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(56) Related Art
US 5912634 A
JP 2002-232869 A
US 2010/0283856 A1
JP 2003-050107 A

Abstract

[0075] Method for verifying a measurement position for a traffic monitoring device (1), wherein a calibrating reference picture of a traffic scene is taken with a camera (2) of a traffic monitoring device (1) which is aligned in a measurement position and, in order to verify the measurement position, calibrating test pictures are taken at spaced intervals of time with a camera (2), which can be either the camera (2) present at the traffic monitoring device or another camera (2) which is substituted along with the traffic monitoring device (1), and are compared with the calibrating reference picture, wherein the images of identical static checking features are selected and their positional deviations from one another are determined and compared with fixed picture tolerance limits so that measurements which were carried out are confirmed as valid or are rejected.

Fig. 1

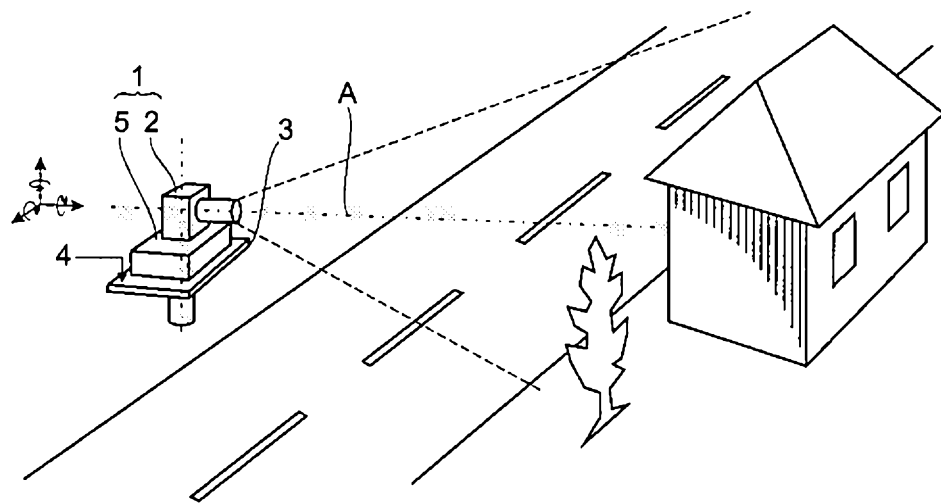


Fig. 1

METHOD FOR VERIFYING THE ALIGNMENT OF A TRAFFIC MONITORING DEVICE

FIELD OF THE INVENTION

[0001] The present invention is concerned with apparatus and devices used in monitoring traffic on roadways, and in particular with mechanisms employed for aligning such equipment to effect precise detection of eg traffic rule violations by vehicles travelling on the roadway.

BACKGROUND OF THE INVENTION

[0002] It is well known that traffic monitoring devices must be aligned in a measurement position in relation to the roadway being monitored, or in relation features of the roadway such as stop marks, in order to provide defined measuring conditions for traffic detection and control.

[0003] With regard to stationary traffic monitoring devices, it is common to position housings or supporting systems on poles or bridge members so as to be roughly aligned by sight, and the housing or supporting system has a reference surface relative to which the traffic monitoring device is mounted in a defined manner in the housing or on the supporting system. When the traffic monitoring device is aligned in the measurement position, this reference surface occupies a determined relative position with respect to the roadway, and the continuous stability of this relative position must be checked so that correct measurements are always ensured. Through knowledge of deviations in the position of the traffic monitoring device relative to the measurement position, measurements can be accepted without change when these measurements lie within predetermined tolerance limits or the altered position can be deliberately corrected back to the measurement position.

[0004] It may be necessary to verify positional deviations from the measurement position on the one hand in order to monitor the long-term stability of the measurement position of a traffic monitoring device once it has been set up and, on the other hand, to make it possible for a measuring traffic monitoring device to occupy a measurement position set up for a traffic monitoring device and to verify this position.

[0005] In practice, applications of this type occur, e.g., when identical housings are installed for traffic monitoring at different locations and successive traffic monitoring devices are selectively inserted therein. In the housings, a reference surface which is fixedly connected to the traffic monitoring device during the setting up of the measurement position and which is subsequently fixed in the housing is aligned relative to the roadway by means of a traffic monitoring device. The position occupied by the reference surface when the traffic monitoring device is in the measurement position is also referred to as measurement position. When the reference surface occupies the measurement position and is fixed, the traffic monitoring device may be removed. At a later time, the same traffic monitoring device or a different traffic monitoring device can be inserted into the housing in a defined relationship to the reference surface and thus automatically takes up the measurement position.

[0006] A traffic monitoring device particularly includes a measuring sensor. This measuring sensor can be a digital camera, a laser scanner or a radar sensor, for example.

[0007] A digital camera is aligned in a measurement position in such a way that the digital camera itself and/or another sensor associated with it can carry out a defined task, whereby three angles are fixed in space which describe the alignment of the digital camera and the other sensor, if any.

[0008] Regardless of which specific measurement position is set up or how this is carried out, the maintaining of the set-up measurement position can be verified by the method according to the invention.

[0009] Also, depending on whether it is arranged alongside the roadway or above the roadway, a radar sensor or a laser scanner is aligned in such a way that the distinguished axes thereof impinge on the roadway at predetermined angles.

[0010] The possibility of correct alignment of the traffic monitoring devices before traffic monitoring starts and repeatable verification of the alignment that is carried out, including a possible correction in case of misalignment, are prerequisites for authorization of traffic monitoring devices of this kind.

[0011] It would be desirable to provide a method by which a set-up measurement position with different traffic monitoring devices, each having a camera, can be verified, in contrast to providing a method by which a measurement position can be set up in the first place.

[0012] German Patent Application DE 10 2011 050 660, not previously published, describes a method for aligning and monitoring the alignment of a traffic monitoring device relative to an edge of a roadway.

[0013] In this case, the traffic monitoring device comprises a radar sensor as measuring sensor and a camera which are already aligned with one another at the factory and accordingly occupy a fixed, known positional relationship with respect to one another. The radar sensor and the camera are advantageously preadjusted relative to one another in such a way that a radar axis of the radar sensor and the camera axis of the camera enclose an angle with one another which is the same as that enclosed by them in the measurement position. The traffic monitoring device is then considered to be aligned in a measurement position when the camera axis forms a predetermined reference camera angle with the roadway edge.

[0014] To align the traffic monitoring device in a measurement position, the traffic monitoring device is mounted at a distance from a roadway edge and the reference camera angle is visually adjusted in an approximate manner by rotating the traffic monitoring device around a vertical axis. The camera then records a first image as a digital picture from which straight lines in the driving direction are derived, an actual vanishing point for the straight lines is determined computationally, and this vanishing point is compared with a predetermined reference vanishing point depending on the reference camera angle. The traffic monitoring device is swiveled horizontally – and during this time further images are produced, from which the instantaneous actual vanishing point is determined in each instance and compared to the predetermined reference vanishing point – until the deviation of the traffic monitoring device from the reference vanishing point lies within a predetermined tolerance limit so that the traffic monitoring device is considered to be aligned in the measurement position (in this case, the operating position).

[0015] For verification and, if necessary, required correction of positional deviations in alignment from the measurement position of a previously aligned traffic monitoring device, the following is suggested:

[0016] A first image is produced as digital picture, and the actual vanishing point is determined computationally and compared with a predetermined reference vanishing point depending on the reference camera angle. If the deviation of the actual vanishing point from

the reference vanishing point does not lie within a predetermined tolerance limit, the traffic monitoring device is swiveled horizontally – and during this time further images are produced, from which the instantaneous actual vanishing point is determined in each instance and compared to the predetermined reference vanishing point – until the deviation of the traffic monitoring device from the reference vanishing point lies within the predetermined tolerance limit.

[0017] In principle, it should also be possible to carry out the method for verification to verify traffic monitoring devices which have not been aligned in accordance with the described method.

[0018] It is pointed out in DE 10 2011 050 660, cited above, that the method can be installed as software on the traffic monitoring device or camera for alignment and for verification of alignment, and the method for verification can be implemented on a computer online as well as offline in the back office to check whether or not the traffic monitoring device was correctly aligned based on pictures taken. This would afford the possibility of limiting monitoring to those pictures whose correctness is in doubt, e.g., in connection with penalties for speed infractions.

[0019] The method described above has the disadvantage that a plurality of straight lines running in driving direction must be shown in the image, which is only possible to a limited degree in dense traffic on the one hand and requires that the roadway extends in a straight line at the measuring site on the other hand. Further, the straight lines running in driving direction in the picture must preferably make up the only, or at least the overwhelming majority of, straight lines in the picture, which is not the case, e.g., in inner-city areas.

[0020] According to the method described above, verification of the measurement position is carried out exclusively with the same traffic monitoring device and, therefore, the same camera with which the measurement position was also set up and with which a picture was taken from the measurement position.

[0021] Against this backdrop, it is desired to provide a method for the verification of a measurement position (of a traffic monitoring apparatus) by which the measurement position can be verified with different cameras and independent roadway features.

SUMMARY OF THE INVENTION

[0022] The present invention provides a method for verifying a measurement position for a traffic monitoring device with a camera which is defined by the calibrating position of a reference surface to which the traffic monitoring device can be arranged in a fixed positional relationship, wherein a calibrating reference picture of a road scene is taken with the camera of the traffic monitoring device which is aligned in a measurement position and which is arranged in a fixed positional relationship to a reference surface located in the calibrating position and, in order to verify the measurement position, calibrating test pictures are taken at spaced intervals of time with a camera, which can be either the present camera or another camera which is substituted along with the traffic monitoring device, and are compared with the calibrating reference picture, the mapping models of the possibly different cameras whose internal imaging characteristics are known are transformed into one another for comparing the calibrating test pictures with the calibrating reference picture, images of identical static checking features are selected from the calibrating reference picture and calibrating test pictures and their positional deviations from one another are determined and compared with fixed picture tolerance limits so that measurements which were carried out previously with the traffic monitoring device are confirmed as valid when positional deviations lie within the picture tolerance limits and measurements which were carried out previously with the traffic monitoring device are rejected when positional deviations lie outside of the picture tolerances.

[0023] Thus, the method will include the following steps, noting that verification of a measurement position for a traffic monitoring device with a camera is effected. A calibrating reference picture of a road scene is taken with the camera of the traffic monitoring device which is aligned in a measurement position and which is arranged in a fixed positional relationship to a reference surface located in a calibrating position when the traffic monitoring device is in the measurement position.

[0024] Subsequently, in order to verify the measurement position, calibrating test pictures are taken at spaced intervals of time with a camera which can be either the present camera or another camera substituted along with the traffic monitoring device and are compared with the calibrating reference picture.

[0025] If the calibrating test pictures and the calibrating reference picture were taken with different cameras, the mapping models of the cameras whose internal imaging characteristics are known are transformed into one another before the comparison.

[0026] Images of identical static checking features are selected from the calibrating reference picture and calibrating test pictures and their positional deviations from one another are determined and compared with fixed picture tolerance limits.

[0027] When positional deviations lie within the picture tolerance limits, measurements which were carried out previously with the traffic monitoring device are confirmed as valid.

[0028] When positional deviations lie outside of the picture tolerances, measurements which were carried out previously with the traffic monitoring device are rejected.

[0029] Advantageously, the calibrating test pictures can be taken during the measuring operation of the traffic monitoring device.

[0030] The method is particularly advantageous when the traffic monitoring devices used for taking the calibrating test pictures are different from the traffic monitoring device which took the calibrating reference picture.

[0031] In an advantageous manner, e.g., physical edges or physical corners of stationary objects in the object field of the camera are selected as checking features and are mapped as an edge jump.

[0032] When positional deviations lying outside the picture tolerance limits are determined, the traffic monitoring device is advantageously realigned in its measurement position based on knowledge of the positional deviation by changing the spatial position of the reference surface while further calibrating test pictures are taken and are compared with the calibrating reference picture until the positional deviations of the images of the checking features lie within the picture tolerance limits.

[0033] The measurement position is advantageously transformed into a new measurement position computationally by the determined positional deviation, a calibrating test picture with this determined positional deviation is defined as a new calibrating reference picture and, for subsequent verification of this new measurement position, calibrating test pictures made subsequently are compared with this new calibrating reference picture.

[0034] Additional and preferred features of the invention will become apparent from the following description of an illustrative embodiment provided with reference to the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS:

- [0035] Fig. 1 shows a schematic view of a traffic monitoring device aligned in a measurement position;
- [0036] Fig. 2a shows a calibrating reference picture taken with a camera or a calibrating camera in performing a preferred embodiment of the method of the invention;
- [0037] Fig. 2b shows a first calibrating test picture taken with the camera or with a measuring camera with the same focal length as the calibrating camera with which Fig 2a was taken;
- [0038] Fig. 2c shows a second calibrating test picture taken with the measuring camera used to take the picture of Fig 2b but with a different focal length than the calibrating camera; and
- [0039] Fig. 2d shows a third calibrating test picture taken with the measuring camera but with a different focal length than the calibrating camera.

DESCRIPTION OF PREFERRED EMBODIMENTS

[0040] The method is used to verify the measurement position of a traffic monitoring device 1 with a camera 2. It is suitable for verifying the maintaining of a measurement position which was set up for a selfsame traffic monitoring device 1 and which is to be maintained over the long term or to verify that a measurement position which was occupied by a different traffic monitoring device 1 taking the place of a traffic monitoring device 1 set up in a measurement position is occupied and maintained.

[0041] In order to clearly describe the method, a traffic monitoring device 1 with a camera 2 will be addressed in the following when, according to a first embodiment example of the method, a calibrating reference picture is taken in the measurement position with a camera 2 with which calibrating test pictures are also taken subsequently to verify the measurement position or when the description is applicable to all of the embodiment examples.

[0042] Instead of a traffic monitoring device 1 and a camera 2, a calibrating traffic monitoring device 1.1 with a calibrating camera 2.1 and a measuring traffic monitoring device 1.2 with a measuring camera 2.2 will be addressed when the method according to

second embodiment example provides that calibrating test pictures for verifying a measurement position are made with a camera 2 (measuring camera 2.2) other than the camera 2 (calibrating camera 2.1) with which a calibrating reference picture was taken previously in the measurement position after a traffic monitoring device 1 (calibrating traffic monitoring device 1.1) for which the measurement position was set up has been exchanged for another traffic monitoring device 1 (measuring traffic monitoring device 1.2).

[0043] The different choice of terms serves only to distinguish the traffic monitoring devices 1 and cameras 2; that is, the calibrating traffic monitoring device 1.1 and the measuring traffic monitoring device 1.2, and therefore the calibrating camera 2.1 and the measuring camera 2.2, may be different or identical devices, but cannot be the same devices.

[0044] In particular, the possibility of verifying a measurement position for a measuring traffic monitoring device 1.2 is of great interest for economical reasons. So-called dummies formed by housings which do not contain a traffic monitoring device 1, although this is not outwardly perceptible, can be installed by an operator at different locations and traffic monitoring devices 1 may be selectively installed therein successively in time. These traffic monitoring devices 1 are positioned in the dummies in a defined manner so that they can be put into operation as far as possible without their measurement position having to be set up first.

[0045] For this purpose, a receptacle for the traffic monitoring device 1, i.e., an adjustable mounting unit 3 with a reference surface 4 at which a traffic monitoring device 1 is or can be fixed in a defined position in relation to the reference surface 4, is located in the interior of the dummy. The defined position can be determined, e.g., by guides, stops or aligning pins.

[0046] The traffic monitoring device 1 comprises a camera 2 and a measuring sensor 5; the camera 2 itself can also be the measuring sensor 5. With respect to device calibration, the traffic monitoring device 1 is already adjusted in the factory so that the camera 2 and, as the case may be, the measuring sensor 5 occupy a fixed relative position with respect to one another which they also occupy in a measurement position from which the measuring operation of the traffic monitoring device 1 takes place. The position and rotation of the camera 2 with respect to a base surface of the traffic monitoring device 1, by means of which the relative position of the traffic monitoring device 1 with respect to the reference surface 4

is fixed, is likewise fixed during device calibration and can be stored in a device data set. During this device calibration, the internal imaging characteristics of the camera 2 can also be determined and stored in the device data set. After the traffic monitoring device 1 has been positioned in a defined, fixed position relative to the reference surface 4, the traffic monitoring device 1 is brought into a measurement position by adjusting the mounting unit 3 which can be tilted in three axes of a Cartesian coordinate system. Various methods are known for this purpose from the prior art which differ in particular depending on the type of measuring sensor 5 and measuring job. An example of this is given in the above-cited patent application DE 10 2011 050 660 which was taken into account in the description of the prior art. The manner in which the measurement position of the traffic monitoring device 1 is set up is not relevant for the method according to the invention.

[0047] The method according to the invention is based on a traffic monitoring device 1 which is set up in a measurement position and, therefore, on a reference surface 4 which is set up in a calibrating position. The calibrating position of the reference surface 4 is determined by the spatial position and the rotation of the reference surface 4 in relation to a fixed Cartesian coordinate system. Fig. 1 shows a mounting unit 3 with a reference surface 4 which is installed at the edge of a road and on which is mounted a traffic monitoring device 1 with a camera 2 and a measuring sensor 5, which can be a radar sensor or a laser scanner, for example. The traffic monitoring device 1 was put in the measurement position by previous tilting in three axes of the mounting unit 3. This measurement position is determined by the spatial position of the optical axis A of the camera 2 and of the picture sensor matrix of the camera 2 with respect to the Cartesian coordinate system. It can be given, for example, by the angular position of the optical axis of the camera 2 with a horizontal measuring angle with respect to the roadway edge and a vertical measuring angle with respect to the roadway surface and the relative position of the picture sensor matrix, namely, the row orientation thereof, to a horizontal plane.

[0048] The method according to a first embodiment example begins with a calibrating reference picture being taken with camera 2 of the traffic monitoring device 1 which is set up in a measurement position. At later points in time, calibrating test pictures are taken with the same camera 2 and the maintaining of the measurement position is verified with the help of these calibrating test pictures for the time at which the picture was taken. Since the

calibrating reference picture and the test reference pictures (collectively referred to as pictures) are taken with the same camera 2, the pictures conform to the same mapping model and the pictures can be directly compared with one another. To this end, images of suitable checking features, e.g., physical edges or physical corners of stationary objects in the object field of the camera 2 which are mapped as an edge jump, are selected in the pictures, i.e., from the picture data, and their position in the pictures are checked for congruity. In this respect, a positional deviation can be caused by translational shifting (shift in position) and by rotation (rotation of position) of the camera 2 relative to its measurement position.

[0049] Assuming that the traffic monitoring device 1 with the camera 2 is stable in itself, a misalignment of the reference surface 4 can be deduced from the positional deviations.

[0050] Fig. 2a shows a calibrating reference picture and Fig. 2b shows a first calibrating test picture taken with the same camera 2 that took the calibrating reference picture. Both pictures follow the same mapping model because the selected checking features cause an identical mapping in the pictures which are imaged at the same location and in an identical alignment to the edges of the frame when the measurement position is maintained.

[0051] In the calibrating test picture shown in Fig. 2b, the imaging of a checking feature, in this case, an edge or corner of a house door reduced to a point in the image for simplicity, is shifted in position.

[0052] The position of the mapped checking feature P in relation to a coordinate system proper to the picture through the center of the picture is indicated in the calibrating reference picture shown in Fig. 2a by values (x_r, y_r) and in the first calibrating test picture shown in Fig. 2b by values (x_{tl}, y_{tl}) . The different position of the mapping of P in the first calibrating test picture compared to the position in the calibrating reference picture results exclusively from a positional shift of camera 2.

[0053] It is checked whether the positional shift lies within fixed picture tolerance limits or outside these picture tolerance limits. If the positional shift lies within the picture tolerance limits, previous or contemporaneous measurements carried out by the traffic monitoring device 1 are declared valid. If the positional shift lies outside these picture tolerance limits, previous or contemporaneous measurements must be rejected.

[0054] In case of a positional deviation lying outside the picture tolerance limits, the traffic monitoring device 1 can be recalibrated with knowledge of the positional deviation, i.e., realigned in its measurement position. The recalibration can be carried out by means of the method described herein by changing the spatial position of the reference surface 4 in relation to which the traffic monitoring device 1 is located in a fixed arrangement, while further calibrating test pictures are taken and compared with the calibrating reference picture, until the positional deviations of the mapping of the checking features lie within the picture tolerance limits.

[0055] Instead of recalibration which requires a specific mechanical movement of the reference surface 4 for which there would also have to exist suitable means which must also be actuated in a corresponding manner, a known positional deviation can also be used to transform the original measurement position computationally by this positional deviation into a new measurement position. A calibrating test picture with this positional deviation is then defined as a new calibrating reference picture and calibrating test pictures made subsequently are compared with this new calibrating reference picture for a subsequent verification of this new measurement position. In this regard, the method according to the invention is applied in an analogous manner.

[0056] In practice, however, the comparison between the picture data of the calibrating test pictures and the calibrating reference picture for determining the positional deviation is not as simple as described above. They can generally not be used for direct comparison because of noise, different lighting conditions, and non-static scenes.

[0057] Accordingly, a lowpass filter is applied to the picture data, for example, for noise suppression.

[0058] Substantial illumination invariance can be achieved by using the mapping of object edges (as was already suggested above) and subsequent normalization.

[0059] The acquisition of static scene features can be realized by taking a plurality of calibrating reference pictures over a longer period of time. For a series of pictures formed in this way, picture edges are identified which are present identically in all of the calibrating reference pictures. A series of pictures of this kind is taken once immediately after setting up

the measurement position to acquire maps of static scene features one time and store them in a location data set.

[0060] The fixed picture tolerance limits for the positional deviation are given by the object tolerance limits determined by the measuring job. For example, if the vehicle is to be photographed when driving over stop marks during a red light in order to detect a traffic light infraction, the measuring sensor 5, e.g., a laser scanner, must be aligned with the stop marks in such a way that when measuring a distance which is known beforehand at a scanning angle which is known beforehand and which can be associated with the measurement point, the vehicle also actually passes the stop marks. If a photograph is taken at this moment with the camera 2 which is also located in the measurement position, the vehicle is imaged, e.g., with its front wheels on the stop marks. If the traffic monitoring device 1 is misaligned relative to the measurement position, the resulting positional deviation of the imaged vehicle and imaged checking features of the imaged traffic scene can appear as inside a picture tolerance limit when this took place, e.g., in the driving direction and can appear as outside the picture tolerance limit when it took place opposite to the driving direction.

[0061] The fixed picture tolerance limits for the positional deviation of the mapped checking features are likewise stored in the location data set.

[0062] As in the first embodiment example, the method according to a second embodiment example begins with a calibrating reference picture being taken with a camera 2, in this case, a calibrating camera 2.1, of a traffic monitoring device 1 which is set up in a measurement position and which in this case is a calibrating traffic monitoring device 1.1. After this calibrating traffic monitoring device 1.1 has been exchanged for a measuring traffic monitoring device 1.2, calibrating test pictures are taken successively in time with a measuring camera 2.2 and used to verify the setup and, subsequently, the maintaining of the measurement position for the measuring traffic monitoring device 1.2 for the respective time at which the calibrating test pictures were taken. Since the pictures are not made with the same camera 2, the pictures do not conform to the same mapping model and the pictures cannot be directly compared with one another.

[0063] The mapping model of the camera 2 is determined by the internal imaging parameters of the camera 2 and the relative position (position and rotation) of the camera 2

with respect to the coordinate system. The mapping models of the calibrating camera 2.1 and measuring camera 2.2 can differ particularly by reason of different imaging parameters such as the focal length of the camera objective. In principle, they can also differ because of a different relative position of the camera 2 in the coordinate system.

[0064] Within the meaning of the invention, however, the effect of a misalignment of the reference surface 4 over which the camera 2 lies indirectly in the coordinate system should not be taken into account in the formation of the mapping model because it is precisely this misalignment that should be determined from the comparison between the calibrating test pictures and the calibrating reference picture. This means that, in this case, only a possibly different relative position of the calibrating camera 2.1 and the measuring camera 2.2 with respect to the reference surface 4 would be incorporated in the formation of the mapping models.

[0065] Whereas it is not absolutely necessary for the first embodiment example of the method that the internal imaging parameters (intrinsic parameters) of the camera 2 and the parameters of the relative spatial position of the camera 2 with respect to the reference surface 4 are known, all of these parameters must be known for a method according to the second embodiment example for the calibrating camera 2.1 and the measuring camera 2.2 in order to form therefrom the mapping model for the calibrating camera 2.1 and measuring camera 2.2.

[0066] In order to normalize the calibrating reference picture to the calibrating test pictures, and vice versa, the two mapping models are transformed into one another.

[0067] A skilled person in the field of optics and picture processing will be familiar with how such mapping models are formed and transformed into one another.

[0068] A method according to the second embodiment example proceeds in the following steps in the same way as in the first embodiment example.

[0069] Figs. 2c and 2d show a second and a third calibrating test picture, this time taken with the measuring camera 2.2. The calibrating reference picture shown in Fig. 2 was taken with the calibrating camera 2.1 for this second embodiment example.

[0070] A comparison of the second calibrating test picture illustrated in Fig. 2c with the calibrating reference picture in Fig. 2a shows that the mapping model of the calibrating

camera 2.1 differs from the mapping model of the measuring camera 2.2, but only because of a different focal length of the two camera objectives. In this case when transforming the mapping models into one another, the mapping model which is associated with the camera objective having the shorter focal length is converted to the mapping model associated with the camera objective having the longer focal length. The conversion of the mapping model of the calibrating camera 2.1 to the mapping model of the measuring camera 2.2 in the present specific example is only exemplary; the reverse may also be carried out. It is clear that after transforming the mapping models into one another there is no positional deviation in the mapping of a selected checking point between the calibrating reference picture and the second calibrating test picture so that the measurement position is verified by means of the second calibrating test picture.

[0071] The position of the mapping of checking feature P in relation to a coordinate system proper to the picture is indicated in the second calibrating test picture shown in Fig. 2c by values (x_2, y_2) . The different position of P in the second calibrating test picture compared to the position in the calibrating reference picture shown in Fig. 2a only results from the different mapping models of the calibrating camera 2.1 and the measuring camera 2.2. Comparing the third calibrating test picture shown in Fig. 2d with the calibrating reference picture in Fig. 2a shows that the mapping model of the calibrating camera 2.1 differs from the mapping model of the measuring camera 2.2 in the same way as was just described. After transforming the mapping models into one another, it is clear that the mapping of a selected checking point in the calibrating reference picture and the third calibrating test picture have a positional deviation with respect to one another which suggests a misalignment of the reference surface 4.

[0072] The position of the mapping of the checking feature P relative to a coordinate system proper to the picture is indicated in the third calibrating test picture shown in Fig. 2d by values (x_3, y_3) . The different position of P in the third calibrating test picture compared to the position in the calibrating reference picture shown in Fig. 2a results from the different mapping models of the calibrating camera 2.1 and the measuring camera 2.2 and a positional deviation of the measuring camera 2.2.

[0073] A misalignment of the reference surface 4 can have many causes such as material fatigue, incorrect operation or unauthorized tampering.

[0074] Therefore, the maintaining of the measurement position of the traffic monitoring device 1 must be monitored and verified, which is made possible by a method according to the invention.

Reference Numerals

- 1 traffic monitoring device
 - 1.1 calibrating traffic monitoring device
 - 1.2 measuring traffic monitoring device
- 2 camera
 - 2.1 calibrating camera
 - 2.2 measuring camera
- 3 mounting unit
- 4 reference surface
- 5 measuring sensor

- A optical axis

Patent Claims

1. Method for verifying a measurement position for a traffic monitoring device (TMD), which position is defined by a calibrating position of a reference surface in relation to which the traffic monitoring device can be located in a fixed positional relationship, comprising the steps of: (i) taking a calibrating reference picture of a road scene with a camera of the TMD aligned in a measurement position and located in a fixed positional relationship to a reference surface located in the calibrating position, (ii) in order to verify the measurement position, taking one or more, interval-timed, calibrating test pictures with a camera, which camera can be that of the TMD or another camera which is substituted along with the TMD, (iii) comparing the calibrating test picture(s) with the calibrating reference picture, wherein the mapping models of the possibly different cameras, whose internal imaging characteristics are known, are transformed beforehand into one another for comparing the calibrating test picture(s) with the calibrating reference picture, (iv) selecting images of identical static checking features from the calibrating reference picture and calibrating test picture(s) and determining positional deviations from one another within fixed picture tolerance limits, and (v) confirming measurements, which were carried out previously with the TMD, as valid when the positional deviations lie within the picture tolerance limits, and rejecting measurements, which were carried out previously with the TMD, as invalid when the positional deviations lie outside of the picture tolerances.
2. Method for verifying a measurement position according to claim 1, wherein the calibrating test pictures are taken during a measuring operation of the TMD.
3. Method for verifying a measurement position according to claim 1 or 2, wherein the TMD used for taking the calibrating test pictures is different from the TMD used for taking the calibrating reference picture.
4. Method for verifying a measurement position according to any one of the preceding claims, wherein physical edges or physical corners of stationary objects in the object field of the camera, which are mapped as an edge jump, are selected as checking features.
5. Method for verifying a measurement position according to any one of the

preceding claims, wherein when positional deviations lying outside the picture tolerance limits are determined, the TMD is realigned in its measurement position based on knowledge of the positional deviation by changing the spatial position of the reference surface while further calibrating test pictures are taken and are compared with the calibrating reference picture until the positional deviations of the images of the checking features lie within the picture tolerance limits.

6. Method for verifying a measurement position according to any one of claims 1 to 4, wherein the measurement position is transformed into a new measurement position computationally using the determined positional deviation, wherein a calibrating test picture with this determined positional deviation is set as a new calibrating reference picture and, for subsequent verification of this new measurement position, calibrating test pictures made subsequently are compared with this new calibrating reference picture.

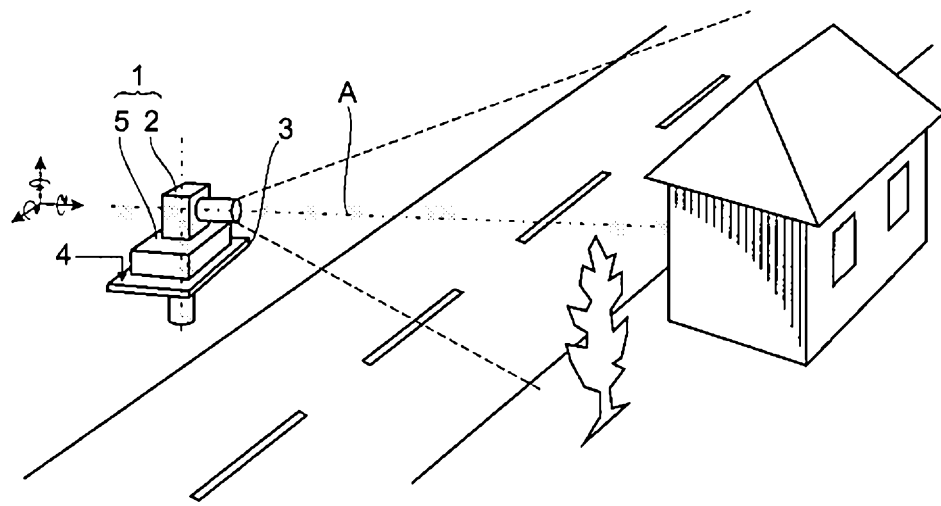


Fig. 1

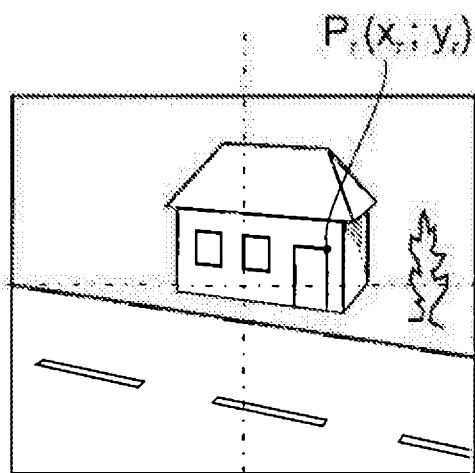


Fig. 2a

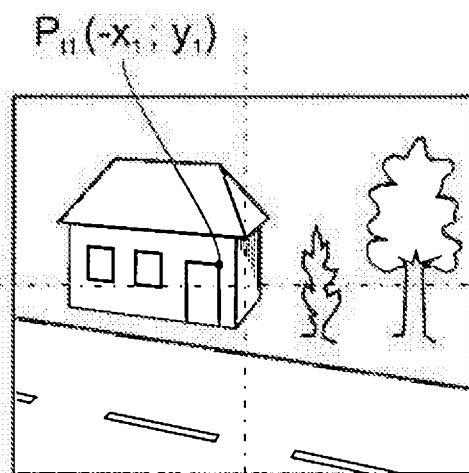


Fig. 2b

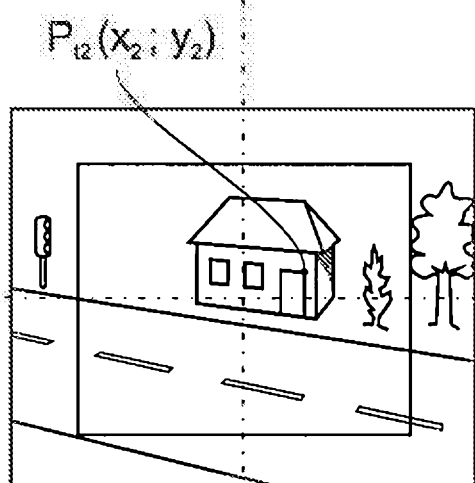


Fig. 2c

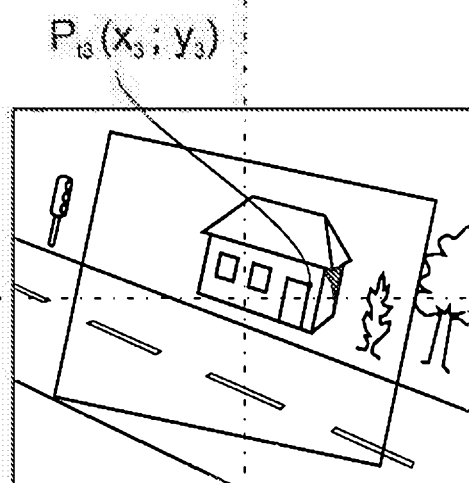


Fig. 2d