license-plate number candidates are the same with each other, determines a license-plate number by majority;

when the plurality of license-plate number candidates are different from one another, detects numbers of characters of the license-plate number candidates;

when the detected numbers of characters of the license-plate number candidates are the same, determines by character similarity a character recognized as a different result across the license-plate number candidates; and

when the detected numbers of characters of the license-plate number candidates are not the same, determines, as a character constituting the license-plate number, a character whose recognition results and character positions are the same across the license-plate number candidates, while setting estimated character positions for a character whose recognition results and character positions are not the same across the license-plate number candidates as well as assigning a weight to each of the estimated character positions, then calculating a score for each of the recognition results corresponding to the estimated character positions based on the similarity of the recognition results and the weights, and thus determining, based on the scores, the character whose recognition results and character positions are not the same across the license-plate number candidates.

[3] The license-plate number recognition system according to claim 1 or 2, wherein the camera captures rear and front number plates of the vehicle, and the captured frame images of the number plates are subjected to a recognition processing of the license-plate number.

[4] The license-plate number recognition system according to

claim 1 or 2, wherein images of the same number plate are captured from different angles, and the captured frame images of the number plate are subjected to a recognition processing of the license-plate number.

[5] The license-plate number recognition system according to claim 1 or 2, wherein, after the recognition processing of the license-plate number, a determined recognition result obtained by the recognition processing of the license-plate number is checked against number plate information managed in a database, so as to correct the determined recognition result.

[6] The license-plate number recognition system according to claim 1 or 2, wherein the license-plate number is determined using a license-plate number recognized from a frame image captured by another camera placed near the camera.

[7] The license-plate number recognition system according to claim 1 or 2, wherein the character similarity is resolution of sections of the number plate captured in the frame images.

[8] The license-plate number recognition system according to claim 1 or 2, wherein the character similarity is contrast of images of the number plate captured in the frame images.

[9] The license-plate number recognition system according to claim 1 or 2, wherein the license-plate number is determined in conjunction with a character arrangement rule of the number plate.

[10] The license-plate number recognition system according to claim 1 or 2, wherein, while the successive images of the number plate of the vehicle running on the road are captured at the constant time intervals by the camera, magnification of a lens of the camera is changed according to the position of the number plate in one of the frame images that is captured most recently.

[11] The license-plate number recognition system according to claim 1 or 2, wherein, while the successive images of the number plate of the vehicle running on the road are captured at the constant time intervals by the camera, magnification of a lens of the camera is changed according to speed of the vehicle calculated based on a displacement of the number plate between two successive frame images most recently captured.

[12] The license-plate number recognition system according to claim 1 or 2, wherein the license-plate number recognition processing means sets a plurality of evaluation values for each of the frame images, and recognizes the license-plate number of the vehicle individually based on the plurality of evaluation values.

[13] The license-plate number recognition system according to claim 12, wherein the evaluation values are threshold values for binarization performed for image processing on the frame images.

[14] The license-plate number recognition system according to claim 12, wherein the evaluation values are number plate cutout positions used in extracting the number plate images from the frame images.

[15] The license-plate number recognition system according to claims 1 or 2, wherein, after the recognition processing of the license-plate number, the determined recognition result is corrected by checking the determined recognition result obtained by the recognition processing of the license-plate number against number plate information previously acquired by using an edit distance used in evaluating similarity of two character strings as an evaluation value based on a minimum number of operations needed to transform one of the two character strings to the other.

[16] The license-plate number recognition system according to claim 15, wherein the evaluation value has a factor varying depending on the operations.

[17] The license-plate number recognition system according to claim 16, wherein the determined recognition result obtained by the recognition processing of the license-plate number is checked against the previously acquired number plate information, the checking being performed based on results of similarity evaluation of characters to be compared using the edit distance up to a previously set specified rank.

[18] The license-plate number recognition system according to claim 16, wherein the factor of the evaluation value is set based on statistical data of likelihood of misrecognizing characters to be compared.

[19] The license-plate number recognition system according to any one of claims 5, 13, and 14, wherein, when the determined recognition result is checked against the number plate information, in addition to checking the license-plate number, shape information of the number plate which is previously acquired is checked, so as to correct the determined recognition result.

[20] The license-plate number recognition system according to any one of claims 5, 13, and 14, wherein, when the determined recognition result is checked against the number plate information, in addition to checking the license-plate number, color information of the number plate which is previously acquired is checked, so as to correct the determined recognition result.

[21] The license-plate number recognition system according to any one of claims 5, 13, and 14, wherein, when the determined

recognition result is checked against the number plate information, in addition to checking the license-plate number, body color information of the vehicle which is previously acquired is checked, so as to correct the determined recognition result.