

DESCRIPTION

Title of Invention

CHARGING PROCESSING SYSTEM

Technical Field

[0001]

The present invention relates to a system that performs charging processing on a vehicle traveling on a road, particularly to a system capable of charging at an arbitrary position.

Background Art

[0002]

As a system that follows an electronic road pricing (ERP) system with a dedicated short range communication (DSRC) method, a system that performs charging according to a travelling position of a vehicle, that is, according to a travelling distance of the vehicle is considered promising. For this purpose, it is desired that the charging is performed with an accuracy of ± 10 m and a notification of the charging is given to the driver in real time. In specifying the travelling position of the vehicle, the global positioning system (GPS) can be used.

[0003]

Incidentally, when adopting the positioning means by

the GPS in an urban street having lines of tall buildings which is a target area of the ERP, there is a multi-path problem in which a GPS signal may be blocked by the buildings or an elevated road or the GPS signal may be irregularly reflected. For this reason, generally on an urban street where there are many tall buildings, it is difficult to obtain the inherent positioning accuracy of the GPS, and thus, there is a concern that a charging position may be deviated or a wrong amount may be charged. In addition, the deterioration of the positioning accuracy of the GPS can occur in an unspecified situation due to an arrangement of the satellites or the conditions of the air, and a size of error also varies with time. Therefore, it is difficult to ensure the accuracy of the charging position or reliability of charging only by the GPS.

[0004]

In order to cope with the deterioration of the GPS accuracy on a tall-building street, it is expected that the accuracy can be corrected by a gyro sensor or an acceleration sensor, or the position on the road can be corrected using map data. For example, PTL 1 discloses a proposal in which the position of the vehicle is corrected using information relating to the positioning errors occurring due to an environment, and then, the position of the vehicle can be specified. Even in a case where the

GPS accuracy deteriorates, the accuracy can be maintained in a certain period by the gyro sensor or the acceleration sensor. However, since this correction is accompanied by integrating the values of the gyro sensor or the acceleration sensor, the error increases as time elapses.

In addition, using positioning devices such as a high-performance vehicle speed pulse or a high-performance gyro sensor, it is possible to estimate the self-location by an inertial navigation even when the GPS is interrupted. However, these devices are too expensive to be mounted on a private user's vehicle.

[0005]

Therefore, as a system that can perform charging according to the travelling position of the vehicle, it is desirable that the travelling position of the vehicle can be specified without depending on the GPS and without mounting expensive devices. For example, in PTL 2, a technology is disclosed, in which an image (observation image) of surroundings of a current position of a moving object and a prepared image (reference image) relating to a predetermined point are collated by image matching, and then, the current position of the moving object is calculated based on the result.

Citation List

Patent Literature

[0006]

[PTL 1] Japanese Unexamined Patent Application
Publication No. 2014-92986

[PTL 2] Japanese Unexamined Patent Application
Publication No. 2013-61270

Summary of Invention

Technical Problem

[0007]

Incidentally, PTL 2 discloses a system that can specify a current position of a vehicle, but does not suggest a system that charges the vehicle.

Therefore, an object of the present invention is to provide a system that can charge a vehicle at an arbitrary position using a method of collating an observation image acquirable from a travelling vehicle and a reference image stored in advance.

Solution to Problem

[0008]

A charging processing system according to the present invention is a system that performs charging processing when a user vehicle travels on a road, and includes a reference image storage unit that stores a reference image acquired in advance in relation to a plurality of charging positions set on the road, an observation image acquisition unit that is provided on the

user vehicle and photographs a landscape of the surroundings of the road where the user vehicle travels, and acquires an observation image, a data processing unit that performs image matching on the stored reference image and the newly acquired observation image; and a charging processing unit that performs charging processing on the user vehicle based on the result of the image matching in the data processing unit.

[0009]

In the charging processing system according to the present invention, the data processing unit can perform an image matching of the reference image which is selected and the observation image which is newly acquired.

[0010]

In the charging processing system according to the present invention, the data processing unit can obtain a similarity degree between the reference image and the observation image by the image matching, and the charging processing unit can perform the charging processing at the charging position corresponding to the reference image based on the similarity degree.

[0011]

In the charging processing system according to the present invention, in relation to the reference image and the observation image on which the image matching is

performed, the data processing unit can estimate a relative position relationship between a position where the reference image is captured and a position where the observation image is captured, and the charging processing unit can perform the charging processing at the charging position corresponding to the reference image based on the result of the estimation.

[0012]

In the charging processing system according to the present invention, the data processing unit can obtain a predicted passing time when the user vehicle passes through the charging position corresponding to the reference image based on the reference image and the observation image, and the charging processing unit can perform the charging processing on the user vehicle at the predicted passing time.

[0013]

In the present invention, there are at least two methods of obtaining the predicted passing time.

In the first method, the data processing unit obtains the predicted passing time based on a distance to the charging position which is calculated based on the relative position relationship between the position where the reference image corresponding to the charging position is captured and the position where the observation image

is captured.

In the second method, the data processing unit obtains the predicted passing time based on the relative position relationship between the position where the reference image corresponding to the charging position is captured and a position where the observation image is captured and a traveling speed of the user vehicle.

[0014]

Some of the configuration elements in the charging processing system according to the present invention described above are realized by an on-board unit which is mounted on the user vehicle. That is, according to the present invention, there is provided an on-board unit that performs charging processing when a user vehicle travels on a road, and is mounted on the user vehicle, the device including: a data processing unit that performs image matching on a reference image acquired in advance in relation to a plurality of charging positions set on the road and an observation image in which a landscape of the surroundings of the road where the user vehicle travels is captured, and a charging processing unit that performs charging processing on the user vehicle based on the result of the image matching in the data processing unit.

[0015]

In the on-board unit in the present invention,

further specific aspects of the charging processing system in the present invention described above can be applied.

Advantageous Effects of the Invention

[0016]

In the charging processing system according to the present invention, since the charging position is set in advance in correspondence to the reference image information, it is possible to specify the charging position by performing the processing of matching the observation image information including the position information with the reference image information.

Therefore, the charging processing system according to the present invention enables charging based on the position through which the user vehicle passes during travelling. Furthermore, since the charging position can be specified without depending on the GPS, the charging processing system can perform the charging processing without being affected by deterioration of the GPS accuracy. In addition, even in a region where the GPS cannot be used such as in a tunnel or on an underground road, for example, if the position and other positions on the captured images can be distinguished by writing or drawing characters or other information on the wall of the tunnel, the charging processing can be performed.

[0017]

In addition, the accuracy of the charging position specified by the charging processing system according to the present invention is determined according to the image capturing conditions of the image information of both the reference image information and the observation image information and the method of matching the reference image information with the observation image information. However, it can be said that the above accuracy is known. In contrast, the accuracy of the GPS varies markedly depending on a position where the GPS signal is received. Therefore, according to the present invention, it is possible to ensure the reliability of charging in contrast to the case of using the GPS.

Brief Description of Drawings

[0018]

Fig. 1 is a diagram illustrating a concept of a charging processing system in a first embodiment of the present invention.

Fig. 2 is a diagram illustrating a state of travelling of an image capturing vehicle that acquires a reference image in the first embodiment.

Fig. 3 is a diagram illustrating a state of travelling of a user vehicle that acquires an observation image in the first embodiment.

Fig. 4 is a diagram illustrating a schematic

configuration of a charging processing system in the first embodiment.

Fig. 5 is a diagram illustrating a content of a database held in a server in the first embodiment.

Fig. 6 is a diagram illustrating a state of matching processing in the user vehicle in the first embodiment.

Fig. 7 is a diagram illustrating a procedure of processing by a user vehicle in the first embodiment.

Fig. 8 is a diagram illustrating a procedure of processing by a user vehicle in a second embodiment.

Fig. 9 is a diagram illustrating a relation between a position where an observation image is acquired and a position where a reference image is acquired in the second embodiment.

Fig. 10 is a diagram illustrating a content of a database held in a server in the second embodiment.

Fig. 11 is a diagram illustrating an estimation of an ego-motion adopted in the second embodiment.

Fig. 12 is a diagram illustrating a method of improving an accuracy of estimating a position in the second embodiment.

Figs. 13(a) to 13 (e) are diagrams illustrating a content of processing of estimating a time at which the vehicle passes through a charging position respectively in a third embodiment (a first method).

Fig. 14 is a diagram illustrating a procedure of charging processing on a user vehicle in the third embodiment (the first method).

Figs. 15(a) to 15(e) are diagrams illustrating a content of processing of estimating a time at which the vehicle passes through a charging position respectively in the third embodiment (a second method).

Fig. 16 is a diagram illustrating a procedure of charging processing on a user vehicle in the third embodiment (the second method).

Description of Embodiments

[0019]

Hereinafter, preferable embodiments of the present invention will be described with reference to the drawings.

[First Embodiment]

A charging processing system 1 of a vehicle illustrated in Fig. 1 to Fig. 3 is a system that performs charging processing on the vehicle according to a travelling position of a user vehicle 30 in a target charging area Z without using the GPS. In addition, the system 1 is a system that can perform charging processing according to the travelling position of the user vehicle 30 without providing a large-scale structure such as a gantry in the related art.

[0020]

The charging processing system 1 specifies a travelling position of the user vehicle 30 by processing of matching observation image information which is continuously imaged and generated by the user vehicle 30 while travelling on a target charging area Z to reference image information which is imaged and generated in advance by an image capturing vehicle 10 while travelling in the target charging area Z. In a case where the specified travelling position corresponds to a position subjected to charging, the charging processing system 1 performs the charging processing on the user vehicle 30. As illustrated in Fig. 1, the charging processing system 1 includes a host server 20 besides the image capturing vehicle 10 and the user vehicle 30, and the host server 20 holds the reference image information.

[0021]

In constructing the charging processing system 1, as illustrated in Fig. 2, the image capturing vehicle 10 travels on a road R in the target charging area Z and photographs the landscape of the surroundings, and then, acquires the reference image. In order to do that, as illustrated in Fig. 4, the image capturing vehicle 10 includes a reference image acquisition unit 11, a positioning unit 13, a reference image storage unit 15,

and a communication unit 17.

[0022]

The reference image acquisition unit 11 includes a camera that obtains the reference image by omnidirectionally photographing the surroundings of the image capturing vehicle 10 at a regular interval such as 10 m or 5 m. The image capturing vehicle 10 measures the latitude and longitude of the image capturing vehicle 10 using the positioning unit 13 while acquiring the reference image. The captured reference image is stored in the reference image storage unit 15 in association with the latitude and longitude (position information) at which the image is captured. The stored information (hereinafter, referred to as reference image information) is transmitted to the host server 20 via the communication unit 17. The reference image information acquired from the entire road R which is the target charging area Z using a single or a plurality of image capturing vehicles 10 is transmitted to the host server 20.

By the positioning unit 13 having a high-performance positioning device, the image capturing vehicle 10 accurately measures the latitude and longitude.

[0023]

As illustrated in Fig. 4, the host server 20 includes a storage unit 21, a data processing unit 25, and

a communication unit 27.

The host server 20 acquires the reference image information transmitted from the image capturing vehicle 10 via the communication unit 27. The reference image information is converted into a feature amount by the data processing unit 25 in order to be provided for the matching with the observation image, and then, stored in the storage unit 21. The storage unit 21 includes, for example, as illustrated in Fig. 5, a reference image information database 22, a charging information database 23, and a customer information database 24.

As illustrated in Fig. 5, the reference image information database 22 holds information in a table format in which image data as the feature amount (image #1, #2, #3, ...) and position data at which the image is acquired ((Lat1, Lon1), (Lat1, Lon2), (Lat1, Lon3), ...) are associated with other.

In addition, as illustrated in Fig. 5, the charging information database 23 stores information in a table format in which charging position data indicated in latitude and longitude of the position to be charged for and a charging amount which is an amount charged based on the charging position data are associated with each other. The charging position (data) stored in the charging information database 23 and the charging amount (data) are

set for operating the charging processing system 1, and are input to the charging information database 23 of the storage unit 21 via the communication unit 27 through an appropriate input means.

In addition, the customer information database 24 stores the situation of charging and identification information (ID) mounted on the user vehicle and assigned to each user vehicle 30 in association with each other. The content of the storage in the customer information database 24 is updated each time a new charging is performed.

[0024]

The data processing unit 25 converts the reference image information transmitted from the image capturing vehicle 10 into the feature amount, and then, the feature amount is stored in the reference image information database 22 of the storage unit 21. In addition, the data processing unit 25 reads out the information stored in the reference image information database 22, the charging information database 23, and the customer information database 24 of the storage unit 21, and transmits the information to the user vehicle 30 via the communication unit 27.

[0025]

Next, as illustrated in Fig. 3, if the user vehicle

30 is recognized as passing through the charging position by the processing of matching the information relating to the landscape of the surroundings (observation image information) imaged during the travelling in the target charging area Z with the reference image information stored in the host server 20, the user vehicle 30 performs the charging processing. In order to do this, as illustrated in Fig. 4, the user vehicle 30 includes an observation image acquisition unit 31, a data processing unit 33, a charging processing unit 35, and a communication unit 37. The configuration part made from the observation image acquisition unit 31, the data processing unit 33, the charging processing unit 35, and the communication unit 37 can be mounted on the user vehicle 30 as a so-called vehicle-mounted unit, but it will be simply described as the user vehicle 30.

The observation image acquisition unit 31 photographs the landscape of the surroundings while the user vehicle 30 travels in the target charging area Z and transmits the captured image information to the data processing unit 33. The observation image converted into the feature amount is referred to as the observation image information.

[0026]

The data processing unit 33 performs the processing

of matching the observation image information captured by the observation image acquisition unit 31 with the reference image information stored in the storage unit 21 of the host server 20, and specifies that the vehicle passes through the charging position as a result of the matching processing. More specifically, the processing is as follows.

The data processing unit 33 takes an observation image captured by the observation image acquisition unit 31 and converts the observation image into the feature amount. On the other hand, the data processing unit 33 takes the entire reference image information items #1 to #N stored in the reference image information database 22 of the host server 20, matches the information items with a just captured new observation image information, calculates a similarity degree between the image information items, and then, specifies the most similar reference image information. For example, if the reference image information #3 in the reference image information database 22 is determined to have a highest similarity, the data processing unit 33 specifies that the position of itself is close to the position (Lat1, Lon3) where the reference image information #3 is acquired. Next, if the reference image information which is close to the position of the data processing unit 33 is specified,

the data processing unit 33 checks for the presence or absence of data that matches the position corresponding to the reference image information with reference to the charging information database 23. Here, since the position (Lat1, Lon3) corresponding to the reference image information #3 is stored in the charging information database 23, the data processing unit 33 recognizes that the position corresponding to the reference image information #3 is the charging position, and then, acquires the corresponding charging amount from the charging information database 23.

[0027]

The grouping of the reference image information database 22, the charging information database 23, and the customer information database 24 is just an example, and for example, the reference image information database 22 and the charging information database 23 can be configured as an integrated database. In short, as long as the charging position and the charging amount in the charging position can be specified, the database can be configured as either an integrated or a divided database.

[0028]

When the data processing unit 33 specifies the charging position, the charging processing unit 35 executes the charging processing.

As the charging processing, the charging processing unit 35 transmits the specified charging position and the charging amount corresponding to the charging position to the host server 20 in association with the ID of itself. The host server 20 stores the acquired information relating to the charging processing in the storage region corresponding to the ID in the customer information database 24.

In addition, as the charging processing, the fact that the charging is processed is displayed on a (not illustrated) display in the user vehicle 30. As a method of displaying, only the charging amount may be displayed or both of the charging position and the charging amount can be displayed together. The fact that the charging is processed can be displayed not only on the display by text information, but also can be notified by a voice.

[0029]

[Operation of the charging processing system 1]

Now, the operation of the charging processing system 1 configured as above will be described with reference to Fig. 7. It is assumed that predetermined reference image information, charging information and customer information are respectively stored in the reference image information database 22, the charging information database 23 and the customer information database 24 in the storage unit 21 of

the host server 20.

[0030]

It is assumed that a user vehicle 30 including a vehicle-mounted unit is travelling in the target charging area Z.

During the travelling, the user vehicle 30 captures the images of the landscape of the surroundings using the observation image acquisition unit 31 of the user vehicle 30, and converts the images into a feature amount, and then, acquires observation image information (S101 in Fig. 7).

Subsequently, if the user vehicle 30 acquires the observation image information, the data processing unit 33 performs matching processing (S103 in Fig. 7). A detailed content of the matching processing is as described above, and the reference image information having a highest similarity degree is specified through the matching processing. For example, in Fig. 6, if the reference image information #3 is assumed to be specified as having the highest similarity to the acquired observation image information, the data processing unit 33 specifies the position corresponding to the reference image information #3 as the current position of the user vehicle 30.

[0031]

Next, the user vehicle 30 determines whether or not

the specified position of the user vehicle 30 is the charging position (S105 in Fig. 7).

This determination is performed by collating the specified position of the user vehicle 30 with the charging information which is read out by the data processing unit 33 from the charging information database 23 of the host server 20. If the corresponding charging position is found (Y in S105 in Fig. 7), next, the data processing unit 33 performs the charging processing (S107 in Fig. 7). The detailed content of the charging processing is as described above. If the charging processing is ended, new observation image information is acquired, and then, the procedures subsequent to the matching processing are repeatedly performed.

On the other hand, if the corresponding charging position is not found (N in S105 in Fig. 7), acquisition of new observation image information is performed and if new observation image information is acquired again, and then, the procedures subsequent to the matching processing are repeatedly performed.

[0032]

[Effects of the charging processing system 1]

As described above, since the charging processing system 1 sets the charging position in advance in correspondence to the reference image information, by

performing the processing of matching the observation image information including the position information with the reference image information, the charging position can be specified.

Therefore, the charging processing system 1 enables the charging based on the position through which the user vehicle 30 passes during the travelling. Furthermore, since the charging position can be specified without depending on the GPS, the charging processing system 1 can perform the charging processing without being affected by the deterioration of the GPS accuracy. In addition, even in a region where the GPS cannot be used such as in a tunnel or on an underground road, for example, if the position and other positions on the images can be distinguished by writing or drawing characters or other information on the wall of the tunnel, the charging processing can be performed.

In addition, the accuracy of the charging position specified by the charging processing system 1 is determined according to the image capturing conditions of the image information of both the reference image information and the observation image information and the method of matching the reference image information with the observation image information. However, it can be said that the above accuracy is known. In contrast, the

accuracy of the GPS varies remarkably depending on a position where the GPS signal is received. Therefore, according to the charging processing system 1, it is possible to ensure the reliability of charging in contrast to the case of using the GPS.

[0033]

[Modification example]

The preferable embodiment of the present invention was described with an example of the charging processing system 1 as above. However, the configuration of the charging processing system 1 can be modified without departing from the spirit of the present invention.

For example, in the charging processing system 1, the reference image information and the charging information are stored in the storage unit 21 of the host server 20 which exists in a remote place as a body separate from the user vehicle 30. However, if the capacity of storage medium allows, the reference image information and the charging information can be stored in the user vehicle 30.

In addition, the charging processing system 1 performs the matching processing and the charging processing in the user vehicle 30. However, in the present invention, the observation image which is an image of the surroundings of the user vehicle 30 captured by the

user vehicle 30 can be transmitted to the host server 20, and the observation image is characterized in the host server 20, and then, the matching processing and the charging processing can be performed. That is, in the present invention, the matching processing and the charging processing may be performed by the entire charging processing system 1 which includes the user vehicle 30.

[0034]

In addition, in the charging processing system 1, currently the information regarding a position which does not correspond to the charging position is stored in the reference image information database 22. However, due to this, it is possible to promptly respond to change the charging position later. For example, currently #3 is the charging position, but in a case where the charging position changes to the position #4 from the position #3 later, there is no need to capture a reference image corresponding to the position #4 again. However, in the present invention, it is possible to make only the observation image information which corresponds to the charging position to be a target for being stored in the reference image information database 22. In this case, the charging information can be included in the observation image information, and thus, there is no need

to provide the charging information database 23 individually.

[0035]

In addition, in the charging processing system 1, all of the reference image information is subjected to being matched with the observation image information. However, it is possible to perform the matching processing by focusing only on a part of the reference images stored in the reference image information database 22. For example, a certain number of charging positions where the user vehicle 30 may subsequently pass are extracted based on the previously specified charging position, and then, the matching processing can be performed by focusing only on the extracted charging position. For example, if the position #3 is previously specified as the charging position and the charging positions where the vehicle may subsequently pass are limited to the positions #5, #11, and #14 according to the connection conditions of the roads, it is possible to perform the processing of matching the observation image information only with the reference image information items corresponding to the positions #5, #11, and #14. In addition, in a case where the user vehicle 30 includes a car navigation system which is based on the GPS, only the reference image information which has a predetermined distance relationship with the

position of the user vehicle 30 itself obtained by the GPS signal may be extracted from the reference image information database 22, and then, the extracted information can be a target of the matching processing.

[0036]

[Second Embodiment]

Next, a second embodiment of the present invention will be described with reference to Fig. 8 to Fig. 10.

In the first embodiment, the accuracy of the position specified by the matching processing depends on the interval of capturing the reference image. That is, as in the first embodiment, in a case where the reference image is captured at a 10 m interval, the obtainable accuracy is limited to a maximum range of ± 5 meters. Therefore, in the second embodiment, a method of specifying the position with a higher accuracy than that using the interval of the reference image is proposed.

[0037]

A charging processing system 2 in the second embodiment is the same as the charging processing system 1 in the first embodiment in the point that the charging processing system 2 has the basic configuration to include the image capturing vehicle 10, the host server 20, and the user vehicle 30 on which the vehicle-mounted unit is mounted. Therefore, hereinafter, the charging processing

system 2 will be described focusing on differences from the charging processing system 1.

[0038]

First, the outline of the charging processing system 2 will be described with reference to Fig. 8 and Fig. 9.

As illustrated in Fig. 8, in the matching processing (corresponding to S103 in Fig. 7), the charging processing system 2 calculates a relative position relationship between the position where the observation image information is captured and the position where the reference image information is captured (S203 in Fig. 8). This calculation is performed by the data processing unit 33 (Fig. 4) as described below. That is, the data processing unit 33 takes all of the reference image information items #1 to #N stored in the reference image information database 22 of the host server 20, performs the matching the information items with a just captured new observation image information, and calculates distances $\Delta L1$ to ΔLN which are the relative position relationships between the image information items. Then, the data processing unit 33 specifies reference image information #1 to #N which has the shortest calculated distance $\Delta L1$ to ΔLN . For example, if the distance $\Delta L3$ to the reference image information #3 in the reference image information database 22 is determined to be the shortest,

the data processing unit 33 specifies that the position of itself is nearest to the position (Lat1, Lon3) from which the reference image information #3 is acquired and is separated from the position as much as the distance $\Delta L3$. Next, if the reference image information that is close to the position of the data processing unit 33 is specified, the data processing unit 33 checks for the presence or absence of the data that matches the position corresponding to the reference image information with reference to the charging information database 23. Here, since the position (Lat1, Lon3) corresponding to the reference image information #3 is stored in the charging information database 23, the data processing unit 33 recognizes that the reference image information #3 is a charging position, and acquires a corresponding charging amount from the charging information database 23.

[0039]

An ego-motion estimation which is processing of estimating a three dimensional movement of cameras using images in the environment may be applied to the calculation of the relative position relationship described above. However, in order to perform the above-described processing, as illustrated in Fig. 10, it is necessary to prepare scale information as the reference image information. In Fig. 10, the customer information

database 24 is omitted to be illustrated.

As illustrated in Fig. 11, the scale information is a length of a line (real dimension: S_{A-B}) connecting two arbitrary points A and B in the reference image information. The method of calculating the relative position relationship by the ego-motion estimation is, for example, known as disclosed in NPL 1 and detailed description thereof will be omitted. However, the relative position relationship can be calculated by regarding the real dimension S_{a-b} of a line connecting two points a and b which are in the observation image information on which the matching processing is performed and corresponds to the two arbitrary points A and B, as S_{A-B} . In Fig. 11, P represents the position where the reference image is captured and D represents the position where the observation image is captured.

[0040]

[Effects of the Second Embodiment]

As described above, according to the second embodiment, the following effects can be achieved.

First, in the second embodiment, the relative position relationship between the position where the observation image information is captured and the position where the reference image information is captured is calculated. Therefore, it is possible to specify the

charging position based on the position estimated with higher accuracy than that in a case of the interval in which the reference image is captured.

In addition, in a case where there exists a plurality of lanes in which the user vehicle 30 travels, even in a case where a lane in which the reference image is captured and a lane in which the user vehicle 30 travels are different from each other, by calculating the relative position relationship, it is possible to specify charging position with high accuracy.

[0041]

In addition, according to the second embodiment, even when the number of reference image information items is decreased, the distance to the charging position can be estimated. Therefore, it is possible to decrease the number of reference image information items captured by the image capturing vehicle 10 and stored in the reference image information database 22 of the host server 20.

[0042]

[Modification of the Second Embodiment]

The accuracy of estimating the position according to the second embodiment described above can be further improved. Hereinafter, such a method will be described. In the method of improving the accuracy, in the image matching processing, the relative position relationship

between a position where a plurality of omni-directional images are captured and the vehicle-mounted camera is calculated, and then, a plurality of information items is obtained as the relative positions at each time. By combining the obtained plurality of information items, typically by averaging, the influence of the errors occurring in the processing of matching each of the images is reduced. Hereinafter, the details will be specifically described with reference to Fig. 12.

[0043]

In Fig. 12, positions where the reference images are captured are indicated as P1, P2, P3, and P4 on the road R, and it is assumed that the user vehicle 30 captures the observation image while traveling on the road R, and performs the matching processing. Here, an example of processing on an observation image \$ captured at a position D1 is illustrated.

The relative position relationship between the observation image captured at a position D1 and the reference images captured at each of the positions P1, P2, P3, and P4 is calculated. An interval between each of the positions P1, P2, P3, and P4 is assumed to be exactly α (for example, 10 m).

[0044]

For example, as illustrated in Fig. 12, as an

obtained calculation result, it is assumed that a distance between the position D1 and the position P1 is $\Delta L1$, a distance between the position D1 and the position P2 is $\Delta L2$, a distance between the position D1 and the position P3 is $\Delta L3$, and a distance between the position D1 and the position P4 is $\Delta L4$. As described above, the distance between the position D1 and the position P1 can be estimated using only $\Delta L1$. However, here, considering the calculation results of $\Delta L2$, $\Delta L3$, and $\Delta L4$, the distance ΔL between the position D1 and the position P1 is calculated. In order to do that, as indicated in Equation (1) below, values in which the exact distances (α , 2α , and 3α) from the position P1 to each of the positions P2, P3, and P4 are subtracted from each of $\Delta L2$, $\Delta L3$, and $\Delta L4$ are added to $\Delta L1$, and then the result is averaged.

$$\Delta L = (\Delta L1 + (\Delta L2 - \alpha) + (\Delta L3 - 2\alpha) + (\Delta L4 - 3\alpha)) / 4 \dots \text{Equation (1)}$$

[0045]

As described above, by averaging the distances, the influence of errors occurring in the matching processing can be reduced. Therefore, it is possible to improve the accuracy of estimating the position in the second embodiment.

In the present invention, not only simply performing the arithmetical averaging, but also a weighting can be

applied. The weighting is, for example, a condition that the coefficients decrease when the distances increase, and thus, the coefficients multiplied to each of the $\Delta L1$, $\Delta L2$, $\Delta L3$, and $\Delta L4$ are set to be smaller in this order.

[0046]

[Third Embodiment]

Next, a third embodiment of the present invention will be described with reference to Fig. 13 to Fig. 16.

In the first embodiment and the second embodiment, whether or not the image is the one most similar to the "landscape of the charging position" can be determined only after the vehicle has passed the charging position. As a result, at a moment when the user vehicle 30 passes through the charging position, it is not possible for the user vehicle 30 to determine this passing and to perform the charging processing.

The third embodiment provides a method in which the charging processing can be performed at the moment when the user vehicle 30 passes through the charging position. In the third embodiment, two methods of a first method and a second method are proposed.

In the first method, by calculating the distance to the charging position of the user vehicle 30 in time series based on the reference image information and the observation image information used in the second

embodiment, a time at which the user vehicle 30 passes through the charging position is estimated. In the second method, by calculating the travelling speed of the user vehicle 30 from the observation image captured by the user vehicle 30, a time at which the user vehicle 30 passes through the charging position is estimated. Hereinafter, the description will be made in the order of the first method and the second method.

[0047]

[First Method]

In the first method, the relative position relationship of the user vehicle 30 is calculated by performing the processing of matching the reference image information in which the charging position is specified with the observation image information. The calculation of the relative position relationship is performed similarly to the case of the second embodiment. When the relative position relationship is calculated, at a position in front of the charging position P, the distance to the charging position P can be calculated. If this processing is performed in time series, a time series variation of the distance to the charging position P can be calculated. However, if this time series variation is extrapolated, a time at which the user vehicle 30 passes through the charging position P can be predicted before

arriving at the charging position P. Therefore, using the predicted passing time, the user vehicle 30 can perform the charging processing at the moment of passing through the charging position P. Hereinafter, the first method will be more specifically described with reference to Fig. 13 and Fig. 14.

[0048]

A charging processing system 3-1 in the first method is to the same as the charging processing system 1 in the first embodiment in the point that the charging processing system 3-1 has the basic configuration to include the image capturing vehicle 10, the host server 20, and the user vehicle 30 on which the vehicle-mounted unit is mounted. Therefore, hereinafter, the charging processing system 3-1 will be described focusing on differences from the charging processing system 1, that is, focusing on the processing tasks relating to the procedures S205 and S206 illustrated in Fig. 14.

[0049]

As illustrated in Fig. 13(a), it is assumed that the user vehicle 30 travels on the road toward the charging position P and the observation image acquisition unit 31 of the user vehicle 30 continuously photographs the landscape of the surroundings. Then, it is assumed that the processing of matching the observation image

information (#N) which is based on the charging position P with the observation image information (\$1 to \$4) which is based on the landscape photographed in the observation positions D1, D2, D3, and D4 on the road R is performed in an order. This matching processing is performed by the data processing unit 33.

The relative position relationship between the observation position D1 and the charging position P is calculated by the matching processing, and subsequently, the distance $\Delta L1$ between the observation position D1 and the charging position P is obtained. This is illustrated on a graph in Fig. 13(b) having a horizontal axis representing time and a vertical axis representing the distance.

Similarly, the distance $\Delta L2$ between the observation position D2 and the charging position P, the distance $\Delta L3$ between the observation position D3 and the charging position P, the distance $\Delta L4$ between the observation position D4 and the charging position P are obtained in time series. In this way, the time series variation of the distances to the charging position P can be obtained, and if those are extrapolated in an order, it is possible to predict the time at which the vehicle passes through the charging position P in advance as illustrated by white arrows in Figs. 13(c), 13(d), and 13(e).

[0050]

As illustrated in Figs. 13 (b) to (e), with the travelling of the user vehicle 30, at each time the user vehicle 30 arrives at the observation positions D1, D2, D3, and D4 in an order, the predicted time of passing through the charging position P is updated. However, in the present invention, the updating of the prediction is not essential, and the prediction of the time of passing the charging position P may be performed only at a specific observation position with respect to the charging position P, for example, only at the observation position D4 which is close to the charging position P. In the region closest to the charging position P, in some cases, the variation of the travelling speed of the user vehicle 30 may be large. Therefore, it is preferable to observe the time series variation during a certain period and predict the time of passing through the charging position P with considering the variation.

[0051]

[Second Method]

The second method is similar to the first method in the point that the distance from the user vehicle 30 to the charging position P is calculated and a time at which the user vehicle 30 passes through the charging position P is predicted. However, in the second method, the

travelling speed of the user vehicle is used for the prediction.

[0052]

A charging processing system 3-2 in the second method is the same as the charging processing system 3-1 in the point that the charging processing system 3-2 has the basic configuration to include the image capturing vehicle 10, the host server 20, and the user vehicle 30 on which the vehicle-mounted unit is mounted. Therefore, hereinafter, the charging processing system 3-2 will be described focusing on differences from the charging processing system 3-1, that is, focusing on the processing tasks relating to the procedures S202, S204, and S205 illustrated in Fig. 16.

[0053]

As illustrated in Fig. 15(a), it is assumed that the user vehicle 30 travels on the road toward the charging position P and the observation image acquisition unit 31 of the user vehicle 30 continuously photographs the landscape of the surroundings. Then, it is assumed that the processing of matching the observation image information (#N) which is based on the charging position P with the observation image information(\$1 to \$4) which is based on the landscape photographed in the observation positions D1, D2, D3, and D4 on the road is performed in

the order. This matching processing is performed by the data processing unit 33.

Similarly to the first method, by the matching processing, the distance $\Delta L1$ between the observation position D1 and the charging position P, the distance $\Delta L2$ between the observation position D2 and the charging position P, the distance $\Delta L3$ between the observation position D3 and the charging position P, and the distance $\Delta L4$ between the observation position D4 and the charging position P are obtained in time series.

[0054]

In parallel with the above calculation of the distances, the data processing unit 33 calculates the travelling speed v of the user vehicle 30 from the continuously captured observation images. The travelling speed v can be calculated by, for example, visual odometry. In order to improve the accuracy of the travelling speed v calculated by the visual odometry, stereo images can be captured by providing the reference image acquisition unit 11. In addition, other than obtaining the travelling speed v from the observation image, the speed obtainable from devices included in the user vehicle 30 such as an acceleration sensor or an encoder can be used.

The data processing unit 33 obtains a travelling speed $v1$ at the observation position D1, a travelling

speed v_2 at the observation position D2, a travelling speed v_3 at the observation position D3, and a travelling speed v_4 at the observation position D4 in time series.

[0055]

The data processing unit 33 can predict the time in advance at which the vehicle passes through the charging position P by integrating the calculated distance ΔL_1 and the travelling speed v_1 using a stochastic model such as the Kalman filter or the like.

Similarly, as illustrated in Figs. 15 (c) to (e), it is possible to predict the time at which the vehicle passes through the charging position P at each of the observation position D2, the observation position D3 and the observation position D4.

[0056]

As illustrated in Figs. 15 (b) to (e), with the travelling of the user vehicle 30, at each time the user vehicle 30 arrives at the observation positions D1, D2, D3, and D4 in an order, the predicted time of passing through the charging position P is updated. However, in the present invention, the updating of the prediction is not essential, and the prediction of the time of passing the charging position P may be performed only at a specific observation position with respect to the charging position P, for example, only at the observation position D4 which

is close to the charging position P. In the region closest to the charging position P, in some cases, the variation of the travelling speed of the user vehicle 30 may be large. Therefore, it is preferable to observe the time series variation during a certain period and predict the time of passing through the charging position P with considering the variation.

[0057]

In predicting the passing time, the charging processing system 3-2 uses the travelling speed v of the user vehicle 30. The travelling speed v tends to vary greatly when the travelling distance is long. However, when the travelling distance including the charging position P is relatively short, since the variation of the speed can be regarded as small, it is possible to predict the passing time. An average travelling speed during a predetermined period can be used as the travelling speed v .

For example, the travelling speed v_1 applied at the observation position D1 can be set as an average value of the travelling speed v during the predetermined period up to the arrival at the observation position D1, and the travelling speed v_2 applied at the observation position D2 can be set as an average value of the travelling speed between the observation position D1 and the observation position D2. Usually, a car navigation system measures

and records the travelling speed, and thus, such data can be used as the travelling speed v of the user vehicle 30.

[0058]

As described above, the preferable embodiments of the present invention have been described. However, without departing from the spirit of the present invention, the configuration listed in the embodiments can be selectively adapted or can appropriately be changed to another configuration. For example, it is possible to cause the host server 20 to have the functions of the data processing unit 33 and the charging processing unit 35 included in the user vehicle 30. Conversely, it is possible to cause the user vehicle 30 to have the function of the data processing unit 25 of the host server 20.

Reference Signs List

[0059]

- 1 charging processing system
- 10 image capturing vehicle
- 11 reference image acquisition unit
- 13 positioning unit
- 15 reference image storage unit
- 17 communication unit
- 20 host server
- 21 storage unit
- 22 reference image information database

23 charging information database
24 customer information database
25 data processing unit
27 communication unit
30 user vehicle
31 observation image acquisition unit
33 data processing unit
35 charging processing unit
37 communication unit
R road
Z target charging area

Claims

[Claim 1]

A charging processing system that performs charging processing when a user vehicle travels on a road, comprising:

a reference image storage unit that stores a reference image acquired in advance in relation to a plurality of charging positions set on the road;

an observation image acquisition unit that is provided on the user vehicle and photographs a landscape of the surroundings of the road where the user vehicle travels, and acquires an observation image;

a data processing unit that performs an image matching of the stored reference image and the newly acquired observation image; and

a charging processing unit that performs charging processing on the user vehicle based on the result of the image matching in the data processing unit.

[Claim 2]

The charging processing system according to Claim 1, wherein the data processing unit performs an image matching of the reference image which is selected and the observation image which is newly acquired.

[Claim 3]

The charging processing system according to Claim 1 or 2,

wherein the data processing unit obtains a similarity degree between the reference image and the observation image by the image matching, and

wherein the charging processing unit performs the charging processing at the charging position corresponding to the reference image based on the similarity degree.

[Claim 4]

The charging processing system according to Claim 1 or 2,

wherein, in relation to the reference image and the observation image on which the image matching is performed, the data processing unit estimates a relative position relationship between a position where the reference image is captured and a position where the observation image is captured, and

wherein the charging processing unit performs the charging processing at the charging position corresponding to the reference image based on the result of the estimation.

[Claim 5]

The charging processing system according to any one of Claims 1 to 4,

wherein the data processing unit obtains a predicted

passing time when the user vehicle passes through the charging position corresponding to the reference image based on the reference image and the observation image, and

wherein charging processing unit performs the charging processing on the user vehicle at the predicted passing time.

[Claim 6]

The charging processing system according to Claim 5, wherein the data processing unit obtains the predicted passing time based on a distance to the charging position which is calculated based on the relative position relationship between the position where the reference image corresponding to the charging position is captured and the position where the observation image is captured.

[Claim 7]

The charging processing system according to Claim 5 or 6,

wherein the data processing unit obtains the predicted passing time based on the relative position relationship between the position where the reference image corresponding to the charging position is captured and a position where the observation image is captured and a traveling speed of the user vehicle.

[Claim 8]

An on-board unit that performs charging processing when a user vehicle travels on a road, and is mounted on the user vehicle, the device comprising:

a data processing unit that performs image matching on a reference image acquired in advance in relation to a plurality of charging positions set on the road and an observation image in which a landscape of the surroundings of the road where the user vehicle travels is captured; and

a charging processing unit that performs charging processing on the user vehicle based on the result of the image matching in the data processing unit.

[Claim 9]

The on-board unit according to Claim 8,

wherein the data processing unit performs an image matching of the reference image which is selected and the observation image which is newly acquired.

[Claim 10]

The on-board unit according to Claim 8 or 9,

wherein the data processing unit obtains a similarity degree between the reference image and the observation image by the image matching, and

wherein the charging processing unit performs the charging processing at the charging position corresponding

to the reference image based on the similarity degree.

[Claim 11]

The on-board unit according to Claim 8 or 9,

wherein, in relation to the reference image and the observation image on which the image matching is performed, the data processing unit estimates a relative position relationship between the position where the reference image is captured and the position where the observation image is captured, and

wherein the charging processing unit performs the charging processing at the charging position corresponding to the reference image based on the result of the estimation.

[Claim 12]

The on-board unit according to any one of Claims 8 to 11,

wherein the data processing unit obtains a predicted passing time when the user vehicle passes through the charging position corresponding to the reference image based on the reference image and the observation image, and

wherein charging processing unit performs the charging processing on the user vehicle at the predicted passing time.

[Claim 13]

The on-board unit according to Claim 12,
wherein the data processing unit obtains the predicted passing time based on a distance to the charging position which is calculated based on the relative position relationship between the position where the reference image corresponding to the charging position is captured and the position where the observation image is captured.

[Claim 14]

The on-board unit according to Claim 12 or 13,
wherein the data processing unit obtains the predicted passing time based on the relative position relationship between the position where the reference image corresponding to the charging position is captured and the position where the observation image is captured and a traveling speed of the user vehicle.