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(54) Title: METHOD FOR CAMERA MOUNTING IN A VEHICLE

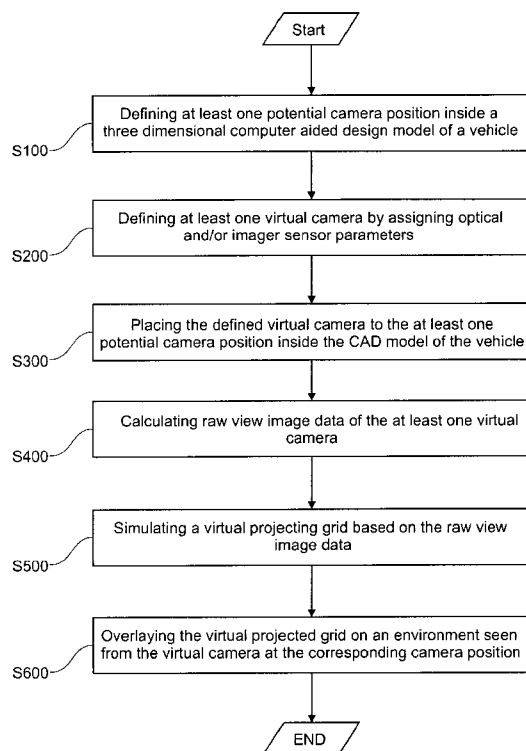


Fig. 1

(57) Abstract: An improved method for camera mounting in a vehicle is disclosed comprising the steps: defining at least one potential camera position (12, 14, 16, 18) in a three dimensional computer aided design (CAD) model of said vehicle (1); defining at least one virtual camera by assigning optical and/or imager sensor parameters; placing said defined virtual camera to said at least one potential camera position (12, 14, 16, 18); calculating raw view image data of said at least one virtual camera, simulating a virtual projection grid (40) based on said raw view image data, wherein at least one imager pixel is retraced as projection pixel through said projection grid (40) during simulation, overlaying said virtual projected grid (40) on a three dimensional environment of said vehicle (1) seen from said virtual camera at a corresponding camera position (12, 14, 16, 18).



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Method for camera mounting in a vehicle

BACKGROUND OF THE INVENTION

Field of the Invention

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The present invention relates in general to the field of driving assistance solutions supporting drivers of a vehicle. Such driving assistance solutions comprise vision systems using at least one camera. Particularly, the present invention relates to a method for camera mounting in a vehicle. Still more particularly, the present invention relates to a data processing program and a computer program product for performing the method for camera mounting in a vehicle.

Description of the Related Art

Driving Assistance solutions support drivers to steer their car. Cameras integrated in bumpers and mirrors provide information about obstacles distance to avoid collisions. Each camera covers a Field of View (FoV) up to 190° and all cameras together are optimized to give the driver a 360° view around the car.

Today camera positions are mechanically adjusted when first car prototypes are available at supplier. During the mechanical camera adjustments each camera position and orientation is optimized through control of the recorded camera image. Through fixtures the camera positions and orientations have to be ensured. Camera positions are documented in the drawings (CAD) and camera integration must be taken into account in the

design of those car components where cameras are integrated, e.g. mirrors, hatchbacks etc.

The cameras deliver raw view images that show all optical distortion of fish eye lenses. Through mathematical processing corrected undistorted images are calculated. With help of ECU algorithms, corrected images are stitched together to visualize the Bird-Eye-View on a display to enable driver to determine obstacles near the car.

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In the Patent Abstracts of Japan JP 2007241398 A a vision field analysis device for a vehicle is disclosed. In the disclosed vision field analysis device, a vehicle model and an image acquisition file set in a three-dimensional CAD (Computer Aided Design), a light source model disposed inside a drivers cab of the vehicle model, a camera model for photographing the light source model, disposed outside the vehicle model, and a plurality of photographing positions of the camera model are set, and a plurality of images photographed by the camera model in each position of the plurality of photographing positions are acquired by use of the three-dimensional CAD. It is distinguished whether or not the light source model is reflected to the plurality of images by an image analysis program, and a distinction result thereof is recorded.

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In the Patent Abstracts of Japan JP 2009064372 A a monitor image simulation device, a monitor image simulation method, and a monitor image simulation program are disclosed, providing means for deciding whether a camera is correctly arranged or not before actually mounting the camera on a camera mounting object such as a vehicle in a monitor image simulation device. The disclosed monitor image simulation device is provided with a processing part, an input part, and a display. The processing part is provided with a data acquisition means for acquiring camera arrangement data showing a camera arrangement state, camera peripheral component data including the shapes

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and positions of components to be arranged in the peripheral part of the camera, and monitor data showing a monitor display state, a virtual projection plane setting means for setting a first virtual projection plane and a second virtual projection plane for projecting components on a virtual three-dimensional space on a virtual two-dimensional plane; and a monitor display image generation means for generating a monitor display image on the basis of the camera arrangement data, the camera peripheral component data, the monitor data and the virtual projection planes.

In the Patent Abstracts of Japan JP 2009064373 A a monitor image simulation device, a monitor image simulation method, and a monitor image simulation program are disclosed, providing means for effectively deciding whether a camera is correctly arranged or not before actually mounting the camera on a camera loading object such as a vehicle even in rotating an image to be displayed by a monitor with respect to an image to be generated by a camera in a monitor image simulation device.

The disclosed monitor image simulation device is provided with a processing part, and a display. The processing part is provided with a data acquisition means for acquiring camera arrangement data showing a camera arrangement state and camera peripheral component data including the shapes and positions of components arranged in the peripheral part of the camera, a virtual projection plane setting means for setting a virtual projection plane for projecting components on a virtual three-dimensional space on a virtual two-dimensional plane, a camera image generation means for generating a camera image on the basis of the camera arrangement data, the camera peripheral component data, and the virtual projection plane; and an enlarged/reduced image rotating means for rotating an enlarged/reduced image generated from the camera image.

Summary of the Invention

The technical problem underlying the present invention is to provide a method for camera mounting in a vehicle, which is able to save time and money for mounting at least one camera in a vehicle, and to provide a data processing program and a computer program product to perform the method for camera mounting in a vehicle.

According to the present invention this problem is solved by providing a method for camera mounting in a vehicle having the features of claim 1, a data processing program for performing the method for camera mounting in a vehicle having the features of claim 16, and a computer program product causing a computer to perform the method for camera mounting in a vehicle having the features of claim 17. Advantageous embodiments of the present invention are mentioned in the sub claims.

Accordingly, in an embodiment of the present invention a method for camera mounting in a vehicle, comprises defining at least one potential camera position in a three dimensional computer aided design model of the vehicle; defining at least one virtual camera by assigning optical and/or imager sensor parameters; placing the defined virtual camera to the at least one potential camera position; calculating raw view image data of the at least one virtual camera, simulating a virtual projection grid based on the raw view image data, wherein at least one imager pixel is retraced as projection pixel through the projection grid during simulation, overlaying the virtual projected grid on a three dimensional environment of the vehicle seen from the virtual camera at a corresponding camera position.

Embodiments of the present invention save time and money due to performing simulation during performing the method for camera mounting in a vehicle. For performing the simulation virtual cameras have to be defined and positioned inside the vehicle CAD model. The virtual cameras have to be defined through optical and imager sensor parameters. Through simula-

tion it is possible to retrace imager pixel through a projected grid that is overlaid on the environment seen from the virtual camera. This procedure is also called "pixel-grid-projection". Advantageously the pixel-grid projection of each camera can be used to optimize field of view (FoV) overlapping areas. The overlapping area information can be presented to vehicle manufacturer to optimize camera positions and to demonstrate vehicle geometry impact. It is quite difficult to develop correction algorithms since raw views have to be translated to get corrected images. Nowadays a trial-and-error method is used to find correction algorithms, a raw image has to be recorded, afterwards the correction algorithm is applied and the corrected image is calculated and compared with reality. The correction algorithm is iteratively adapted until the corrected image is close to reality. By use of pixel-grid-projection, a systematic approach can be implemented by distortion correction of grid projection; translation of each grid node is given. With this knowledge, correction algorithm parameters can be determined easily.

Another benefit of the camera mounting simulation is to get earlier results to calculate a "Bird-Eye-View". For the Bird-Eye-View the corrected images are stitched together. Stitching algorithms can be created and presented to the vehicle manufacturer based on simulated camera raw views.

As another advantage a potential customer and/or development teams can see the implications of a camera design in term of tolerances, autoexposure control, and auto-white balance. lens properties (e.g., MTF, large angle effects), overlap of more than one camera, pixel size representation on the ground and its implications for pixel mosaicing, topographic changes and their implication for the introduction of three dimensional effects, representations of three dimensional object displacements in terms of two dimensional aliases and so forth. Also, the effects of tolerances on vehicle and/or structural vignetting can be asserted. Furthermore, such a tolerance analysis

can be used by a vision system itself in determining the relative reliability of object detection by multi camera and/or stereo camera applications.

5 In further embodiments of the present invention, during simulation a simulated ray from at least one pixel on the camera imager is projected through the camera lens into at least one object space of the camera lens. Alternatively and/or additionally during simulation a simulated ray from a region of
10 interest on the camera imager comprising a certain number of pixels is projected through the camera lens into the object space of the camera lens.

In further embodiments of the present invention, the calculated raw view image data consider a distortion of the camera
15 lens and/or the camera imager and/or a shape of the vehicle and/or a three dimensional model of the environment of the vehicle.

20 In further embodiments of the present invention, the simulated data are presented to a user using a CAD image of the vehicle including the object space of the camera lens of the at least one virtual camera. Additionally or alternatively the simulated data are provided to a post-processing step for further
25 analysis or computation. In the case where the simulated data are provided to a post-processing step for further analysis or computation the simulated data may or may not include object space data since it may not be necessary to use the whole object space of the camera lens. Instead it may be sufficient to
30 pass on simpler data from the simulation such as a percentage of occlusion for the camera lens of the at least one virtual camera and not the whole object space.

In further embodiments of the present invention, the projected
35 grid representing at least one pixel of a field of view of said virtual camera is projected through the CAD of surrounding objects of the vehicle.

In further embodiments of the present invention, during simulation of the virtual projected grid visible effects of various tolerances and/or limitations of the at least one virtual camera and/or the at least one potential camera position are considered. Further the various tolerances and/or limitations comprise position and/or orientation tolerances with respect to objects in the field of view of the camera due to mechanical mounting of the camera. Alternatively and/or additionally the various tolerances and/or limitations comprise effects of occlusions of the field of view on the camera imager and/or effects on pixel and/or regions of interest at imager level.

In further embodiments of the present invention, the simulated data are used to choose appropriate regions of interest in image space for autoexposure control and/or automatic gain control and/or autowhite balance for the at least one virtual camera based on projections of the corresponding object space.

In further embodiments of the present invention, overlapping areas are identified if at least two virtual cameras are used, wherein the at least two virtual cameras are placed at different potential camera positions. Additionally a relationship between mechanical tolerances and a resolution in image space and expected location of the object space region of interest as seen by the respective cameras is determined; if a common region of interest of two or more cameras in object space is given. Further minimum resolution requirements in the object space are translated into pixel densities in image space and corresponding optical requirements of the at least one virtual camera. Further data reflecting reliability of picking up a location of an object in object space as seen by more than one camera with sufficient accuracy and/or precision is determined.

In further embodiments of the present invention, a first virtual camera is placed at a vehicle front position, a second

virtual camera is placed at a vehicle left side position, a third virtual camera is placed at a vehicle right side position and a fourth virtual camera is placed at a vehicle rear position, wherein images of the four cameras are merged together to calculate a Bird-Eye-View of the vehicle environment. The Bird-Eye-View of the vehicle shows information regarding close vehicle environment.

The inventive method for camera mounting in a vehicle can be implemented as an entirely software embodiment, or an embodiment containing both hardware and software elements. In a preferred embodiment, the present invention is implemented in software, which includes but is not limited to firmware, resident software, microcode, etc.

All in all, embodiments of the present invention save time and money due to performing simulation during performing the method for camera mounting in a vehicle.

The core idea of the present invention is to implement a pixel-grid-projection to retrace imager pixel through a projected grid that is overlaid on the environment seen from the virtual camera. The pixel-grid-projection of each camera can then be used to optimize the field of view overlapping areas. The overlapping area information can be presented to vehicle manufacturer to optimize camera positions and to demonstrate car geometry impact.

Embodiments of the present invention allow also to see and subsequently compensate for effects of deformation between the object space and the image space, due to effects taken together, in isolation or in various combinations such as general mechanical tolerances of mounting to vehicle, lens distortion, changes in topography, changes due to the "settling tolerances" as the relative mechanical positions of mounting elements between the cameras and the ground settle over time, e.g., body settling on chassis, wing mirrors containing cam-

eras increasing tolerances over time, effect of diverse loading of vehicle, different levels of tyre pressures and/or effect of towing a load on the configuration of the cameras.

- 5 The above, as well as additional purposes, features, and advantages of the present invention will become apparent in the following detailed written description.

Brief Description of the Drawings

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A preferred embodiment of the present invention, as described in detail below, is shown in the drawings, in which

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Fig. 1 is a schematic flow diagram of a method for camera mounting in a vehicle, in accordance with an embodiment of the present invention.

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Fig. 2 is a schematic top view of a vehicle, showing fields of view of four cameras placed at four different potential camera positions.

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Fig. 3 is a schematic perspective view of a virtual camera.

Fig. 4 is a schematic Bird-Eye-View of a vehicle, shown on a display unit inside the vehicle.

Detailed Description of the Preferred Embodiments

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Referring to Fig. 1 to 3 a method for camera mounting in a vehicle 1, defines at least one potential camera position 12, 14, 16, 18 in a three dimensional computer aided design (CAD) model of the vehicle 1 during step S100. In step S200 at least one virtual camera 50 is defined by assigning optical and/or

imager sensor 54 parameters. In step S300 the defined virtual cameras 50 are placed to the at least one potential camera position 12, 14, 16, 18. During step S400 raw view image data of the at least one virtual camera 50 are calculated. The calculated raw view image data consider a distortion of a camera lens 52 and/or the camera imager 54 and/or a shape of the vehicle 1 and/or a three dimensional model of the environment of the vehicle 1. Based on the raw view image data virtual projection grid 40 is simulated during step S500, wherein at least one imager pixel 56 is retraced as projection pixel 58 through the projection grid 40 during simulation. In step S600 the virtual projected grid 40 is overlaid on a three dimensional environment of the vehicle 1 seen from the virtual camera 50 at a corresponding camera position 12, 14, 16, 18. This procedure is also called pixel-grid-projection. The pixel-grid projection of each camera 50 can be used to optimize the field of view (FoV) overlapping areas 32, 34, 36, 38. The overlapping area information can be presented to vehicle manufacturer to optimize camera positions 12, 14, 16, 18 and to demonstrate vehicle geometry impact. Based on the raw view image a Bird-Eye-View 61 of the vehicle 1 shown in Fig. 4 can also be calculated. The Bird-Eye-View 61 may be displayed by using a display unit 60 of a vision system in the vehicle 1.

The imager 54 of the camera 50 consists of a two dimensional array of pixel 56. Based on the number and size of the imager pixels 56 a virtual projected grid 40 could be simulated. The projected grid 40 will be overlaid on the environment like a thin blanket. If at least two cameras 50 are considered there will be overlapping areas 32, 34, 36, 38, where at least two cameras 50 could deliver information. In the shown embodiment four cameras 50 are used to give the driver a total view around the vehicle 1. So camera images of the front, left, right and rear camera positions 12, 14, 16, 18 are merged together to have the Bird-Eye-View 61. The Bird-Eye-View 61 is calculated from the corrected images and shows information regarding the close vehicle environment 62, 64, 66, 68. In the

shown embodiment a first object 72 is identified in the front environment 62 of the vehicle 1, represented by a optical representation 70, a second object 74 is identified in the right environment 64 of the vehicle 1, a third object 78 is identified in the rear environment 66 of the vehicle 1 and a empty space 76 is identified in the left environment 66 of the vehicle 1. In the overlapping areas 32, 34, 36, 38 a special stitch has to be made when the pictures are merged together.

Embodiments of the present invention have the advantage that

potential customer and development teams can see the implications of a camera design in term of tolerances, autoexposure control, auto-white balance, lens properties (e.g., MTF, large angle effects), overlap of more than one camera, pixel size representation on the ground and its implications for pixel mosaicing, topographic changes and their implication for the introduction of three dimensional effects, representations of three dimensional object displacements in terms of two dimensional aliases and so forth. Also, the effects of tolerance on vehicle and/or structural vignetting can be asserted also.

Furthermore, such a tolerance analysis can be used by a vision system itself in determining the relative reliability of object detection by multi camera and/or stereo camera applications.

Embodiments of the present invention also offer a weighting concept for image merging which uses such data based on comparative brightness of respective scenes.

A common problem during the design process of a vision system is determining at an early stage in the design what the impact of the position(s), orientation(s) and occlusion(s) of the camera(s) 50 will have on the performance of the vision system so that it may inform the system design. For this reason it is very useful to be able to have a simulation whereby a field of view projection of a camera 50 is projected through the CAD of surrounding objects such as the ground near the camera 50 or

object occlusions of the field of view 22, 24, 26, 28 by the camera 50.

The first step is to have a method that can perform a simulated ray projection from a region of interest on an imager 54, through the lens 52 and into object space 58 of the lens 52, i.e. the outside world, with the ray intersecting objects in the world and to be able to present this data to a user by either displaying this in a CAD image or providing data that shows that the ray intersects a specific object.

A key step then is to extend the ray projection to take into account the visible effects of the various tolerances and limitations of the camera 50 and the camera's mounting positions 12, 14, 16, 18 in the system. These include position and orientation tolerances with respect to the objects in the field of view 22, 24, 26, 28 of the corresponding camera 50 due to the mechanical mounting of the camera 50. These include also effects of occlusions of the field of view 22, 24, 26, 28 on the image of the camera 50 and how these affect the data that the vision system uses or the user sees displayed on the display unit 60. Further these include effects of flare on the cameras 50 at high angles and/or effects on pixel and/or region of interest at imager level, i.e., determining and/or displaying pixel and/or region of interest by projection the size of a region in object space corresponding to a pixel or other region of interest at the imager array in image space. This allows a limit of the pixel size to be seen and also ensures that the corresponding camera 50 will not be under designed by using insufficiently high resolution imagers, lenses or other optical elements for the application or will be over-designed by using too high resolution imagers or lenses. These include also effects of pixel mosaicing at high angles. For several video formats, pixel mosaics are used, whereby combinations of adjacent pixels are used to generate an output pixel value. This is typical in color sensors which use Bayer mo-

saicing.

In particular, it is important to be able to see in a system the effect of these projected overlapping zones 32, 34, 36, 38 when comparing the fields of view 22, 24, 26, 28 of cameras 50 for overlapping zones 32, 34, 36, 38 for image merging.

Furthermore, it allows addressing vision system issues associated with two very important camera and/or system properties, namely AEC and/or AGC (autoexposure control and/or automatic gain control) and AWB (autowhite balance).

When a camera 50 looks at the world, it has to determine what the optimal exposure and gain it should apply to the pixels 56 in order to provide a reasonable picture to the vehicle system. If it decides on too short an exposure time or too low a gain, the picture will look too dark and can lose information by clipping it out ("black-out") and if it decides on too long an exposure time or too large a gain, then the picture will be too bright and can lose information by clipping it ("white out").

Normally, a camera 50 uses automatic exposure and/or gain control to determine the best compromise based on pixels 56 from a region of interest on the pixel array of the camera imager 54. For general and inexpensive applications this region of interest is usually the complete active video pixel array of the camera imager 54. However, undesirable occlusions or objects in the field of view 22, 24, 26, 28 of the corresponding camera 50 can skew the exposure and/or gain values. For example, particularly for wide angled lenses, much of the field of view 22, 24, 26, 28 can be taken up with a black vehicle body, which may be seen by the camera 50 but not by the end user or not used by the video processing system.

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A similar problem arises for AWB, where for example the field of view 22, 24, 26, 28 of the camera 50 but not necessarily in

the field of view 62, 64, 66, 68 of the user may contain a considerable part of the vehicle body that is red, thereby compensating for this by making the world bluer or greener than it should be. So it would be very useful to be able to

5 use the projection method to see what areas of object space correspond to arbitrary regions of interest in the image space and vice-versa in order to choose an appropriate region of interest in image space, i.e., an appropriate pixel array region of interest for AEC and/or AGC and AWB based on projections

10 from object space, in terms of what objects are included or excluded in the object space view field, deduce an object space field of view corresponding to an image space region of interest, comparing the behavior of different image space and object space regions of interest in terms of their susceptibility to being skewed by objects. This can be done by looking

15 at the different relative content of R(ed), G(reen) and B(lue) in different regions of interest. This can be quite broad, as these regions of interest can include the vehicle body, the sky, or areas of a scene visible to a customer or back end vision system, but not of interest to them. The projection method may also be used to select a zone for color reference, an

20 example of which is "white patch" white balance algorithms.

By extension, it will be possible to extend this region of interest information to an underlying vision system so that it

25 can use it for image processing functions such as BSDF for further possible processing. It will also allow a developer of a backend system to predict where an object of interest might be in a video data stream so that they can perform backend

30 video stream mapping and algorithmic optimization without requiring the front-end camera system on the vehicle existing. Furthermore, when this concept is extended to more than one camera 50, further possibilities are open up. For example,

given a common region of interest of two or more cameras 50 in

35 object space, the relationship between mechanical tolerances and the resolution in image space and expected location of the object space region of interest as seen by the respective cam-

eras 50 can be determined. This allows the system to go between the properties of a camera set and the corresponding resolution of the image presented by a vision system to a user. So minimum resolution requirements in object space may be translated into pixel densities in image space and/or in corresponding optical requirements.

This allows also determining data which reflects the reliability of picking up the location of an object in object space

with sufficient accuracy and precision as seen by more than one camera 50, so that this information can be used to efficiently do overlapping in overlapping zones 32, 34, 36, 38 between more than one camera 50. Furthermore, such a tolerance analysis can be used by a vision system itself in determining the relative reliability of object detection by multi-camera and/or stereo camera applications.

Embodiments of the present invention allow to see and subsequently compensate for effects of deformation between the object space and the image space, due to following effects taken together, in isolation or in various combinations such as general mechanical tolerances of mounting to vehicle, lens distortion, changes in topography, changes due to the "settling tolerances" as the relative mechanical positions of mounting elements between the cameras and the ground settle over time, e.g., body settling on chassis, wing mirrors containing cameras increasing tolerances over time, effect of diverse loading of vehicle, different levels of tyre pressures and/or effect of towing a load on the configuration of the cameras 50.

The inventive method for camera mounting in a vehicle can be implemented as an entirely software embodiment, or an embodiment containing both hardware and software elements. In a preferred embodiment, the present invention is implemented in software, which includes but is not limited to firmware, resident software, microcode, etc.

Furthermore, the present invention can take the form of a computer program product accessible from a computer-usable or computer-readable medium providing program code for use by or in connection with a computer or any instruction execution system. For the purposes of this description, a computer-usable or computer-readable medium can be any apparatus that can contain, store, communicate, propagate, or transport the program for use by or in connection with the instruction execution system, apparatus, or device.

The medium can be an electronic, magnetic, optical, electro-magnetic, infrared, or semiconductor system (or apparatus or device) or a propagation medium. Examples of a computer-readable medium include a semiconductor or solid state memory, magnetic tape, a removable computer diskette, a random access memory (RAM), a read-only memory (ROM), a rigid magnetic disk, and an optical disk. Current examples of optical disks include compact disk - read only memory (CD-ROM), compact disk - read/write (CD-R/W), and DVD. A data processing system suitable for storing and/or executing program code will include at least one processor coupled directly or indirectly to memory elements through a system bus. The memory elements can include local memory employed during actual execution of the program code, bulk storage, and cache memories which provide temporary storage of at least some program code in order to reduce the number of times code must be retrieved from bulk storage during execution. Input/output or I/O devices (including but not limited to keyboards, displays, pointing devices, etc.) can be coupled to the system either directly or through intervening I/O controllers.

Network adapters may also be coupled to the system to enable the data processing system to become coupled to other data processing systems or remote printers or storage devices through intervening private or public networks. Modems, cable modems, and Ethernet cards are just a few of the currently available types of network adapters.

Claims

What is claimed is:

1. A method for camera mounting in a vehicle, comprising the
5 steps:
defining at least one potential camera position (12, 14, 16, 18) in a three dimensional computer aided design (CAD) model of said vehicle (1);
defining at least one virtual camera (50) by assigning
10 optical and/or imager sensor (54) parameters;
placing said defined virtual camera (50) to said at least one potential camera position (12, 14, 16, 18);
calculating raw view image data of said at least one virtual camera (50);
15 simulating a virtual projection grid (40) based on said raw view image data, wherein at least one imager pixel (56) is retraced as projection pixel (58) through said projection grid (40) during simulation; and
overlaying said virtual projected grid (40) on a three
20 dimensional environment of said vehicle (1) seen from said virtual camera (50) at a corresponding camera position (12, 14, 16, 18).
2. The method according to claim 1, wherein during simulation
25 a simulated ray from at least one pixel (56) on said camera imager (54) is projected through said camera lens (52) into at least one object space (58) of said camera lens (52).
3. The method according to claim 1 or 2, wherein during simulation
30 a simulated ray from a region of interest on said camera imager (54) comprising a certain number of

pixels (56) is projected through said camera lens (52) into said object space (58) of said camera lens (52).

4. The method, according to one of the preceding claims 1 to 3, wherein said calculated raw view image data consider a distortion of said camera lens (52) and/or said camera imager (54) and/or a shape of said vehicle (1) and/or a three dimensional model of said environment of said vehicle (1).
5. The method according to one of the preceding claims 1 to 4, wherein said simulated data are presented to a user by using a CAD image of said vehicle (1) including said object space (58) of said camera lens (52) of said at least one virtual camera (50) and/ or to a post-processing step for further analysis or computation.
6. The method according to one of the preceding claims 1 to 5, wherein said projected grid representing at least one pixel of a field of view of said virtual camera (50) is projected through said CAD of surrounding objects of said vehicle (1).
7. The method according to one of the preceding claims 1 to 6, wherein during simulation of said virtual projected grid (40) visible effects of various tolerances and/or limitations of said at least one virtual camera (50) and/or said at least one potential camera position (12, 14, 16, 18) are considered.
8. The method according to claim 7, wherein said various tolerances and/or limitations comprise position and/or orientation tolerances with respect to objects in said field of view of said camera (50) due to mechanical mounting of said camera (50).

9. The method according to claim 7 or 8, wherein said various tolerances and/or limitations comprise effects of occlusions of said field of view on said camera imager (54) and/or effects on pixel and/or regions of interest at imager level.
10. The method according to one of the preceding claims 1 to 9, wherein said simulated data are used to choose appropriate regions of interest in image space for autoexposure control and/or automatic gain control and/or auto-white balance for said at least one virtual camera (50) based on projections of said corresponding object space.
11. The method according to one of the preceding claims 1 to 10, wherein overlapping areas (32, 34, 36, 38) are identified if at least two virtual cameras (50) are used, wherein said at least two virtual cameras (50) are placed at different potential camera positions (12, 14, 16, 18).
12. The method according to claim 11, wherein a relationship between mechanical tolerances and a resolution in image space and expected location of said object space region of interest as seen by said respective cameras (50) is determined, if a common region of interest of two or more cameras (50) in object space is given.
13. The method according to claim 11 or 12, wherein minimum resolution requirements in said object space are translated into pixel densities in image space and corresponding optical requirements of said at least one virtual camera (50).
14. The method according to one of the preceding claims 11 to 13, wherein data reflecting reliability of picking up a location of an object in object space as seen by more than one camera (50) with sufficient accuracy and/or precision are determined.

15. The method according to one of the preceding claims 1 to 14, wherein a first virtual camera (50) is placed at a vehicle front position (12), a second virtual camera (50) is placed at a vehicle left side position (14), a third virtual camera (50) is placed at a vehicle right side position (16) and a fourth virtual camera (50) is placed at a vehicle rear position (18), wherein images of said four cameras (50) are merged together to calculate a Bird-Eye-View (61) of said vehicle environment.
16. A data processing program for execution in a data processing system comprising software code portions for performing a method for camera mounting in a vehicle according to one of the preceding claims 1 to 15 when said program is run on said data processing system.
17. A computer program product stored on a computer-usable medium, comprising computer-readable program means for causing a computer to perform a method for camera mounting in a vehicle according to one of the preceding claims 1 to 15 when said program is run on said computer.

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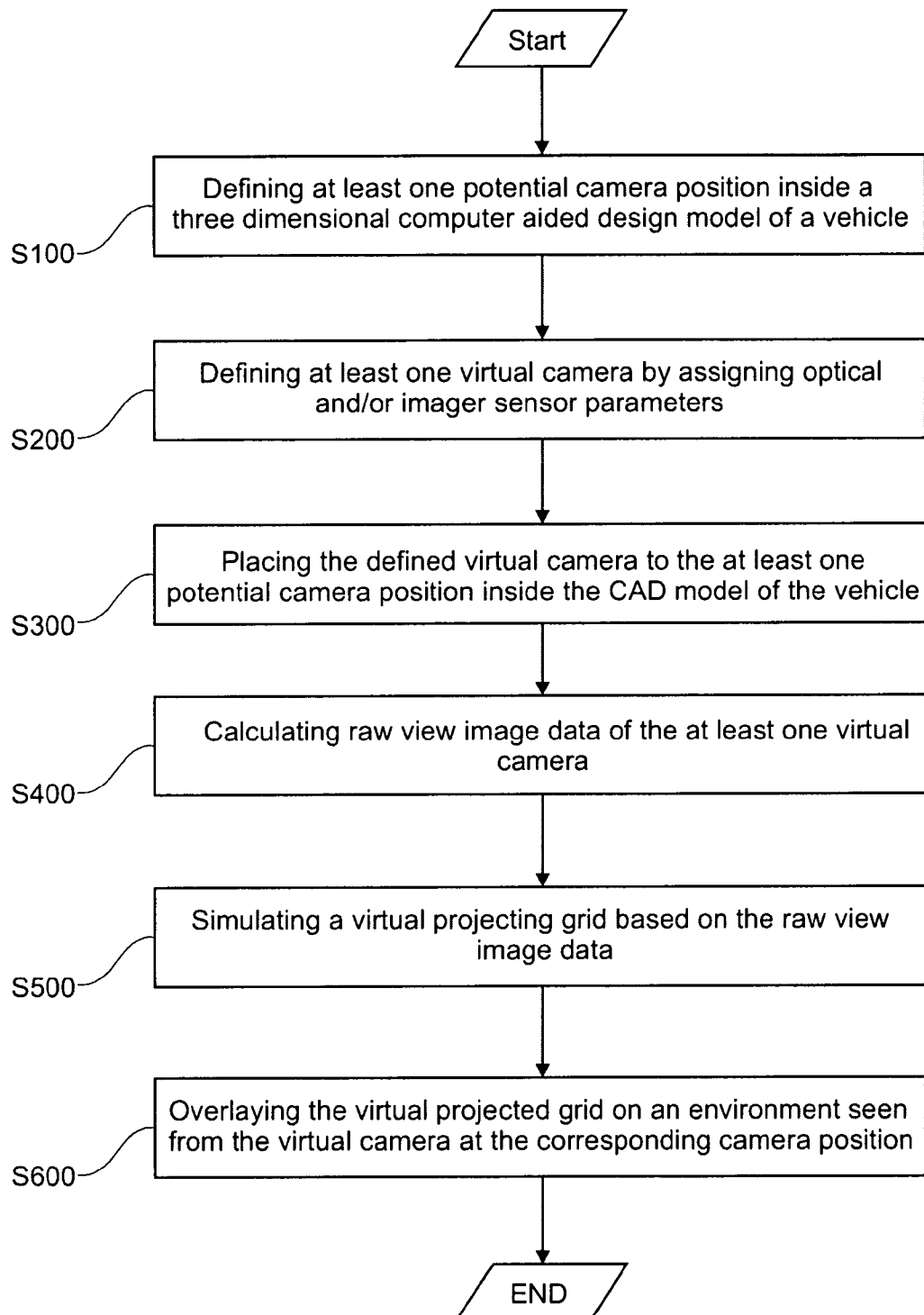


Fig. 1

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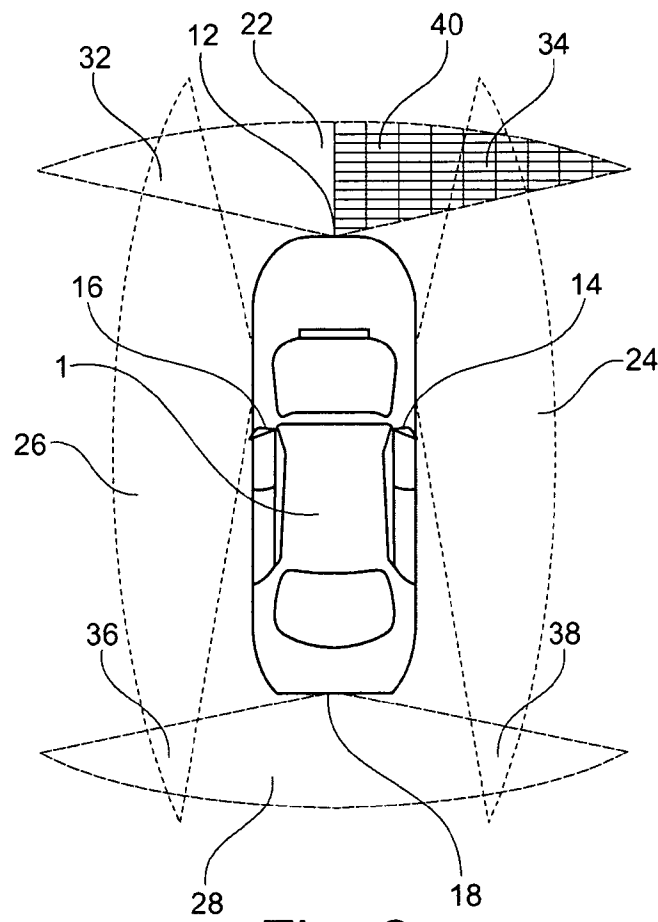


Fig. 2

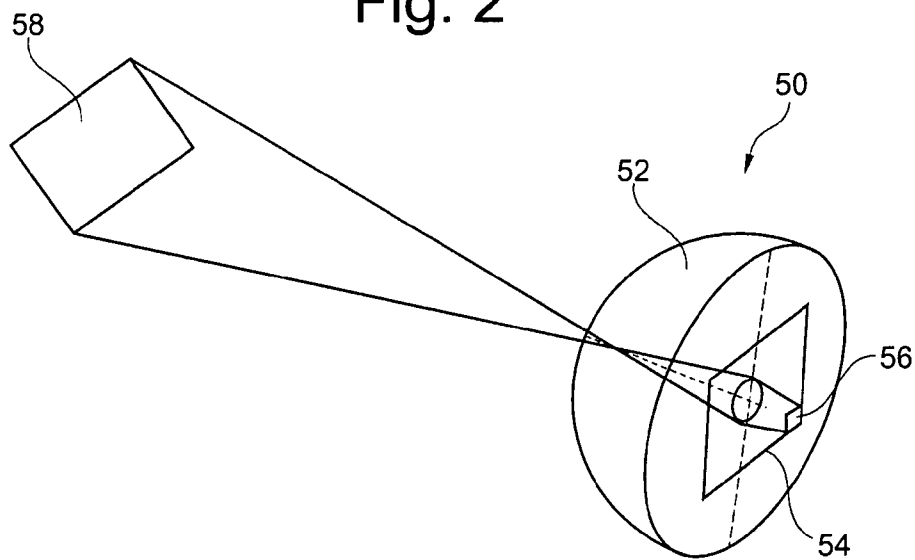


Fig. 3

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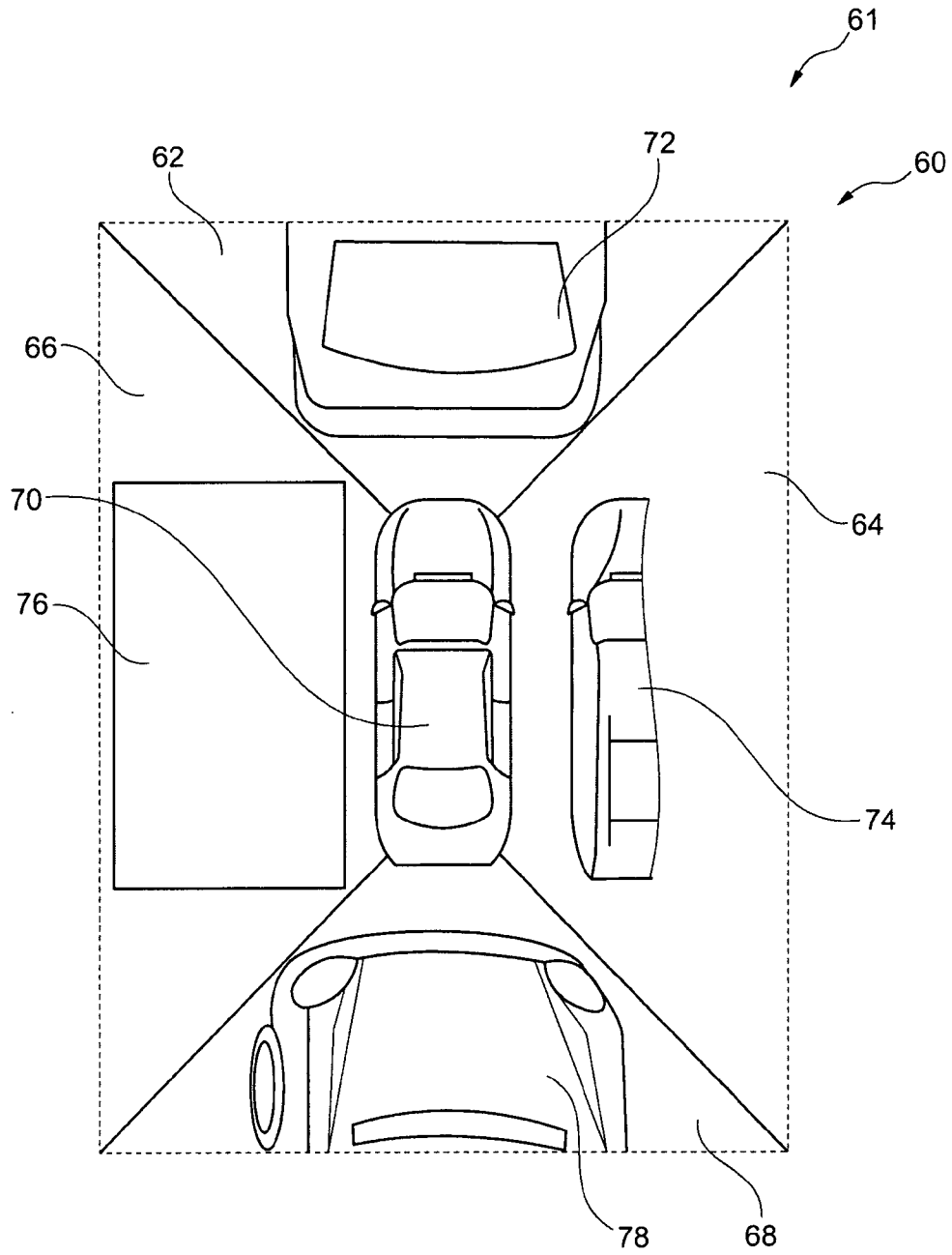


Fig. 4

INTERNATIONAL SEARCH REPORT

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A. CLASSIFICATION OF SUBJECT MATTER

INV. G06T15/20 G06T19/00 B60R11/04
ADD. G03B37/04 G06T3/00 G06T5/00

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 B60R G03B

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, EMBASE, INSPEC, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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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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"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed

"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
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"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.
"&" document member of the same patent family

Date of the actual completion of the international search

2 August 2011

Date of mailing of the international search report

10/08/2011

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Authorized officer

Gauthier, J

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International application No

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International application No
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International application No

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A	RACZKOWSKY J ET AL: "SIMULATION OF CAMERAS IN ROBOT APPLICATIONS", IEEE COMPUTER GRAPHICS AND APPLICATIONS, IEEE SERVICE CENTER, NEW YORK, NY, US, vol. 9, no. 1, 1 January 1989 (1989-01-01), pages 16-25, XP000115878, ISSN: 0272-1716, DOI: DOI:10.1109/38.20330 page 16, left-hand column, line 1 - right-hand column, line 7 page 16, right-hand column, line 1, paragraph Modeling - page 17, left-hand column, line 16 page 19, left-hand column, line 1, paragraph Camera Model - line 25 page 20, right-hand column, line 1, paragraph Hidden-surface projection - line 24 page 22, left-hand column, line 1, paragraph - page 23, left-hand column, last line figures 4-6,10,11 -----	1-17
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