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(54) Title: ONLINE VEHICLE CAMERA CALIBRATION BASED ON CONTINUITY OF FEATURES

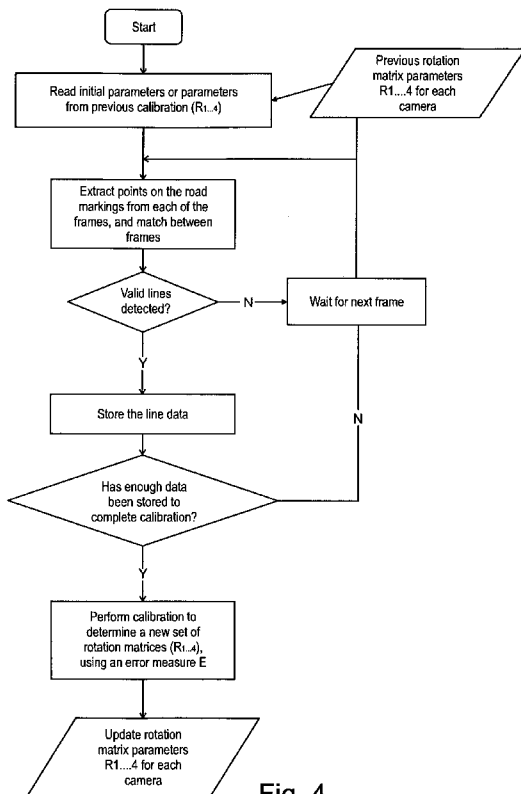
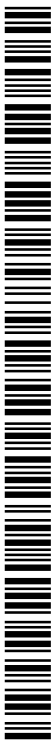


Fig. 4

(57) Abstract: The invention relates to a method for online calibration of a vehicle video system evaluated from image frames containing longitudinal road features. Adjacent portions of a road surface are captured by at least two cameras of the vehicle video system. Longitudinal road features are identified within the image frames. Identified longitudinal road features are selected within at least two image frames respectively taken by two cameras as matching a single line between the two image frames. An analysis of the matching of the single line is performed by determining an offset of the line between the two image frames. The consequently determined offset of the line is applied for a calibration of the cameras of the vehicle video system.



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ONLINE VEHICLE CAMERA CALIBRATION BASED ON CONTINUITY OF FEATURES

BACKGROUND OF THE INVENTION

FIELD OF THE INVENTION

[0001] This invention relates generally to an online calibration of a vehicle video system, and particularly to a method for online calibration of the vehicle video system evaluated from image frames of a camera. It is also related to a computer program product for processing data relating to the online calibration of the vehicle video system, the computer program product comprising a computer usable medium having a computer usable program code embodied therewith, the computer program code being configured to perform any of the method steps. The present invention is further related to an online calibration system for a vehicle video system for processing the computer implemented online calibration method.

DESCRIPTION OF BACKGROUND

[0002] It is known to mount image capture devices, such as, for example, digital or analogue video cameras, on a motor vehicle in order to produce a video image of an aspect of the environment exterior of the vehicle. For example, in order to assist in parking and manoeuvring a vehicle in confined spaces, it is known to mount such image capturing devices on respective opposite sides of the vehicle, for example, on side rear view mirror housings which extend sidewardly from the driver and front passenger doors of the vehicle. The image capture devices are mounted in the side rear view mirror housings with the field of view of the image capture devices directed downwardly towards the ground for capturing plan view images of the ground on respective opposite sides of the vehicle adjacent the vehicle. Typically, a visual display unit is located in the vehicle, either in or on the dashboard, or in a location corresponding to that of a conventional interiorly mounted rear view mirror. Nowadays, also head-up displays are used for vehicle. Even, a projection onto the windscreen is now possible. When a driver

is undertaking a parking manoeuvre or a manoeuvre in a confined space, a plan view image of the vehicle with the respective plan view images of the ground on respective opposite sides of the vehicle can be displayed on the visual display unit. The plan view display of the vehicle and the ground on respective opposite sides of the vehicle assists the driver in parking, and in particular, carrying out a parking manoeuvre for parking the vehicle in a parking space parallel to a kerb of a footpath or the like.

[0003] However, in order that the view images of the ground accurately reflect the positions of objects relative to the vehicle, which are captured in the images, it is essential that the view images of the ground juxtapositioned with the view image of the vehicle should accurately represent a top view of the ground adjacent the respective opposite sides of the vehicle exactly as would be seen when viewed from above. In other words, the edges of the respective view images of the ground which extend along the sides of the view image of the vehicle must correspond directly with the edge of the ground along the sides of the vehicle when viewed in view from a position above the vehicle. Otherwise, the positions of objects in the respective view images of the ground will not be accurately positioned relative to the vehicle. For example, if the edge of one of the view images of the ground adjacent the corresponding side of the view image of the vehicle corresponds with a portion of a view of the ground which is spaced apart from the side of the vehicle, then the positions of objects in the view image of the ground will appear closer to the vehicle in the image than they actually are. Conversely, if one of the image capture devices is mounted on a side mirror housing so that an image of a portion of the ground beneath a side of the vehicle is captured, the positions of objects captured in the view image will appear farther away from the vehicle than they actually are, with disastrous results, particularly if a driver is parking the vehicle parallel to a wall or bollards. Similar requirements apply also for front or rear placed image capture devices. Often, the most obvious effect of poor calibration happens when a merged image is presented to the user and one of the cameras is not correctly calibrated. In this case an object/feature on the ground can appear disjointed or elongated or disappear completely from the view presented to the user.

[0004] Accordingly, it is essential that the view images of the ground when displayed on the visual display screen juxtapositioned along with the plan view image of the vehicle must be representative of plan views of the ground on respective opposite sides of the vehicle exactly as would be seen from a top plan view of the vehicle and adjacent ground. In order to achieve such accuracy, the image capture devices would have to be precision mounted on the vehicle. In practice this is not possible. Accordingly, in order to achieve the appropriate degree of exactness and accuracy of the plan view images of the ground relative to the plan view image of the vehicle, it is necessary to calibrate the outputs of the image capture devices. Calibration values determined during calibration of the image capture devices are then used to correct subsequently captured image frames for offset of the image capture devices from ideal positions thereof, so that plan view images of the ground subsequently outputted for display with the plan view image of the vehicle are exact representations of the ground on respective opposite sides of the vehicle. Such calibration can be accurately carried out in a factory during production of the motor vehicle. The calibration may also use the absolute position/rotation of the camera. Typically, the image capture devices are relatively accurately fitted in the side mirror housings of the motor vehicle, and by using suitable grid patterns on the ground, calibration can be effected. However, the environments in which motor vehicles must operate are generally relatively harsh environments, in that side mirror housings are vulnerable to impacts with other vehicles or stationary objects. While such impacts may not render the orientation of the side mirror housing unsuitable for producing an adequate rear view from a rear view mirror mounted therein, such impacts can and in general do result in the image capturing device mounted therein being knocked out of alignment, in other words, being offset from its ideal position. Additionally, where a vehicle is involved in a crash, or alternatively, where a side mirror housing requires replacement, re-calibration of the image capture device refitted in the new side mirror housing will be required. Such re-calibration, which typically would be carried out using a grid pattern on the ground, is unsatisfactory, since in general, it is impossible to accurately align the vehicle with the grid pattern in order to adequately calibrate the image capture device, unless the calibration is being carried out under factory conditions. The same applies for

rear or front placed image capture devices even in the case, those devices are placed in the interior of the vehicle since harsh conditions apply also there.

[0005] In WO2009/027090 is described a method and system for online calibration of a vehicle video system using vanishing points evaluated from frames of a camera image containing identified markings or edges on a road. In US2010/0110194 is described a method for producing a time sequence of images of motor vehicle surroundings from a virtual elevated central perspective on a display wherein several cameras are used to record time sequences of subimage data records from a plurality of real perspective differently offset and tilted with respect to the virtual perspective. Recurrently, a calibration is performed using a prescribed quality criterion for the overall image. The quality criterion is stipulated such that it reflects the quality of the overall image.

SUMMARY OF THE INVENTION

[0006] In view of the above, there is a need for a method and a calibration system for calibrating an output of an image capture device or camera mounted on a vehicle to compensate for offset of the camera from an ideal position, such method and calibration system being based on a simple use of available longitudinal road features without requiring a calibration of the camera to be carried out in a controlled environment.

[0007] According to a first aspect of the embodiment of the present invention, a method for online calibration of a vehicle video system is achieved by evaluating image frames of a camera containing longitudinal road features. The method comprises the following steps of capturing in image frames by at least two cameras of the vehicle video system of adjacent portions of the road surface. Longitudinal road features are identified within the image frames. Identified longitudinal road features are selected within at least two image frames respectively taken by two cameras as matching a single line between the two image frames. An analysis of the matching of the single line is performed by determining an offset of the line between the two image frames. The consequently determined offset of the line is applied for a calibration of the camera.

[0008] Advantageously, the determined offset is applied as error measure to be minimised when adjusting rotation parameters used for the calibration of the cameras. In an embodiment according to the invention, the two considered image frames comprise an overlapping area. In an alternative, more than two image frames are considered captured respectively by more than two adjacent cameras of the vehicle video system, the image frames comprising some overlapping area between each other.

[0009] In some embodiment according to the invention, selected longitudinal road features corresponding to the matching line are stored over a period of time. This is used for a determination of a deviation of the points applied as error measure to be minimised when adjusting rotation parameters used for the calibration of the camera.

[0010] Advantageously, longitudinal road features are selected corresponding to at least two matching lines. In some embodiment, the calibration are performed for a vehicle video system adapted for displaying a virtual bird view of the adjacent environment of the vehicle by transforming each image frame from the cameras to a top down view to be merged into a single bird view.

[0011] Steering angle of the vehicle can be considered when selecting longitudinal road features as lines. This allows applying present online calibration method also when the vehicle is possibly not moving straight ahead.

[0012] It is also possible to analyse the selected longitudinal road features to be rejected as outlier if fulfilling some criteria. Such selection of the identified longitudinal road features as outlier can be performed if corresponding to a line with an angle curvature greater than a predefined value.

[0013] According to a second aspect of the embodiment, a computer program product for processing data relating to online calibration of a vehicle video system is also described and claimed herein. The computer program product comprises a computer usable medium having computer usable program code embodied therewith, the computer usable program code being configured to perform the above summarized methods.

[0014] According to a third aspect of the embodiment, a online calibration system for a vehicle video system is also described and claimed herein. The online calibration system comprises a computer program product for processing data relating to an online calibration method and an image processing apparatus with a camera for taking image frames to be used by the online calibration method such to perform the above summarized methods.

[0015] Additional features and advantages are realized through the techniques of the present invention. Other embodiments and aspects of the invention are described in detail herein and are considered a part of the claimed invention. For a better understanding of the invention with advantages and features, refer to the description and to the drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

[0016] The subject matter which is regarded as the invention is particularly pointed out and distinctly claimed in the claims at the conclusion of the specification. The foregoing and other objects, features, and advantages of the invention are apparent from the following detailed description taken in conjunction with the accompanying drawings in which:

[0017] FIG. 1 illustrates a side view and a top view of a vehicle with a 3d co-ordinate system;

[0018] FIG. 2 illustrates a side view of a vehicle with cameras of the vehicle video system;

[0019] FIG. 3 illustrates a schematic view of a vehicle video system for a bird view display;

[0020] FIG. 4 illustrates a flow diagram according to the invention;

[0021] FIG. 5 illustrates a bird view display according to the invention;

[0022] FIG. 6 illustrates a corrected bird view display according to the invention.

[0023] The detailed description explains the preferred embodiments of the invention, together with advantages and features, by way of example with reference to the drawings.

DETAILED DESCRIPTION OF THE INVENTION

[0024] As will be appreciated by one skilled in the art, aspects of the present invention may be embodied as a system, method or computer program product. Accordingly, aspects of the present invention may take the form of an entirely hardware embodiment, an entirely software embodiment (including firmware, resident software, micro-code, etc.) or an embodiment combining software and hardware aspects that may all generally be referred to herein as a “circuit,” “module” or “system.” Furthermore, aspects of the present invention may take the form of a computer program product embodied in one or more computer readable medium(s) having computer readable program code embodied thereon.

[0025] Any combination of one or more computer readable medium(s) may be utilized. The computer readable medium may be a computer readable signal medium or a computer readable storage medium. A computer readable storage medium may be, for example, but not limited to, an electronic, magnetic, optical, electromagnetic, infrared, or semiconductor system, apparatus, or device, or any suitable combination of the foregoing. More specific examples (a non-exhaustive list) of the computer readable storage medium would include the following: an electrical connection having one or more wires, a portable computer diskette, a hard disk, a random access memory (RAM), a read-only memory (ROM), an erasable programmable read-only memory (EPROM or Flash memory), an optical fiber, a portable compact disc read-only memory (CD-ROM), an optical storage device, a magnetic storage device, or any suitable combination of the foregoing. In the context of this document, a computer readable storage medium may be any tangible medium that can contain, or store a program for use by or in connection with an instruction execution system, apparatus, or device.

[0026] A computer readable signal medium may include a propagated data signal with computer readable program code embodied therein, for example, in baseband or as part of a carrier wave. Such a propagated signal may take any of a variety of forms, including, but not limited to, electro-magnetic, optical, or any suitable combination thereof. A computer readable signal medium may be any computer readable medium that is not a computer readable storage medium and that can communicate, propagate, or transport a program for use by or in connection with an instruction execution system, apparatus, or device.

[0027] Program code embodied on a computer readable medium may be transmitted within the vehicle using any appropriate medium, including but not limited to wireless, wireline, optical fiber cable, RF, etc., or any suitable combination of the foregoing.

[0028] Computer program code for carrying out operations for aspects of the present invention may be written in any combination of one or more programming languages, including an object oriented programming language such as Java, Smalltalk, C++ or the like and conventional procedural programming languages, such as the "C" programming language or similar programming languages. The program code may execute entirely on the vehicle's computer, partly on the vehicle's computer, as a stand-alone software package, partly on the vehicle's computer and partly on a remote computer or entirely on the remote computer or server. In the latter scenario, the remote computer may be connected to the vehicle's computer through any type of wireless network, including a wireless local area network (WLAN), possibly but not necessarily through the Internet using an Internet Service Provider.

[0029] Aspects of the present invention are described below with reference to flowchart illustrations and/or block diagrams of methods, apparatus (systems) and computer program products according to embodiments of the invention. It will be understood that each block of the flowchart illustrations and/or block diagrams, and combinations of blocks in the flowchart illustrations and/or block diagrams, can be implemented by computer program instructions. These computer program instructions may be provided to

a processor of a general purpose computer, special purpose computer, or other programmable data processing apparatus to produce a machine, such that the instructions, which execute via the processor of the computer or other programmable data processing apparatus, create means for implementing the functions/acts specified in the flowchart and/or block diagram block or blocks.

[0030] These computer program instructions may also be stored in a computer readable medium that can direct a computer, other programmable data processing apparatus, or other devices to function in a particular manner, such that the instructions stored in the computer readable medium produce an article of manufacture including instructions which implement the function/act specified in the flowchart and/or block diagram block or blocks.

[0031] The computer program instructions may also be loaded onto a computer, other programmable data processing apparatus, or other devices to cause a series of operational steps to be performed on the computer, other programmable apparatus or other devices to produce a computer implemented process such that the instructions which execute on the computer or other programmable apparatus provide processes for implementing the functions/acts specified in the flowchart and/or block diagram block or blocks.

[0032] Present invention is a means of calibrating a camera on a vehicle to determine the extrinsic camera rotation parameters relative to the vehicle co-ordinate system when the camera is positioned in an undertermined relevant position on the vehicle body. Calibration allows the vehicle manufacturer to provide a geometrically representative and more importantly a useful view to a vehicle user. Additionally, by extension, the height of the camera off the ground plane (XY-plane) can be determined.

[0033] Turning now to the drawings in greater detail, it will be seen that in Figure 1 is shown a side view and a top view of a vehicle 1 with a defined three dimensional co-ordinate system x, y, z as used in the following. x-axis is chosen along the longitudinal direction, y-axis along the transverse direction and z-axis along the vertical direction of the vehicle 1.

[0034] Figure 2 shows a side view of the vehicle 1 together with the x, y, z coordinate system and three cameras 21-23 from the vehicle video system. One camera 21 is placed at the rear of the vehicle, another 22 at the side usually at the wing-mirror and another 23 at the front. A further camera is placed on the other side of the vehicle and is accordingly not visible on figure 2. All the cameras of the video vehicle system capture a significant portion of road surfaces in the scene. Such portion of road surfaces is stored in image frames from which longitudinal road features like markings or road edge are identified to be selected.

[0035] Figure 3 shows a schematic view of the vehicle video system with four cameras from a video vehicle system as of fig. 2. Four video streams are obtained from the four cameras C1 to C4 to be merged into a bird view. Each frame from the cameras is transformed to a top down view (T1 to T4). The transforms are functions of the camera rotation matrices (R1 to R4). Additionally, the transforms are functions of the position of each camera in the reference coordinate system and (if applicable) the fisheye function that describes the intrinsic parameters of the camera (see, for example, http://en.wikipedia.org/wiki/Fisheye_lens#Mapping_function, though any appropriate function can be used). However, these additional parameters are not determined by the online calibration, and can therefore be considered as constant within the transforms T1 to T4. The rotations matrices (R1 to R4) are 3x3 matrices that can typically be generated from three rotation angles (see http://en.wikipedia.org/wiki/Euler_angles#Matrix_notation, the angles can be xyz, xzz or any appropriate combination). The merge function M combines the four transformed frames into a single bird view (or top view) for display to the driver.

[0036] Figure 4 shows a flow diagram according to present invention. The online calibration method is started at some stage when vehicle is driving. Such starting event can be programmed in different ways e.g. after a predefined time during driving or after travelling some predefined distance or a combination of several parameters. Some initial parameters of the vehicle video system can be loaded first. Alternatively or in combination with that, some parameters from previous calibration (R1 to R4 being the

previous rotation matrix parameters for each camera) can be loaded to be considered for the new started calibration procedure.

[0037] Then, some points on the longitudinal road features like road markings (e.g. broken lines, or edgeline) or road edges are extracted from each of the frames. Any adequate method can be used here to extract those longitudinal road features. One possibility is obtained by analyzing several columns of the raw video within a predetermined region of interest of the frame at regular vertical intervals to detect light colored blobs. The blob detection itself can be performed by looking for a rising edge followed by a falling edge. For road marking, a blob is accepted only if its average luminance is significantly greater than the surrounding road and its width is within the road marking min and max constraints. Accordingly, this must be adapted if edge of the road are considered instead. A set of points are extracted from each of the imaged road marking. The longitudinal road features are extracted from each of the four cameras. If no valid road marking (or edge of the road) are present in the frames (e.g. no road marking is present that spans more than one camera view or if for any other reason the road marking is not valid), the frame is ignored.

[0038] Advantageously, the steering angle of the vehicle can be currently used to ensure that the vehicle is travelling along a straight direction when online calibration shall be applied. Additionally, a rejection criterion can be defined for outlier such that a longitudinal road feature detected with an angle greater than a given threshold could be rejected. The threshold can be predefined possibly according to some experience collected in advance. Alternatively, the constraint that the tracks are parallel to the x-axis of the vehicle could be relaxed for by using the steering information or by having a range of predefined expected steering curvature. If initial estimates of the camera extrinsic parameters are known (e.g. from vehicle mechanical data), they can be used as starting points for the calibration. Advantageously, the speed and steering information possibly available on the vehicular network (e.g. via CAN, LIN, Wireless or other) can be used when transforming the extracted points to remove (relax) the necessity for the vehicle to be moving in a straight line and at constant speed. Furthermore, if the speed of the

vehicle is considered, then the actual physical distance between the extracted points from the longitudinal road features could be computed. And this combined with a triangulation method would allow determining the height of the camera.

[0039] The criteria for rejecting extracted points as outliers using the velocity of the vehicle can be based on the fact that when a vehicle is travelling faster, it is more likely to be travelling parallel to the longitudinal road features like the markings or the edge of the road. In contrast, when a vehicle is travelling slower (e.g. at junctions and roundabouts, etc.) it is likely that the road features captured by the camera are not actually parallel to the direction of the vehicle motion (i.e. parallel to the vehicle x-axis). Road-marking color information can also be considered as rejection criteria possibly but not necessarily in combination with the vehicle velocity. For example, if a green road blob is detected in areas where only white or yellow/orange markings are expected, it is highly likely that this is an erroneous detection and should be rejected as outlier.

[0040] The extracted longitudinal road features once extracted are stored. Several alternatives can be used for this purpose. For example, the point locations on the longitudinal road markings extracted from each of the frames are simply stored. These can then be transformed later by some error function E using T1 to T4. Alternatively, each point on each longitudinal road feature is transform as it is extracted using T1 to T4. Than the transformed points are stored for use with the error function E . A third possibility involves to transform each point of each longitudinal road feature from each frame using T1 to T4 and then fit the equation of a line (e.g. $y = mx + c$, where m is the slope of the line, and c is the y axis intercept) to the transformed points. The equation parameters can then be stored for use by the error function E . The line fitting can be carried out using any suitable method (e.g. Hough or least-squares).

[0041] A single line or pair of lines can have multiple (till infinite) rotation parameters that cause them to align. Therefore, to find the correct set of rotation parameters, the error minimization will need a larger set of extracted road marking lines. Prior to performing the error minimization, a set of lines corresponding to road markings is gathered over a

period of time. Once enough lines have been gathered, the error minimization can be applied to determine the optimal rotation parameters. Several appropriate methods can be used to determine if enough data has been gathered. Advantageously, the frames are divided into regions. Only when a line has been extracted from each of these regions (or a percentage of the regions) then the calibration procedure will be pursued. Such method offers the best potential for accurate results to be returned. Finally, a new set of rotation matrices $R1$ to $R4$ using the error measure E is determined and used to update the rotation matrix parameters $R1$ to $R4$ for each of the four cameras from the vehicle video system.

[0042] Figure 5 shows a top down or bird view obtained by combining the image frames of the four cameras and performing some appropriate transformation taking possibly into account distortions coming e.g. by the use of fish eye camera lenses. In the middle is drawn in black the location of the vehicle 50 while at the bottom and the top are displayed the image frame 51, 53 gathered by the camera respectively at the back and at the front of the vehicle. At the left and at the right of the vehicle 50 are displayed the image frames 52, 54 gathered by the respective left and right wing mirror cameras. Clearly visible from figure 5 is the fact that the four image frames 51 to 54 have some overlapping area 55 to 58 between two adjacent image frames. Also shown are the identified longitudinal road features (in the present case two road marking possibly but not necessarily edgelines) which on figure 5 do not match between the different image frames. The two lines 51' and 51'' identified within the image frame 51 taken by the rear camera (see figure 2) do not match with the lines 52' and 54' identified within the image frame 52 and 54 of the respective wing mirror camera in the corresponding overlapping area 55 and 58. Similar situation are shown for the same lines 53' and 53'' this time identified within the image frame 53 taken by the front camera which also do not match with the lines 52' and 54' now in the overlapping area 56 and 57.

[0043] Figure 5 describes how the extracted lines do not align when transformed using $T1$ to $T4$ with an incorrect choice of the rotation parameters for the cameras. This misalignment of extracted lines between image frames is used as a measure of error. Any suitable measure of misalignment of the extracted lines can be used. Advantageously, the

difference between the slope m and the y -intercept c (see above equation) are used as a measure of the misalignment after the fitting of a line to the transformed points. Additionally, if the vehicle is traveling in a straight line, the longitudinal road features (marking or edge) are parallel to the direction of travel of the vehicle (i.e. parallel to the x -axis, see fig. 1) once transformed. Therefore, the parallelism of the lines to the vehicle x -axis can also be used as an additional error measure. Furthermore, given a set of line data extracted from the longitudinal road features over a period of time, the total error can be computed as the sum of the errors in alignment.

[0044] By applying the method according to the invention, any offset between the lines 51', 52' and 53' as well as between 51'', 54' and 53' can be detected and used for defining an online calibration of the cameras from the vehicle video system. As offset, a difference (deviation) in the slope of the identified lines 51', 51'', 52', 53', 53'', 54' can be measured and used for the calibration. An error function expressing such offset is defined to be minimized using some appropriate algorithm like Nelder-Mead, Levenberg-Marquardt. For present case with tree parameters for each camera i.e. in total 12 parameters to take into account during the minimization procedure, Levenberg-Marquardt may offer the better convergence.

[0045] Figure 6 shows a top down or bird view similar to figure 5 with the effect of the online calibration performed on the vehicle video system i.e. with the consideration of correct rotation parameters for the camera of the vehicle video system. The vehicle 60 is surrounded by four image frames 61 to 64 from the four cameras. The two identified lines 69, 69' one at the left and the other at the right of the vehicle 60 parallel to its longitudinal direction are now well matching within the overlapping area 65, 66, 67, 68.

[0046] The capabilities of the present invention can be implemented in software, firmware, hardware or some combination thereof.

[0047] As one example, one or more aspects of the present invention can be included in an article of manufacture (e.g., one or more computer program products) having, for instance, computer usable media. The media has embodied therein, for instance,

computer readable program code means for providing and facilitating the capabilities of the present invention. The article of manufacture can be included as a part of a computer system or sold separately. Additionally, at least one program storage device readable by a machine, tangibly embodying at least one program of instructions executable by the machine to perform the capabilities of the present invention can be provided.

[0048] While the preferred embodiment to the invention has been described, it will be understood that those skilled in the art, both now and in the future, may make various improvements and enhancements which fall within the scope of the claims which follow. These claims should be construed to maintain the proper protection for the invention first described.

CLAIMS

1. A method for online calibration of a vehicle video system evaluated from image frames of a camera containing longitudinal road features, the method comprising the following steps of:
 - Capturing in image frames (51, 52, 53, 54, 61, 62, 63, 64) by at least two cameras (21, 22, 23) of the vehicle video system of adjacent portions of the road surface;
 - Identifying longitudinal road features (51', 51'', 52', 53', 54') within the image frames;The method being **characterised by** the further steps of
 - Selecting identified longitudinal road features within at least two image frames respectively taken by two cameras as matching a single line between the two image frames;
 - Analysing the matching of the single line by determining an offset of the line between the two image frames;
 - Applying the determined offset of the line for a calibration of the camera.
2. The online calibration method according to claim 1 whereby the determined offset is applied as error measure to be minimised when adjusting rotation parameters used for the calibration of the cameras.
3. The online calibration method according to claim 1 whereby the two considered image frames comprise an overlapping area.
4. The online calibration method according to claim 1 whereby selected longitudinal road features corresponding to the matching line are stored over a period of time for a determination of a deviation of the points applied as error measure to be minimised when adjusting rotation parameters used for the calibration of the camera.
5. The online calibration method according to claim 1 whereby selecting longitudinal road features corresponding to at least two matching lines.
6. The online calibration method according to claim 1 whereby the calibration are performed for a vehicle video system adapted for displaying a virtual bird view of the adjacent environment of the vehicle by transforming each image frame from the cameras to a top down view to be merged into a single bird view.
7. The online calibration method according to claim 1 whereby steering angle of the vehicle is used when selecting longitudinal road features as lines.
8. The online calibration method according to claim 1 whereby analysing the selected longitudinal road features to be rejected as outlier if fulfilling some criteria.

9. The online calibration method according to claim 8 whereby rejecting the selected identified longitudinal road features if corresponding to a line with an angle curvature greater than a predefined value.
10. A computer program product for processing data relating to online calibration of a vehicle video system, the computer program product comprising a computer usable medium having computer usable program code embodied therewith, the computer usable program code being configured to perform the steps of any of the preceding claims 1 to 10.
11. An online calibration system for a vehicle video system, the online calibration system comprising a computer program product for processing data relating to an online calibration method and an image processing apparatus with a camera for taking image frames to be used by the online calibration method such to perform the steps of any of the preceding claims 1 to 10.

* * * * *

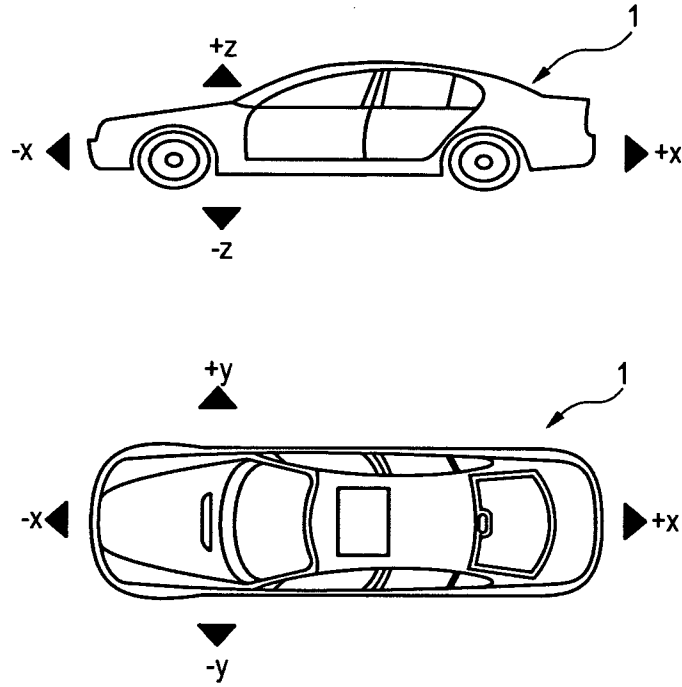


Fig. 1

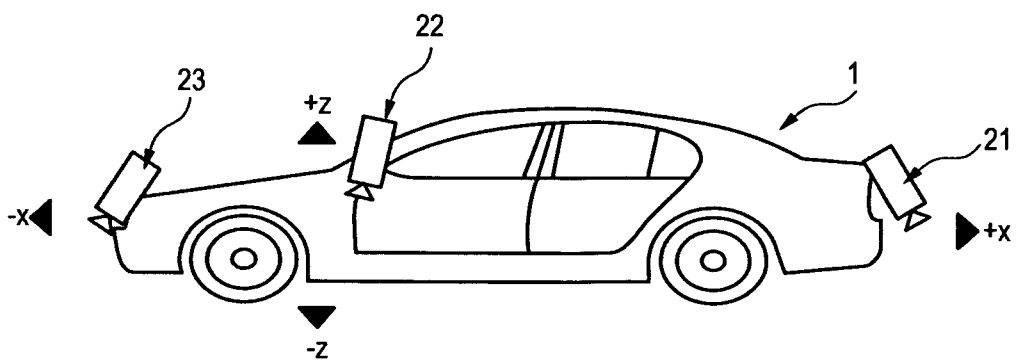


Fig. 2

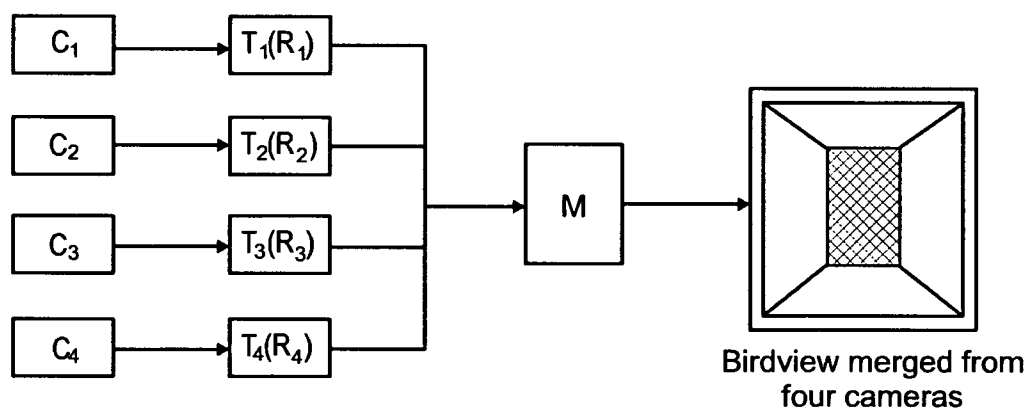


Fig. 3

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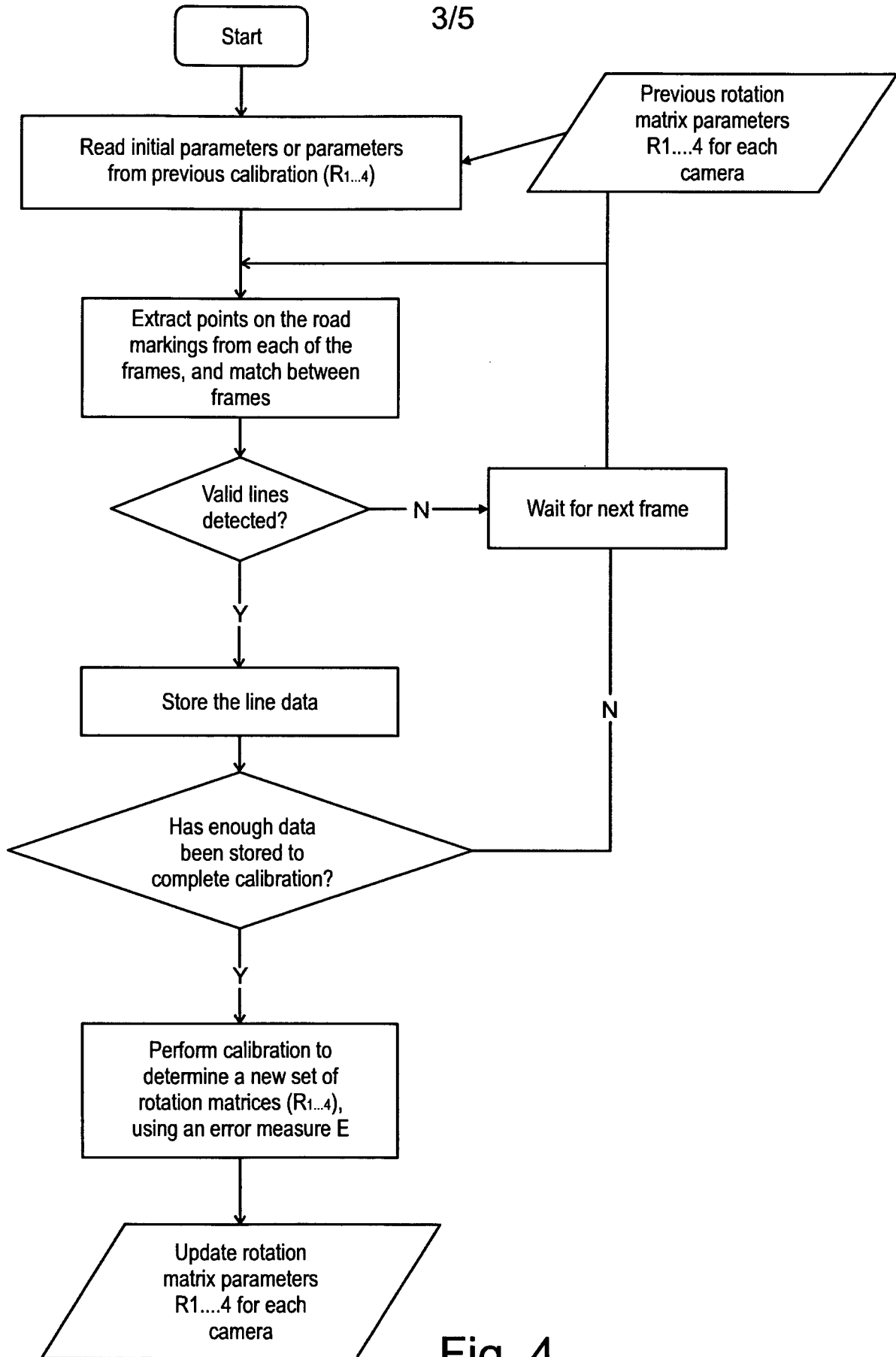


Fig. 4

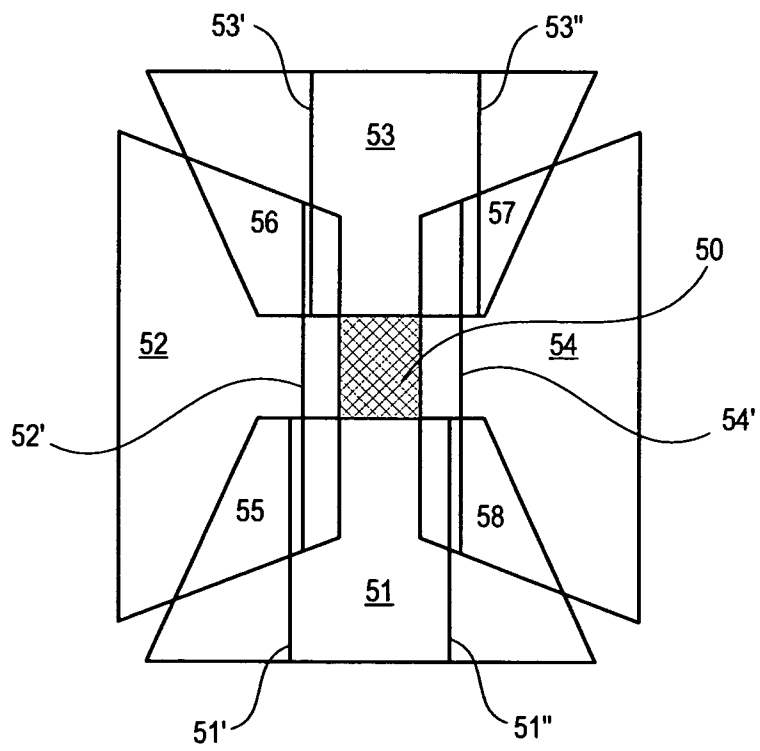


Fig. 5

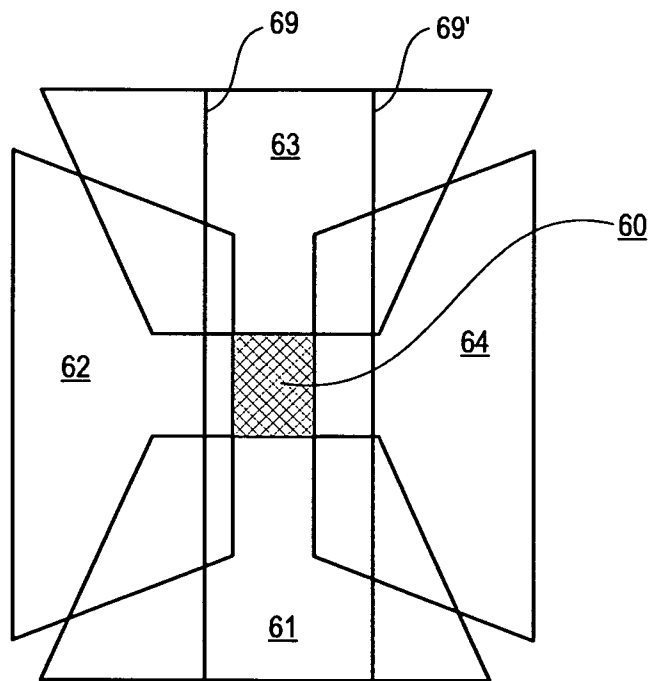


Fig. 6

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2011/056107

A. CLASSIFICATION OF SUBJECT MATTER
INV. G06T7/00
ADD.
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED
Minimum documentation searched (classification system followed by classification symbols)
G06T G06K

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)
EPO-Internal, COMPENDEX, INSPEC, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

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Further documents are listed in the continuation of Box C.

See patent family annex.

* Special categories of cited documents :

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| <p>"A" document defining the general state of the art which is not considered to be of particular relevance</p> <p>"E" earlier document but published on or after the international filing date</p> <p>"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)</p> <p>"O" document referring to an oral disclosure, use, exhibition or other means</p> <p>"P" document published prior to the international filing date but later than the priority date claimed</p> | <p>"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention</p> <p>"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone</p> <p>"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.</p> <p>"&" document member of the same patent family</p> |
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| Date of the actual completion of the international search 19 December 2011 | Date of mailing of the international search report 27/12/2011 |
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| Name and mailing address of the ISA/ European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016 | Authorized officer Krawczyk, Grzegorz |
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INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2011/056107

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Information on patent family members

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