US 20170223306A1

(19) United States
(12) Patent Application Publication (10) Pub. No.: US 2017/0223306 A1
Lu et al. (43) Pub. Date: Aug. 3, 2017

(54) **VEHICLE VISION SYSTEM WITH SMART CAMERA VIDEO OUTPUT**

(71) Applicant: **MAGNA ELECTRONICS INC.,** Auburn Hills, MI (US)

(72) Inventors: **Yuesheng Lu**, Farmington Hills, MI (US); **Vivek Vaid**, South Lyon, MI (US); **Patrick A. Miller**, Grand Blanc, MI (US)

(21) Appl. No.: **15/421,483**

(22) Filed: **Feb. 1, 2017**
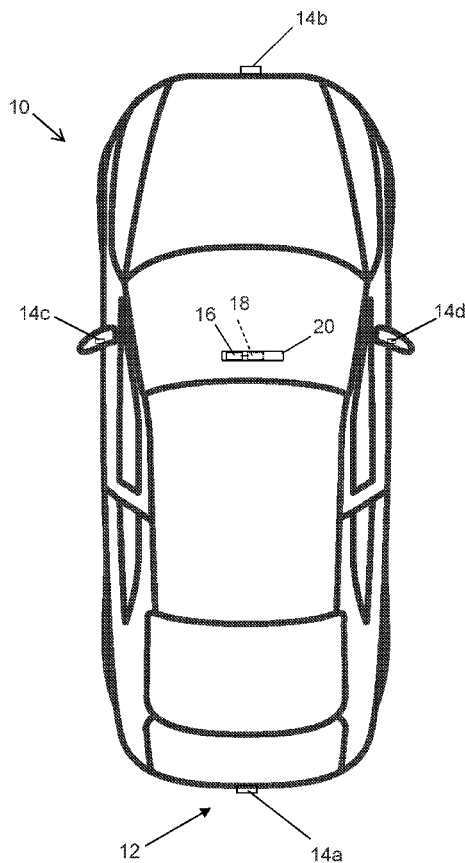
Related U.S. Application Data

(60) Provisional application No. 62/290,168, filed on Feb. 2, 2016.

Publication Classification

(51) **Int. Cl.**

H04N 7/01	(2006.01)
H04N 5/232	(2006.01)
H04N 5/262	(2006.01)
B60K 35/00	(2006.01)
H04N 9/64	(2006.01)
G06K 9/00	(2006.01)
B60R 1/00	(2006.01)
H04N 7/18	(2006.01)
H04N 9/09	(2006.01)

(52) **U.S. Cl.**
CPC *H04N 7/01* (2013.01); *H04N 7/181* (2013.01); *H04N 5/23293* (2013.01); *H04N 5/262* (2013.01); *H04N 9/09* (2013.01); *H04N 9/646* (2013.01); *G06K 9/00711* (2013.01); *G06K 9/00791* (2013.01); *B60R 1/00* (2013.01); *B60K 35/00* (2013.01); *B60R 2300/80* (2013.01); *B60R 2300/30* (2013.01); *B60R 2300/105* (2013.01); *B60R 2300/8066* (2013.01); *B60R 2300/804* (2013.01); *B60K 2350/2013* (2013.01); *B60Q 1/04* (2013.01)

(57) **ABSTRACT**

A vision system for a vehicle includes at least one camera disposed at a vehicle and having an image sensor operable to capture image data. A display is operable to display video images for viewing by a driver of the vehicle during normal operation of the vehicle. A first system on chip (SoC) receives captured image data and processes the received captured image data for machine vision. The first SoC, responsive to image processing of the received captured image data, generates an output for a driver assistance system of the vehicle. A second system on chip (SoC) receives captured image data and communicates the image data to the display.
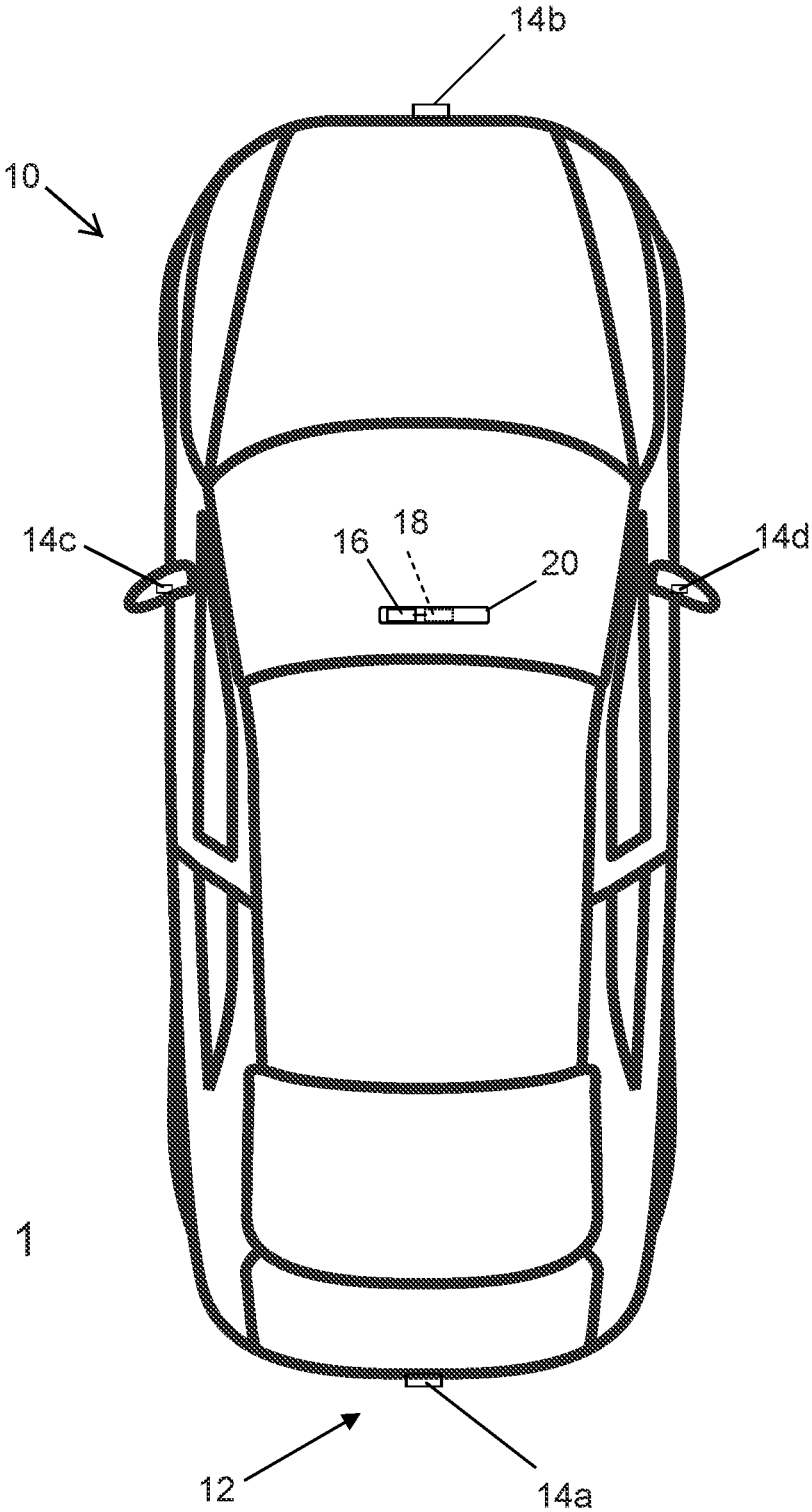
14b

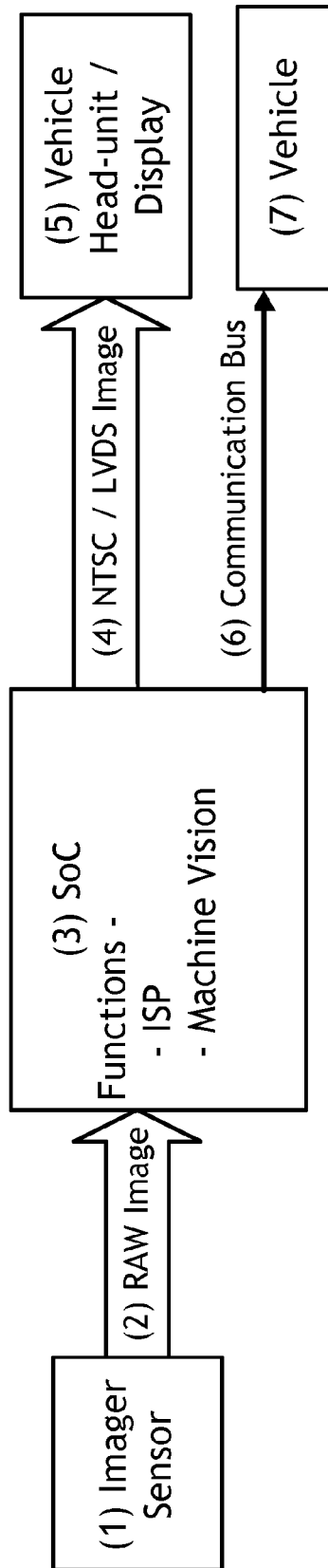10

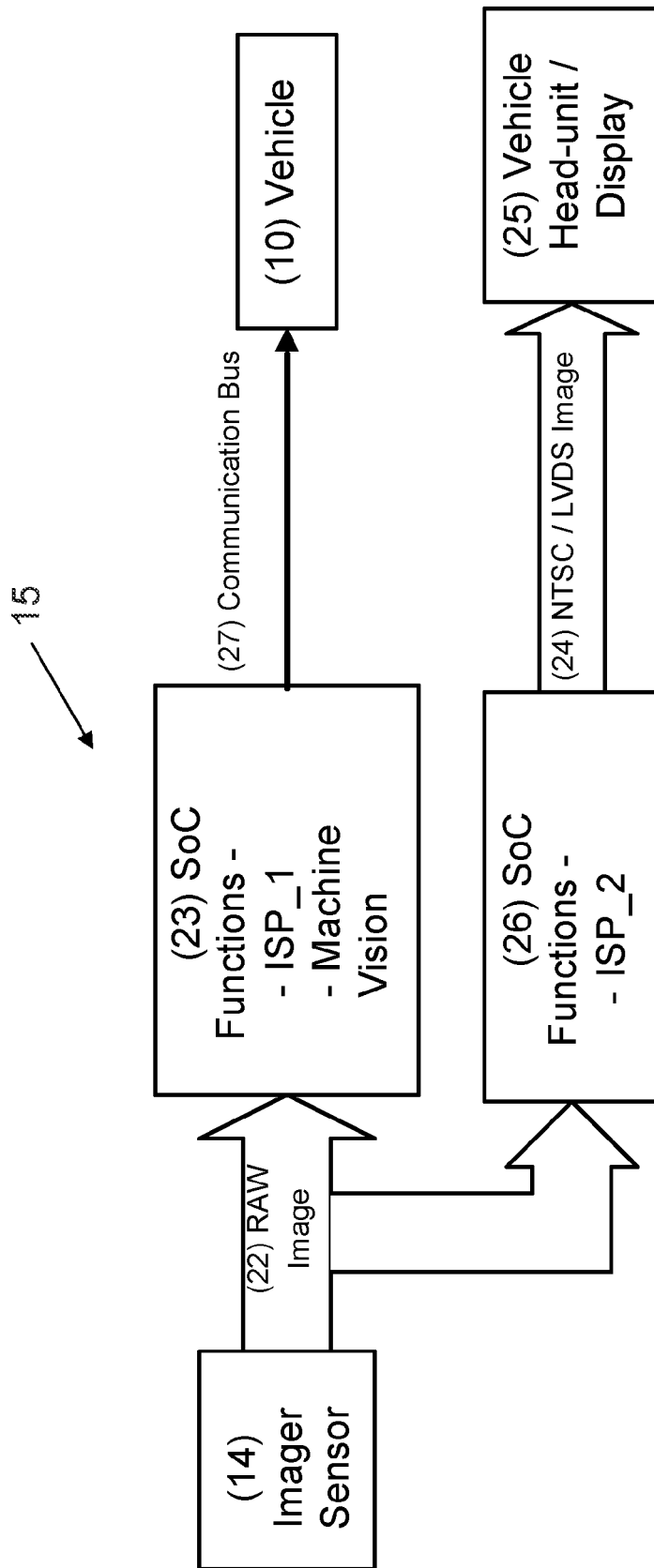16 18 20

14c

14d

FIG. 1

12

14a

(5) Vehicle Head-unit / Display

(7) Vehicle

(4) NTSC / LVDS Image

(6) Communication Bus

(3) SoC
Functions -
- ISP
- Machine Vision

(2) RAW Image

(1) Imager Sensor

FIG. 2

FIG. 3

VEHICLE VISION SYSTEM WITH SMART CAMERA VIDEO OUTPUT

CROSS REFERENCE TO RELATED APPLICATION

[0001]   The present application claims the filing benefits of U.S. provisional application Ser. No. 62/290,168, filed Feb. 2, 2016, which is hereby incorporated herein by reference in its entirety.

FIELD OF THE INVENTION

[0002]   The present invention relates generally to a vehicle vision system for a vehicle and, more particularly, to a vehicle vision system that utilizes one or more cameras.

BACKGROUND OF THE INVENTION

[0003]   Use of imaging sensors in vehicle imaging systems is common and known. Examples of such known systems are described in U.S. Pat. Nos. 5,949,331; 5,670,935 and/or 5,550,677, which are hereby incorporated herein by reference in their entireties.

SUMMARY OF THE INVENTION

[0004]   The present invention provides a driver assistance system or vision system or imaging system for a vehicle that utilizes one or more cameras to capture image data representative of images exterior of the vehicle. The camera includes a first chip having a processor that receives captured image data (such as captured by an imager or imaging sensor of the camera) and processes the received captured image data for machine vision, wherein, responsive to image processing of the received captured image data, the first chip or processor generates an output for a driver assistance system of the vehicle. The camera includes a second chip or processor that receives the captured image data and that communicates video images to a display for viewing by the driver of the vehicle during normal operation of the vehicle.

[0005]   The present invention thus provides a smart camera that can quickly (upon initial vehicle start up) provide video images for display to the driver of the vehicle, without having to wait for the machine vision processor to warm up and process the image data captured by the camera. The smart camera provides an output responsive to image processing of the captured image data for a vehicle driver assistance system, and also provides an output for displaying video images at a display of the vehicle.

[0006]   These and other objects, advantages, purposes and features of the present invention will become apparent upon review of the following specification in conjunction with the drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

[0007]   FIG. 1 is a plan view of a vehicle with a vision system that incorporates cameras in accordance with the present invention;

[0008]   FIG. 2 is a block diagram of a known vision system; and

[0009]   FIG. 3 is a block diagram of the vision system of the present invention.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0010]   A vehicle vision system and/or driver assist system and/or object detection system and/or alert system operates to capture images exterior of the vehicle and may process the captured image data to display images and to detect objects at or near the vehicle and in the predicted path of the vehicle, such as to assist a driver of the vehicle in maneuvering the vehicle in a rearward direction. The vision system includes an image processor or image processing system that is operable to receive image data from one or more cameras and provide an output to a display device for displaying images representative of the captured image data. Optionally, the vision system may provide display, such as a rearview display or a top down or bird's eye or surround view display or the like.

[0011]   Referring now to the drawings and the illustrative embodiments depicted therein, a vehicle 10 includes an imaging system or vision system 12 that includes at least one exterior facing imaging sensor or camera, such as a rearward facing imaging sensor or camera 14a (and the system may optionally include multiple exterior facing imaging sensors or cameras, such as a forwardly facing camera 14b at the front (or at the windshield) of the vehicle, and a sidewardly/rearwardly facing camera 14c, 14d at respective sides of the vehicle), which captures images exterior of the vehicle, with the camera having a lens for focusing images at or onto an imaging array or imaging plane or imager of the camera (FIG. 1). Optionally, a forward viewing camera may be disposed at the windshield of the vehicle and view through the windshield and forward of the vehicle, such as for a machine vision system (such as for traffic sign recognition, headlamp control, pedestrian detection, collision avoidance, lane marker detection and/or the like). The vision system 12 includes a control or electronic control unit (ECU) or processor 18 that is operable to process image data captured by the camera or cameras and may detect objects or the like and/or provide displayed images at a display device 16 for viewing by the driver of the vehicle (although shown in FIG. 1 as being part of or incorporated in or at an interior rearview mirror assembly 20 of the vehicle, the control and/or the display device may be disposed elsewhere at or in the vehicle). The data transfer or signal communication from the camera to the ECU may comprise any suitable data or communication link, such as a vehicle network bus or the like of the equipped vehicle.

[0012]   The present invention provides a vision system that has a reduced video start-up time for smart camera applications. The system creates a high reliability video pipeline independent of a machine vision pipeline. Since video is considered a fundamental feature to be provided by a vehicle camera, the independence from complex software associated with machine vision and image processing creates inherent reliability for the video pipeline. The increased reliability in hardware allows for an enhanced safety critical system design. The present invention also improves the quality of the machine vision algorithm by avoiding the digital image manipulation that is applied to enhance human perception in a viewing application.

[0013]   The image sensor of a vision system captures image data to create an image of the environment, and outputs the captured image data (such as shown in FIG. 2). The image format could be many of the known formats (such as, for example, Bayer, RGB, YUV and/or the like).

The system on chip (SoC) is responsible for machine vision. The SoC includes an ISP block (shown as ISP) to convert the raw image into a format suitable for machine vision algorithms as well as for display.

[0014] FIG. 2 shows the common implementation block diagram of a camera for a vehicle vision system. The input image, image processing (including both for viewing and for machine vision), and output image are in series. The drawback of such system is that there is a delay in video startup for the vehicle driver due to delay caused by software boot-up and initialization of the system on chip (SoC) 3. The SoC software is complicated and lengthy and thus the boot-time is long, however the vehicle driver expects the video from the vehicle camera 1 to be viewable (such as at a display 5) as soon as the vehicle 7 is switched on. There is a NHSTA requirement for video start-up time as well in FMVSS 111.

[0015] The output of the system on chip 3 includes the results of machine vision algorithms and status information for the vehicle (such as, for example, objects detected, location of pedestrians detected and any warnings) on a communication bus 6. The communication bus 6 may be any physical layer common in automotive industry (such as, for example, a CAN bus, LIN bus, Ethernet, I2C encoded on LVDS and/or the like).

[0016] The SoC 3 is also responsible for video output to vehicle display. It includes the ISP block which converts the raw video 2 to an output format suitable for display. This output to the display could be either NTSC or LVDS 4 or any other video format which can be sent to vehicle display.

[0017] For better human perception of displayed images, the system may apply digital sharpening, higher contrast and more saturated color in image signal processing (ISP) of captured image data for generating video images for the display. However, these changes sometimes pose challenges to machine vision algorithms that process the changed image data.

[0018] As shown in FIG. 3, the system and smart camera of the present invention provides two chips 23, 26 for a smart camera 15 of an advanced driver assistance system (ADAS). The image sensor 14 captures image data and creates an image of the environment, and outputs it in an image format 22. The image format 22 may comprise any known formats (such as, for example, Bayer, RGB, YUV and/or the like). The first system on chip (SoC) 23 is responsible for machine vision and includes an independent ISP block (shown as ISP_1) to convert the image data into format suitable for machine vision algorithms (where the first SoC may perform further processing for machine vision systems or may communicate the converted image data to an image processor of a driver assistance system that processes the communicated converted image data (such as for object detection or lane marker detection or traffic sign recognition or the like). The second SoC 26 communicates the unconverted image data for display by the display screen for viewing by the driver of the vehicle.

[0019] The output 27 of the first SoC 23 includes the results of machine vision algorithms and status information for the vehicle (such as, for example, objects detected, location of pedestrians detected and any warnings).

[0020] The second SoC 26 is responsible for video output 24 to the vehicle display 25. The SoC 26 includes an ISP block (shown as ISP_2) tailored to convert raw video 22 to an output format suitable for display. The output of the

second SoC 26 may comprise NTSC video or LVDS or any format which can be sent to vehicle display. Because the output of the second SoC is based on image data that is not processed for machine vision (by the first SoC 23), the second SoC may also apply digital sharpening, higher contrast and/or more saturated color in the image signal processing (ISP) of the captured image data for generating enhanced video images for the display.

[0021] The image format (in its as-captured format) for the image data communicated by the second SoC is uncompressed data directly output from the imager's array (such as a color Bayer pixelated array or the like) and may be any suitable format. The first SoC is responsible for machine vision (which processes converted data), while the second SoC communicates unprocessed image data (that may be converted to color space such as via, for example, RGB, YUV and/or the like) to the display system for display of video images. Both processors may be disposed at or may be part of the camera or may be remote from the camera, such as at a control of the vehicle or system.

[0022] Thus, the present invention provides two processors or chips that receive the raw image data captured by the imaging sensor or imaging array or imager of the camera, with one processor converting and/or processing the image data for machine vision functions (such as object detection or the like) and communicating an output to one or more vehicle systems (such as a backup assist system or adaptive cruise control system or headlamp control system or lane departure warning system or the like), and with the other processor providing video images for display at a display unit of the vehicle. Thus, the system and camera of the present invention provides for rapid display of video images when the vehicle is first turned on (such as when the ignition is initially turned to on or start), since the video images are not processed by the machine vision processor (which may still be warming up after video images are being displayed on the display screen). The present invention provides enhanced early display of video images, which is important at the onset of a reversing maneuver, so the driver can quickly see the displayed video images without having to wait for processing algorithms to "wake up" and start processing the raw image data to detect objects or the like.

[0023] The cameras may comprise any suitable camera or sensor. Optionally, the camera may comprise a "smart camera" that includes the imaging sensor array and associated circuitry and image processing circuitry and electrical connectors and the like as part of a camera module, such as by utilizing aspects of the vision systems described in International Publication Nos. WO 2013/081984 and/or WO 2013/081985, which are hereby incorporated herein by reference in their entireties.

[0024] The system includes an image processor operable to process image data captured by the camera or cameras, such as for detecting objects or other vehicles or pedestrians or the like in the field of view of one or more of the cameras. For example, the image processor (SoC 23) may comprise an image processing chip selected from the EyeQ family of image processing chips available from Mobileye Vision Technologies Ltd. of Jerusalem, Israel, and may include object detection software (such as the types described in U.S. Pat. Nos. 7,855,755; 7,720,580 and/or 7,038,577, which are hereby incorporated herein by reference in their entireties), and may analyze image data to detect vehicles and/or other objects. Responsive to such image processing,

and when an object or other vehicle is detected, the system may generate an alert to the driver of the vehicle and/or may generate an overlay at the displayed image to highlight or enhance display of the detected object or vehicle, in order to enhance the driver's awareness of the detected object or vehicle or hazardous condition during a driving maneuver of the equipped vehicle.

[0025] The vehicle may include any type of sensor or sensors, such as imaging sensors or radar sensors or lidar sensors or ladar sensors or ultrasonic sensors or the like. The imaging sensor or camera may capture image data for image processing and may comprise any suitable camera or sensing device, such as, for example, a two dimensional array of a plurality of photosensor elements arranged in at least 640 columns and 480 rows (at least a 640×480 imaging array, such as a megapixel imaging array or the like), with a respective lens focusing images onto respective portions of the array. The photosensor array may comprise a plurality of photosensor elements arranged in a photosensor array having rows and columns. Preferably, the imaging array has at least 300,000 photosensor elements or pixels, more preferably at least 500,000 photosensor elements or pixels and more preferably at least 1 million photosensor elements or pixels. The imaging array may capture color image data, such as via spectral filtering at the array, such as via an RGB (red, green and blue) filter or via a red/red complement filter or such as via an RCC (red, clear, clear) filter or the like. The logic and control circuit of the imaging sensor may function in any known manner, and the image processing and algorithmic processing may comprise any suitable means for processing the images and/or image data.

[0026] For example, the vision system and/or processing and/or camera and/or circuitry may utilize aspects described in U.S. Pat. Nos. 8,694,224; 7,005,974; 5,760,962; 5,877, 897; 5,796,094; 5,949,331; 6,302,545; 6,396,397; 6,498, 620; 6,523,964; 6,611,202; 6,201,642; 6,690,268; 6,717, 610; 6,757,109; 6,802,617; 6,806,452; 6,822,563; 6,891,563 6,946,978; 7,859,565; 5,550,677; 5,670,935; 7,881,496; 7,720,580; 7,038,577; 6,882,287; 5,929,786 and/or 5,786, 772, which are all hereby incorporated herein by reference in their entireties. The system may communicate with other communication systems via any suitable means, such as by utilizing aspects of the systems described in International Publication Nos. WO 2010/144900; WO 2013/043661 and/ or WO 2013/081985, and/or U.S. Publication No. US-2012-0062743, which are hereby incorporated herein by reference in their entireties.

[0027] Optionally, the vision system may include a display for displaying images captured by one or more of the imaging sensors for viewing by the driver of the vehicle while the driver is normally operating the vehicle. Optionally, for example, the vision system may include a video display device disposed at or in the interior rearview mirror assembly of the vehicle, such as by utilizing aspects of the video mirror display systems described in U.S. Pat. Nos. 5,530,240; 6,329,925; 7,855,755; 7,626,749; 7,581,859; 7,446,650; 7,370,983; 7,338,177; 7,274,501; 7,255,451; 7,195,381; 7,184,190; 5,668,663; 5,724,187 and/or 6,690, 268, and/or U.S. Publication Nos. US-2006-0061008; US-2006-0050018, and/or US-2012-0162427, which are hereby incorporated herein by reference in their entireties. The display may utilize aspects of the display systems described in U.S. Pat. Nos. 8,427,751 and/or U.S. Publication Nos. US-2014-0333729; US-2014-0139676; US-2015-

0092042; US-2015-0232030 and/or US-2016-0209647, which are all hereby incorporated herein by reference in their entireties. Optionally, the vision system (utilizing the forward facing camera and a rearward facing camera and other cameras disposed at the vehicle with exterior fields of view) may be part of or may provide a display of a top-down view or birds-eye view system of the vehicle or a surround view at the vehicle, such as by utilizing aspects of the vision systems described in International Publication Nos. WO 2010/099416; WO 2011/028686; WO 2012/075250; WO 2013/019795; WO 2012/075250; WO 2012/145822; WO 2013/081985; WO 2013/086249 and/or WO 2013/109869, and/or U.S. Publication No. US-2012-0162427, which are hereby incorporated herein by reference in their entireties.

[0028] Changes and modifications in the specifically described embodiments can be carried out without departing from the principles of the invention, which is intended to be limited only by the scope of the appended claims, as interpreted according to the principles of patent law including the doctrine of equivalents.

1. A vision system for a vehicle, said vision system comprising:
   a camera disposed at a vehicle and having a field of view exterior the vehicle, said camera comprising an image sensor, wherein said camera is operable to capture image data;
   a display disposed in the vehicle and operable to display video images for viewing by a driver of the vehicle during operation of the vehicle;
   a first system on a chip (SoC) that includes an image signal processor that receives image data captured by said camera and converts the received image data to a format suitable for machine vision processing;
   wherein said first SoC processes converted image data and, responsive to processing of the converted image data, generates an output for a driver assistance system of the vehicle;
   a second system on a chip (SoC) that receives image data captured by said camera and communicates unconverted image data to said display; and
   wherein said display displays images derived from the unconverted image data received from said second SoC.

2. The vision system of claim 1, wherein said second SoC, responsive to receiving captured image data, communicates video images in a raw image format to said display.

3. The vision system of claim 2, wherein said second SoC communicates video images in the raw image format upon initial startup of the vehicle and said camera.

4. The vision system of claim 3, wherein said second SoC is able to communicate video images upon initial startup of the vehicle and said camera while said first SoC is warming up and not yet able to process the converted image data.

5. The vision system of claim 1, wherein said second SoC, responsive to receiving captured image data, communicates the image data upon initial startup of the vehicle and said camera.

6. The vision system of claim 1, wherein said second SoC converts raw video image data to an output format suitable for display and communicates the output to said display.

7. The vision system of claim 1, wherein video images communicated by said second SoC are based on captured image data that is not processed by said first SoC.

4

8. The vision system of claim **7**, wherein said second SoC applies digital sharpening, enhanced contrast and enhanced saturated color to the captured image data for generating enhanced video images for said display.

9. The vision system of claim **1**, wherein the output of said first SoC is communicated to the driver assistance system via a communication bus of the vehicle.

10. The vision system of claim **1**, wherein the image data communicated by said second SoC is communicated to said display via a communication bus of the vehicle.

11. The vision system of claim **1**, wherein the driver assistance system comprises at least one of a backup assist system, an adaptive cruise control system, a headlamp control system and a lane departure warning system.

12. The vision system of claim **1**, wherein said at least one camera comprises a plurality of cameras disposed at the vehicle.

13. The vision system of claim **1**, wherein said camera comprises a smart camera module comprising said image sensor, said first SoC and said second SoC.

14. The vision system of claim **13**, wherein the output of said first SoC is communicated to the driver assistance system via a communication bus of the vehicle.

15. The vision system of claim **13**, wherein said second SoC communicates video images to said display via a communication bus of the vehicle.

16. A vision system for a vehicle, said vision system comprising:

a camera disposed at a vehicle and having a field of view exterior the vehicle, said camera comprising an image sensor, wherein said camera is operable to capture image data;

a display disposed in the vehicle and operable to display video images for viewing by a driver of the vehicle during operation of the vehicle;

wherein said camera comprises a first system on a chip (SoC) that includes an image signal processor that converts image data captured by said camera to a format suitable for machine vision processing;

wherein said first SoC processes converted image data and, responsive to processing of the converted image data, generates an output for a driver assistance system of the vehicle;

wherein said camera comprises a second system on a chip (SoC) that communicates unconverted image data captured by said camera to said display;

wherein said display displays images derived from the unconverted image data received from said second SoC; and

wherein video images communicated by said second SoC are based on captured image data that is not processed by said first SoC.

17. The vision system of claim **16**, wherein said second SoC communicates video images in a raw image format upon initial startup of the vehicle and said camera.

18. The vision system of claim **17**, wherein said second SoC is able to communicate video images upon initial startup of the vehicle and said camera while said first SoC is warming up and not yet able to process the converted image data.

19. A vision system for a vehicle, said vision system comprising:

a camera disposed at a vehicle and having a field of view exterior the vehicle, said camera comprising an image sensor, wherein said camera is operable to capture image data;

a display disposed in the vehicle and operable to display video images for viewing by a driver of the vehicle during operation of the vehicle;

wherein said camera comprises a first system on a chip (SoC) that includes an image signal processor that converts image data captured by said camera to a format suitable for machine vision processing;

wherein said first SoC processes converted image data and, responsive to processing of the converted image data, generates an output for a driver assistance system of the vehicle;

wherein the output of said first SoC is communicated to the driver assistance system via a communication bus of the vehicle;

wherein said camera comprises a second system on a chip (SoC) that, responsive to said camera capturing image data, communicates video images in a raw image format to said display;

wherein said second SoC communicates video images in the raw image format upon initial startup of the vehicle and said camera;

wherein the image data communicated by said second SoC is communicated to said display via the communication bus of the vehicle; and

wherein said display displays images derived from the communicated video images received from said second SoC.

20. The vision system of claim **19**, wherein the driver assistance system comprises at least one of a backup assist system, an adaptive cruise control system, a headlamp control system and a lane departure warning system.

* * * * *